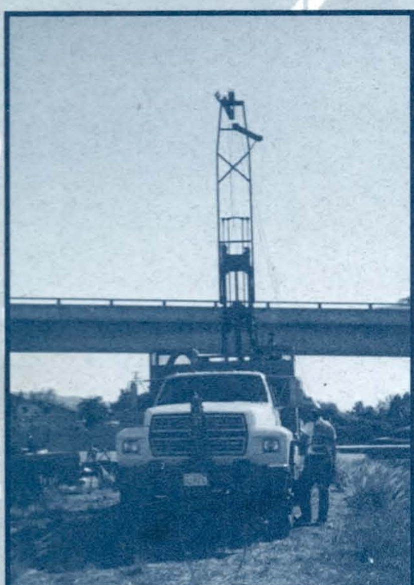
Eng Copy

GEOTECHNICAL EVALUATION
10TH STREET WASH STORM DRAIN
PHOENIX, ARIZONA
CONTRACT FCD 2003C013
ASSIGNMENT NO. 5



Geotechnical

and

Environmental

Sciences

Consultants

Ninyo & Moore

Ninyo & Moore
Geotechnical and Environmental Sciences Consultants

GEOTECHNICAL EVALUATION
10TH STREET WASH STORM DRAIN
PHOENIX, ARIZONA
CONTRACT FCD 2003C013
ASSIGNMENT NO. 5

PREPARED FOR:
Flood Control District of Maricopa County
2801 West Durango Street
Phoenix, Arizona 85009-6399

PREPARED BY:
Ninyo & Moore
Geotechnical and Environmental Sciences Consultants
3001 South 35th Street, Suite 6
Phoenix, Arizona 85034

June 17, 2005
Project No. 600550005

Ninyo & Moore
Geotechnical and Environmental Sciences Consultants

June 17, 2005
Project No. 600550005

Mr. Warren Rosebraugh, P.E.
Flood Control District of Maricopa County
2801 West Durango Street
Phoenix, Arizona 85009-6399

Subject: Geotechnical Evaluation
10th Street Wash Storm Drain
Phoenix, Arizona
Contract FCD 2003C013
Assignment No. 5

Dear Mr. Rosebraugh:

In accordance with our authorization dated January 24, 2005, Ninyo & Moore has performed a geotechnical evaluation for the above referenced site. The attached report represents our deliverable for this project and presents our methodology, findings, conclusions, and recommendations regarding the geotechnical conditions at the project site.

We appreciate the opportunity to be of service to you during this phase of the project. If you have any questions or comments regarding this report, please call at your convenience.

Sincerely,
NINYO & MOORE

Registered Professional Engineer (Civil) CERTIFICATE NO. 34866 STEVEN D. NOWACZYK Date Signed 6.17.05 ARIZONA, U.S.A.

Steven D. Nowaczyk, P.E.
Principal Engineer

Robert W. McMichael, P.E.
Principal Engineer

SDN/RM/avv

Distribution: (3) Addressee

TABLE OF CONTENTS

Tables

Figures

Appendices

1. INTRODUCTION

In accordance with our authorization dated January 24, 2005, we have performed a geotechnical evaluation for the 10th Street Wash Storm Drain project located in Phoenix, Arizona. The purpose of our evaluation was to assess the subsurface conditions at the project site in order to formulate geotechnical recommendations for design and construction of the wash improvements. This report presents the results of our evaluation and our geotechnical conclusions and recommendations regarding the proposed construction.

2. SCOPE OF SERVICES

The scope of our services for the project generally included the following:

- Visual reconnaissance of the project site, including utility location and mark-out of the exploration plan.
- Reviewing of available topographic information, soil surveys, geologic literature and aerial photographs of the project area.
- Drilling of 16 borings with hollow-and solid-stem augers. The borings were advanced to a depth ranging from approximately 4 inches to 15 feet below the ground surface (bgs). A Ninyo & Moore geologist observed the drilling. In-situ testing was conducted, and soil samples were collected at approximately 2.5 to 5.0-foot depth intervals.
- Conducting two seismic refraction surveys along the alignment of the proposed improvements, to develop depths to competent bedrock and rippability information.
- Conducting geotechnical laboratory testing of representative soil samples that included in-situ moisture content and dry density, grain size analysis, Atterberg limits, maximum density/optimum moisture relationship, direct shear tests, expansion index, and corrosion potential.
- Preparing this report that presents our findings, conclusions, and recommendations regarding the design and construction of the project.

3. SITE DESCRIPTION

The project site is located in the central portion of Maricopa County, in the City of Phoenix, Arizona within Section 33, Township 3 North, and Range 3 East. Figure 1 depicts the approximate location of the site. The project limits generally follow the alignment of 10th Street, from roughly Alice Avenue to Griswold Road and then west to the AC-DC drainage structure, where an existing open channel, known as the 10th Street Wash, is located. The wash bottom is covered with scattered low-lying vegetation and some trees, while the ground surface adjacent to the wash is covered with low-lying vegetation and asphalt pavement. The area surrounding the alignment has been developed with single-family homes. The existing wash in this area crosses nine street alignments: Ruth Avenue, Diana Avenue, Orchid Lane, Seldon Lane, Butler Drive, Echo Lane, El Caminito Drive, Las Palmaritas Drive, and El Camino Drive; however, Butler Drive currently crosses the wash with a box culvert structure.

According to the *Sunnyslope, Arizona 7.5-Minute United States Geological Survey (USGS) Topographic Quadrangle Map (1978)*, the proposed alignment (at the bottom of the existing wash) lies at an average elevation of roughly 1,240 feet relative to mean sea level (MSL). Based on the information from these quadrangle maps, the alignment slopes very gently from the northeast to the southwest, with a vertical drop in elevation of about 20 feet.

Two aerial photographs were reviewed for this project. A 1973 United States Department of Agriculture (USDA) and a 1999 aerial photograph from *Landiscor's Phoenix Real Estate Photo Book* depicted the site to be surrounded by residential roads and residential/commercial development, similar to its current condition.

4. PROPOSED CONSTRUCTION

The improvements proposed for this project include the enclosure of the existing wash with Reinforced Concrete Pipe (RCP) or Cast in Place (CIP) concrete pipe that will be on the order of 72 to 90 inches in diameter. The new pipe will be located about 12 to 18 feet bgs adjacent to the existing wash.

5. FIELD EXPLORATION

On February 10 and June 3, 2005, Ninyo & Moore conducted subsurface explorations at the project site in order to evaluate the existing subsurface conditions and to collect soil samples for laboratory testing. Our exploration consisted of the excavation, logging, and sampling of 16, small-diameter borings. Six of the borings (denoted as borings B-1 through B-6) were drilled using a CME-75 truck-mounted drill rig, equipped with hollow-stem augers and the remaining 10 (denoted as borings B-7 through B-16) were drilled with a jeep-mounted rig equipped with solid-stem augers. Borings B-1 through B-6 were drilled within the 10th Street alignment, adjacent to the existing wash and at current street level. Borings B-7 through B-16 were drilled within the existing 10th Street wash, about 5 feet below current street level. Bulk and relatively undisturbed soil samples were collected at selected depth intervals. Detailed descriptions of the soils encountered are presented in the boring logs in Appendix A.

The ground surface elevations at each boring location were estimated based on the information we received from your office and are depicted on the logs. The general locations of the borings are shown on the Soil Boring Location Map (Figure 2).

In addition to the borings drilled, on April 18, 2005, two seismic refraction survey traverses, designated as SL-1 and SL-2, were performed to develop depths to competent rock and to evaluate the rippability of the soil and the underlying bedrock materials. Detailed results of the seismic refraction surveys, including depth profiles and estimated rippability, are provided in Appendix C of this report.

6. LABORATORY TESTING

The soil samples collected from our drilling activities were transported to the Ninyo & Moore laboratory in Phoenix, Arizona, for geotechnical testing. The testing included in-situ moisture content and dry density, grain size analysis, Atterberg limits, maximum density/optimum moisture relationship, direct shear testing, expansion index, and corrosivity characteristics (including pH, minimum electrical resistivity, soluble sulfates, and chlorides). The results of the laboratory testing are presented on the boring logs and/or in Appendix B.

7. GEOLOGY AND SUBSURFACE CONDITIONS

Our findings regarding geology, subsurface earth materials, and groundwater conditions along the proposed alignment are provided in the following sections.

7.1. Geologic Setting

The project site is located in the Sonoran Desert Section of the Basin and Range physiographic province, which is typified by broad alluvial valleys separated by steep, discontinuous, sub parallel mountain ranges. The mountain ranges generally trend north-south and northwest-southeast. The basin floors consist of alluvium with thickness extending to several thousands of feet.

Extensional tectonics began approximately 20 million years ago during the Middle Tertiary, resulting in the formation of horsts (mountains) and grabens (basins) with vertical displacement along high-angle normal faults (Moores, Twiss, 1995). Intermittent volcanic activity also occurred during this time. The surrounding basins filled with alluvium from the erosion of the surrounding mountains as well as from deposition from rivers. Coarser-grained alluvial material was deposited at the margins of the basins near the mountains. The surficial geology of the site is described as late to middle Pleistocene basin-floor deposits consisting of sand, silt, clay and fine gravel with substantial soil clay accumulation (Spencer et al., 1996).

7.2. Subsurface Conditions

Our knowledge of the subsurface conditions at the project site is based on our field exploration and laboratory testing, and our understanding of the general geology of the area. The following sections provide generalized descriptions of the materials encountered. More detailed descriptions are presented on the boring logs in Appendix A.

7.2.1. Undocumented Fill

Undocumented fill was encountered near the surface at borings B-1 and B-6, and extended to depths of approximately 3 to 5 feet. The fill generally consisted of medium dense sandy silt, sandy clay, and sandy gravel.

7.2.2. Alluvium

Alluvium was encountered in our borings below the fill soils, and extended to the total depths explored, with the exception of boring B-5, where alluvium extended to 8.5 feet bgs. The alluvium generally consisted of medium dense to very dense clayey sand, very dense sandy gravels, and hard sandy clays. Caliche nodules and filaments were present in the borings to the total depth explored.

7.2.3. Metamorphosed Basalt

Basalt bedrock was encountered below the alluvium soils in borings B-5, B-8, B-9, B-10, B-11, B-12, B-13, B-14, and B-16. This bedrock layer was observed at a depth of about 8.5 feet bgs at street level and less than 1 foot bgs within the borings drilled in the existing wash and caused auger refusal within the borings mentioned above.

7.3. Groundwater

Groundwater was not encountered in our borings. Insufficient groundwater data provided by the Arizona Department of Water Resources (ADWR) was available for the Section, Township, and Range that the project site lies within; however, groundwater data for adjacent Sections, Townships, and Ranges were reviewed. Based on this adjacent well data information (Township 2 North, Range 3 East, and Sections 4, 5, and 32) groundwater levels could be as shallow as 150 feet bgs. Groundwater levels can fluctuate due to seasonal variations, irrigation, groundwater withdrawal or injection, and other factors. Groundwater is not expected to be a constraint to the construction of this project.

8. GEOLOGIC HAZARDS

The following sections describe potential geologic hazards at the site, including earth fissures, faulting and seismicity, surface rupture, and liquefaction.

8.1. Land Subsidence and Earth Fissures

Groundwater depletion, due to groundwater pumping, has caused land subsidence and earth fissures in numerous alluvial basins in southern Arizona. It has been estimated that subsidence has affected more than 3,000 square miles and has caused damage to a variety of engineered structures and agricultural land (Schumann and Genualdi, 1986). From 1948 to 1983, excessive groundwater withdrawal has been documented in several alluvial valleys where groundwater levels have been reportedly lowered by up to approximately 500 feet. With such large depletions of groundwater, the alluvium has undergone consolidation resulting in large areas of land subsidence.

In some areas of Arizona, earth fissures are associated with land subsidence and pose an ongoing geologic hazard. Earth fissures generally form near the margins of geomorphic basins where significant amounts of groundwater depletion have occurred. Reportedly, earth fissures have also formed due to tensional stress caused by differential subsidence of the unconsolidated alluvial materials over buried bedrock ridges and irregular bedrock surfaces (Schumann and Genualdi, 1986).

Based on our field reconnaissance and review of the referenced material, there are no known earth fissures underlying or near the subject site. The closest documented earth fissure is approximately 8 miles to the northeast; therefore, earth fissures are not expected to be a constraint to the project.

8.2. Faulting and Seismicity

The site lies within the Sonoran zone, which is a relatively stable tectonic region located in southwestern Arizona, southeastern California, southern Nevada, and northern Mexico (Euge et al., 1992). This zone is characterized by sparse seismicity and few Quaternary faults. Based on our field observations, review of pertinent geologic data, and analysis of aerial photographs, faults are not located on or adjacent to the property. The closest fault to the site with documented Quaternary age movement is the 7.5 mile-long northwest striking Carefree fault zone, located approximately 20 miles to the northeast of the site (Pearthree, 1998). Approximately 2 meters of displacement has occurred along this fault within middle Pleistocene deposits (<750,000 years), but the upper Pleistocene and Holocene deposits (<250,000 years) are generally not displaced. Estimates for a possible credible earthquake magnitude that could be generated along the Carefree fault zone (Skotnicki et al., 1997) yield a range of magnitudes from about 6.3 to 6.5.

Based on a Probabilistic Seismic Hazard Assessment for the Western United States, issued by the USGS (1999), peak ground accelerations are expressed in units of percentage of standard gravitational acceleration (g). The probabilistic accelerations for the project site which have a 10 percent, 5 percent, and 2 percent probability of being exceeded in 50 years are 0.05g, 0.07g and 0.10g respectively. These ground motion values are calculated for "firm rock" sites, which correspond to a shear-wave velocity of approximately 2,500 feet per second in approximately the top 100 feet bgs. Different soil sites may amplify or de-amplify these values. Seismic design parameters according to the 2000 International Building Code (IBC) are presented in Table 1. The applicable IBC soil profile type is D. The requirements of the governing jurisdictions and applicable building codes should be considered in the design of the subsurface structures. The remaining seismic design parameters according to the IBC are presented in Table 1.

Table 1 – Seismic Design Parameters

Parameter	Value	2000 IBC Reference
Soil Profile Type	D	Table 1615.1.1
Seismic Coefficient F_a	1.6	Table 1615.1.2(1)
Seismic Coefficient F_v	2.4	Table 1615.1.2(2)

8.3. Liquefaction Potential

Based on the Standard Penetration Test values recorded at various depths in our exploratory borings, the lack of shallow groundwater, and the relatively low peak ground accelerations, the likelihood or potential for soil liquefaction is considered negligible. Liquefaction is therefore not considered to be a design factor for the project.

9. CONCLUSIONS

Based on the results of our subsurface evaluation, laboratory testing, and data analysis, it is our opinion that the proposed construction is feasible from a geotechnical standpoint, provided that the recommendations of this report are incorporated into the design and construction of the proposed project, as appropriate. Geotechnical considerations include the following:

- The on-site soils should generally be excavatable to planned depths with conventional earthmoving construction equipment in good working condition. However, the underlying bedrock materials, where encountered, will call for more aggressive equipment or blasting to excavate.
- Imported soils and soils generated from on-site excavation activities that exhibit relatively low plasticity indices and a very low to low swell potential can generally be used for engineered fill.
- Temporary cut slopes associated with this project should be constructed at a slope ratio no steeper than 1:1 (H:V) up to a height of 10 feet. If the height of the temporary cut slope exceeds 10 feet, the slope should be constructed at a slope ratio of 1.5:1 (H:V) or flatter.
- Groundwater was not observed in our borings. Based on data from ADWR, the groundwater table could be as shallow as about 150 feet bgs.
- No known or reported geologic hazards are present underlying or adjacent to the site.
- Corrosivity test results indicate that subgrade soils at the site may be corrosive to ferrous metals and the sulfate content of the soils present a negligible to moderate sulfate exposure to concrete.

10. RECOMMENDATIONS

The following sections present our geotechnical recommendations for the improvements. If the proposed construction is changed from that discussed in this report, Ninyo & Moore should be contacted for additional recommendations.

10.1. Earthwork

The following sections provide our earthwork recommendations. In general, the earthwork specifications contained in Maricopa Association of Governments (MAG), *Uniform Stan-*

dard Specifications and Details for Public Works Construction and/or any City of Phoenix supplements, are expected to apply, except as noted.

10.1.1. Excavations

Our evaluation of the excavation characteristics of the on-site materials is based on the results of the 16 exploratory borings, two seismic refraction surveys, our site observations, and our experience with similar materials. In our opinion, excavation of the on-site alluvium soils can generally be accomplished to the expected depths with conventional earthmoving equipment in good operating condition. However, bedrock was encountered in some of our borings and interpreted from our seismic refraction surveys, which will likely be encountered when excavating for this project. The following table summarizes the estimated depths at which we encountered this bedrock material at our exploration locations.

Table 2 – Summary of Estimated Depth to Bedrock

Boring Designation	Approximate Depth to Bedrock from Surface of Boring, feet
B-5	8.5
B-8	6.0
B-9	1.5
B-10	0.3
B-11	0.5
B-12	1.0
B-13	1.0
B-14	3.5
B-16	9.5
Please note that boring B-5 was drilled on the roadway adjacent to the existing 10th Street Wash and the remainder of the borings were drilled at the bottom of the existing 10th Street Wash.	

Based on our evaluation, blasting and/or special rock excavation equipment may be needed to facilitate excavations within this bedrock material along the proposed alignment. We understand that blasting at these sites may be undesirable because of the nearby residential environment and the excessive noise and vibrations that could be generated. A contractor with experience in difficult excavation conditions should be consulted for alternatives to blasting and shall be consulted for expert advice on excavation methodology. The contractor should use the borings and seismic refraction survey data presented in Appendix A and C as a tool for estimating the excavation parameters associated with this project. The estimated depth to bedrock presented in Table 2 may not correlate with rippability.

Depending on the excavation method used, the proposed excavations will likely generate oversize material (particles larger than 3 inches) that will not be suitable for reuse as trench backfill. Screening, disposal, and/ or crushing of this material should be anticipated if reuse is considered.

The contractor should provide safely sloped excavations or an adequately constructed and braced shoring system, in compliance with Occupational Safety and Health Administration (OSHA) regulations, for employees working in an excavation that may expose employees to the danger of moving ground. If material is stored or equipment is operated near an excavation, stronger shoring should be used to resist the extra pressure due to superimposed loads.

We recommend that trenches and excavations be designed and constructed in accordance with OSHA regulations. These regulations provide trench sloping and shoring design parameters for trenches up to 20 feet deep based on a description of the soil types encountered. Trenches greater than 20 feet deep should be designed by the Contractor's engineer based on site-specific geotechnical analyses. For planning purposes, we recommend that the OSHA soil classification for the encountered alluvial soil be considered as Type C.

10.1.2. Earthwork Factors

Based on comparisons between the in-place density and Proctor tests performed in our laboratory, we recommend using an earthwork shrinkage factor of 10 percent for excavated fill and alluvium soils associated with this project. For the bedrock material, we recommend using an earthwork expansion factor of 5 percent. These factors represent an average of the materials observed with varying densities and consistencies. Potential bidders should consider this in preparing estimates and should review the available data to make their own conclusions regarding the earthwork factors.

10.1.3. Constructed Slopes

Based on the boring information and our experience with similar projects, we recommend that temporary cut slopes associated with this project be constructed at a slope ratio no steeper than 1:1 (H:V) up to a depth of 10 feet. If the depth of the temporary cut slope exceeds 10 feet, the slope should be constructed at a slope ratio of 1.5:1 (H:V) or flatter. Permanent cut and fill slopes associated with this project should be constructed at a slope ratio no steeper than 2:1 (H:V). The fill slope recommendation assumes that the fill material used to construct the slope meets the criteria in this report. It also assumes that new embankment fills will be benched into existing embankments, where appropriate. Benches should be level and wide enough to allow operation of, and compaction by, construction equipment. Cut and fill slopes should be protected from erosion.

10.1.4. Temporary Earth Retaining Systems

As an alternative to laying back the side walls, the excavations may be shored or braced. Temporary earth retaining systems will be subject to lateral loads resulting from earth pressures. Shored or braced trench excavations in alluvial soils may be designed using the parameters presented on Figure 3. Trench boxes may also be a suitable alternative to laying back the side walls. Some sloughing is possible at the ends of the trench box, and any loose material should be removed prior to backfilling of the trench.

The design earth pressure diagram assumes that spoils from the excavation or other surcharge loads will not be placed above the excavation within a 1:1 plane extending upward from the base of the excavation. If stockpiles of excavation spoils are placed within the 1:1 plane, the resulting surcharge loads should be considered in the bracing or trench box design. We recommend that an experienced structural engineer design the shoring system. The shoring parameters presented in this report should be considered as guidelines.

10.1.5. Grading, Fill Placement, and Compaction

Vegetation and debris from the clearing operation should be removed from the site and disposed of at a legal dumpsite. Demolition debris should also be removed from the site and disposed of at a legal dumpsite. Obstructions that extend below finish grade, if present, should be removed and the resulting holes filled with compacted soil.

The geotechnical consultant should carefully evaluate any areas of loose or soft and wet soils prior to placement of fill or other construction. Drying or overexcavation and replacement of such materials should be anticipated.

Imported soils and soils generated from on-site excavation activities that exhibit relatively low plasticity indices and very low to low expansion potential are generally suitable for reuse as engineered fill. Relatively low plasticity indices are defined as a value of 20 or less (by ASTM D 4318). Very low to low expansion potential soils are defined as having an Expansion Index (by ASTM D 4829) of 50 or less. Our laboratory tests performed on a soil samples from the boring excavations indicated a plasticity index ranging from 0 (or non-plastic) to 23 and an Expansion Index of 0. As such, some of the on-site soils may not be suitable for re-use as engineered fill. To better delineate the presence of these unsuitable soils, we recommend that additional observation, soil sampling, and possible laboratory testing be conducted during construction.

Suitable fill should not include organic material, clay lumps, construction debris, rock particles, and other non-soil fill materials larger than 3 inches in dimension. This material should be disposed of offsite or in non-structural areas.

We recommend that new fill be placed in horizontal lifts approximately 9 inches in loose thickness and compacted by appropriate mechanical methods, to 95 percent or more relative compaction, in accordance with ASTM D 698-00 at a moisture content within 2 percent of its optimum.

It is our option that the on site alluvium soils encountered in our borings will likely shrink on the order of 10 to 15 percent during the earthwork operations. Alternatively, the bedrock will likely swell on the order of 5 to 10 percent.

10.1.6. Imported Fill Material

Imported fill, if utilized for this project, should consist of clean, granular material with a relatively low plasticity index and very low to low expansion potential. The imported material should be free of organics, debris, and other deleterious materials. Import material in contact with ferrous metals or concrete should preferably have low corrosion potential (minimum resistivity greater than 2,000 ohm-cm, chloride content less than 25 parts per million [ppm], and soluble sulfate content of less than 0.1 percent). The geotechnical consultant should evaluate such materials and details of their placement prior to importation.

In addition to the above requirements, we recommend imported fill materials meet the following gradations:

Table 3 – Imported Fill Gradation

Sieve Size	Percent Passing (By Weight)
3 inch	100
No. 4	40 – 100
No. 200	5 – 50

10.2. Pipe Installation and Trench Backfill

We understand that this storm drain may be installed using either cut-and-cover or cast-in-place techniques. The following sections provide our recommendations with regards to the installation of this storm drain, regardless of the construction type used.

10.2.1. Construction Dewatering

Shallow groundwater is not anticipated along the alignment during construction. However, surface run-off may be encountered where the alignment crosses existing drainage paths or above the alluvium/bedrock interface. Surface run-off will vary seasonally depending on rainfall. Given the low probability of encountering significant seepage along the alignments, we anticipate that the excavations that do encounter nuisance seepage or surface run-off, could be dewatered by sumping the water from the bottom of the excavation. However, saturated sands, if encountered, may need more aggressive means of dewatering such as well points.

10.2.2. Pipe Bedding and Modulus of Soil Reaction (E')

For a cut-and-cover installation technique, we recommend that the new pipe be supported on 6 or more inches of granular bedding material such as graded sand or crushed rock with a particle size of 3/4-inch or less. Bedding materials should be durable and relatively clean, with no more than 10 percent (by weight) passing the No. 200 sieve. Bedding materials should be compacted in lifts. The compaction requirements should be in accordance with the recommendations in this report and the MAG specifications for Public Works Construction (MAG, 1992). Pipe bedding and trench backfill details are presented on Figure 4.

The modulus of soil reaction (E') is used to characterize the stiffness of soil backfill placed at the sides of buried pipe for the purpose of evaluating deflection caused by the weight of the backfill over the pipe. It is our understanding that the depth of pipe will generally be about 10 to 13 feet bgs. For granular backfill soils, we recommend using an E' value of 1,500 pounds per square inch (psi).

10.2.3. Trench Backfill

Deleterious material, such as non-soil objects, trash, or debris, was generally not encountered during our reconnaissance or subsurface exploration; however, if encountered during construction, these materials should not be reused. It is possible that cobble or boulder pieces and/or caliche deposits greater than approximately 3 inches in diameter could be generated in some of the excavations. Particles larger than approximately 3 inches should be screened or crushed to a finer size. Potential fill soil imported to the site should consist of non-expansive, non-corrosive, durable, and graded granular material. The project geotechnical consultant should evaluate materials prior to importation.

Backfill should be placed at a moisture content within 2 percent of its optimum. Backfill should be compacted to a relative compaction of 95 percent or more of the maximum dry density as evaluated by ASTM D 698-00. The backfill in the upper 2 foot zone below pavement sections should, however, be placed to 100 percent relative density. Lift thickness for backfill will be dependent upon the type of compaction equipment utilized, but should generally be placed in uniform lifts not exceeding 9 inches in loose thickness. Special care should be exercised to avoid damaging the pipe or other structures during the compaction of the backfill. In addition, the underside (or haunches) of the buried pipe should be supported on bedding material that is compacted as described above. Manual placement and compaction may be needed to keep pipe haunches continuously supported.

10.2.4. Cast-In-Place Pipe

It is our opinion that cast-in-place concrete pipes can be used for this project. For this construction technique, we recommend that subgrade material supporting the new pipe consist of native alluvium soils. In areas where bedrock is exposed at the bottom of the new pipe elevation, we recommend that the bedrock be overexcavated and replaced with engineered fill soil, such that 2 or more feet of engineered fill is situated between the pipe invert and the surface of the underlying bedrock. Under no circumstance should the new pipe be supported directly on bedrock material.

10.2.5. Pipeline Frictional Resistance

For frictional resistance of an uncoated pipe, we recommend a coefficient of friction of 0.4. If the pipe is wrapped in a corrosion resistant tape or enamel, we recommend a coefficient of friction of 0.2.

10.3. Pavement

Some pavement replacement is anticipated in areas of this project. For our design of this new pavement section, we assumed that the roads in questions are classified as Local Residential Streets. Based on the current City of Phoenix Standard Detail for pavements, our experience with similar projects and the soil/laboratory information we collected, new pavements associated with this project should consist of 3 inches of asphalt concrete over 8 inches of base course material. The asphalt concrete can be placed in one lift and should conform to Section 321 and 710 of the MAG Specifications and the City of Phoenix Supplements. The base course material should consist of 4 inches of aggregate base coarse (ABC) over 6 inches of ABC or "Select Material" in accordance with Table 702 of the MAG Specifications. ABC material should be compacted to a relative compaction of 98 percent or more of the maximum dry density, as evaluated by ASTM D 698-00, at a moisture content of approximately 2 to 3 percent above the optimum.

10.4. Corrosion Potential

The corrosion potential of the on-site materials was analyzed to evaluate its potential effect on the foundations and structures. Corrosion potential was evaluated using the results of laboratory testing of samples obtained during our subsurface evaluation that were considered representative of soils at the subject site.

Laboratory testing consisted of pH, minimum electrical resistivity, and chloride and soluble sulfate contents. The pH and minimum electrical resistivity tests were performed in general accordance with Arizona Test 236b, while sulfate and chloride tests were performed in accordance with Arizona Test 733 and 736 , respectively. The results of the corrosivity tests are presented in Appendix B.

The soil pH value of a sample tested was 7.8, which is considered to be alkaline. The minimum electrical resistivity measured in the laboratory was 472 ohm-cm, which is considered to be corrosive to ferrous materials. The chloride content of a samples tested was measured to be 250 ppm, which is also considered to be corrosive to ferrous materials. The soluble sulfate content of a soil sample tested was measured to be 0.0068 percent, which is considered to represent a negligible sulfate exposure for concrete.

The results of the laboratory testing indicate that the on-site materials could be corrosive to ferrous metals. Therefore, special consideration should be given to the use of heavy gauge, corrosion protected, underground steel pipe or culverts, if any are planned. As an alternative, plastic pipe or reinforced concrete pipe could be considered. A corrosion specialist should be consulted for further recommendations.

10.5. Concrete

Laboratory chemical tests performed on selected samples of on-site soils indicated a sulfate content of 0.0068 percent by weight. Based on the following UBC table, the on-site soils should be considered to have a negligible sulfate exposure to concrete.

Table 4 – UBC Requirements for Concrete Exposed to Sulfate-Containing Soil

Sulfate Exposure	Water-Soluble Sulfate (SO_4) in Soil, Percentage by Weight	Cement Type	Maximum Water-Cementitious Materials Ratio, by Weight, Normal-Weight Aggregate Concrete[1]	Minimum f'_c, Normal-Weight and Lightweight Aggregate Concrete, psi
				x 0.00689 for MPa
Negligible	0.00 - 0.10	--	--	--
Moderate[2]	0.10 - 0.20	II, IP(MS), IS (MS)	0.50	4,000
Severe	0.20 - 2.00	V	0.45	4,500
Very severe	Over 2.00	V plus pozzolan[3]	0.45	4,500

[1] A lower water-cementitious materials ratio or higher strength may be required for low permeability or for protection against corrosion of embedded items or freezing and thawing (Table 19-A-2).
[2] Seawater.
[3] Pozzolan that has been determined by test or service record to improve sulfate resistance when used in concrete
containing Type V cement.

Not withstanding the laboratory results, we recommend the use of Type II cement for construction of concrete structures at this site. Due to potential uncertainties as to the use of reclaimed irrigation water, or topsoil that may contain higher sulfate contents, pozzolan or admixtures designed to increase sulfate resistance may be considered.

The concrete should have a water-cementitious materials ratio no greater than 0.45 by weight for normal weight aggregate concrete. From a quality standpoint, a 28-day compressive strength of 4,000 psi or higher is desirable because it will improve concrete durability and resistance to sulfate attack.

10.6. Pre-Construction Conference

We recommend that a pre-construction conference be held. Representatives of the owner, the civil engineer, the geotechnical consultant, and the contractor should be in attendance to discuss the project plans and schedule. Our office should be notified if the project description included herein is incorrect, or if the project characteristics are significantly changed.

10.7. Construction Observation and Testing

During construction operations, we recommend that a qualified geotechnical consultant perform observation and testing services for the project. These services should be performed to evaluate exposed subgrade conditions, including the extent and depth of overexcavation, to evaluate the suitability of proposed borrow materials for use as fill and to observe placement and test compaction of fill soils. If another geotechnical consultant is selected to perform observation and testing services for the project, we request that the selected consultant provide a letter to the owner, with a copy to Ninyo & Moore, indicating that they fully understand our recommendations and that they are in full agreement with the recommendations contained in this report. Qualified subcontractors utilizing appropriate techniques and construction materials should perform construction of the proposed improvements.

11. LIMITATIONS

The field evaluation, laboratory testing, and geotechnical analyses presented in this geotechnical report have been conducted in general accordance with current practice and the standard of care exercised by geotechnical consultants performing similar tasks in the project area. No warranty, expressed or implied, is made regarding the conclusions, recommendations, and opinions presented in this report. There is no evaluation detailed enough to reveal every subsurface condition. Variations may exist and conditions not observed or described in this report may be encountered during construction. Uncertainties relative to subsurface conditions can be reduced through additional subsurface exploration. Additional subsurface evaluation will be performed upon request. Please also note that our evaluation was limited to assessment of the geotechnical aspects of the project, and did not include evaluation of structural issues, environmental concerns, or the presence of hazardous materials.

This document is intended to be used only in its entirety. No portion of the document, by itself, is designed to completely represent any aspect of the project described herein. Ninyo & Moore should be contacted if the reader requires additional information or has questions regarding the content, interpretations presented, or completeness of this document.

This report is intended for design purposes only. It does not provide sufficient data to prepare an accurate bid by contractors. It is suggested that the bidders and their geotechnical consultant perform an independent evaluation of the subsurface conditions in the project areas. The independent evaluations may include, but not be limited to, review of other geotechnical reports prepared for the adjacent areas, site reconnaissance, and additional exploration and laboratory testing.

Our conclusions, recommendations, and opinions are based on an analysis of the observed site conditions. If geotechnical conditions different from those described in this report are encountered, our office should be notified and additional recommendations, if warranted, will be provided upon request. It should be understood that the conditions of a site could change with time as a result of natural processes or the activities of man at the subject site or nearby sites. In addition, changes to the applicable laws, regulations, codes, and standards of practice may occur due to government action or the broadening of knowledge. The findings of this report may, therefore, be invalidated over time, in part or in whole, by changes over which Ninyo & Moore has no control.

This report is intended exclusively for use by the client. Any use or reuse of the findings, conclusions, and/or recommendations of this report by parties other than the client is undertaken at said parties' sole risk.

12. SELECTED REFERENCES

American Society for Testing and Materials (ASTM), 1997 Annual Book of ASTM Standards.

Arizona Department of Water Resources (ADWR). Drillers logs in file.

Euge, K.M., Schell, B.A., and Lam, I.P., 1992, Development of Seismic Acceleration Contour Maps for Arizona: Arizona Department of Transportation Report No. AZ 92-344: dated September.

Frankel, A., Mueller, C., Barnhard, T., Perkins, D., Leyendecker, E.V., Dickman, N., Hanson, S., and Hopper, M., 1997, Seismic Hazard Maps for California, Nevada and Western Arizona/Utah, Map B-Peak Horizontal Acceleration with a 5% Probability of Exceedance in 50 Years: United States Geological Survey, Open-File Report 97-130-B.

International Building Code, 2000, International Code Council.

Landiscor, 1999, Real Estate Photo Book for the Greater Phoenix Area.

Maricopa Association of Governments, 1998, Uniform Standard Specifications and Details for Public Works Construction.

Ninyo & Moore, In-house proprietary information.

Pearthree, P.A., 1998, Quaternary Fault Data and Map for Arizona: Arizona Geological Survey, Open-File Report 98-24.

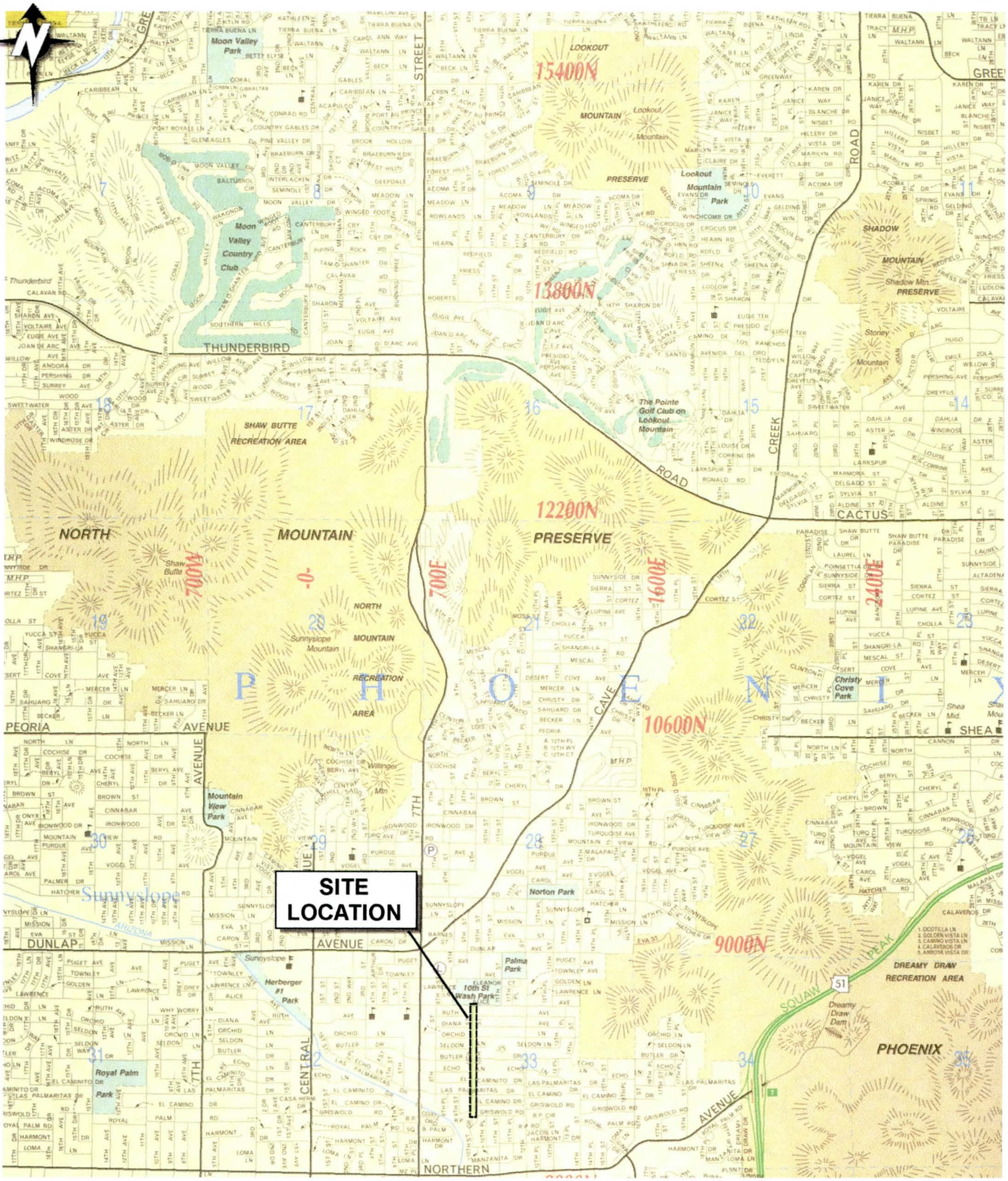
Reynolds, Stephen J., Grubensky, Michael J., Geologic Map of the North 30' x 60' Quadrangle, Central Arizona: Arizona Geological Survey, Open-File Report 93-17.

Schumann, H.H. and Genualdi, R., 1986, Land Subsidence, Earth Fissures, and Water Level Changes in Southern Arizona: Arizona Geological Survey OFR 86-14, Scale 1:500,000.

United States Department of Agriculture, 1973, Soil Survey of Maricopa County: Central Part, Arizona.

United States Geological Survey, 1978, Sunnyslope, Arizona, Maricopa County, 7.5 Minute Series (Topographic): Scale 1" = 24,000'.

United States Geological Survey, 1997, 1998, 1999, National Seismic Hazard Mapping Project, World Wide Web, http://geohazards.cr.usgs.gov/eq.

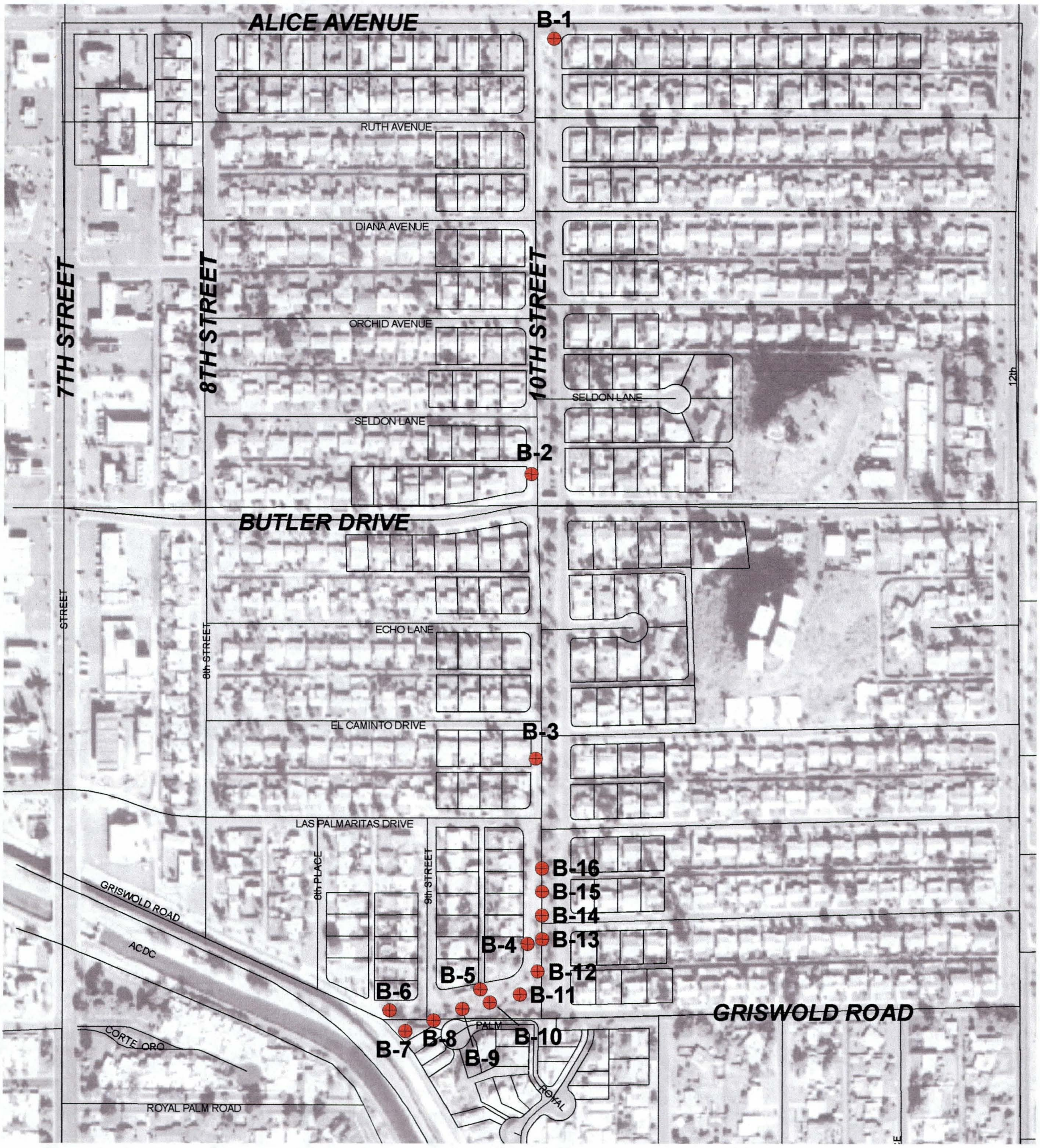


0 3333

Approximate Scale:
1 inch = 3333 feet

SOURCE: Phoenix Mapping Company, Phoenix Metro Edition, 2002.

Ninyo & Moore	SITE LOCATION MAP		
10TH STREET WASH IMPROVEMENTS BETWEEN ALICE AVENUE AND GRISWOLD ROAD PHOENIX, ARIZONA			FIGURE 1
PROJECT No: 600550005	FILE No: 550vm0305	DATE: 06/05	



LEGEND

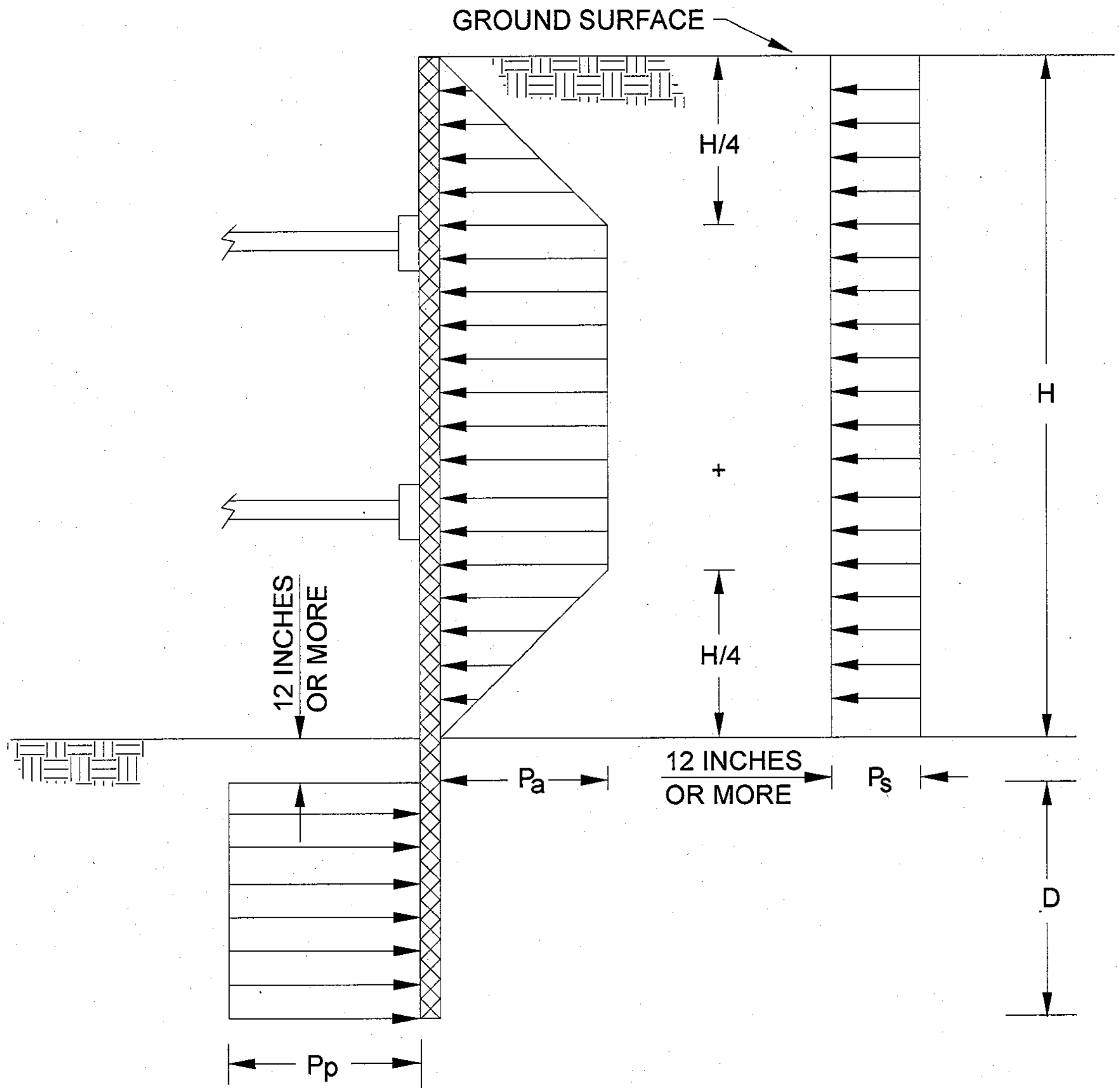
B-1 ⊕ Approximate Soil Boring Location

0 150 300

Approximate Scale: 1 inch = 300 feet

SOURCE: Maricopa County Assessor's GIS Dept, 2004.

Ninyo & Moore	SOIL BORING LOCATION MAP	
10TH STREET WASH IMPROVEMENTS BETWEEN ALICE AVENUE AND GRISWOLD ROAD PHOENIX, ARIZONA		FIGURE 2
PROJECT No: 600550005	FILE No: 550sp0605b	DATE: 06/05

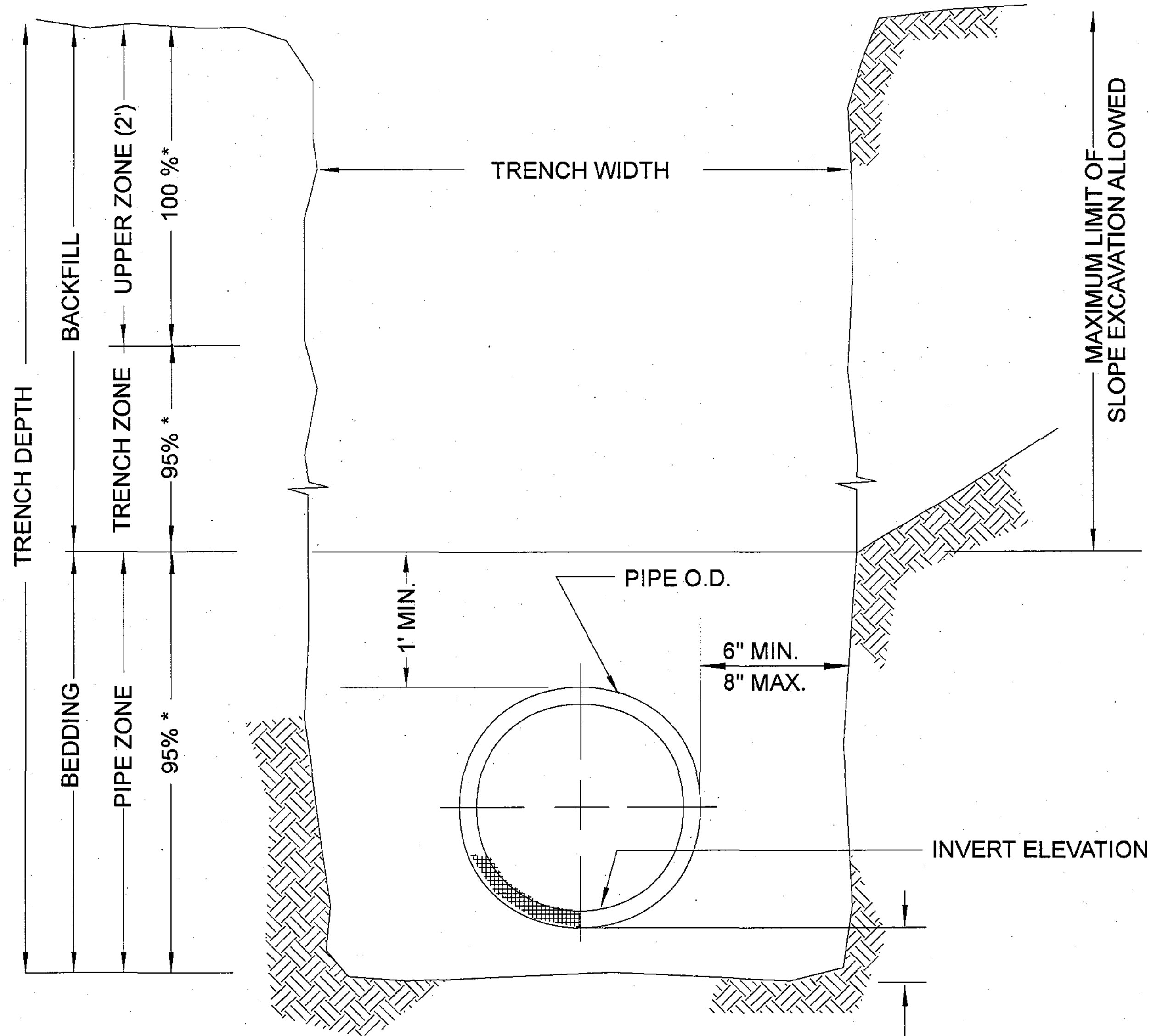


NOTES:

1. APPARENT LATERAL EARTH PRESSURE, P_a
   $P_a = 22 * H$ psf
2. CONSTRUCTION TRAFFIC INDUCED SURCHARGE PRESSURE, P_s
   $P_s = 120$ psf
3. PASSIVE LATERAL EARTH PRESSURE, P_p
   $P_p = 235 * D$ psf
4. ASSUMES GROUNDWATER NOT PRESENT
5. SURCHARGES FROM EXCAVATED SOIL OR CONSTRUCTION MATERIALS ARE NOT INCLUDED
6. H AND D ARE IN FEET

NOT TO SCALE

Ninyo & Moore	LATERAL EARTH PRESSURES FOR BRACED EXCAVATION		
10TH STREET WASH IMPROVEMENTS BETWEEN ALICE AVENUE AND GRISWOLD ROAD PHOENIX, ARIZONA			FIGURE 3
PROJECT No: 600550005	FILE No: 550dtl0305a	DATE: 06/05	



SECTION

NOTE

* Indicates minimum relative compaction (see report for details).

Upper zone required for pavement areas only.

Diagram not drawn to scale.

NOT TO SCALE

Ninyo & Moore	PIPE BEDDING DETAIL	
10TH STREET WASH IMPROVEMENTS BETWEEN ALICE AVENUE AND GRISWOLD ROAD PHOENIX, ARIZONA		FIGURE 4
PROJECT No: 600550005	FILE No: 550dtl0305b	DATE: 06/05

Ninyo & Moore

APPENDIX A

BORING LOGS

Field Procedure for the Collection of Disturbed Samples
Disturbed soil samples were obtained in the field using the following methods.

Bulk Samples
Bulk samples of representative earth materials were obtained from the exploratory borings. The samples were bagged and transported to the laboratory for testing.

The Standard Penetration Test (SPT) Spoon
Disturbed drive samples of earth materials were obtained by means of a SPT spoon sampler. The sampler is composed of a split barrel with an external diameter of 2 inches and an unlined internal diameter of 1-3/8 inches. The spoon was driven up to 18 inches into the ground with a 140-pound hammer free-falling from a height of 30 inches in general accordance with ASTM D 1586-84. The blow counts were recorded for every 6 inches of penetration; the blow counts reported on the logs are those for the last 12 inches of penetration. Soil samples were observed and removed from the spoon, bagged, sealed, and transported to the laboratory for testing.

Field Procedure for the Collection of Relatively Undisturbed Samples
Relatively undisturbed soil samples were obtained in the field using the following method.

The Modified Split-Barrel Drive Sampler
The sampler, with an external diameter of 3.0 inches, was lined with 1-inch long, thin brass rings with inside diameters of approximately 2.4 inches. The sample barrel was driven into the ground with a 140-pound hammer free-falling from a height of 30 inches in general accordance with ASTM D 1586-84. The samples were removed from the sample barrel in the brass rings, sealed, and transported to the laboratory for testing.

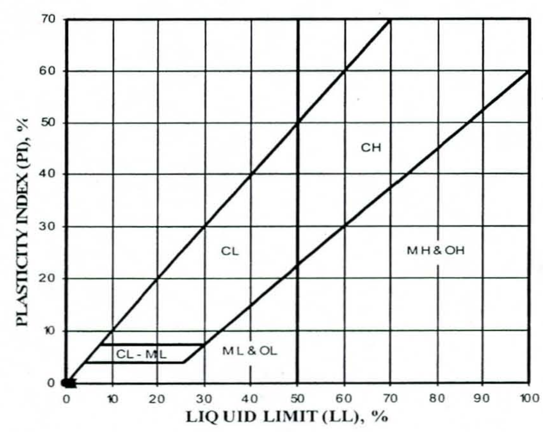
U.S.C.S. METHOD OF SOIL CLASSIFICATION

MAJOR DIVISIONS		SYMBOL	TYPICAL NAMES
COARSE-GRAINED SOILS (More than 1/2 of soil >No. 200 sieve size)	GRAVELS (More than 1/2 of coarse fraction > No. 4 sieve size)	GW	Well graded gravels or gravel-sand mixtures, little or no fines
		GP	Poorly graded gravels or gravel-sand mixtures, little or no fines
		GM	Silty gravels, gravel-sand-silt mixtures
		GC	Clayey gravels, gravel-sand-clay mixtures
	SANDS (More than 1/2 of coarse fraction <No. 4 sieve size)	SW	Well graded sands or gravelly sands, little or no fines
		SP	Poorly graded sands or gravelly sands, little or no fines
		SM	Silty sands, sand-silt mixtures
		SC	Clayey sands, sand-clay mixtures
FINE-GRAINED SOILS (More than 1/2 of soil <No. 200 sieve size)	SILTS & CLAYS Liquid Limit <50	ML	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands or clayey silts with
		CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean
		OL	Organic silts and organic silty clays of low plasticity
	SILTS & CLAYS Liquid Limit >50	MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts
		CH	Inorganic clays of high plasticity, fat clays
		OH	Organic clays of medium to high plasticity, organic silty clays, organic silts
HIGHLY ORGANIC SOILS		Pt	Peat and other highly organic soils

GRAIN SIZE CHART

CLASSIFICATION	RANGE OF GRAIN SIZE	
	U.S. Standard Sieve Size	Grain Size in Millimeters
BOULDERS	Above 12"	Above 305
COBBLES	12" to 3"	305 to 76.2
GRAVEL Coarse Fine	3" to No. 4 3" to 3/4" 3/4" to No. 4	76.2 to 4.76 76.2 to 19.1 19.1 to 4.76
SAND Coarse Medium Fine	No. 4 to No. 200 No. 4 to No. 10 No. 10 to No. 40 No. 40 to No. 200	4.76 to 0.075 4.76 to 2.00 2.00 to 0.420 0.420 to 0.075
SILT & CLAY	Below No. 200	Below 0.075

PLASTICITY CHART



Ninyo & Moore | U.S.C.S. METHOD OF SOIL CLASSIFICATION

BORING LOG EXPLANATION SHEET

DEPTH (feet)	SAMPLES Bulk	SAMPLES Driven	BLOWS/FOOT	MOISTURE (%)	DRY DENSITY (PCF)	SYMBOL	CLASSIFICATION U.S.C.S.	
0								Bulk sample.
								Modified split-barrel drive sampler.
								No recovery with modified split-barrel drive sampler.
								Sample retained by others.
								Standard Penetration Test (SPT).
5								No recovery with a SPT.
			XX/XX					Shelby tube sample. Distance pushed in inches/length of sample recovered in inches.
								No recovery with Shelby tube sampler.
								Continuous Push Sample.
								Seepage.
10								Groundwater encountered during drilling.
								Groundwater measured after drilling.
							SM	ALLUVIUM: Solid line denotes unit change.
								Dashed line denotes material change.
								Attitudes: Strike/Dip b: Bedding c: Contact j: Joint f: Fracture F: Fault cs: Clay Seam s: Shear bss: Basal Slide Surface sf: Shear Fracture sz: Shear Zone sbs: Sheared Bedding Surface
15								
								The total depth line is a solid line that is drawn at the bottom of the boring.
20								

Ninyo & Moore

BORING LOG

EXPLANATION OF BORING LOG SYMBOLS

PROJECT NO.	DATE	FIGURE
	Rev. 01/03	

DATE DRILLED 02/10/05 BORING NO. B-1

GROUND ELEVATION ±1260' MSL SHEET 1 OF 1

METHOD OF DRILLING CME-75, 6.5" HOLLOW-STEM AUGER

DRIVE WEIGHT 140 lbs. (AUTOMATIC) DROP 30"

SAMPLED BY JSR LOGGED BY JSR REVIEWED BY RDL

DEPTH (feet)	SAMPLES (Bulk / Driven)	BLOWS/FOOT	MOISTURE (%)	DRY DENSITY (PCF)	SYMBOL	CLASSIFICATION U.S.C.S.	DESCRIPTION/INTERPRETATION
0						ML	FILL: Light brown, damp, medium dense, sandy SILT; few fine gravel; scattered roots.
	Driven	11				MH	Light brown, damp, very stiff, sandy SILT; few clay; few gravel; scattered caliche filaments.
	Driven	82/11"	7.8	96.1		GP	ALLUVIUM: Light brown, damp, very dense, sandy fine to medium GRAVEL; few silt; trace clay; scattered to numerous caliche filaments.
5	Driven	76				SC	Light brown, damp, very dense, clayey fine to coarse SAND; trace fine gravel; scattered to numerous caliche filaments.
	Driven	83/11"	7.3	97.3		CL	Light brown, damp, hard, sandy CLAY; few silt; scattered to numerous caliche filaments; scattered pinhole sized voids.
10						GP	Light brown, damp, very dense, sandy fine to coarse GRAVEL; few silt; trace clay; scattered caliche filaments; possible cobbles and boulders.
	Driven	39					
15							Total Depth = 15.0 feet. Groundwater not encountered. Backfilled on 02/10/05.
20							

Ninyo & Moore

BORING LOG

10th STREET WASH IMPROVEMENTS
PHOENIX, ARIZONA

PROJECT NO.	DATE	FIGURE
600550005	06/05	A-1

DEPTH (feet)	SAMPLES Bulk	SAMPLES Driven	BLOWS/FOOT	MOISTURE (%)	DRY DENSITY (PCF)	SYMBOL	CLASSIFICATION U.S.C.S.	DATE DRILLED 02/10/05 BORING NO. B-2 GROUND ELEVATION ±1248' MSL SHEET 1 OF 1 METHOD OF DRILLING CME-75, 6.5" HOLLOW-STEM AUGER DRIVE WEIGHT 140 lbs. (AUTOMATIC) DROP 30" SAMPLED BY JSR LOGGED BY JSR REVIEWED BY RDL **DESCRIPTION/INTERPRETATION**
0							SM	FILL: Brown, damp, loose, silty fine to medium SAND; few fine gravel; scattered roots.
			13	3.7	106.6			
							SC	Light brown, damp, loose to medium dense, clayey fine to coarse SAND; few silt; trace coarse gravel; scattered caliche filaments.
			7					
5								
			29	4.4	110.2			
							GP	ALLUVIUM: Brown, damp, medium dense, sandy fine to coarse GRAVEL; trace silt; trace clay; possible cobbles and boulders.
			21					Dense; few clay.
10								
			11	4.9	115.2			Reddish brown; loose.
15								Total Depth = 15.0 feet. Groundwater not encountered. Backfilled on 02/10/05.
20								

Ninyo & Moore

BORING LOG

10th STREET WASH IMPROVEMENTS
PHOENIX, ARIZONA

PROJECT NO.	DATE	FIGURE
600550005	06/05	A-2

DATE DRILLED	02/10/05	BORING NO.	B-3
GROUND ELEVATION	±1245' MSL	SHEET	1 OF 1
METHOD OF DRILLING	CME-75, 6.5" HOLLOW-STEM AUGER		
DRIVE WEIGHT	140 lbs. (AUTOMATIC)	DROP	30"
SAMPLED BY	JSR	LOGGED BY	JSR
REVIEWED BY	RDL		

DEPTH (feet)	SAMPLES Bulk	SAMPLES Driven	BLOWS/FOOT	MOISTURE (%)	DRY DENSITY (PCF)	SYMBOL	CLASSIFICATION U.S.C.S.	DESCRIPTION/INTERPRETATION
0	X	X	13				SM	FILL: Brown, damp, medium dense, silty fine to coarse SAND; trace clay; scattered roots.
		X	36	3.3	110.8		GP	Light brown, damp, medium dense, sandy fine to coarse GRAVEL; few clay; trace silt; scattered to numerous caliche filaments.
5		X	52				GP	ALLUVIUM: Light brown, damp, very dense, sandy fine to coarse GRAVEL; trace clay; possible cobbles and boulders.
		X	29					Dense; little clay; scattered caliche filaments.
10								
		X	36	16.3	94.6		SM	Light brown, damp, medium dense, silty fine to medium SAND; trace clay; scattered caliche filaments.
15								Total Depth = 15.0 feet. Groundwater not encountered. Backfilled on 02/10/05.
20								

Ninyo & Moore

BORING LOG

10th STREET WASH IMPROVEMENTS
PHOENIX, ARIZONA

PROJECT NO.	DATE	FIGURE
600550005	06/05	A-3

DATE DRILLED	02/10/05	BORING NO.	B-4
GROUND ELEVATION	±1240' MSL	SHEET	1 OF 1
METHOD OF DRILLING	CME-75, 6.5" HOLLOW-STEM AUGER		
DRIVE WEIGHT	140 lbs. (AUTOMATIC)	DROP	30"
SAMPLED BY	JSR	LOGGED BY	JSR
REVIEWED BY	RDL		

DEPTH (feet)	SAMPLES (Bulk / Driven)	BLOWS/FOOT	MOISTURE (%)	DRY DENSITY (PCF)	SYMBOL	CLASSIFICATION U.S.C.S.	DESCRIPTION/INTERPRETATION
0						GP	FILL: Blackish brown, damp, medium dense, sandy coarse GRAVEL.
		22	5.3	120.4		SM	Brown, damp, medium dense, silty fine SAND; scattered roots.
		41				GP	ALLUVIUM: Brown, damp, very dense, sandy fine to coarse GRAVEL; few silt; possible cobbles and boulders.
5							
		49					
		50/4"					No recovery.
10							
						CL	Light brown, damp, hard, silty CLAY; few fine sand; few fine gravel.
		25					
15							Total Depth = 15.0 feet. Groundwater not encountered. Backfilled on 02/10/05.
20							

Ninyo & Moore

BORING LOG

10th STREET WASH IMPROVEMENTS
PHOENIX, ARIZONA

PROJECT NO.	DATE	FIGURE
600550005	06/05	A-4

DATE DRILLED 02/10/05 BORING NO. B-5

GROUND ELEVATION ±1240' MSL SHEET 1 OF 1

METHOD OF DRILLING CME-75, 6.5" HOLLOW-STEM AUGER

DRIVE WEIGHT 140 lbs. (AUTOMATIC) DROP 30"

SAMPLED BY JSR LOGGED BY JSR REVIEWED BY RDL

DEPTH (feet)	SAMPLES (Bulk / Driven)	BLOWS/FOOT	MOISTURE (%)	DRY DENSITY (PCF)	SYMBOL	CLASSIFICATION U.S.C.S.	DESCRIPTION/INTERPRETATION
0						GP	FILL: Brown, damp, medium dense, sandy fine to medium GRAVEL; few silt.
	Driven	12					
	Driven	58	4.1	115.9		GP	ALLUVIUM: Light brown, damp, dense, sandy fine to coarse GRAVEL; few silt; scattered caliche filaments.
5							
	Driven	55				SC	Light brown, damp, very dense, clayey fine to coarse SAND; few gravel; trace silt; scattered to numerous caliche filaments; weak cementation.
	Driven	50/3"					METAMORPHOSED BASALT: Green, soft, METAMORPHOSED BASALT; weathered; foliated.
10							
	Driven	78/9"					
15							Total Depth = 14.2 feet. Groundwater not encountered. Backfilled on 02/10/05.
20							

Ninyo & Moore

BORING LOG

10th STREET WASH IMPROVEMENTS
PHOENIX, ARIZONA

PROJECT NO.	DATE	FIGURE
600550005	06/05	A-5

DATE DRILLED 02/10/05 BORING NO. B-6

GROUND ELEVATION ±1239' MSL SHEET 1 OF 1

METHOD OF DRILLING CME-75, 6.5" HOLLOW-STEM AUGER

DRIVE WEIGHT 140 lbs. (AUTOMATIC) DROP 30"

SAMPLED BY JSR LOGGED BY JSR REVIEWED BY RDL

DEPTH (feet)	SAMPLES Bulk	SAMPLES Driven	BLOWS/FOOT	MOISTURE (%)	DRY DENSITY (PCF)	SYMBOL	CLASSIFICATION U.S.C.S.	DESCRIPTION/INTERPRETATION
0							SM	FILL: Brown, damp, medium dense, silty fine to coarse SAND; trace fine gravel.
			23	5.4	120.1			
			9				ML	Reddish brown, damp, medium dense, sandy SILT; few fine gravel.
5								
			21	4.3	105.1		SC	ALLUVIUM: Brown, damp, medium dense, clayey fine to coarse SAND; few to coarse gravel; trace silt.
			32					Dense.
10								
			85/9"	4.6	113.8			Very dense; scattered to numerous caliche filaments; scattered pinhole- sized pore spaces.
15								Total Depth = 14.7 feet. Groundwater not encountered. Backfilled on 02/10/05.
20								

Ninyo & Moore

BORING LOG

10th STREET WASH IMPROVEMENTS
PHOENIX, ARIZONA

PROJECT NO.	DATE	FIGURE
600550005	06/05	A-6

DEPTH (feet)	SAMPLES Bulk	SAMPLES Driven	BLOWS/FOOT	MOISTURE (%)	DRY DENSITY (PCF)	SYMBOL	CLASSIFICATION U.S.C.S.	DESCRIPTION/INTERPRETATION
0							SM	ALLUVIUM: Brown, damp, silty fine to coarse SAND; few fine to coarse gravel; few cobbles.
							GP	Brown, damp, sandy fine to coarse GRAVEL; few silt and cobbles; possible boulders.
5								
10								Total depth = 10.0 feet. Groundwater not encountered. Backfilled on 06/03/05.
15								
20								

DATE DRILLED 06/03/05 BORING NO. B-7

GROUND ELEVATION ±1235' MSL SHEET 1 OF 1

METHOD OF DRILLING 12-Inch, Solid-Stem Auger

DRIVE WEIGHT -- DROP --

SAMPLED BY -- LOGGED BY JSR REVIEWED BY SDN

Ninyo & Moore

BORING LOG

10th STREET WASH IMPROVEMENTS
PHOENIX, ARIZONA

PROJECT NO.	DATE	FIGURE
600550005	06/05	A-7

DATE DRILLED	06/03/05	BORING NO.	B-8
GROUND ELEVATION	±1235' MSL	SHEET	1 OF 1
METHOD OF DRILLING	12-Inch, Solid-Stem Auger		
DRIVE WEIGHT	--	DROP	--
SAMPLED BY	--	LOGGED BY	JSR
REVIEWED BY	SDN		

DEPTH (feet)	SAMPLES Bulk	SAMPLES Driven	BLOWS/FOOT	MOISTURE (%)	DRY DENSITY (PCF)	SYMBOL	CLASSIFICATION U.S.C.S.	DESCRIPTION/INTERPRETATION
0							GP	ALLUVIUM: Light brown, damp, sandy fine to coarse GRAVEL; few silt; possible cobbles and boulders.
5								
								METAMORPHOSED BASALT: Greenish brown, hard, METAMORPHOSED BASALT; weathered.
								Total depth = 7.0 feet. (Auger refusal on bedrock.) Groundwater not encountered. Backfilled on 06/03/05.
10								
15								
20								

Ninyo & Moore

BORING LOG

10th STREET WASH IMPROVEMENTS
PHOENIX, ARIZONA

PROJECT NO.	DATE	FIGURE
600550005	06/05	A-8

DATE DRILLED	06/03/05	BORING NO.	B-9
GROUND ELEVATION	±1235' MSL	SHEET	1 OF 1
METHOD OF DRILLING	12-Inch, Solid-Stem Auger		
DRIVE WEIGHT	--	DROP	--
SAMPLED BY	--	LOGGED BY	JSR
REVIEWED BY	SDN		

DEPTH (feet)	SAMPLES Bulk	SAMPLES Driven	BLOWS/FOOT	MOISTURE (%)	DRY DENSITY (PCF)	SYMBOL	CLASSIFICATION U.S.C.S.	DESCRIPTION/INTERPRETATION
0							GP	ALLUVIUM: Light brown, damp, sandy fine to coarse GRAVEL; few silt; cobbles; possible boulders.
								METAMORPHOSED BASALT: Green, hard, METAMORPHOSED BASALT; weathered; foliated.
								Total depth = 2.0 feet. (Auger refusal on bedrock.) Groundwater not encountered. Backfilled on 06/03/05.
5								
10								
15								
20								

Ninyo & Moore

BORING LOG

10th STREET WASH IMPROVEMENTS
PHOENIX, ARIZONA

PROJECT NO.	DATE	FIGURE
600550005	06/05	A-9

DATE DRILLED	06/03/05
BORING NO.	B-10
GROUND ELEVATION	±1235' MSL
SHEET	1 OF 1
METHOD OF DRILLING	12-Inch, Solid-Stem Auger
DRIVE WEIGHT	--
DROP	--
SAMPLED BY	--
LOGGED BY	JSR
REVIEWED BY	SDN

DEPTH (feet)	SAMPLES Bulk	SAMPLES Driven	BLOWS/FOOT	MOISTURE (%)	DRY DENSITY (PCF)	SYMBOL	CLASSIFICATION U.S.C.S.	DESCRIPTION/INTERPRETATION
0								METAMORPHOSED BASALT: Green, damp, hard, METAMORPHOSED BASALT; weathered; foliated.
								Total depth = 4.0 inches. (Auger refusal on bedrock.) Groundwater not encountered. Backfilled on 06/03/05.
5								
10								
15								
20								

Ninyo & Moore

BORING LOG

10th STREET WASH IMPROVEMENTS
PHOENIX, ARIZONA

PROJECT NO.	DATE	FIGURE
600550005	06/05	A-10

DATE DRILLED	06/03/05	BORING NO.	B-11
GROUND ELEVATION	±1235' MSL	SHEET 1 OF 1	
METHOD OF DRILLING	12-Inch, Solid-Stem Auger		
DRIVE WEIGHT	--	DROP	--
SAMPLED BY --	LOGGED BY JSR	REVIEWED BY	SDN

DEPTH (feet)	SAMPLES Bulk	SAMPLES Driven	BLOWS/FOOT	MOISTURE (%)	DRY DENSITY (PCF)	SYMBOL	CLASSIFICATION U.S.C.S.	DESCRIPTION/INTERPRETATION
0								METAMORPHOSED BASALT: Green, damp, hard, METAMORPHOSED BASALT; weathered; foliated; moderate cementation.
								Total depth = 6.0 inches. (Auger refusal on bedrock.) Groundwater not encountered. Backfilled on 06/03/05.
5								
10								
15								
20								

Ninyo & Moore

BORING LOG

10th STREET WASH IMPROVEMENTS
PHOENIX, ARIZONA

PROJECT NO.	DATE	FIGURE
600550005	06/05	A-11

DEPTH (feet)	SAMPLES Bulk	SAMPLES Driven	BLOWS/FOOT	MOISTURE (%)	DRY DENSITY (PCF)	SYMBOL	CLASSIFICATION U.S.C.S.

DATE DRILLED 06/03/05 BORING NO. B-12

GROUND ELEVATION ±1235' MSL SHEET 1 OF 1

METHOD OF DRILLING 12-Inch, Solid-Stem Auger

DRIVE WEIGHT -- DROP --

SAMPLED BY -- LOGGED BY JSR REVIEWED BY SDN

DESCRIPTION/INTERPRETATION

Depth	Classification	Description/Interpretation
0	GP	ALLUVIUM: Grayish brown, damp, sandy fine to coarse GRAVEL; few silt; cobbles.
		METAMORPHOSED BASALT: Green, hard, METAMORPHOSED BASALT; foliated; weathered.
		Total depth = 1.0 foot. (Auger refusal on bedrock.) Groundwater not encountered. Backfilled on 06/03/05.
5		
10		
15		
20		

Ninyo & Moore

BORING LOG

10th STREET WASH IMPROVEMENTS
PHOENIX, ARIZONA

PROJECT NO.	DATE	FIGURE
600550005	06/05	A-12

DEPTH (feet)	SAMPLES Bulk	SAMPLES Driven	BLOWS/FOOT	MOISTURE (%)	DRY DENSITY (PCF)	SYMBOL	CLASSIFICATION U.S.C.S.	DESCRIPTION/INTERPRETATION
0								METAMORPHOSED BASALT: Green, damp, hard, METAMORPHOSED BASALT; foliated; weathered; Stage II caliche cementation.
								Total depth = 1.0 foot. (Auger refusal on bedrock.) Groundwater not encountered. Backfilled on 06/03/05.
5								
10								
15								
20								

DATE DRILLED 06/03/05 BORING NO. B-13

GROUND ELEVATION ±1236' MSL SHEET 1 OF 1

METHOD OF DRILLING 12-Inch, Solid-Stem Auger

DRIVE WEIGHT -- DROP --

SAMPLED BY -- LOGGED BY JSR REVIEWED BY SDN

Ninyo & Moore

BORING LOG

10th STREET WASH IMPROVEMENTS
PHOENIX, ARIZONA

PROJECT NO.	DATE	FIGURE
600550005	06/05	A-13

DEPTH (feet)	SAMPLES Bulk	SAMPLES Driven	BLOWS/FOOT	MOISTURE (%)	DRY DENSITY (PCF)	SYMBOL	CLASSIFICATION U.S.C.S.	DESCRIPTION/INTERPRETATION
0							GP	ALLUVIUM: Grayish brown, damp, sandy fine to coarse GRAVEL; few silt; cobbles; possible boulders.
								METAMORPHOSED BASALT: Green, damp, hard, METAMORPHOSED BASALT; weathered; foliated.
								Total depth = 4.0 feet. (Auger refusal on bedrock.) Groundwater not encountered. Backfilled on 06/03/05.
5								
10								
15								
20								

DATE DRILLED 06/03/05 BORING NO. B-14

GROUND ELEVATION ±1236' MSL SHEET 1 OF 1

METHOD OF DRILLING 12-Inch, Solid-Stem Auger

DRIVE WEIGHT -- DROP --

SAMPLED BY -- LOGGED BY JSR REVIEWED BY SDN

Ninyo & Moore

BORING LOG

10th STREET WASH IMPROVEMENTS
PHOENIX, ARIZONA

PROJECT NO.	DATE	FIGURE
600550005	06/05	A-14

DEPTH (feet)	SAMPLES Bulk	SAMPLES Driven	BLOWS/FOOT	MOISTURE (%)	DRY DENSITY (PCF)	SYMBOL	CLASSIFICATION U.S.C.S.	DESCRIPTION/INTERPRETATION
0							GP	ALLUVIUM: Light brown, damp, sandy fine to coarse GRAVEL; few silt; cobbles; possible boulders.
5								
							SM	Light brown, damp, silty fine to coarse SAND; little coarse gravel.
10								Total depth = 10.0 feet. Groundwater not encountered. Backfilled on 06/03/05.
15								
20								

DATE DRILLED 06/03/05 BORING NO. B-15

GROUND ELEVATION ±1236' MSL SHEET 1 OF 1

METHOD OF DRILLING 12-Inch, Solid-Stem Auger

DRIVE WEIGHT -- DROP --

SAMPLED BY -- LOGGED BY JSR REVIEWED BY SDN

Ninyo & Moore

BORING LOG

10th STREET WASH IMPROVEMENTS
PHOENIX, ARIZONA

PROJECT NO.	DATE	FIGURE
600550005	06/05	A-15

DATE DRILLED	06/03/05	BORING NO.	B-16
GROUND ELEVATION	1236' MSL	SHEET	1 OF 1
METHOD OF DRILLING	12-Inch, Solid-Stem Auger		
DRIVE WEIGHT	--	DROP	--
SAMPLED BY	--	LOGGED BY	JSR
REVIEWED BY	SDN		

DEPTH (feet)	SAMPLES Bulk	SAMPLES Driven	BLOWS/FOOT	MOISTURE (%)	DRY DENSITY (PCF)	SYMBOL	CLASSIFICATION U.S.C.S.	DESCRIPTION/INTERPRETATION
0							SM	ALLUVIUM: Brown, damp, sandy fine to coarse SAND; few gravel.
							GP	Brown, damp, silty fine to coarse GRAVEL; little silt; cobbles; possible boulders.
5								
								Difficult drilling at 7.0 feet.
10								Total depth = 9.5 feet. (Auger refusal on bedrock.) Groundwater not encountered. Backfilled on 06/03/05.
								Pipe Invert
15								
20								

Ninyo & Moore

BORING LOG

10th STREET WASH IMPROVEMENTS
PHOENIX, ARIZONA

PROJECT NO.	DATE	FIGURE
600550005	06/05	A-16

Ninyo & Moore

APPENDIX B

LABORATORY TESTING

Classification

Soils were visually and texturally classified in accordance with the Unified Soil Classification System (USCS) in general accordance with ASTM D 2488-93. Soil classifications are indicated on the logs of the exploratory borings in Appendix A.

Moisture Content

The moisture content of samples obtained from the exploratory borings was evaluated in accordance with ASTM D 2216-92. The test results are presented on the logs of the exploratory borings in Appendix A.

In-Place Moisture and Density Tests

The moisture content and dry density of relatively undisturbed samples obtained from the exploratory borings were evaluated in general accordance with ASTM D 2937-94. The test results are presented on the logs of the exploratory borings in Appendix A.

Gradation Analysis

Gradation analysis tests were performed on selected representative soil samples in general accordance with ASTM D 422-02. The grain-size distribution curves are shown on Figures B-1 through B-3. These test results were utilized in evaluating the soil classifications in accordance with the USCS.

Atterberg Limits

Tests were performed on selected representative fine-grained soil samples to evaluate the liquid limit, plastic limit, and plasticity index in general accordance with ASTM D 4318-00. These test results were utilized to evaluate the soil classification in accordance with the USCS. The test results and classifications are shown on Figure B-4.

Direct Shear Tests

Direct shear tests were performed on undisturbed samples in general accordance with ASTM D 3080-03 to evaluate the shear strength characteristics of selected materials. The samples were inundated during shearing to represent adverse field conditions. The results are shown on Figures B-5 and B-6.

Maximum Dry Density and Optimum Moisture Content Tests

The maximum dry density and optimum moisture content of selected representative soil samples were evaluated in general accordance with ASTM D 698-00. The results of these tests are summarized on Figure B-7.

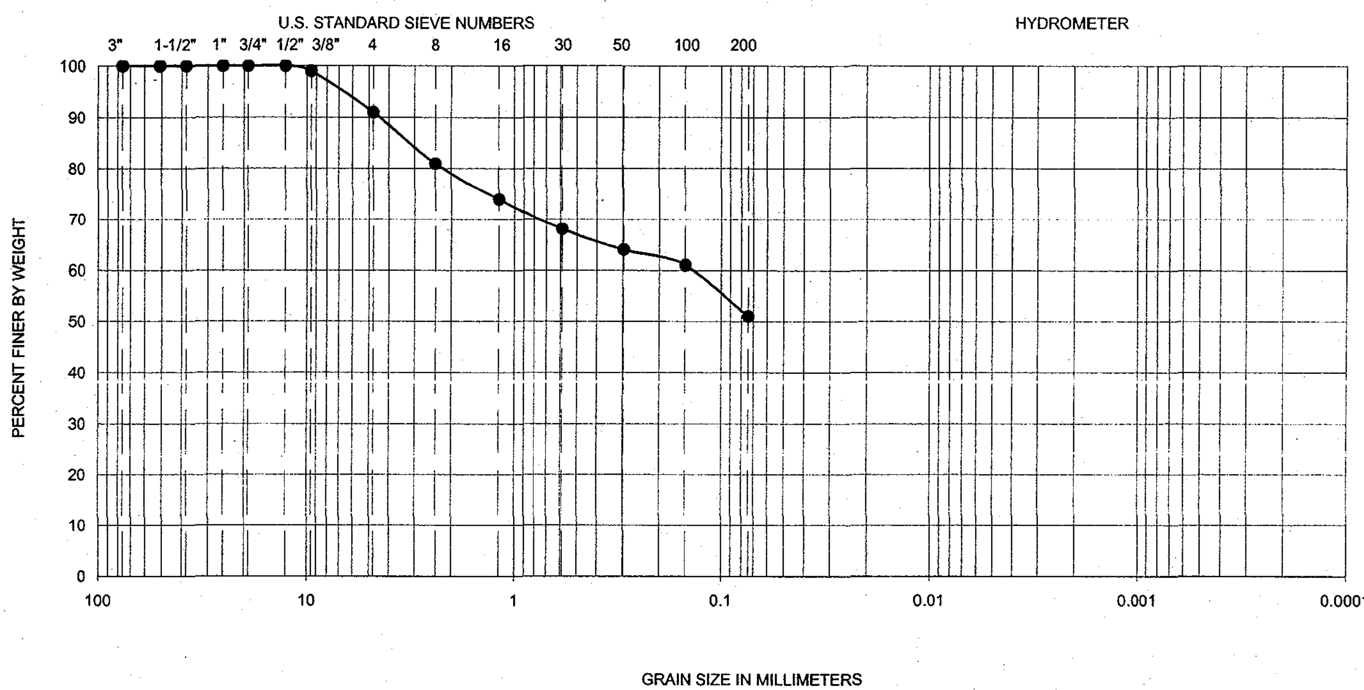
Expansion Index Tests

The expansion index of selected materials was evaluated in general accordance with ASTM 4829-95. Specimens were molded under a specified compactive energy at approximately 50 percent saturation (plus or minus 5 percent). The prepared 1-inch thick by 4-inch diameter specimens were loaded with a surcharge of 144 pounds per square foot and were inundated with tap water. Readings of volumetric swell were made for a period of 24 hours. The results of these tests are presented on Figure B-8.

Soil Corrosivity Tests

Soil pH and minimum resistivity tests were performed on representative samples in general accordance with Arizona Test 236b. The chloride contents of selected samples were evaluated in general accordance with Arizona Test 736. The sulfate contents of selected samples were evaluated in general accordance with Arizona Test 733. The test results are presented on Figure B-9.

GRAVEL		SAND			FINES	
Coarse	Fine	Coarse	Medium	Fine	Silt	Clay



Symbol	Hole No.	Depth (ft)	Liquid Limit	Plastic Limit	Plasticity Index	D_{10}	D_{30}	D_{60}	C_u	C_c	Passing No. 200 (%)	U.S.C.S
●	B-1	3.5-5	53	30	23	--	--	--	--	--	51	MH

PERFORMED IN GENERAL ACCORDANCE WITH ASTM D 422-02

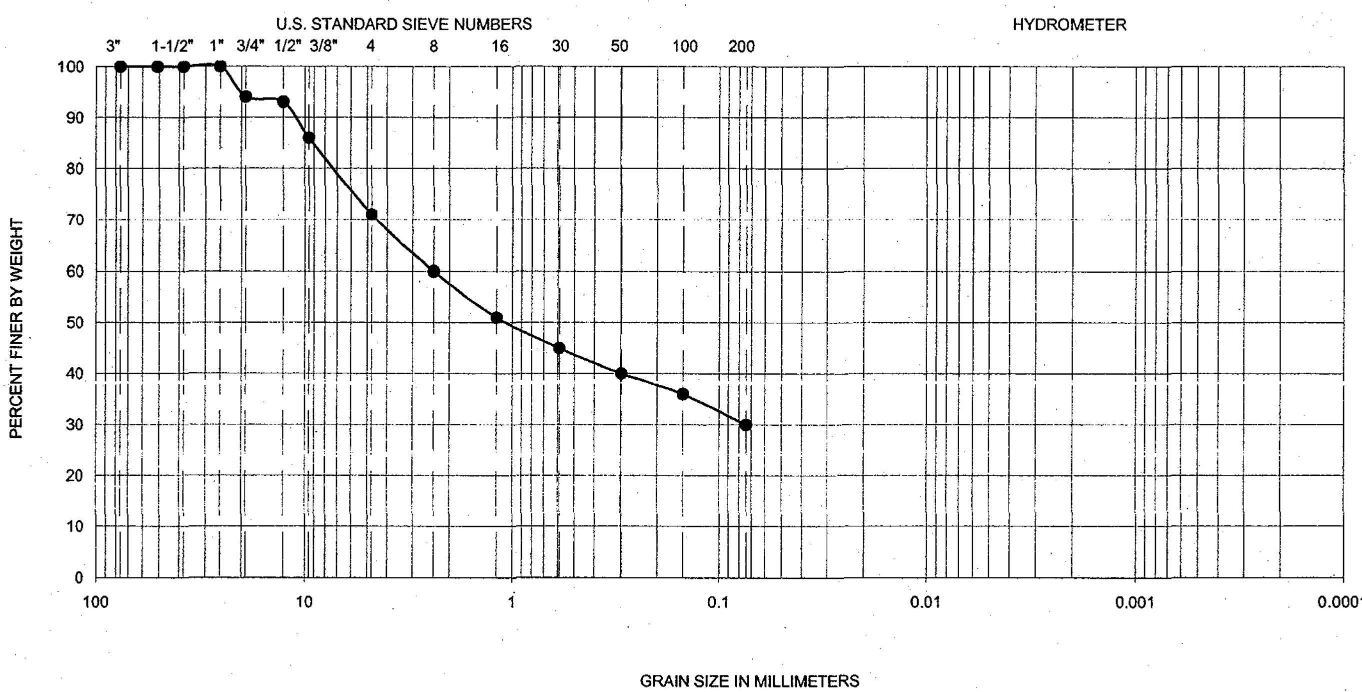
Ninyo & Moore

GRADATION TEST RESULTS

10TH STREET WASH IMPROVEMENT
PHOENIX, ARIZONA

PROJECT NO.	DATE	LAB NO.
600550005	06/05	B-1

GRAVEL		SAND			FINES	
Coarse	Fine	Coarse	Medium	Fine	Silt	Clay



Symbol	Hole No.	Depth (ft)	Liquid Limit	Plastic Limit	Plasticity Index	D_{10}	D_{30}	D_{60}	C_u	C_c	Passing No. 200 (%)	U.S.C.S
●	B-4	1-2.5	NP	NP	NP	--	--	--	--	--	30	SM

NP-INDICATES NON-PLASTIC

PERFORMED IN GENERAL ACCORDANCE WITH ASTM D 422-02

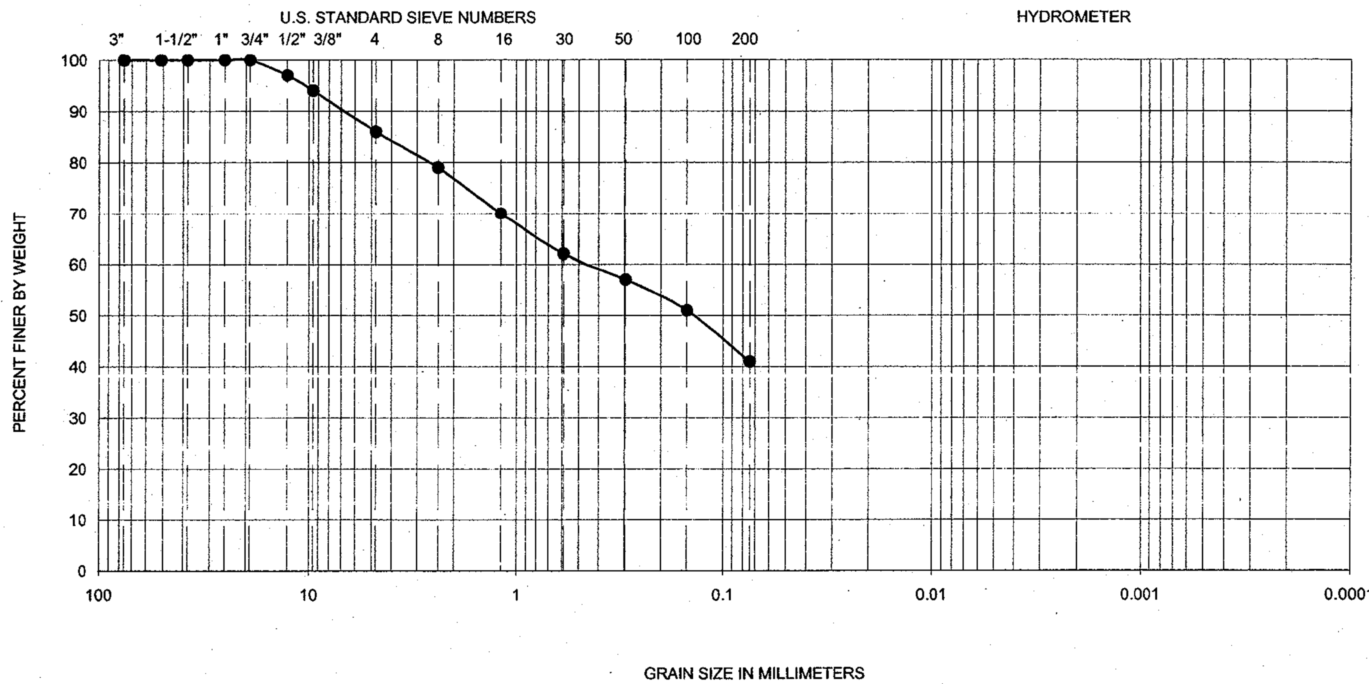
Ninyo & Moore

GRADATION TEST RESULTS

10TH STREET WASH IMPROVEMENT
PHOENIX, ARIZONA

PROJECT NO.	DATE	LAB NO.
600550005	06/05	B-2

GRAVEL		SAND			FINES	
Coarse	Fine	Coarse	Medium	Fine	Silt	Clay



Symbol	Hole No.	Depth (ft)	Liquid Limit	Plastic Limit	Plasticity Index	D_{10}	D_{30}	D_{60}	C_u	C_c	Passing No. 200 (%)	U.S.C.S
●	B-6	6-7.5	34	23	11	--	--	--	--	--	41	SC

PERFORMED IN GENERAL ACCORDANCE WITH ASTM D 422-02

Ninyo & Moore

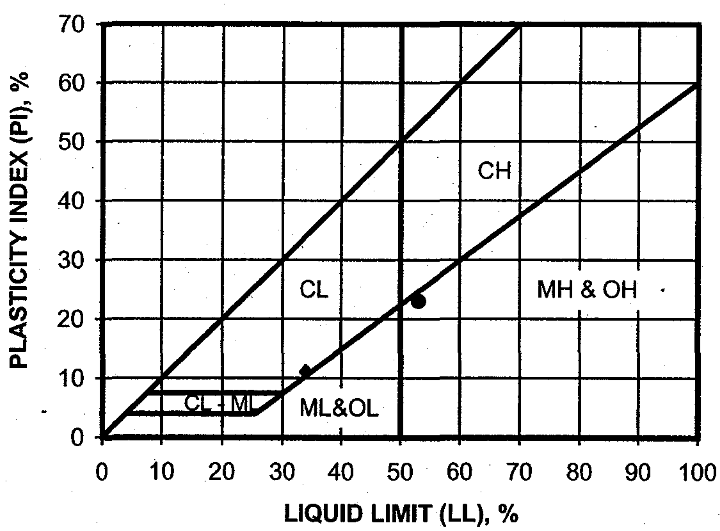
GRADATION TEST RESULTS

10TH STREET WASH IMPROVEMENT
PHOENIX, ARIZONA

PROJECT NO.	DATE	LAB NO.
600550005	06/05	B-3

SYMBOL	LOCATION	DEPTH (FT)	LL (%)	PL (%)	PI (%)	U.S.C.S. CLASSIFICATION (Minus No. 40 Sieve Fraction)	U.S.C.S. (Entire Sample)
●	B-1	3.5-5	53	30	23	MH	MH
■	B-4	1-2.5	NP	NP	NP	NP	SM
◆	B-6	6-7.5	34	23	11	CL	SC

NP - Indicates non-plastic



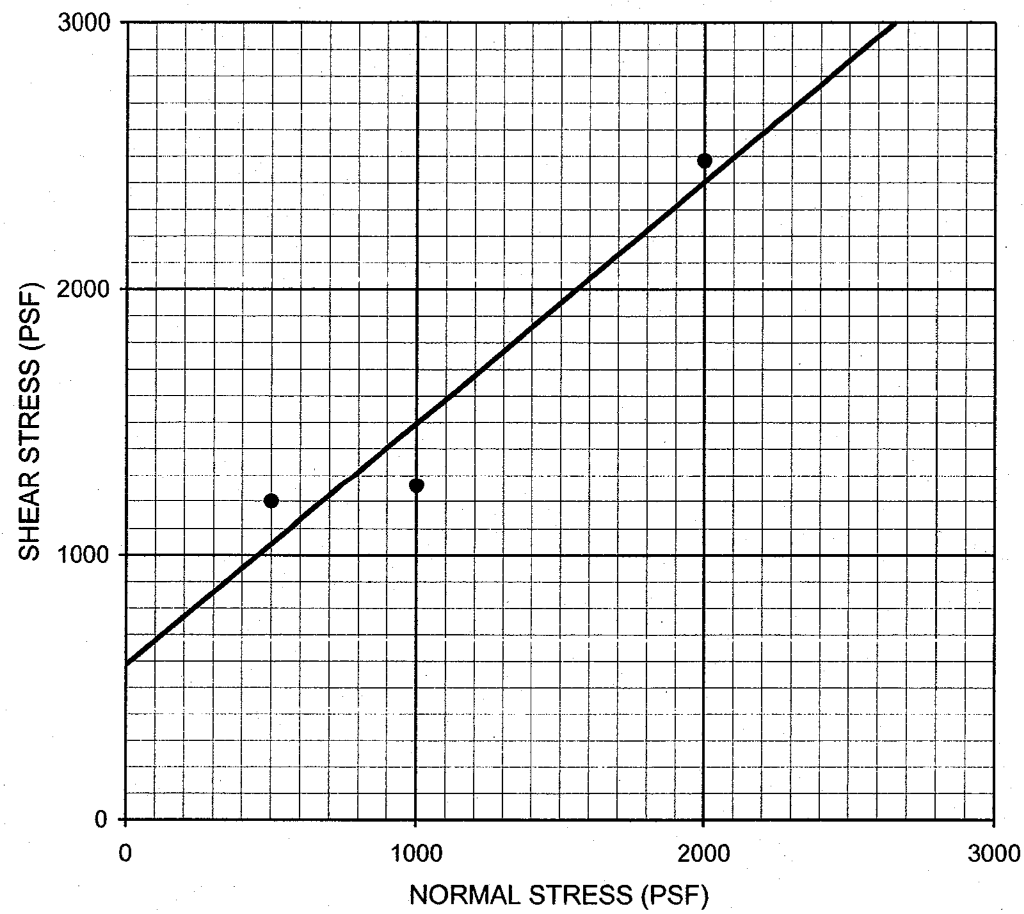
PERFORMED IN GENERAL ACCORDANCE WITH ASTM D 4318-00

Ninyo & Moore

ATTERBERG LIMITS TEST RESULTS

10TH STREET WASH IMPROVEMENT
PHOENIX, ARIZONA

PROJECT NO.	DATE	FIGURE
600550005	06/05	B-4



Description	Symbol	Sample Location	Depth (ft)	Shear Strength	Cohesion, C (psf)	Friction Angle, F (degrees)	Soil Type
UNDISTURBED	—●—	B-1	8.5-9.4	Peak	558	42	CL

PERFORMED IN GENERAL ACCORDANCE WITH ASTM D 3080-03

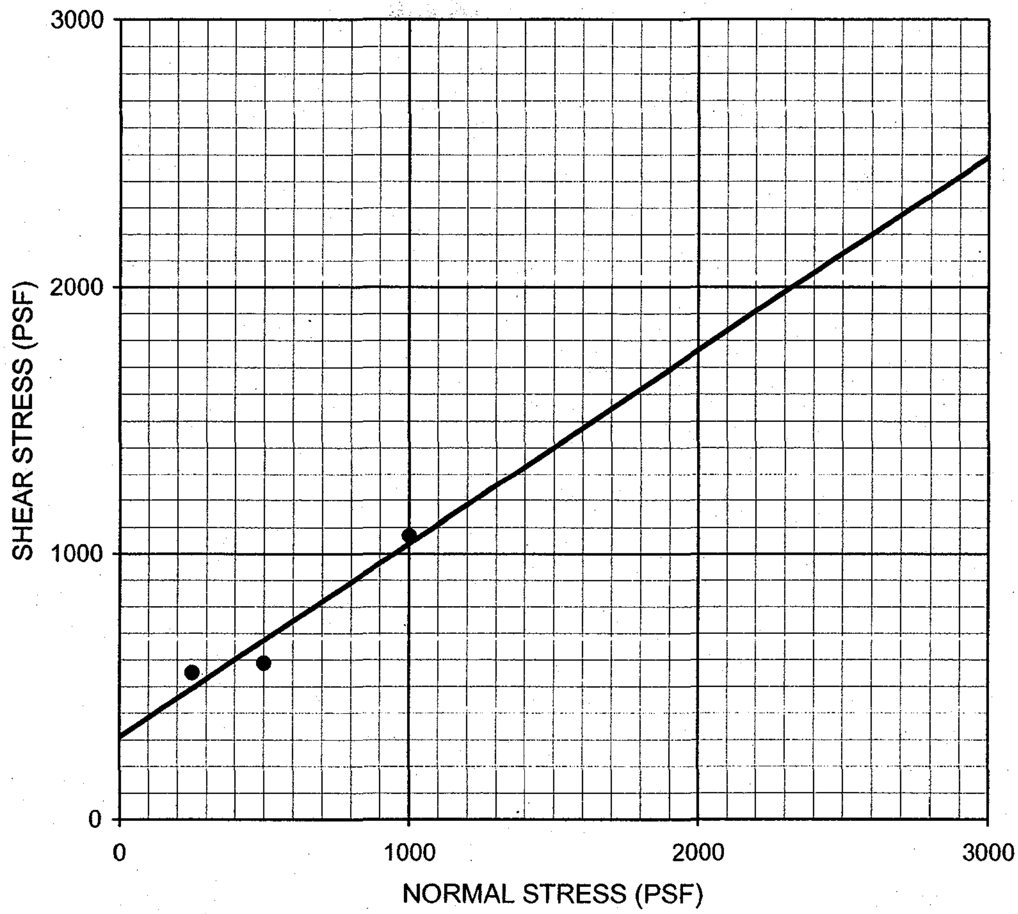
Ninyo & Moore

DIRECT SHEAR TEST RESULTS

10TH STREET WASH IMPROVEMENT
PHOENIX, ARIZONA

PROJECT NO.	DATE	FIGURE
600550005	06/05	B-5

Direct Shear P10029



Description	Symbol	Sample Location	Depth (ft)	Shear Strength	Cohesion, C (psf)	Friction Angle, F (degrees)	Soil Type
UNDISTURBED	—●—	B-5	3.5-5	Peak	312	36	GP

PERFORMED IN GENERAL ACCORDANCE WITH ASTM D 3080-03

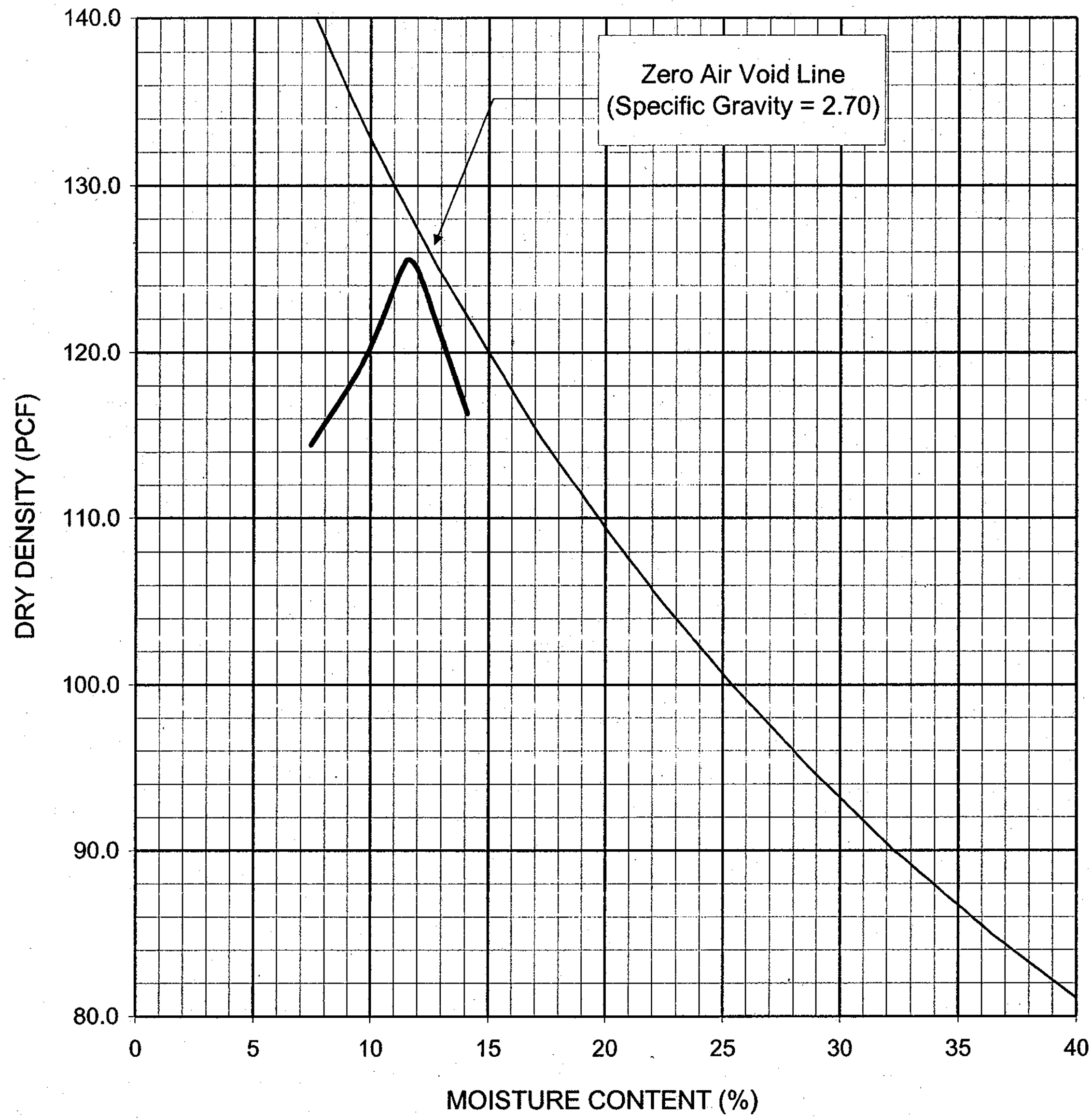
Ninyo & Moore

DIRECT SHEAR TEST RESULTS

10TH STREET WASH IMPROVEMENT
PHOENIX, ARIZONA

PROJECT NO.	DATE
600550005	06/05

FIGURE B-6



Sample Location	Depth (ft)	Soil Description	Maximum Dry Density (pcf)	Optimum Moisture Content (%)
B-3	0-2	Silty Fine to Coarse Sand	125.5*	11.5*

* 17 % PLUS NO. 4 ROCK WAS FOUND IN THE LABORATORY SAMPLE
PERFORMED IN GENERAL ACCORDANCE WITH ASTM D 698-00 MEHTOD "A"

Ninyo & Moore

MAXIMUM DENSITY TEST RESULTS

10TH STREET WASH IMPROVEMENT
PHOENIX, ARIZONA

PROJECT NO.	DATE	FIGURE
600550005	06/05	B-7

EXPANSION INDEX TEST RESULTS

SAMPLE LOCATION	SAMPLE DEPTH (FT)	INITIAL MOISTURE (%)	COMPACTED DRY DENSITY (PCF)	FINAL MOISTURE (%)	VOLUMETRIC SWELL (IN)	EXPANSION INDEX	EXPANSION POTENTIAL
B-3	0-2	8.7	113.3	16.3	0	0	VERY LOW

PERFORMED IN GENERAL ACCORDANCE WITH ASTM D 4829-95

Ninyo & Moore

EXPANSION INDEX TEST RESULTS

10TH STREET WASH IMPROVEMENT
PHOENIX, ARIZONA

PROJECT NO.	DATE	FIGURE
600550005	06/05	B-8

CORROSIVITY TEST RESULTS

SAMPLE ID	DEPTH (FT)	pH *	RESISTIVITY * (ohm-cm)	WATER-SOLUBLE SULFATE CONTENT IN SOIL ** (%)	CHLORIDE CONTENT *** (ppm)
B2-B6	1-5	7.8	472	0.0068	250

* PERFORMED IN GENERAL ACCORDANCE WITH ADOT TEST METHOD ARIZ 236b
** PERFORMED IN GENERAL ACCORDANCE WITH ADOT TEST METHOD ARIZ 733
*** PERFORMED IN GENERAL ACCORDANCE WITH ADOT TEST METHOD ARIZ 736

Ninyo & Moore

CORROSIVITY TEST RESULTS

10TH STREET WASH IMPROVEMENT
PHOENIX, ARIZONA

PROJECT NO.	DATE	FIGURE
600550005	06/05	B-9

Ninyo & Moore

APPENDIX C

GEOPHYSICAL RESULTS

Ninyo & Moore personnel conducted seismic refraction surveys at the site on April 19, 2005, to evaluate the rippability characteristics of the near surface materials. The seismic refraction data were collected with a SmartSeis S24, high performance exploration seismograph and 24 vertical component geophones. A 10-pound hammer and metal plate were used as the seismic wave source. A total of two seismic refraction traverses, denoted as SL-1 and SL-2, were conducted for this project. Seismic refraction traverse line SL-1 was located within the wash bottom and was situated roughly between borings B-8 and B-10. Seismic refraction traverse line SL-2 was also located within the wash bottom and was situated roughly between borings B-7 and B-8.

The seismic refraction method uses first-arrival times of refracted seismic waves to evaluate the thicknesses and seismic velocities of subsurface layers. Seismic waves generated at the surface are refracted at boundaries separating materials of contrasting velocities. These refracted seismic waves are then detected by a series of surface geophones and recorded with a seismograph. The travel times of the seismic waves are used in conjunction with the shot-to-geophone distances to obtain thickness and velocity information on the subsurface materials.

The refraction method requires that subsurface velocities (and therefore material density) increase with depth. A layer having a velocity lower than that of the layer above will not be detectable by the seismic refraction method and, therefore, could lead to errors in the depth calculations of subsequent layers. In addition, lateral variations in velocity can also result in the misinterpretation of the subsurface conditions.

In general, seismic wave velocities can be correlated to material density and/or rock hardness. The relationship between rippability and seismic velocity is empirical and assumes a homogenous mass. Areas of differing composition, texture, or structure may affect both the measured data and the actual rippability of the mass. The rippability of a mass is also dependent on the excavation equipment used and the skill and experience of the equipment operator.

The following rippability chart (Table C-1) is based on our experience with similar materials. It assumes that a Caterpillar D-9 dozer ripping with a single shank is used. We emphasize that the cutoffs in this classification scheme are approximate and that soil characteristics can play a significant role in determining excavation rates and rippability. In addition, where excavations encounter or penetrate weathered or fresh bedrock, rock characteristics, such as depth of and degree of weathering, and fracture spacing and orientation, also play a significant role in determining rock rippability. These soil and rock characteristics may also vary with location and depth.

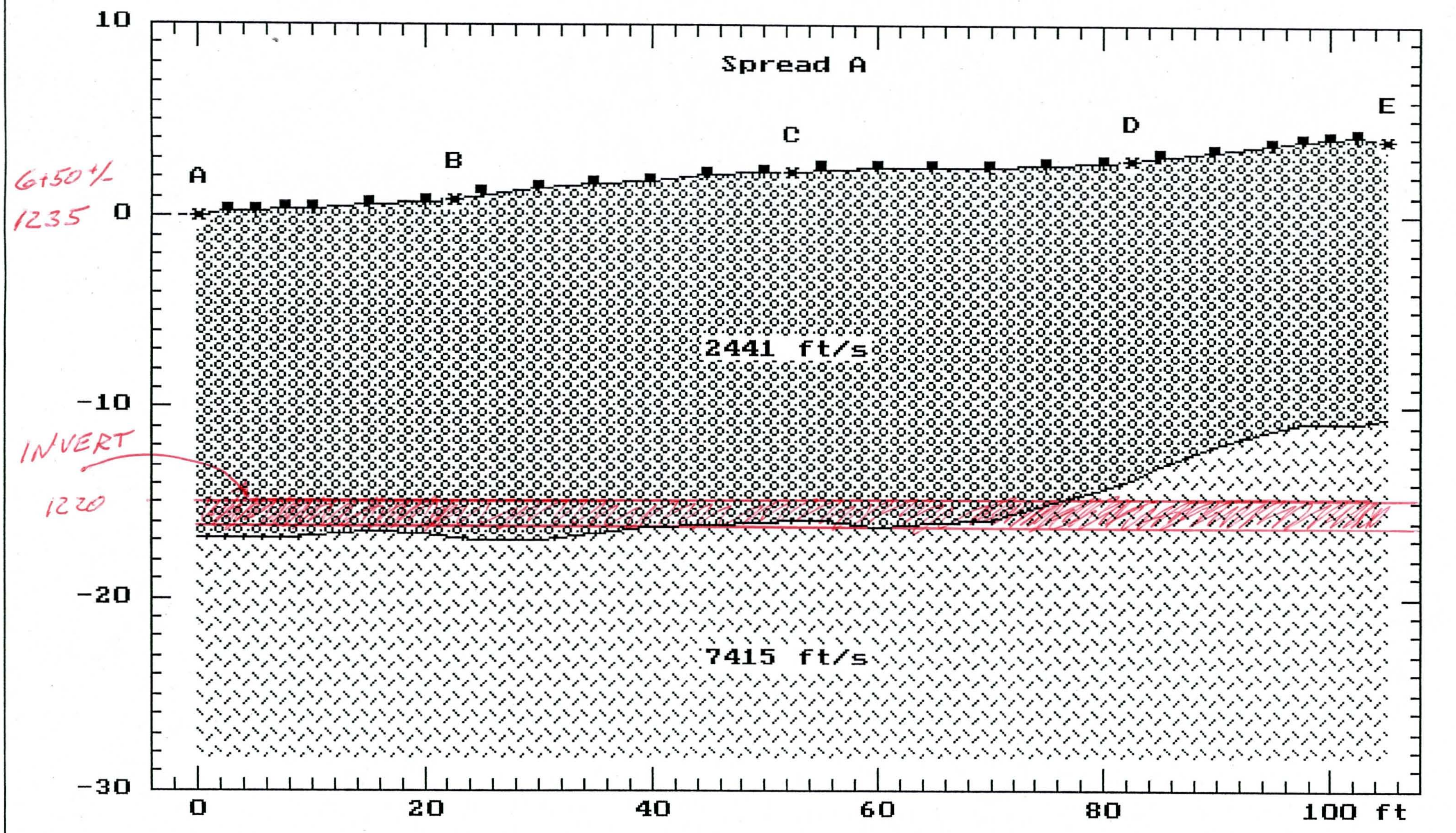
Table C-1 - Qualitative Rippability Classification

0 to 2000 ft/s	Easy Ripping
2000 to 4000 ft/s	Moderate Ripping
4000 to 5500 ft/s	Difficult Ripping, Possible Blasting
5500 to 7000 ft/s	Very Difficult Ripping, Probable Blasting
Greater than 7000 ft/s	Blasting Generally Needed

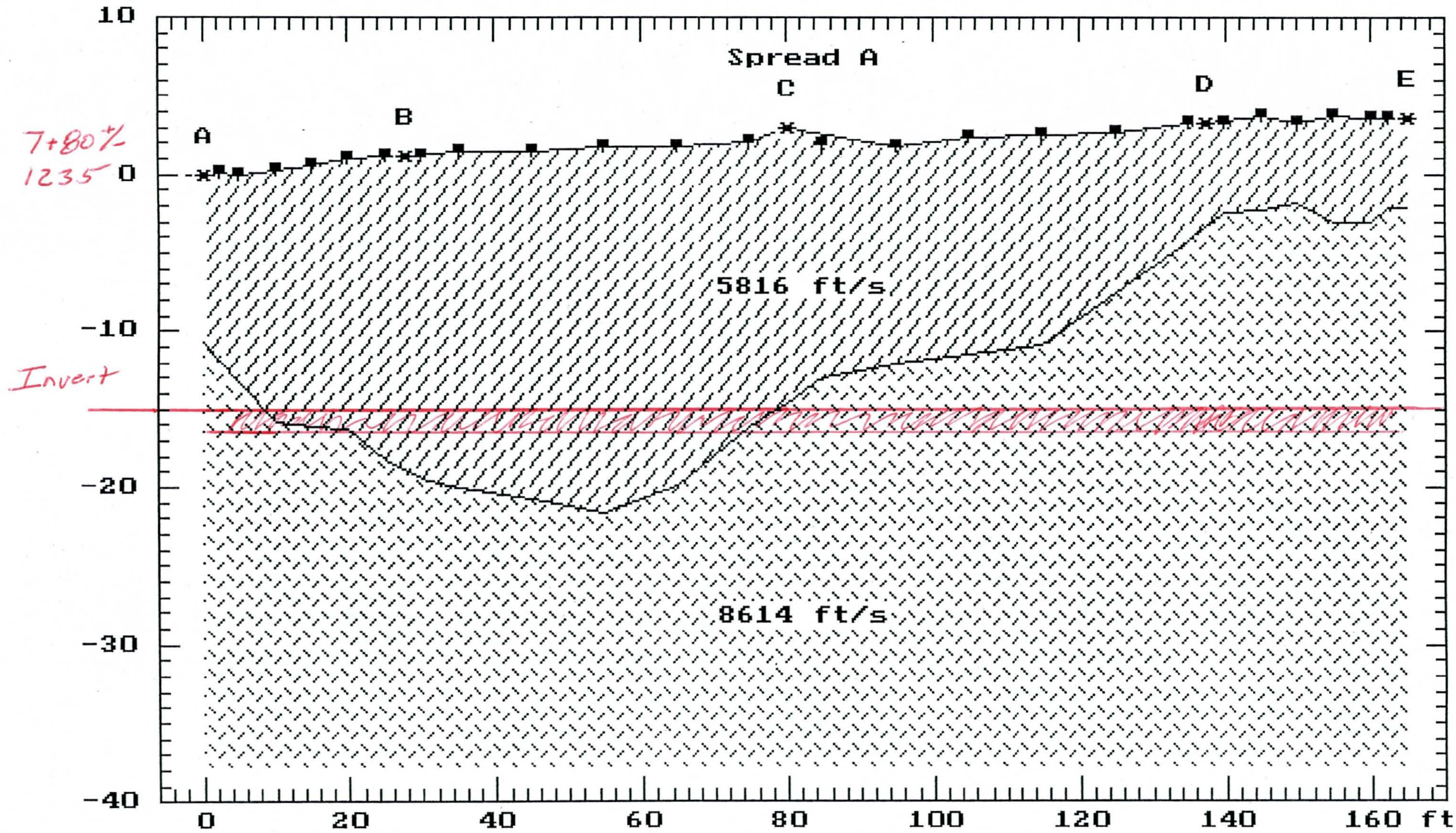
For trenching operations, the rippability figures should be scaled downward. For example, velocities as low as 3,500 feet per second may indicate difficult ripping during trenching operations. In addition, the presence of cobbles and boulders, which can be troublesome in a narrow trench, should be anticipated. Based on our visual field observations, and our seismic results, the presence of near-surface bedrock should also be anticipated in this area. Variations in erosion rates and fracture density and spacing may have caused variable depths to bedrock, and varying presence of buried bedrock boulders, cobbles, and weathered and nonweathered bedrock remnants. The above classification scheme should be used with discretion, and contractors should not be relieved of making their own independent evaluation of the rippability of the on-site materials prior to submitting their bids.

Table C-2 lists the average velocities and depths calculated from the seismic refraction traverses conducted during this evaluation. Layer profiles are presented in Figures C-1 through C-2, which are attached to this appendix.

SEISMIC REFRACTION SURVEY: FCDMC/10TH STREET WASH, SL-2



SEISMIC REFRACTION SURVEY: FCDMC/10TH STREET WASH, SL-1

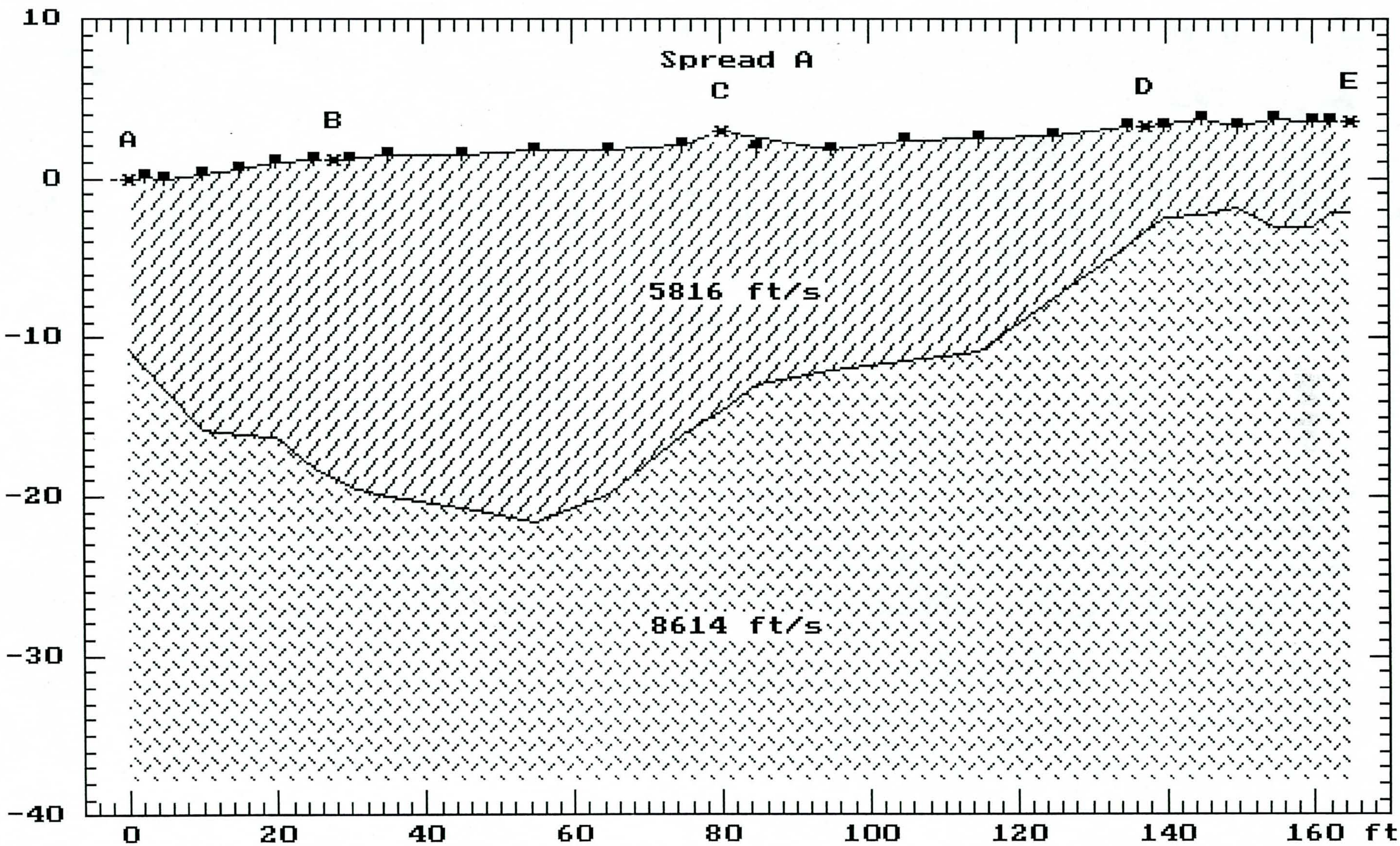


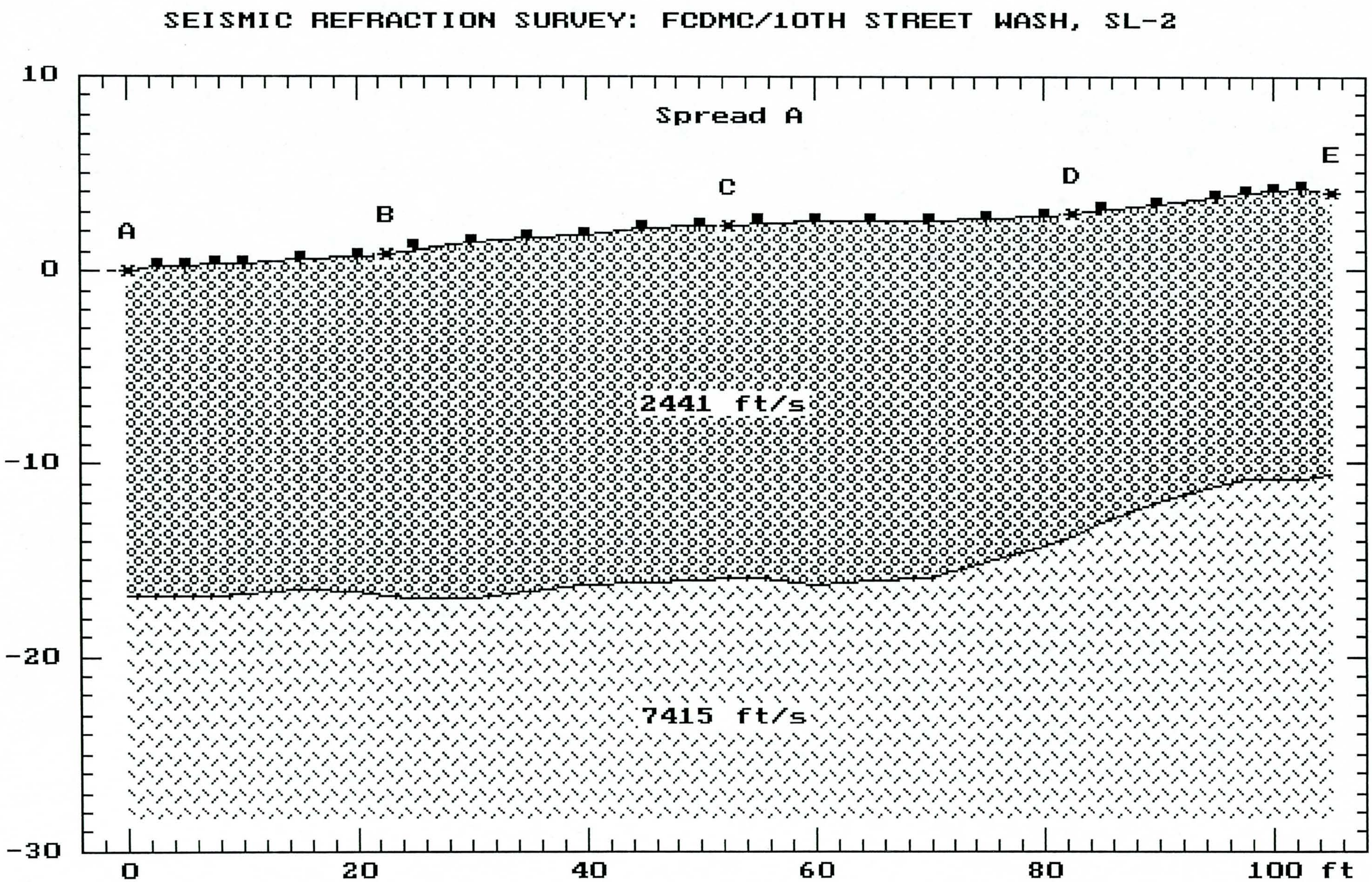
It should also be noted that, as a general rule of thumb, the effective depth of evaluation for a seismic refraction traverse is approximately one-third to one-fifth the length of the refraction line. The lengths of the seismic refraction lines are listed, with their interpretations, in Table C-2.

Table C-2 – Seismic Refraction Results

Traverse No. And Length	Velocity Feet/Second	Approximate Depth to Bottom of Layer (feet)	Rippability
SL-1 165 feet	V1 = 2,500 V2 = 7,400	14-17 ---	Moderate Ripping Blasting Generally Needed
SL-2 105 feet	V1 = 5,800 V2 = 8,600	4-20 ---	Very Difficult, Probable Blasting Blasting Generally Needed

SEISMIC REFRACTION SURVEY: FCDMC/10TH STREET WASH, SL-1




SEISMIC REFRACTION SURVEY: FCDMC/10TH STREET WASH, SL-2
Spread A
A
B
C
D
E
2441 ft/s
7415 ft/s
10
0
-10
-20
-30
0
20
40
60
80
100 ft