BULLARD WASH
PHASE II
-LOWER BUCKEYE
TO I-10 -

ATL, INC.
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Q.A./Q.C. ENGINEERING CONSULTANTS
GEOTECHNICAL ▪ CIVIL ▪ ENVIRONMENTAL

GEOTECHNICAL INVESTIGATION REPORT

WOOD, PATEL AND ASSOCIATES
BULLARD WASH CHANNEL IMPROVEMENTS PROJECT, PHASE II
FCD NO. 2001C023
GOODYEAR, ARIZONA

ATL JOB NO. 101015

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Reviewed by:

Registered Professional Engineer (Civil) CERTIFICATE NO. 22719 David Preston Hayes Date Signed 7/26/02 ARIZONA, U.S.A.

David P. Hayes, P.E.
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Prepared by:

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July 26, 2002

Mr. Ashok Patel, P.E.
Wood, Patel and Associates
2051 West Northern, Suite 100
Phoenix, Arizona 85021

Re: Geotechnical Investigation Report
Bullard Wash Channel Improvements, Phase II
FCD No. 2001C023
Goodyear, Arizona
ATL Job No. 101015

Dear Mr. Patel:

This report presents the results of a geotechnical investigation performed for the proposed channel improvements along Bullard Wash alignment from Lower Buckeye Road extending to the south side of Interstate 10, in Goodyear, Arizona. Field exploration, laboratory testing and engineering analysis are included in the report, along with bore hole logs and laboratory test results. ATL's effort was performed in accordance with Proposal No. P01337, dated January 29, 2002.

The exploration program consisted of the subsurface exploration and sampling of a total of nineteen (19) bore holes and subsequent laboratory analysis for the project. The purpose of the investigation was to develop design parameters for bridge/box culvert structures, pedestrian and equestrian underpasses, determine the quality of the excavated materials for landscaping and turf planting and to provide specifications for soils placement and compaction. General recommendations are presented in Section 7.0, along with suggested construction materials specifications, presented in Section 8.0.

ATL has appreciated the opportunity to be of service to Wood, Patel & Associates and looks forward to a continued association on future projects. Should any questions arise, please do not hesitate to contact us at your earliest convenience.

Reviewed by:

[Seal: Registered Professional Engineer (Civil), Certificate No. 22719, David Preston Hayes, Arizona, U.S.A., 7/26/02]

David P. Hayes, P.E.
Executive Vice President

Very truly yours,

[Seal: Registered Professional Engineer (Civil), Certificate No. 35056, Ammi N. Osorio, Arizona, U.S.A., 7/26/02]

Ammi Osorio, P.E.
Geotechnical Engineer

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Addendum

Project:	Bullard Wash Channel Improvements, Phase II FCD No. 2001C023 Goodyear, Arizona
Client:	Wood, Patel and Associates 2051 West Northern, Suite 100 Phoenix, Arizona 85021

Addendum No. 1

ATL Job No.: 101015 — Date: August 7, 2002

This addendum is issued to be included in the Geotechnical Report for Bullard Wash Improvements Phase II, ATL Job No. 101015 where indicated. The general character of the work called for in this addendum shall be the same as originally set forth in the applicable portions of the original report, unless otherwise specified under this addendum.

Registered Professional Engineer (Civil)
CERTIFICATE NO.
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AMMI N. OSORIO
Date Signed 8/08/02
ARIZONA, U.S.A.

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1. Add **Section 7.7** **Subsidence and Earth Fissures**, **page 14** to the Table of Contents on page i.

2. Add **Appendix D Research on Subsidence and Earth Fissures**, after Appendix C Pile Capacity Graphs and Calculations on page ii.

3. Add the following section as page 14 after Section 7.6 - Utility Trenches.

Section 7.7 Subsidence and Earth Fissures

Earth fissures are tension cracks that result from land subsidence, which is caused most commonly by groundwater withdrawal, oil extraction, dissolution of soluble rocks and underground mining. In Arizona, land subsidence and earth fissures are common in large alluvial basins where extensive groundwater pumping has lowered water table as much as 600 feet. Subsidence can cause flooding of lowered areas, and can change drainage gradients and directions, thereby disrupting storm drains, sewers, and canals. Earth fissures can cause significant damage to structures such as buildings, roads, pipelines, flood control structures and aqueducts. Fissures can provide a conduit for surface pollution to reach aquifers. Land subsidence and earth fissures are serious geologic hazards and their impacts will increase as Arizona's population grows.

South-central Arizona, geologically classified as basin and range, is the main area of the state affected by subsidence. The geological conditions of the area are such that over pumping of the underlying stores of water can result in the settling of the land or subsidence. Earth fissures have been reported found in Arizona in the following areas; *Avra Valley, Picacho Basin, Casa Grande Basin, Mesa-Chandler area, Apache Junction area, Queen Creek-Chandler Heights area, Tempe-Paradise Valley area, West Phoenix-Luke AFB area, Harquahala Valley, McMullen Valley, Willcox-Kansas Settlement area, and Bowie-San Simon area.*

The nearest area to the site is the Luke Air Force Base area, which is located approximately 7 miles north of the Lower Buckeye Road. Although the project site is not included in the areas reported above, the contractor should be aware that potential land subsidence and fissures may exist. The occurrence of land subsidence and earth fissures in the channel alignment area can effect the channel invert elevation, disrupt the flow of water in the channel, create damage to the box culvert, underpass structures and bridge crossings and erosion on the side slopes. Subsidence usually occurs so slowly that it is undetectable unless careful land surveys are made or until the cumulative effects become apparent.

Therefore, potential subsidence and fissures are events that need to be carefully considered when designing, constructing and maintaining the channel. Predicting and interpreting areas of subsidence will be essential. This task will be done by using test wells and geophysical surveys to establish soil profiles to measure the settlement of the subsurface soils within the area. This determines the extent to which the soils are dewatered and therefore susceptible to compaction. Well records of the areas will also be examined to ascertain a history of pumpage. History of water pumpage may also be researched by reviewing bench mark placements. Then, the future occurrence of subsidence will be estimated thru analysis. Another method to monitor subsidence is by the use of the Global Positioning System (GPS). GPS uses satellites to fix the latitude, longitude and elevation of the point. Results are compared with previous readings to determine the rate of land subsidence.

Fissures are difficult to predict and identify at an early stage in their development. Horizontal and vertical extensometers are devices used measure the tension in the soil to interpret the probability and development of fissures.

3. Add the following items to **Section 10.0 References** to read:

- ***FIELD NOTES, from the Arizona Bureau of Geology and Mineral Technology***, Volume 14, No.3 Fall 1984

- ***Newsletter - Land Subsidence, Earth Fissures Change Arizona's Landscape***, by Joe Gelt page 1 thru 8.

- ***Land Subsidence And Earth-Fissure Hazards Near Luke Air Force Base, Arizona,*** by Herbert H. Schumann (U.S. Geological Survey, Tempe, Arizona).

4. Add the attached **Appendix D "Research on Subsidence and Earth Fissures"** to the report.

Please contact us if you have further questions regarding this addendum.

GEOTECHNICAL INVESTIGATION

REPORT FOR

WOOD, PATEL & ASSOCIATES

PROJECT

BULLARD WASH CHANNEL IMPROVEMENTS, PHASE II
FCD 2001C023
GOODYEAR, ARIZONA

ATL JOB NO. 101015

1.0 PROJECT DESCRIPTION

The Bullard Wash Phase II Improvements project is a partnership between the Flood Control District of Maricopa County and the City of Goodyear. The project includes the design of a greenbelt channel along the Bullard Wash alignment from Lower Buckeye Road to Interstate 10, channelizing the existing floodplain. Landscaping, turf planting, irrigation, trails and other multi-use facilities will be provided along the channel alignment.

Bullard Wash will be designed with a 100-year level of protection. An existing tailwater facility will be accommodated in the channel cross section. Street crossings to accommodate storm flows will be designed at Yuma Road and Van Buren Street, along with pedestrian and equestrian underpasses. As an alternate to box culvert, an overhead bridge will be considered in the design of street crossings.

2.0 LOCATION AND GEOLOGIC DESCRIPTION

The project is located within the City of Goodyear, along the Bullard Wash, which is between Estrella Parkway and Bullard Avenue. The Project extends the existing Bullard Wash from Lower Buckeye Road to south of Interstate 10.

Geologically, the soil formation in this area of Goodyear, Arizona consists of unconsolidated, fine-textured, alluvial deposits of clay, silt, and sand occurring on gently sloping to nearly level surfaces in the floors of the valley basins. Most of these surficial materials were deposited as sediments brought down by sheet wash from the higher parts of the alluvial fans.

3.0 SCOPE OF WORK

ATL's responsibility was to drill and sample the subsurface material in order to determine the allowable bearing capacity for the structures within an acceptable differential and total settlement range.

Specifically, field and laboratory data were used in the development of the following recommendations:

- Foundation Recommendations for Bridges or Box Culvert Structures.
- Seismic Analysis per 1997 UBC Code.
- Cut and Fill Slope Recommendations.
- Embankment Recommendations.
- Adequacy of Local Soils for Turf and Landscaping.
- Pavement Design for approach slabs.
- Suggested Construction Materials Specifications.

4.0 EXPLORATION PROGRAM

The investigation consisted of drilling a total of nineteen (19) bore holes to depths of ten (10) feet to seventy (70) feet below existing grade. Six (6) of these bore holes were drilled on bridge or tunnel structure locations with depths ranging from fifty (50) to seventy (70) feet below existing grade. The remaining bore holes were drilled along the Bulllard Wash channel alignment to depths of ten (10) feet below existing grade.

A Mobile BK-81 truck-mounted drill rig with an 8-inch outside diameter auger operated by Yellow Jacket Drilling Co was used to drill the deeper bore holes. A Mobile B-50 truck-mounted drill rig with an 8-inch outside diameter auger operated by ATL was used to drill the shallow bore holes.

Standard Penetration Test (SPT) values were obtained on bridge or tunnel bore holes by lowering a 1⅜-inch split-spoon sampler into the hole through the hollow stem of the auger to the desired depth. The sampler was subsequently driven 18-inches with a 140-pound hammer in accordance with ASTM Standard D-1586 in order to obtain undisturbed samples. The number of blows required to drive the sampler every 6-inch increment was recorded, with the sum of the final two 6-inch increments recorded on the final borehole log. This is the uncorrected ‘N’ value for that depth. The material inside the sampler was collected in a plastic bag, sealed and transported to the laboratory. In order to collect “undisturbed” samples, a 2½-inch diameter ring sampler was driven in cohesive material layers at 10-foot intervals or until the proposed bore hole depth was obtained. Bulk samples were also continuously obtained off the auger flights during the drilling operation for tests that required large sample quantities.

Upon completion of the field operations, each bore hole was backfilled with excess cuttings. All samples were then transported to ATL's Phoenix laboratory for analysis. After the samples were delivered to the laboratory, the samples were checked by the Project Engineer and laboratory tests were assigned. Soil samples were also send to IAS Laboratories for Agronomy analysis. The following laboratory tests were performed to provide the project design information:

- Sieve Analysis
- Plasticity Index
- pH and Resistivity
- Moisture Content
- Standard Proctors
- Unit Weights
- Consolidation
- Swell Potential
- Hydrometers
- Direct Shear
- Agronomy tests

5.0 LABORATORY TESTING

The following explains the type of testing performed on selected samples from the field investigation:

Visual field classifications were modified by the results of laboratory index testing (*Sieve Analysis* and *Plasticity Index)*.

Moisture Content tests were performed to determine the amount of water present in the soil at the time of sampling.

Standard Proctor Analysis was completed to determine the relationship between the maximum dry density and optimum moisture content of the tested material.

A *Consolidation* test was conducted on an "undisturbed" sample to determine the amount of vertical movement a sample would experience under specific loading conditions at both the in-situ moisture content and at saturated conditions. The sample was saturated after applying a vertical stress of 2,280 psf and this moisture level maintained throughout the loading sequence.

A *Swell Potential* test was performed to determine the expansion tendencies of the subgrade material under an anticipated load represented by a 100 psf surcharge weight.

The *Direct Shear* tests were performed to determine the friction angle of the in-situ materials.

Hydrometer analyses were performed to determine the percentage of materials finer than a 75 *μmm* (No.200) mesh screen by sedimentation process.

Unit Weight Determinations were conducted to determine the dry density of the in-situ soils.

The *pH* and soil box *Resistivities* were conducted to determine corrosivity potential of the in-situ soils.

Agronomy tests were performed by IAS Laboratories to assist in determining the adequacy of excavated soil for landscaping and turf planting. and provide recommendations for soil improvement.

The following table lists the types and quantities of tests performed to provide the project design information:

TEST	QUANTITY
Sieve Analysis	13
Plasticity Index	17
Moisture Content	13
Hydrometer Analysis	5
Standard Proctor	2
Consolidation	1
Swell Potential	1
Unit Weights	2
pH and Resistivity	3
Agronomy tests	6

All physical laboratory tests were conducted in accordance with ASTM published procedures. The soils shown on the edited borehole logs were classified using the Unified Soils Classifications System (USCS) as presented in ASTM D2487.

6.0 SUMMARY OF EXISTING CONDITIONS

Classification data for the soils sampled from the bore holes suggest the following generalized soil profile. Detailed bore hole logs are presented in Appendix A.

a) The subsoil in the bridge/box culvert locations generally consisted of varying layers of clayey and sandy materials extending to the bottom of the bore holes, 50 feet to 70 feet below grade. The clayey materials were classified as either a **sandy lean CLAY (CL)** or a **sandy, silty CLAY (CL-ML)**. The sandy materials were either a **silty SAND (SM)**, a **clayey SAND (SC)**, a

sandy SILT (ML), a **poorly graded SAND (SP)**, or a **well-graded SAND (SW-SM)**. Varying degrees of cementation, either weak or moderate, were noted at each bore hole. The "N" values, determined from the Standard Penetration Test (SPT), revealed a "soft" to "moderately firm" condition in the top 10 feet of the SC and CL-ML subsoils. The "N" values generally increased to "firm" to "hard" as depth of drilling increased. "Caliche" layers were encountered in Bore Hole No. B-1 at layer depths of 15 feet to 16 feet below grade and at 40 feet to 43 feet below grade.

b) Within the Channel alignment, the subsoil consisted of either a **silty SAND (SM)**, a **sandy lean CLAY (CL)**, a **sandy SILT (ML)** or a **sandy, silty CLAY (CL-ML)** extending to the bottom of each bore hole, approximately 10 feet below existing grade. Weak to moderate cementation was noted at each bore hole. The "N" values, determined from the Standard Penetration Test (SPT), revealed a "firm" condition on the top 10 feet of the SM, CL, ML and CL-ML subsoils.

c) Ground water was encountered on Bore Hole Nos. B-3, B-4 and B-5 at the depths of 47 feet, 59 feet and 55 feet below existing grade.

Laboratory tests were performed on selected samples and are presented in Appendix B. We have summarized the results below:

a) The amount of *fines* present in the *non-plastic* **SM** materials ranged from 15.7% to 24.9%. The amount of *fines* in the **SC** material was 31.6%, with a *Plasticity Index* of 14. The amount of *fines* in the **CL** materials ranged from 54.5% to 87.4%, with *Plasticity Indices* ranging from 8 to 19. The amount of *fines* in the *non-plastic* **SW-SM** materials ranged from 9.6% to 11.0%. The amount of *fines* in the **CL-ML** materials were 52.7% and 60.0%, with *Plasticity Indices* of 5 for both. The amount of *fines* in the **ML** material was 63.4%, with a *Plasticity Index* of 1.

b) *Standard Proctor Analyses* were performed on the **SM** material from Bore Hole No. B-3 at the layer depth of 25 feet to 30 feet below grade and on the **CL** material from Bore Hole No. B-18, obtained 5 feet to 10 feet below grade. The maximum dry densities were 126.5pcf and 109.1 pcf at optimum moisture contents of 7.5% and 16.8%, respectively.

c) The *Dry Unit Weights* obtained from Bore Hole Nos. B-12 and B-16 sampled at depths of 5 feet to 6 feet below grade, were 100.6 pcf and 102.9 pcf, respectively.

d) A *Consolidation* test was performed on the **CL-ML** material from Bore Hole No.B-3 obtained 10 feet to 11 feet below existing grade. The sample tested exhibited a 2.5% total consolidation when the samples were saturated with water under a vertical stress of 2280 psf.

e) *Swell Potential* tests were performed on the **CL-ML** material from Bore Hole No.B-3 and on the **SM** material from Bore Hole No. B-18 obtained on the top ten (10) feet. The **CL-ML** sample did not experience swell when the sample was saturated with water under a surcharge stress of 100 psf. The **SM** sample experienced 0.98% swell when the sample was saturated with water under a surcharge stress of 100 psf.

f) A friction angle of 32° was obtained when a *Direct Shear* test was performed on the **CL** material from Bore Hole No. B-1. A friction angle of 40° was obtained when the same test was performed on the **SW-SM** material from Bore Hole No. B-5.

g) *Hydrometer Analyses* were performed on **SC, SM, CL** and **CL-ML** materials at depths of 5 feet and 10 feet below existing grade. The results of the analysis are included in Appendix C and were used by the Hydrologist to predict flow characteristics on the channel.

h) The *pH* and *Soil Box Resistivity* tests were performed on **SC** material from Bore Hole B-1, on **CL** material from Bore Hole B-4 and on **CL-ML** from Bore Hole B-15 obtained in the top 10 feet resulted in pH values were 8.0, 8.1 and 8.5 with corresponding Resistivity results of 671ohm-cm, 597 ohm-cm and 1141 ohm-cm.

i) The *Agronomy* tests results are shown in Appendix B and the interpretation/recommendations are presented in Section 7.0 of the Report.

7.0 DISCUSSIONS AND RECOMMENDATIONS

ATL investigated the soils within the channel alignment to determine classifications and suitability for re-use as fill on other parts of the project. Additional testing for soil nutrients was also conducted in order to plan landscaping along the channel banks.

The other prime issue addressed in this section is the type of overpass to construct at Yuma and Van Buren Streets, where the channel passes through. ATL has provided foundation information based on parameters provided by Structural Grace for both AASHTO girder bridges and box culverts. The client also requested analysis for pedestrian and equestrian use areas depending on the underpass option.

Other information relative to soil corrosivity and pavement approach slabs are included in ATL's analysis and are provided in the subsection below.

Recommendations presented in the following sections are based on the assumption that the soils encountered during construction will be similar to those encountered in the bore holes. If variations are noted during construction, or if changes are made in the site plan, structural loadings, etc. ATL should be notified to determine if the foundation design parameters have been altered.

7.1 Seismic Considerations

The following information is provided relative to Seismic activity in the area of Goodyear, Arizona. According to the ***1997 Uniform Building Code, Volume II***, Goodyear, Arizona is located in Seismic Zone 2B. Please note that since the soil properties were not known in sufficient detail to determine the profile type over 100 feet, type S_D was selected.

Seismic Zone	2B
Soil Profile Type	S_D
Seismic Zone Factor (Z)	0.20
Seismic Coefficient (C_a)	0.28
Seismic Coefficient (C_V)	0.40

7.2 Green Belt Channel

The subsoil in the green belt channel alignment consisted of SM, CL, and CL-ML materials that are generally suitable as subgrade fill and fill behind structures. However, there are ML material that should be mixed with native granular materials prior to its use as structural fill and should follow gradation and plasticity requirements for borrow as mentioned in Section 8.2 of this Report. Ground water was encountered at elevations of about 47 feet to 59 below existing grade. (See Bore Hole Log Nos. B-3, B-4 and B-5 in Appendix A).

The side slope of the channel should be cut no steeper than 2H: 1V. Prior to placing slope protection, the subgrade should be proof rolled to a density of no less than 95% of the maximum dry density as determined by ASTM D 698. In areas where concrete is placed on the bottom of the channel , the subgrade should be scarified to a depth of 10 inches and recompacted to no less than 95% of the maximum dry density as determined by ASTM D 698, prior to placing no less than 6 inches of Aggregate Base Course (ABC) compacted as required in Section 8.0 of this report.

Channel slope protection will be required to protect it against erosion and scour. Several slope protection materials may be used such as applying seed mixes, grouted riprap, shotcrete, gabions or cement stabilized alluvium.

In preparing the subgrade for the channel bottoms, scarification and compaction on the existing ground will be required. The difference is the "Ground Compaction Factor" (GCF). It is anticipated **GCF value is 0.10 feet.**

The soils that will be excavated from the proposed channel location and from the street crossing structures, moved and compacted to near maximum density will experience a reduction in volume in relation to previous volume. This change in volume is "shrink". The estimated value for **Shrinkage is 15%**.

7.3 Street Undercrossings

Bridge and box culvert alternates are being reviewed by the engineer. The following subsections provide foundation support information for those alternates. Since there are several combinations of loadings, Shaft Capacity Charts are presented for each location (since the subsoils are different) within the range of shaft loads anticipated by the designer. This range of loadings and shaft diameters was developed based on ATL's discussion with the bridge-structural designers.

ATL also performed shallow foundation analysis to determine the allowable capacities of near surface soil substrata. The heaviest load was used to evaluate the settlements using the maximum 0.5" differential settlement as the governing criteria.

7.3.1 Bridge Structures

If a bridge is chosen as the structure crossing Yuma and Van Buren Streets, a straight drilled shaft or a shallow spread footings will be used as foundation systems. Structural configurations, loads and foundation parameters for each systems are included in each subsection as follows:

Straight Drilled Cast In-placed Concrete Shafts:

Two (2) alternates were proposed for the bridge structure;, 1) Type III Girder Bridge, single span or 2) Slab Bridge, two (2) spans with pier.

The structural configurations and loadings information for each bridge were provided by Structural Grace. Please note that the bridge pier for Van Buren Street is anticipated to be supported by two (2) shafts. The bridge pier for Yuma Street will be supported by three (3) shafts. The load on each shaft was determined from the total pier loads divided by the number of shafts on each pier.

The following minimum design parameters were determined for the bridge structure:

-Table 1-

ITEM	YUMA ROAD	VAN BUREN STREET
Embedment Depth	Varies - See chart	Varies - See chart
Skin Friction Capacity	Varies - See chart	Varies - See chart
Bridge Width	53'-10"	41'-10"
Bridge Length	86'-00"	86'-00"
Unit Weight of Soil	SC - 115 pcf SP - 118 pcf SW-SM - 118 pcf	CL-ML - 122 pcf SM - 120 pcf CL - 108 pcf
Coefficient of Lateral Earth Pressure	K_c =0.6, K_t =0.40	K_c =0.6, K_t =0.40
Internal Friction Angle of Soils	SC - 34° SP - 36° SW-SM - 40°	CL-ML - 30° SM - 34° CL - 32°
Cohesion for Soils	500 psf @ 0 - 15' 0 psf @ 15' - 25' 0 psf @ 25' - 70'	500 psf @ 0 - 20' 100 psf @ 20' - 35' 1,500 psf @ 35' - 70'
Ground Water Elevation (at the time of Drilling)	47 feet	55 feet

The approach slab connecting the bridge structures into the existing Yuma and Van Buren Streets should be designed following ADOT's Detail B-19.11.

Drilled shafts allowable capacities for various pile diameters were calculated using the "SHAFT", version 4.0 program and are based on side friction bearing only. Shafts spacings should be no less than 3 pile diameters, center-to-center, in order to consider them as individual shafts. Load-Capacity graphs including computer calculations for various pile diameters are presented in Appendix C.

All drilled shafts should be constructed in compliance to the project specifications and should include the following construction considerations:

- The straight, drilled shaft excavation should be advanced with a single-flight auger or bucket auger bits to the recommended depth.

- It should be verified by inspection and measurement that the excavation is open to the recommended depth. The shaft excavation should be cleaned such that no more than 4 inches of slough or loose material is present in the bottom of the hole.

- Concrete should be placed through a hopper or other device approved by the geotechnical engineer so that it is channeled in such a manner to free fall and clear the walls of the excavation and reinforcing steel until it strikes the bottom.

- Adequate compaction will be achieved by free fall of the concrete up to the top 5 feet. The top 5 feet of concrete should be vibrated in order to achieve proper compaction. The concrete should br designed from the strength standpoint, so that the slump during placement is in the range of 5 to 7 inches.

- Continuous observation of the construction of the drilled shaft should be carried out by the geotechnical engineer. The geotechnical engineer should verify proper diameter, depth and cleaning, and should also confirm the nature of the materials encountered in the shaft excavation.

- Concrete placement should be continuously observed to ensure that it meets requirements. A quality assurance report should be submitted for each shaft stating, in writing, that all details have been inspected and meet requirements. Occupation Safety and Health Act(OSHA) regulations will require casing and air quality monitoring if workmen are required to enter the drilled shaft excavation.

- Very little or no caving is expected in the clayey soils. Some, to possibly considerable caving, could occur in the granular soils. It is possible that stabilization techniques such as casing or slurry assistance will be necessary for drilling into the granular soil stratum. In order to minimize potential caving problems, it is recommended that drilled shaft excavations be concreted as soon as feasible(no less than 12 hours after excavation).

Shallow Spread Type Foundations:

Another type of foundation system considered to support the abutments and pier will be a shallow spread type foundation. Using the heaviest load provided by Structural Grace for each bridge, the following foundation parameters are provided:

-Table 2-

ITEM	YUMA ROAD	VAN BUREN STREET
Minimum Footing Depth Below Channel Invert	5 feet	5 feet
Minimum Footing Width	6 ft	5 ft
Anticipated Maximum Loads	1400 kips	1100 kips
Coefficient of Sliding Friction for Native Material	0.40	0.40
Footing Bearing Material	Scarify / Recompact 10 inches of Native SC	Scarify / Recompact 10 inches of Native CL-ML
Allowable Bearing Capacity	5000 psf	5000 psf
Friction Angle (Native)	34°	30°
Anticipated Settlements (inches) Total: Differential:	 Less than 0.50 Less than 0.50	 Less than 0.50 Less than 0.50

ATL suggested that abutment skirt be constructed consisting of stable materials either shotcrete or grouted rip-rap to provide for scour protection during the 100-year storm. Material and construction specifications for shotcrete and grouted rip-rap is provided in Section 8.0 of this report.

The following recommendations for the lateral earth pressures and other parameters required for the fill placed behind abutments and backfill behind the side walls of the culvert using the native SC/CL-ML :

- Table 3 -

Description	Value
Friction Angle	32°
Wet Unit Weight	121 lbs/ft^3
Active Pressure	37 lbs/ft^2
Passive Pressure	394 lbs/ft^2
At-Rest Pressure	57 lbs/ft^2

7.3.2 Box Culvert

Another structure option considered underneath the street crossings is to construct a box culvert. The information provided by Structural Grace indicated that the proposed box culvert will have a structural loading per unit area of 2250 psf. The box culvert will consist of seven (7) open concrete barrels, wherein the outer two (2) will serve as the pedestrian and the equestrian underpasses. The invert elevation of the box culvert will be approximately 8 feet.

Based on the information provided, the following foundation parameters are provided:

Allowable Bearing Capacity	-	5000 psf
Founding Material	-	SC/CL-ML
Coefficient of Friction	-	0.40
Total and Differential Settlement	-	0.50 inch maximum

When constructing for the culvert bottom slab, 10 inches of the native SC/CL-ML should be scarified and recompacted to 95% of the maximum dry density prior to placing 6 inches of ABC. See ADOT's Detail B-01-10 for Box Culvert Construction details.

7.4 Pedestrian and Equestrian Underpass

It is our understanding that a pedestrian and an equestrian underpasses will be constructed on either side of the bridge or culvert structures. The pedestrian underpass will bear approximately one (1) foot below channel invert located on one side of the bridge or box culvert structures. The equestrian underpass will bear approximately 3 feet below channel invert that will be located on the other side of the bridge or box culvert structures. The following foundation parameters are provided for the underpasses when box culvert structure option is chosen:

Allowable Bearing Capacity	-	5000 psf
Founding Material	-	SC/CL-ML
Coefficient of Friction	-	0.40
Total and Differential Settlement	-	0.50 inch maximum

For the bridge option undercrossings, the pedestrian and equestrian underpasses will be constructed as a slab on grade bearing on the same elevation as the underpasses for the culvert structures option. Slab concrete thickness shall be determined by the engineer. Prior to placing portland cement concrete(PCC) for the underpasses, 6 inches of Aggregate Base Course (ABC) will be placed. Scarify and recompact 10 inches of native subgrade prior to placing ABC.Material and compaction requirements are detailed in Section 8.0 of this report.

7.5 Landscaping

Agronomy tests were performed on soil samples from six (6) bore holes obtained on the top 12 inches to determine the suitability of existing soils for landscaping and turf planting. Based on the information supplied by Logan Simpson Design, Landscape Architect for this project, Cynodon Dactylon will be specified for turf planting. The landscape will be of Sonoran Desert Species. Details of the plants were not provided at the time the Report is published.

The results indicated that Nitrate, ph and salinity contents of the existing soils were high. The soil specialist of IAS Laboratories recommended application of dispursul at the rate of 25 pounds per 1000 square of soil and leach in water. This will allow some of the Calcium Carbonate to dissolve, lower the pH and the sodium to be leached overtime. As the pH lowers most of the micronutrients will become more available to the plants. Do not add any micronutrients at the time of application of dispursul. For soils near the areas of Bore hole Nos. 7 and 10, apply 5 pounds of Single Superphosphate per 1000 square feet and work into soil. Once the leaching has been properly carried out, the salinity contents will lower to acceptable levels. The contractor's landscaper should have additional recommendations depending on the specific plants and ground cover chosen for the project.

7.6 Utility Trenches

Corrosivity tests were performed for this project and the results were all below 1500 ohm-cm indicating that soil in this area is corrosive. It is recommended that concrete and/or plastic pipe be used in the construction of utility lines.

8.0 GENERAL CONSTRUCTION RECOMMENDATIONS

For this project, ATL recommends that the ***Uniform Standards Specifications for Public Works Construction by the Maricopa Association of Governments (MAG)*** 1997 (Including revisions through 2001) be generally used as a guideline. Areas not addressed by the MAG specifications and areas where the Engineer suggests a deviation are presented below.

8.1 Structural Excavation and Backfill

The excavated native SM, SC, SW-SM, and CL-ML materials may be used as fill, placed and compacted per Section 8.5 of this report. The isolated CL material with high plasticity may be used for landscaped areas only. The ML material should be mixed with SM and SW-SM prior to its use as structural fill and should follow gradation and plasticity index requirements of Section 8.2 of this Report. All vegetation and root systems from the construction areas should be stripped and removed. Care should be exercised to separate the excavated native materials to avoid incorporation of the organic matter in the structural fill sections.

8.2 Borrow

Import borrow material from offsite sources is not anticipated, however if needed should conform to the following criteria:

Sieve Size	Percent Passing
3"	100
¾"	55 - 80
No. 4	35 - 60
No.40	5 - 20
No. 200	0 - 12

Plasticity Index $\leq$ 10

In addition, the borrow shall contain no “chunks” of clay, organic matter, tree limbs, excess moisture and stones larger than 3 inches.

8.3 Aggregate Base Course

The aggregate base course (ABC) material shall conform to Table 702-1 of MAG. The Plasticity Index as tested in accordance with AASHTO T-146 Method A (Wet Preparation), T-89 and T-90 shall not be more than 5. In addition, the material shall contain no "chunks" of clay, organic matter, tree limbs, excess moisture and stones larger than 3 inches.

8.4 Placement and Compaction

MAG Sections 211 and 215 should be followed, using either AASHTO T-99 or ASTM D698 procedures in obtaining the laboratory proctor maximum dry density and optimum moisture content. This report provides several proctor values but the contractor should confirm these during actual construction. Compaction should meet the requirements of Table 4, as follows:

- Table 4 -

DESCRIPTION	MOISTURE REQUIREMENT	COMPACTION REQUIREMENT
Native Structural Fill	Optimum, ±2%	95% ASTM D698
Aggregate Base	Optimum, ±2%	95% ASTM D698
Pavement Subgrades	Optimum, ±2%	95% ASTM D698

8.5 Portland Cement Concrete

All structural concrete shall meet the compressive strength requirements specified by the structural engineer. The supplier should submit a mix design for approval prior to beginning of construction, and include any admixtures needed.

The portland cement concrete for drilled shafts should be equivalent to a MAG Class A, 3,500 psi, 28-day compressive strength. A mix design must be submitted for approval prior to use on this project. The mix design should provide compressive strength results at 7 and 28 days. Placement should conform to MAG Section 505.

8.6 Shotcrete

Material and construction requirements of Section 912 of ADOT's standard specification should be followed. Shotcrete shall be mortar or concrete conveyed through a hose and pneumatically applied using either the dry mix process or the wet mix process.

8.7 Rip-rap

Material and construction requirements should conform to the applicable provisions of MAG Section 703.

9.0 LIMITS OF SERVICE

The analyses and recommendations in this report are based in part upon data obtained from the field exploration. The nature and extent of variations beyond the location of test bore holes may not become evident until construction. If variations then appear evident, it may be necessary to reevaluate the recommendations of this report.

ATL's professional services were performed using that degree of care and skillordinarily exercised, under similar circumstances, by reputable geotechnical engineers practicing in this or similar localities. No warranty, express or implied, is made. We prepared the report as an aid in design of the proposed project.

This report is for the exclusive purpose of providing geotechnical engineering and/or testing information and recommendations. The scope of services for this project does not include, either specifically or by implication, and environmental assessment of the site or identification of contaminated or hazardous materials or conditions.

If there are questions concerning this report, do not hesitate to contact the author. If you need materials testing services during the construction of this project, ATL is a full-service laboratory that maintains a staff of certified technicians and professional engineers that are proficient in all aspects of inspection and testing, including NDT for steel erection.

10.0 REFERENCES

- ***Arizona Materials Inventory Aggregate Sources and Geology of Maricopa County***.
- ***GeoCal for Windows***, Data Surge.
- ***Uniform Standard Specifications for Public Works Construction***, Maricopa Association of Governments, 2001
- ***"SHAFT", Version 4.0 for Windows***, Ensoft, Inc.

PLATES

ATL, INC.
Excellence In Quality

GUIDELINES IN THE USE AND INTERPRETATION OF THIS GEOTECHNICAL REPORT

ATL Job No. 101015

Our professional services were performed, our findings obtained, and our recommendations prepared in accordance with generally accepted engineering principles and practices. This warranty is in lieu of all other warranties, either expressed or implied.

The geotechnical report was prepared for the use of the Owner in the design of the subject facility and should be made available to potential contractors and/or the Contractor for information on factual data only. This report should not be used for contractual purposes as a warranty of interpreted subsurface conditions such as those indicated by the interpretive boring and test pit logs, cross sections, or discussion of subsurface conditions contained herein.

The analyses, conclusions and recommendations contained in the report are based on site conditions as they presently exist and assume that the exploratory borings, test pits, and/or probes are representative of the subsurface conditions of the site. If, during construction, subsurface conditions are found which are significantly different from those observed in the exploratory borings and test pits, or assumed to exist in the excavations, we should be advised at once so that we can review these conditions and reconsider our recommendations where necessary. If there is a substantial lapse of time between the submission of this report and the start of work at the site, or if conditions have changed due to natural causes or construction operations at or adjacent to the site, this report should be reviewed to determine the applicability of the conclusions and recommendations considering the changed conditions and time lapse.

The Summary Boring Logs are our opinion of the subsurface conditions revealed by periodic sampling of the ground as the borings progressed. The soil descriptions and interfaces between strata are interpretive and actual changes may be gradual.

The boring logs and related information depict subsurface conditions only at these specific locations and at the particular time designated on the logs. Soil conditions at other locations may differ from conditions occurring at these boring locations. Also, the passage of time may result in a change in the soil conditions at these boring locations.

Groundwater levels often vary seasonally. Groundwater levels reported on the boring logs or in the body of the report are factual data only for the dates shown.

Unanticipated soil conditions are commonly encountered on construction sites and cannot be fully anticipated by merely taking soil samples, borings or test pits. Such unexpected conditions frequently require that additional expenditures be made to attain a properly constructed project. It is recommended that the Owner consider providing a contingency fund to accommodate such potential extra costs.

This firm cannot be responsible for any deviation from the intent of this report including, but not restricted to, any changes to the scheduled time of construction, the nature of the project or the specific construction methods or means indicated in this report; nor can our firm be responsible for any construction activity on sites other than the specific site referred to in this report.

SOIL CLASSIFICATION & TERMINOLOGY

GRAPHIC SYMBOL	GROUP SYMBOL	TYPICAL NAMES
	GM	Silty gravels, gravel-sand-silt mixtures
	GW	Well-graded gravels, gravel-sand mixtures, or sand-gravel-cobble mixture
	GW-GM	Well-graded gravel with silt
	GP-GM	Poorly graded gravel with silt, sand, cobbles and boulders
	SP-SM	Poorly graded sand with silt
	SW-SM	Well-graded sand with silt
	SM	Silty sands, sand-silt mixtures
	SC-SM	Clayey silty sands, clayey sands with silt silty clays with sand
	SC	Clayey sands, sand-clay mixtures
	ML	Inorganic silts, clayey silts with slight plasticity
	CL	Inorganic clays of low to medium plasticity gravely clays, sandy clays, silty clays, lean clays
	CL - ML	Clays and silts with sands Clay, silt and sand mixtures
	-	Hardened/Cemented Lense (Caliche)
	-	Aggregrate Base Course
	-	Asphaltic Concrete
	-	Portland Cement Concrete Pavement

1. RELATIVE DENSITY - TERMS FOR DESCRIPTION OF RELATIVE DENSITY OF COHESIONLESS, UNCEMENTED SANDS AND SAND-GRAVEL MIXTURES

N	RELATIVE DENSITY
0-4	VERY LOOSE
5-10	LOOSE
11-30	MEDIUM DENSE
31-50	DENSE
>50	VERY DENSE

2. RELATIVE CONSISTENCY - TERMS FOR DESCRIPTION OF CLAYS WHICH ARE SATURATED OR NEAR SATURATION

N	RELATIVE CONSISTENCY	REMARKS
0-2	VERY SOFT	EASILY PENETRATED SEVERAL INCHES WITH FIST
3-4	SOFT	EASILY PENETRATED SEVERAL INCHES WITH THUMB
5-8	MEDIUM STIFF	CAN BE PENETRATED SEVERAL INCHES WITH THUMB WITH MODERATE EFFORT
9-15	STIFF	READILY INDENTED WITH THUMB BUT PENETRATED ONLY WITH GREAT EFFORT
16-30	VERY STIFF	READILY INDENTED WITH THUMB NAIL
>30	HARD	INDENTED ONLY WITH DIFFICULTY BY THUMB NAIL

3. RELATIVE FIRMNESS - TERMS FOR DESCRIPTION OF PARTIALLY SATURATED AND/OR CEMENTED SOILS WHICH COMMONLY OCCUR IN THE SOUTHWEST INCLUDING CLAYS, CEMENTED GRANULAR MATERIALS, SILTS AND SILTY AND CLAYEY GRANULAR SOILS

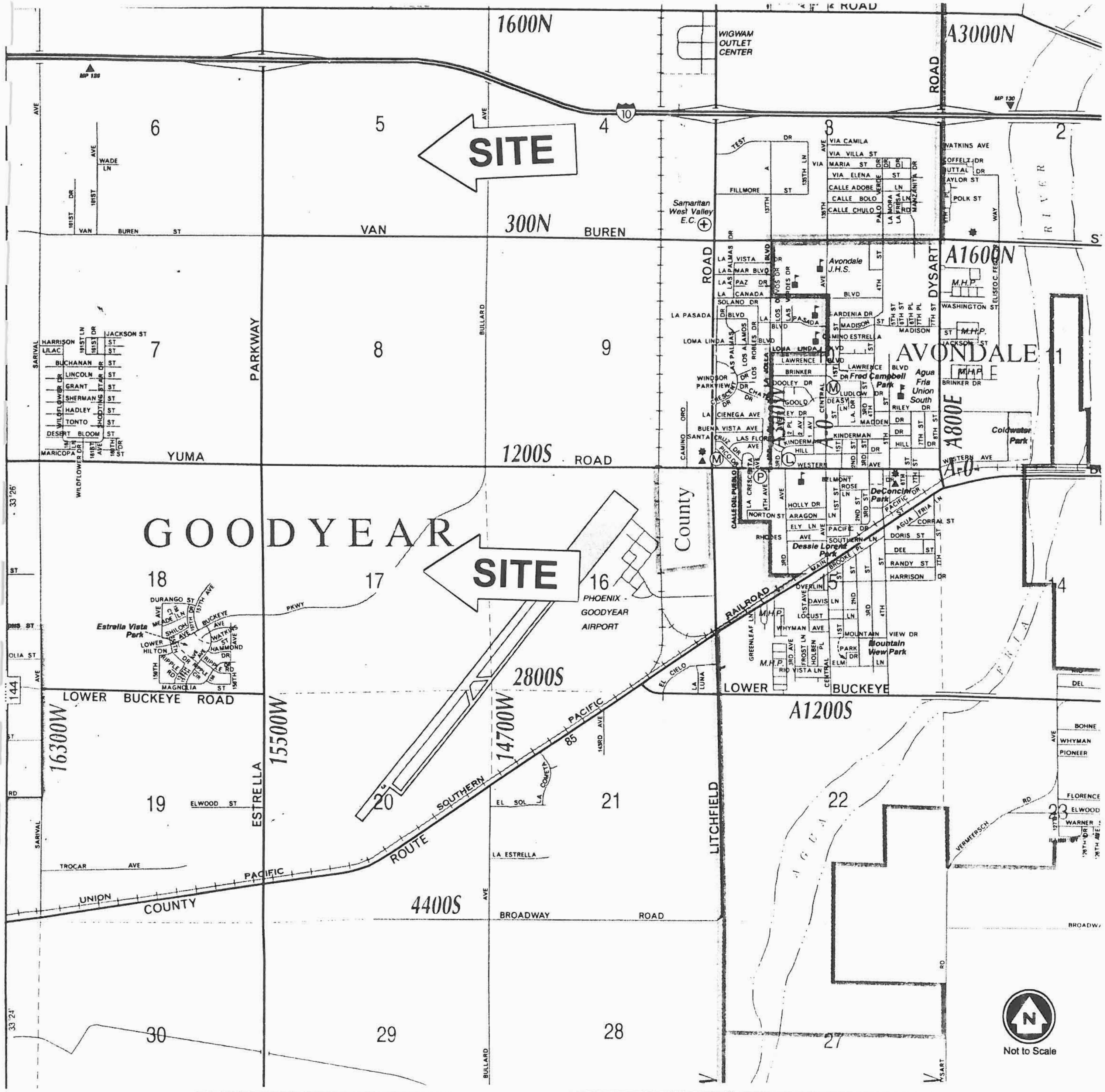
N	RELATIVE FIRMNESS
0-4	VERY SOFT
5-8	SOFT
9-15	MODERATELY FIRM
16-30	FIRM
31-50	VERY FIRM
>50	HARD

4. STANDARD PENETRATION TESTS (SPT)

■ - Blows/ft

DEFINITIONS OF SOIL FRACTIONS

SOIL COMPONENT	PARTICLE SIZE RANGE
COBBLES	Above 3 inches
GRAVEL	3 inches to No.4 sieve
Coarse gravel	3 inches to 3/4 inch
Fine gravel	3/4 inch to No. 4 sieve
SAND	No. 4 sieve to No. 200
Coarse	No. 4 sieve to No. 10
Medium	No. 10 sieve to No. 40
Fine	No. 40 sieve to No. 200
FINES (silt or clay)	Below No. 200 sieve



SITE LOCATION MAP

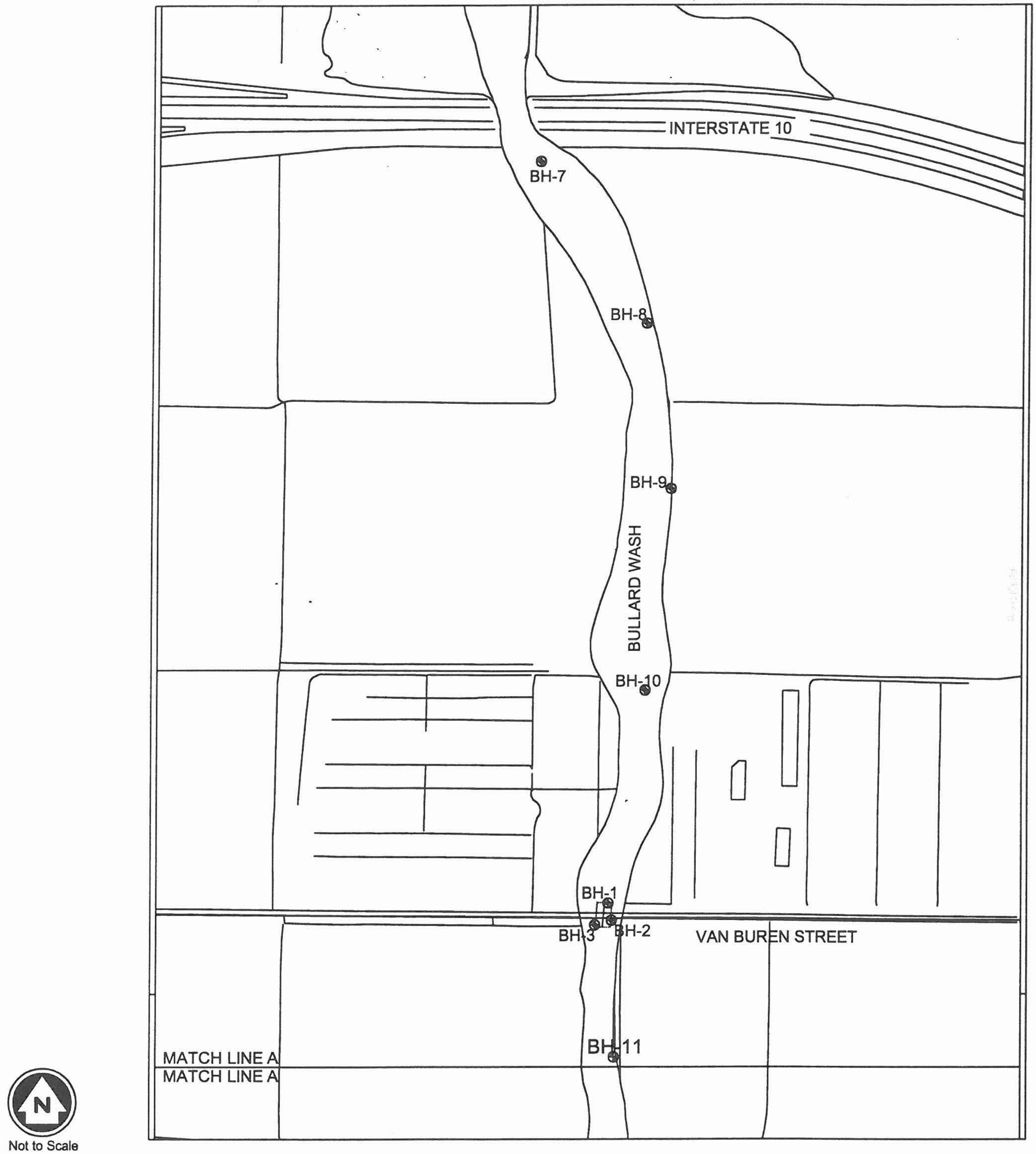
WOOD, PATEL AND ASSOCIATES

BULLARD WASH IMPROVEMENTS, PHASE II

GOODYEAR, ARIZONA

ATL JOB NO. 101015

PLATE NO. 3



BORE HOLE LOCATION MAP

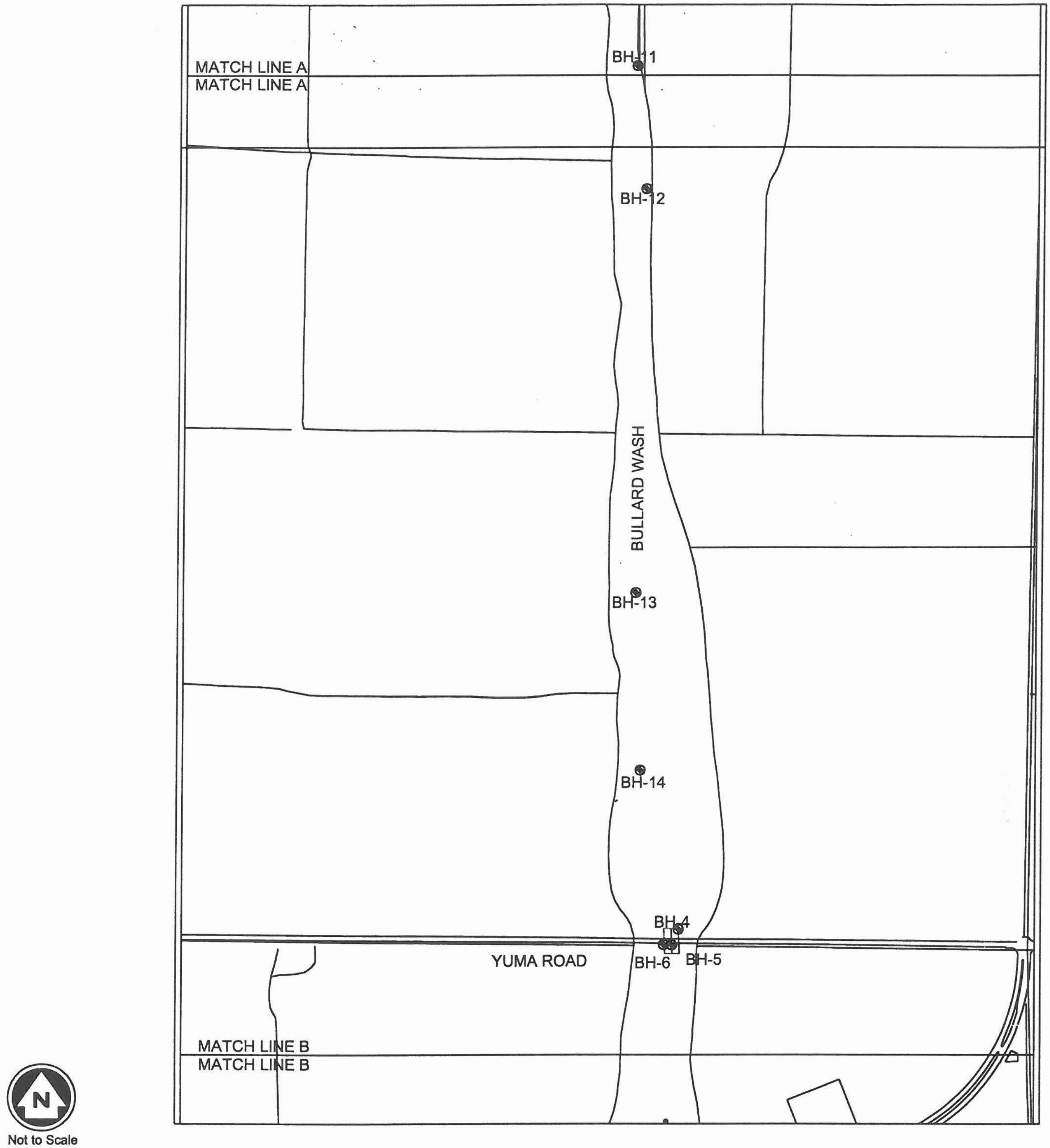
BULLARD WASH PHASE II

PHOENIX, ARIZONA

BORE HOLE

ATL JOB NO. 101015

PLATE NO. 4a



BORE HOLE LOCATION MAP

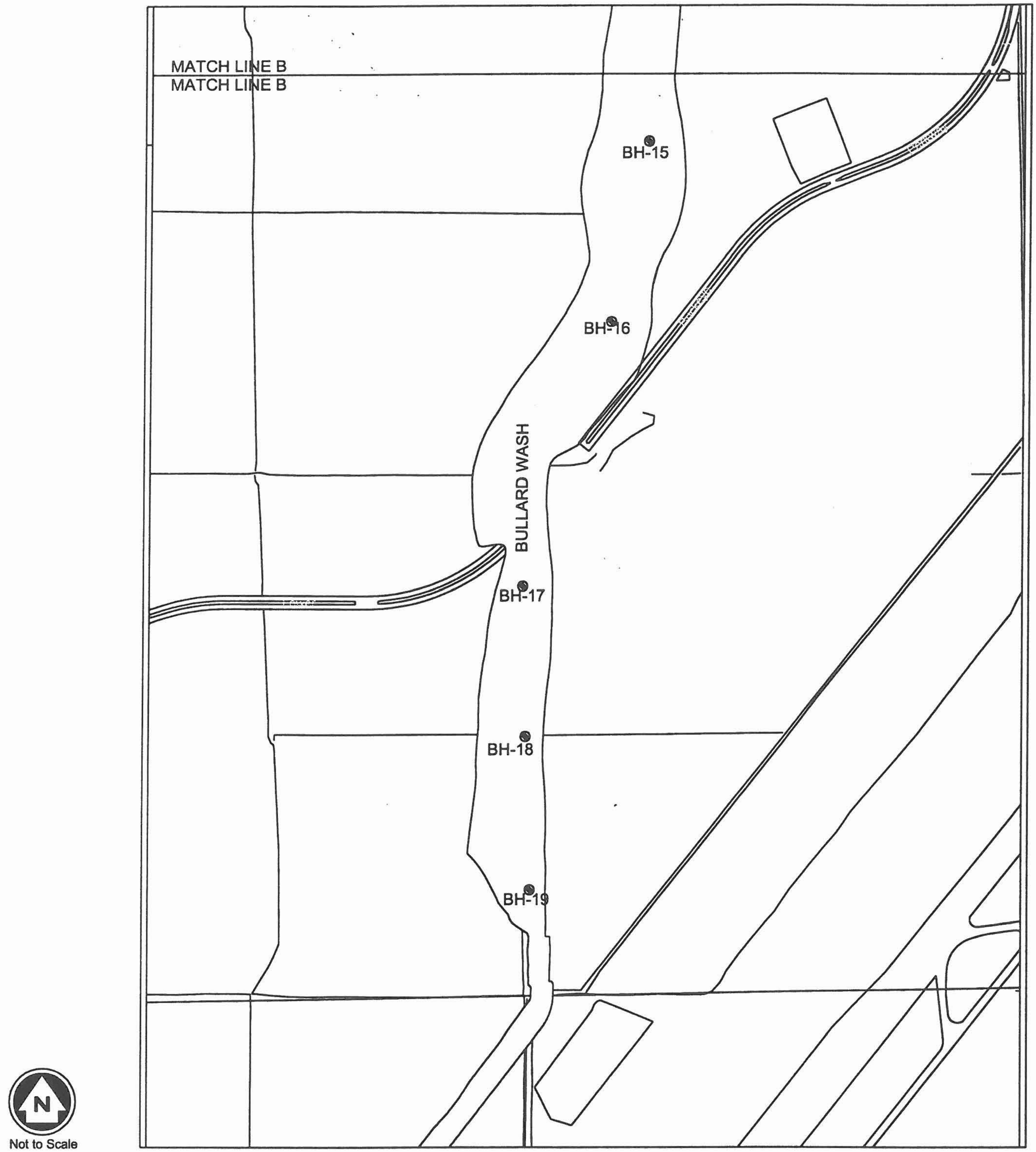
BULLARD WASH PHASE II

PHOENIX, ARIZONA

BORE HOLE

ATL JOB NO. 101015

PLATE NO. 4b



BORE HOLE LOCATION MAP

BULLARD WASH PHASE II

PHOENIX, ARIZONA

BORE HOLE

ATL JOB NO. 101015

PLATE NO. 4c

APPENDIX A

BORE LOGS

WOOD, PATEL AND ASSOCIATES
BULLARD WASH IMPROVEMENTS, PHASE II
Goodyear, Arizona

ATL Job No. 101015
Bore No. B -1

Boring Location: Structural Investigation Bore, 35 Feet West of Wash x 73 Feet North of Van Buren St., North 33° 27.015' x West 112° 22.950' (GPS)

Boring Equipment: BK-61 With 8" Hollow Stem Auger

Driller: K. Enlow - Yellow Jacket Environmental Drilling

Date of Boring: 6/13/02

Elevation of Boring: Existing Grade

Logger: B. Burgess - ATL, Inc.

Reviewed By: D. Smith

Graphical Log	Depth (Feet)	SOIL DESCRIPTION	SPT Blows/ft	Ring Blows/ft	Water Content %	Dry Density (pcf)
Clayey sand	0.0–15.0	Light Brown, Clayey SAND (SC), Slightly Moist, Strong Reaction with HCL. Loose - Medium Dense, Low Plasticity, Moderate Cementation				
			7			
	5.0	Note: Very Moist Condition Encountered At 5 Feet				
				13		
			24			
	10.0		32			
Caliche	15.0	Note: Extremely Hard Lense(Caliche) Encountered At 15 Feet. Lense Is Approximately 2 Feet Thick with Strong Reaction with HCL		50/2"		
			50/2"			
Sandy lean clay	17.0–40.0	Brown, Sandy Lean CLAY (CL) with Trace Gravel , Moist, Hard. Strong Reaction with HCL, Medium Plasticity, Weak to Moderate Cementation				
	20.0			50/4"		
			42			
	25.0		55			
	30.0			53		
			41			
	35.0		52			
	40.0					

Continued On Next Log

Ground water	Groundwater Observed	Initial Depth	24 Hour Depth
	None	–	–

NOTE: THE ABOVE DATA FOR DESIGN PURPOSES ONLY.

ATL

WOOD, PATEL AND ASSOCIATES
BULLARD WASH IMPROVEMENTS, PHASE II
Goodyear, Arizona

ATL Job No. *101015*
Bore No. *B -1*

Boring Location: *Structural Investigation Bore, 35 Feet West of Wash x 73 Feet North of Van Buren St., North 33° 27.015' x West 112° 22.950' (GPS)*

Boring Equipment: *BK-61 With 8" Hollow Stem Auger*

Driller: *K. Enlow - Yellow Jacket Environmental Drilling*

Date of Boring: *6/13/02*   Elevation of Boring: *Existing Grade*

Logger: *B. Burgess - ATL, Inc.*   Reviewed By: *D. Smith*

Graphical Log	Depth (Feet)	SOIL DESCRIPTION	SPT Blows/ft	Ring Blows/ft	Water Content %	Dry Density (pcf)
		Note: Extremely Hard Lense(Caliche) Encountered At 40 Feet Lense Is Approximately 3 Feet Thick with Strong Reaction with HCL	50/6"	90/6"		
	45.0	*Brown, Clayey SAND (SC), Moist, Strong Reaction with HCL Dense, Low Plasticity, Moderate Cementation*	52			
	50.0 55.0 60.0	*Brown, Lean CLAY (CL) with Sand and Trace Gravel , Moist, Hard Strong Reaction with HCL, Medium Plasticity, Weak Cementation*	50/5" 50 43	50/1" 50/5"		
	65.0	*Light Brown, Clayey SAND (SC), Moist, Strong Reaction with HCL Dense, Low Plasticity, Moderate Cementation*	31			
	70.0 75.0 80.0	*(Bore Terminated at 70 Feet Below Existing Grade)* *(Ring Depth To 71.0 Feet Below Existing Grade)* *(SPT Depth To 72.5 Feet Below Existing Grade)* *(Hole Depth Measured After Completion of Bore Was 14 Feet Below Existing Grade)*	53	58		

Bore Stopped at *70.0* Feet below Existing Grade

Ground water	Groundwater Observed	Initial Depth	24 Hour Depth
	None	–	–

NOTE: THE ABOVE DATA FOR DESIGN PURPOSES ONLY.

WOOD, PATEL AND ASSOCIATES
BULLARD WASH IMPROVEMENTS, PHASE II
Goodyear, Arizona

ATL Job No. 101015
Bore No. B -2

Boring Location: *Structural Investigation Bore, 35 Feet West of Wash x 33 Feet South of Van Buren St., North 33° 26.992' x West 112° 22.952' (GPS)*

Boring Equipment: *BK-61 With 8" Hollow Stem Auger*

Driller: *K. Enlow - Yellow Jacket Environmental Drilling*

Date of Boring: *6/13/02* Elevation of Boring: *Existing Grade*

Logger: *B. Burgess - ATL, Inc.* Reviewed By: *D. Smith*

Graphical Log	Depth (Feet)	SOIL DESCRIPTION	SPT Blows/ft	Ring Blows/ft	Water Content %	Dry Density (pcf)
	0.0–20.0	*Light Brown, Clayey SAND (SC), Slightly Moist, Strong Reaction with HCL Loose - Medium Dense, Low Plasticity, Moderate Cementation*				
			18			
	5.0	*Note: Trace Gravel Encountered At 5 Feet*				
				53		
			50/5"			
	10.0		50/3"			
	15.0			50/5"		
			50/5"			
	20.0–27.0	*Brown, Sandy SILT, Moist, Hard, Strong Reaction with HCL Medium Plasticity, Moderate Cementation*	50			
	25.0			61		
			44			
	27.0–30.0	*Brown, Lean CLAY (CL) with Sand and Trace Gravel, Moist, Stiff Strong Reaction with HCL, Medium Plasticity, Weak Cementation*				
	30.0	*Note: Sand Lense Encountered At 30 Feet (Approximately 1 Feet Thick)*	22			
	31.0–40.0	*Brown, Lean CLAY (CL) with Sand and Trace Gravel, Moist, Stiff Strong Reaction with HCL, Medium Plasticity, Weak Cementation*				
	35.0			50/5"		
			34			
	40.0					

Continued On Next Log

Ground water	Groundwater Observed	Initial Depth	24 Hour Depth
	None	–	–

NOTE: THE ABOVE DATA FOR DESIGN PURPOSES ONLY.

WOOD, PATEL AND ASSOCIATES
BULLARD WASH IMPROVEMENTS, PHASE II
Goodyear, Arizona

ATL

ATL Job No. *101015*
Bore No. *B -2*

Boring Location: *Structural Investigation Bore*
35 Feet West of Wash x 33 Feet South of Van Buren St.
North 33° 26.992' x West 112° 22.952' (GPS)

Boring Equipment: *BK-61 With 8" Hollow Stem Auger*

Driller: *K. Enlow - Yellow Jacket Environmental Drilling*

Date of Boring: *6/13/02* Elevation of Boring: *Existing Grade*

Logger: *B. Burgess - ATL, Inc.* Reviewed By: *D. Smith*

Graphical Log	Depth (Feet)	SOIL DESCRIPTION	SPT Blows/ft	Ring Blows/ft	Water Content %	Dry Density (pcf)
(hatched)		*Light Brown, Lean CLAY (CL) with Sand, Moist, Strong Reaction with HCL Medium Dense, Medium Plasticity, Moderate Cementation*	35			
	45.0			30		
			37			
	50.0		48			
	55.0			11		
			27			
	60.0	*(Bore Terminated at 60 Feet Below Existing Grade)* *(SPT Depth To 61.5 Feet Below Existing Grade)* *(Hole Depth Measured After Completion of Bore Was 48 Feet Below Existing Grade)*	51			
	65.0					
	70.0					
	75.0					
	80.0					

Bore Stopped at	Ground water	Groundwater Observed	Initial Depth	24 Hour Depth
60.0 Feet below Existing Grade		None	–	–

NOTE: THE ABOVE DATA FOR DESIGN PURPOSES ONLY.

ATL	WOOD, PATEL AND ASSOCIATES BULLARD WASH IMPROVEMENTS, PHASE II Goodyear, Arizona	ATL Job No. 101015 Bore No. B -3

Boring Location: *Structural Investigation Bore*
120 Feet West of Wash x 35 Feet South of Van Buren St.
North 33° 26.992' x West 112° 22.972' (GPS)

Boring Equipment: *BK-61 With 8" Hollow Stem Auger*

Driller: *K. Enlow - Yellow Jacket Environmental Drilling*

Date of Boring: *6/13/02* Elevation of Boring: *Existing Grade*

Logger: *B. Burgess - ATL, Inc.* Reviewed By: *D. Smith*

Graphical Log	Depth (Feet)	SOIL DESCRIPTION	SPT Blows/ft	Ring Blows/ft	Water Content %	Dry Density (pcf)
		Continued From Previous Page		50/5"		
		Brown, Lean CLAY (CL) with Sand and Trace Gravel , Moist, Hard *Strong Reaction with HCL, Medium Plasticity, Moderate Cementation*	50/5"			
	45.0		34			
		Note: Ground Water Encountered At 47 Feet				
	50.0			50/5"		
			60			
	55.0		50/3"			
	60.0			50/5"		
		(Bore Terminated at 60 Feet Below Existing Grade) *(Ring Depth To 61.0 Feet Below Existing Grade)* *(SPT Depth To 62.5 Feet Below Existing Grade)* *(Hole Depth Measured After Completion of Bore Was 36 Feet Below Existing Grade)*	83			
	65.0					
	70.0					
	75.0					
	80.0					

Bore Stopped at *60.0* Feet below Existing Grade	Ground water	Groundwater Observed	Initial Depth	24 Hour Depth
		YES	47	N/A

NOTE: THE ABOVE DATA FOR DESIGN PURPOSES ONLY.

WOOD, PATEL AND ASSOCIATES
BULLARD WASH IMPROVEMENTS, PHASE II
Goodyear, Arizona

ATL Job No. 101015
Bore No. B -3

Boring Location: Structural Investigation Bore
120 Feet West of Wash x 35 Feet South of Van Buren St.
North 33° 26.992' x West 112° 22.972' (GPS)

Date of Boring: 6/13/02 — Elevation of Boring: Existing Grade

Boring Equipment: BK-61 With 8" Hollow Stem Auger

Driller: K. Enlow - Yellow Jacket Environmental Drilling

Logger: B. Burgess - ATL, Inc. — Reviewed By: D. Smith

Graphical Log	Depth (Feet)	SOIL DESCRIPTION	SPT Blows/ft	Ring Blows/ft	Water Content %	Dry Density (pcf)
CL - ML	0.0 – 20.0	Light Brown, Sandy, Silty CLAY (CL - ML), Slightly Moist, Strong Reaction with HCL Loose - Medium Dense, Low Plasticity, Moderate Cementation	15			
	5.0		6			
	10.0		30	42		
	15.0	Note: Increase In Sands Encountered At 16 Feet	15			
SM	20.0 – 35.0	Brown, Silty SAND (SM) with Gravel, Moist, Dense Strong Reaction with HCL, Non-Plastic, Moderate Cementation	56	39		
	25.0		57			
	30.0		46	58		
CL	35.0 – 40.0	Brown, Lean CLAY (CL) with Sand and Trace Gravel , Moist, Hard Strong Reaction with HCL, Medium to High Plasticity, Moderate Cementation	44			
	40.0					

Continued On Next Log

Ground water	Groundwater Observed	Initial Depth	24 Hour Depth
	YES	47'	N/A

NOTE: THE ABOVE DATA FOR DESIGN PURPOSES ONLY.

ATL

WOOD, PATEL AND ASSOCIATES
BULLARD WASH IMPROVEMENTS, PHASE II
Goodyear, Arizona

ATL Job No. *101015*
Bore No. *B - 4*

Boring Location: *Structural Investigation Bore*
70 Feet East of Wash x 61 Feet North of Yuma St.
North 33° 26.145' x West 112° 22.885' (GPS)

Boring Equipment: *BK-61 With 8" Hollow Stem Auger*

Driller: *K. Enlow - Yellow Jacket Environmental Drilling*

Date of Boring: *6/14/02* Elevation of Boring: *Existing Grade*

Logger: *B. Burgess - ATL, Inc.* Reviewed By: *D. Smith*

Graphical Log	Depth (Feet)	SOIL DESCRIPTION	SPT Blows/ft	Ring Blows/ft	Water Content %	Dry Density (pcf)
Lean clay		*Brown, Lean CLAY (CL) with Sand, Moist, Strong Reaction with HCL Loose - Medium Dense, Medium Plasticity, Moderate Cementation*				
			11			
	5.0					
				22		
			10			
	10.0		9			
Poorly graded sand	15.0	*Brown, Poorly Graded SAND (SP), Moist, Strong Reaction with HCL Loose - Medium Dense, Low Plasticity, Weak Cementation*		20		
			16			
	20.0		12			
Well graded sand with silt and gravel	25.0	*Brown, Well Graded SAND (SW - SM) with Silt and Gravel, Moist Loose - Medium Dense, Low Plasticity, Weak Cementation Strong Reaction with HCL*		43		
			25			
	30.0		54			
		Note: Increase in Gravel Encountered At 32 Feet				
	35.0			45		
			50/4"			
	40.0					

Continued On Next Log

Bore Stopped at	*70.0* Feet below Existing Grade	Ground water	Groundwater Observed	Initial Depth	24 Hour Depth
			YES	59'	N/A

NOTE: THE ABOVE DATA FOR DESIGN PURPOSES ONLY.

WOOD, PATEL AND ASSOCIATES
BULLARD WASH IMPROVEMENTS, PHASE II
Goodyear, Arizona

ATL Job No. *101015*
Bore No. *B - 4*

Boring Location: *Structural Investigation Bore*
70 Feet East of Wash x 61 Feet North of Yuma St.
North 33° 26.145' x West 112° 22.885' (GPS)

Boring Equipment: *BK-61 With 8" Hollow Stem Auger*

Driller: *K. Enlow - Yellow Jacket Environmental Drilling*

Date of Boring: *6/14/02* Elevation of Boring: *Existing Grade*

Logger: *B. Burgess - ATL, Inc.* Reviewed By: *D. Smith*

Graphical Log	Depth (Feet)	SOIL DESCRIPTION	SPT Blows/ft	Ring Blows/ft	Water Content %	Dry Density (pcf)
		Brown, Well Graded SAND (SW - SM) with Silt and Gravel, Moist Loose - Medium Dense, Low Plasticity, Weak Cementation Strong Reaction with HCL	70			
	45.0	*Note: Gravel and Cobbles Encountered At 42 Feet (From 42' to 55')*		50/4"		
			50/4"			
	50.0		50/3"			
	55.0	*Brown, Gravelly Lean CLAY (CL) with Sand, Moist, Hard, High Plasticity, Moderate Cementation*		36		
			65			
		Note: Groundwater Encountered At 59 Feet				
	60.0	*Brown, Poorly Graded SAND (SP) with Gravel, Saturated Dense, Angular, Low Plasticity, Weak Cementation*	68			
	65.0			9		
			70			
	70.0	*(Bore Terminated at 70 Feet Below Existing Grade) (SPT Depth To 71.5 Feet Below Existing Grade) (Hole Depth Measured After Completion of Bore Was 48 Feet Below Existing Grade)*	55			
	75.0					
	80.0					

Bore Stopped at	*70.0* Feet below Existing Grade	Ground water	Groundwater Observed	Initial Depth	24 Hour Depth
			YES	59'	N/A

NOTE: THE ABOVE DATA FOR DESIGN PURPOSES ONLY.

WOOD, PATEL AND ASSOCIATES
BULLARD WASH IMPROVEMENTS, PHASE II
Goodyear, Arizona

ATL

ATL Job No. *101015*
Bore No. *B - 5*

Boring Location: *Structural Investigation Bore*
20 Feet East of Wash x 25 Feet South of Yuma St.
North 33° 26.128' x West 112° 22.903' (GPS)

Boring Equipment: *BK-61 With 8" Hollow Stem Auger*

Driller: *K. Enlow - Yellow Jacket Environmental Drilling*

Date of Boring: *6/15/02* Elevation of Boring: *Existing Grade*

Logger: *B. Burgess - ATL, Inc.* Reviewed By: *D. Smith*

Graphical Log	Depth (Feet)	SOIL DESCRIPTION	SPT Blows/ft	Ring Blows/ft	Water Content %	Dry Density (pcf)
	0.0–15.0	*Light Brown, Clayey SAND (SC) with Gravel, Moist, Strong Reaction with HCL Loose - Medium Dense, Medium Plasticity, Moderate Cementation*				
			7			
	5.0			10		
			5			
	10.0			12		
			5			
	15.0–25.0	*Brown, Poorly Graded SAND (SP) with Trace Gravel, Moist, Dense Weak Reaction with HCL, Non-Plastic, Moderate Cementation*	13			
	20.0			34		
			20			
	25.0–40.0	*Brown, Well-Graded SAND (SW-SM) with Trace Gravel, Moist, Dense Weak Reaction with HCL, Non-Plastic, Moderate Cementation*	22			
	30.0	*Note: Increase In Gravel Encountered At 30 Feet*		82		
			38			
	35.0		50/6"			
	40.0					

Continued On Next Log

Bore Stopped at *60.0* Feet below Existing Grade	Ground water	Groundwater Observed	Initial Depth	24 Hour Depth
		YES	55'	N/A

NOTE: THE ABOVE DATA FOR DESIGN PURPOSES ONLY.

WOOD, PATEL AND ASSOCIATES
BULLARD WASH IMPROVEMENTS, PHASE II
Goodyear, Arizona

ATL Job No. *101015*
Bore No. *B - 5*

Boring Location: *Structural Investigation Bore*
20 Feet East of Wash x 25 Feet South of Yuma St.
North 33° 26.128' x West 112° 22.903' (GPS)

Boring Equipment: *BK-61 With 8" Hollow Stem Auger*

Driller: *K. Enlow - Yellow Jacket Environmental Drilling*

Date of Boring: *6/15/02* **Elevation of Boring:** *Existing Grade*

Logger: *B. Burgess - ATL, Inc.* **Reviewed By:** *D. Smith*

Graphical Log	Depth (Feet)	SOIL DESCRIPTION	SPT Blows/ft	Ring Blows/ft	Water Content %	Dry Density (pcf)
		Continued From Previous Page		50/2"		
		Brown, Well-Graded SAND (SW-SM) with Trace Gravel, Moist, Dense Weak Reaction with HCL, Non-Plastic, Moderate Cementation	50/3"			
	45.0		56			
	50.0			50/5"		
			50/6"			
		Note: Water Table Encountered At 55 Feet				
	55.0		47			
	60.0			50/5"		
		(Bore Terminated at 60 Feet Below Existing Grade) *(Ring Depth To 61.0 Feet Below Existing Grade)* *(SPT Depth To 62.5 Feet Below Existing Grade)* *(Hole Depth Measured After Completion of Bore Was 41 Feet Below Existing Grade)*	50/5"			
	65.0					
	70.0					
	75.0					
	80.0					

Bore Stopped at	Ground water	Groundwater Observed	Initial Depth	24 Hour Depth
60.0 Feet below Existing Grade		YES	55'	N/A

NOTE: THE ABOVE DATA FOR DESIGN PURPOSES ONLY.

WOOD, PATEL AND ASSOCIATES
BULLARD WASH IMPROVEMENTS, PHASE II
Goodyear, Arizona

ATL

ATL Job No. *101015*

Bore No. *B - 6*

Boring Location: *Structural Investigation Bore*
20 Feet West of Wash x 20 Feet South of Yuma St.
North 33° 26.123' x West 112° 22.906' (GPS)

Boring Equipment: *BK-61 With 8" Hollow Stem Auger*

Driller: *K. Enlow - Yellow Jacket Environmental Drilling*

Date of Boring: *6/15/02*

Elevation of Boring: *Existing Grade*

Logger: *B. Burgess - ATL, Inc.*

Reviewed By: *D. Smith*

Graphical Log	Depth (Feet)	SOIL DESCRIPTION	SPT Blows/ft	Ring Blows/ft	Water Content %	Dry Density (pcf)
	0.0 – 15.0	*Light Brown, Clayey SAND (SC), Slightly Moist, Strong Reaction with HCL Loose - Medium Dense, Low Plasticity, Moderate Cementation*	9			
	5.0			16		
			6			
	10.0		12			
	15.0 – 20.0	*Light Brown, Poorly Graded SAND (SP) with Gravel, Moist Loose - Medium Dense, Low Plasticity, Moderate Cementation*		17		
			13			
	20.0 – 40.0	*Light Brown, Well-Graded SAND (SW-SM) with silt and Gravel, Moist, Loose to Medium Dense, Low Plasticity, Moderate Cementation*	35			
	25.0			50/6"		
			45			
	30.0		56			
	35.0			50/5"		
			50/5"			
	40.0					

Continued On Next Log

Bore Stopped at *50.0* Feet below Existing Grade	Ground water	Groundwater Observed	Initial Depth	24 Hour Depth
		None	–	–

NOTE: THE ABOVE DATA FOR DESIGN PURPOSES ONLY.

WOOD, PATEL AND ASSOCIATES
BULLARD WASH IMPROVEMENTS, PHASE II
Goodyear, Arizona

ATL Job No. 101015
Bore No. B - 6

Boring Location: *Structural Investigation Bore, 20 Feet West of Wash x 20 Feet South of Yuma St., North 33° 26.123' x West 112° 22.906' (GPS)*

Boring Equipment: *BK-61 With 8" Hollow Stem Auger*

Driller: *K. Enlow - Yellow Jacket Environmental Drilling*

Date of Boring: *6/15/02* Elevation of Boring: *Existing Grade*

Logger: *B. Burgess - ATL, Inc.* Reviewed By: *D. Smith*

Depth (Feet)	SOIL DESCRIPTION	SPT Blows/ft	Ring Blows/ft	Water Content %	Dry Density (pcf)
	Continued From Previous Page	76			
	Light Brown, Well-Graded SAND (SW-SM) with silt and Gravel, Moist, Loose to Medium Dense, Low Plasticity, Moderate Cementation				
45.0			42		
		44			
50.0	*(Bore Terminated at 50 Feet Below Existing Grade)* *(SPT Depth To 51.5 Feet Below Existing Grade)* *(Hole Depth Measured After Completion of Bore Was 38 Feet Below Existing Grade)*	35			
55.0					
60.0					
65.0					
70.0					
75.0					
80.0					

Bore Stopped at *50.0* Feet below Existing Grade

Ground water	Groundwater Observed	Initial Depth	24 Hour Depth
	NONE	–	–

NOTE: THE ABOVE DATA FOR DESIGN PURPOSES ONLY.

ATL	WOOD, PATEL AND ASSOCIATES BULLARD WASH IMPROVEMENTS, PHASE II Goodyear, Arizona	ATL Job No. 101015 Bore No. B - 7

Boring Location: *Structural Investigation Borehole, 20 Feet East of Wash, N 33° 27.628' x W 112° 23.015' (GPS)*

Boring Equipment: *Mobile B - 51 With 8-Inch Hollow Stem Auger*

Driller: *B. Burgess - ATL, Inc.*

Date of Boring: *6/24/02* Elevation of Boring: *Existing*

Logger: *B. Burgess - ATL, Inc.* Reviewed By: *D. Smith*

Graphical Log	Depth (Feet)	SOIL DESCRIPTION	SPT Blows/ft	Ring Blows/ft	Water Content %	Dry Density (pcf)
(hatched)	0.0 – 10.0	*Light Brown, Sandy Lean Clay, Slightly Moist, Strong Reaction with HCL Low Dry Strength, Medium Plasticity with Moderate Cementation*				
	10.0	*(Bore Terminated At 10 Feet Below Existing Grade)* *(Hole Depth After Completeion of Boring Was 7 Feet Below Existing Grade)*				
	15.0					
	20.0					
	25.0					
	30.0					

Bore Stopped at 10 Feet Below Existing Grade	Ground water	Groundwater Observed	Initial Depth	24 Hour Depth
		NONE		

NOTE: THE ABOVE DATA FOR DESIGN PURPOSES ONLY.

The Stratification Lines Represent the Approximate Soil Boundaries And The In-Situ Transitions May Be Gradual

WOOD, PATEL AND ASSOCIATES
BULLARD WASH IMPROVEMENTS, PHASE II
Goodyear, Arizona

ATL Job No. *101015*
Bore No. *B - 8*

Boring Location: *Structural Investigation Borehole, 25 Feet East of Wash N 33° 27.491' x W 112° 22.912' (GPS)*

Boring Equipment: *Mobile B - 51 With 8-Inch Hollow Stem Auger*

Driller: *B. Burgess - ATL, Inc.*

Date of Boring: *6/24/02* Elevation of Boring: *Existing*

Logger: *B. Burgess - ATL, Inc.* Reviewed By: *D. Smith*

Graphical Log	Depth (Feet)	SOIL DESCRIPTION	SPT Blows/ft	Ring Blows/ft	Water Content %	Dry Density (pcf)
(hatched, 0–10 ft)	0.0–10.0	*Light Brown, Sandy Lean Clay (CL), Slightly Moist, Strong Reaction with HCL Low Dry Strength, Medium Plasticity with Moderate Cementation*			7.4	
	10.0	*(Bore Terminated At 10 Feet Below Existing Grade)* *(Hole Depth After Completeion of Boring Was 8 Feet Below Existing Grade)*				

Depth scale: 5.0, 10.0, 15.0, 20.0, 25.0, 30.0

Bore Stopped at 10 Feet Below Existing Grade

Ground water	Groundwater Observed	Initial Depth	24 Hour Depth
	NONE		

NOTE: THE ABOVE DATA FOR DESIGN PURPOSES ONLY.

The Stratification Lines Represent the Approximate Soil Boundaries And The In-Situ Transitions May Be Gradual

ATL	WOOD, PATEL AND ASSOCIATES BULLARD WASH IMPROVEMENTS, PHASE II Goodyear, Arizona	ATL Job No. *101015* Bore No. *B - 9*

Boring Location: *Structural Investigation Borehole, 21 Feet East of Wash, N 33° 27.342' x W 112° 22.896' (GPS)*	Boring Equipment: *Mobile B - 51 With 8-Inch Hollow Stem Auger*
	Driller: *B. Burgess - ATL, Inc.*
Date of Boring: *6/24/02* Elevation of Boring: *Existing*	Logger: *B. Burgess - ATL, Inc.* Reviewed By: *D. Smith*

Graphical Log	Depth (Feet)	SOIL DESCRIPTION	SPT Blows/ft	Ring Blows/ft	Water Content %	Dry Density (pcf)
//////	0.0–10.0	*Light Brown, Sandy Lean Clay, Slightly Moist, Strong Reaction with HCL Medium Dry Strength, Medium Plasticity with Moderate Cementation*				
	5.0			22		
	10.0	*(Bore Terminated At 10 Feet Below Existing Grade)* *(Hole Depth After Completeion of Boring Was 8 Feet Below Existing Grade)*				
	15.0					
	20.0					
	25.0					
	30.0					

Bore Stopped at 10 Feet Below Existing Grade	Ground water	Groundwater Observed	Initial Depth	24 Hour Depth
		NONE		

NOTE: THE ABOVE DATA FOR DESIGN PURPOSES ONLY.

The Stratification Lines Represent the Approximate Soil Boundaries And The In-Situ Transitions May Be Gradual

ATL	WOOD, PATEL AND ASSOCIATES BULLARD WASH IMPROVEMENTS, PHASE II Goodyear, Arizona	ATL Job No. *101015* Bore No. *B - 10*

Boring Location: *Structural Investigation Borehole, 20 Feet West of Wash N 33° 27.185' x W 112° 22.905' (GPS)*

Boring Equipment: *Mobile B - 51 With 8-Inch Hollow Stem Auger*

Driller: *B. Burgess - ATL, Inc.*

Date of Boring: *6/24/02* Elevation of Boring: *Existing*

Logger: *B. Burgess - ATL, Inc.* Reviewed By: *D. Smith*

Graphical Log	Depth (Feet)	SOIL DESCRIPTION	SPT Blows/ft	Ring Blows/ft	Water Content %	Dry Density (pcf)
(hatched)	0.0–10.0	*Light Brown, Sandy Lean Clay, Slightly Moist, Strong Reaction with HCL Medium Dry Strength, Medium Plasticity with Weak Cementation*				
	10.0	*(Bore Terminated At 10 Feet Below Existing Grade)* *(Hole Depth After Completeion of Boring Was 6 Feet Below Existing Grade)*				
	15.0					
	20.0					
	25.0					
	30.0					

Bore Stopped at 10 Feet Below Existing Grade	Ground water	Groundwater Observed	Initial Depth	24 Hour Depth
		NONE		

NOTE: THE ABOVE DATA FOR DESIGN PURPOSES ONLY.

The Stratification Lines Represent the Approximate Soil Boundaries And The In-Situ Transitions May Be Gradual

ATL	WOOD, PATEL AND ASSOCIATES BULLARD WASH IMPROVEMENTS, PHASE II Goodyear, Arizona	ATL Job No. *101015* Bore No. *B - 11*

Boring Location: *Structural Investigation Borehole, 20 Feet West of Wash, N 33° 27.185' x W 112° 22.905' (GPS)*	Boring Equipment: *Mobile B - 51 With 8-Inch Hollow Stem Auger*
	Driller: *B. Burgess - ATL, Inc.*
Date of Boring: *6/24/02* Elevation of Boring: *Existing*	Logger: *B. Burgess - ATL, Inc.* Reviewed By: *D. Smith*

Graphical Log	Depth (Feet)	SOIL DESCRIPTION	SPT Blows/ft	Ring Blows/ft	Water Content %	Dry Density (pcf)
(hatched)	0.0–10.0	*Light Brown, Sandy Lean Clay, Slightly Moist, Strong Reaction with HCL Medium Dry Strength, Medium Plasticity with Weak Cementation*				
	10.0	*(Bore Terminated At 10 Feet Below Existing Grade)* *(Hole Depth After Completeion of Boring Was 7 Feet Below Existing Grade)*				
	15.0					
	20.0					
	25.0					
	30.0					

Bore Stopped at 10 Feet Below Existing Grade	Ground water	Groundwater Observed	Initial Depth	24 Hour Depth
		NONE		

NOTE: THE ABOVE DATA FOR DESIGN PURPOSES ONLY.

The Stratification Lines Represent the Approximate Soil Boundaries And The In-Situ Transitions May Be Gradual

ATL	WOOD, PATEL AND ASSOCIATES BULLARD WASH IMPROVEMENTS, PHASE II Goodyear, Arizona	ATL Job No. *101015* Bore No. *B - 12*

Boring Location: *Structural Investigation Borehole, 10 Feet east of Wash N 33° 26.572' x W 112° 22.928' (GPS)*

Date of Boring: *6/24/02* Elevation of Boring: *Existing*

Boring Equipment: *Mobile B - 51 With 8-Inch Hollow Stem Auger*

Driller: *B. Burgess - ATL, Inc.*

Logger: *B. Burgess - ATL, Inc.* Reviewed By: *D. Smith*

Graphical Log	Depth (Feet)	SOIL DESCRIPTION	SPT Blows/ft	Ring Blows/ft	Water Content %	Dry Density (pcf)
	0.0–10.0	*Light Brown, Sandy, Silty Clay (CL - ML), Slightly Moist, Strong Reaction with HCL,Medium Dry Strength, Low Plasticity with Weak Cementation*				
	5.0			39		
	10.0	*(Bore Terminated At 10 Feet Below Existing Grade)* *(Hole Depth After Completeion of Boring Was 7 Feet Below Existing Grade)*				
	15.0					
	20.0					
	25.0					
	30.0					

Bore Stopped at 10 Feet Below Existing Grade	Ground water	Groundwater Observed	Initial Depth	24 Hour Depth
		NONE		

NOTE: THE ABOVE DATA FOR DESIGN PURPOSES ONLY.

The Stratification Lines Represent the Approximate Soil Boundaries And The In-Situ Transitions May Be Gradual

ATL

WOOD, PATEL AND ASSOCIATES
BULLARD WASH IMPROVEMENTS, PHASE II
Goodyear, Arizona

ATL Job No. *101015*
Bore No. *B - 13*

Boring Location: *Structural Investigation Borehole, 10 Feet east of Wash, N 33° 26.572' x W 112° 22.928' (GPS)*

Date of Boring: *6/24/02* Elevation of Boring: *Existing*

Boring Equipment: *Mobile B - 51 With 8-Inch Hollow Stem Auger*

Driller: *B. Burgess - ATL, Inc.*

Logger: *B. Burgess - ATL, Inc.* Reviewed By: *D. Smith*

Graphical Log	Depth (Feet)	SOIL DESCRIPTION	SPT Blows/ft	Ring Blows/ft	Water Content %	Dry Density (pcf)
	0–10.0	*Light Brown, Sandy, Silty Clay (CL - ML), Slightly Moist, Strong Reaction with HCL,Medium Dry Strength, Low Plasticity with Moderate Cementation*				
	10.0	*(Bore Terminated At 10 Feet Below Existing Grade)* *(Hole Depth After Completeion of Boring Was 7 Feet Below Existing Grade)*				
	15.0					
	20.0					
	25.0					
	30.0					

Bore Stopped at	10	Feet Below Existing Grade	Ground water	Groundwater Observed	Initial Depth	24 Hour Depth
				NONE		

NOTE: THE ABOVE DATA FOR DESIGN PURPOSES ONLY.

The Stratification Lines Represent the Approximate Soil Boundaries And The In-Situ Transitions May Be Gradual

WOOD, PATEL AND ASSOCIATES
BULLARD WASH IMPROVEMENTS, PHASE II
Goodyear, Arizona

ATL Job No. *101015*
Bore No. *B - 14*

Boring Location: *Structural Investigation Borehole, 17 Feet West of Wash, N 33° 26.269' x W 112° 22.930' (GPS)*	Boring Equipment: *Mobile B - 51 With 8-Inch Hollow Stem Auger*
	Driller: *B. Burgess - ATL, Inc.*
Date of Boring: *6/24/02* — Elevation of Boring: *Existing*	Logger: *B. Burgess - ATL, Inc.* — Reviewed By: *D. Smith*

Graphical Log	Depth (Feet)	SOIL DESCRIPTION	SPT Blows/ft	Ring Blows/ft	Water Content %	Dry Density (pcf)
	0.0–5.0	*Light Brown, Lean Clay (CL), Slightly Moist, Strong Reaction with HCL, Medium Dry Strength, Low Plasticity with Moderate Cementation*				
	5.0–10.0	*Light Brown, Sandy, Silty Clay (CL - ML), Moist, Strong Reaction with HCL, Soft to Firm, Low Plasticity with Moderate Cementation*				
	10.0	*(Bore Terminated At 10 Feet Below Existing Grade)* *(Hole Depth After Completeion of Boring Was 7 Feet Below Existing Grade)*				
	15.0					
	20.0					
	25.0					
	30.0					

Bore Stopped at 10 Feet Below Existing Grade	Ground water	Groundwater Observed: NONE	Initial Depth	24 Hour Depth

NOTE: THE ABOVE DATA FOR DESIGN PURPOSES ONLY.

The Stratification Lines Represent the Approximate Soil Boundaries And The In-Situ Transitions May Be Gradual

ATL	WOOD, PATEL AND ASSOCIATES BULLARD WASH IMPROVEMENTS, PHASE II Goodyear, Arizona	ATL Job No. *101015* Bore No. *B - 15*

Boring Location: *Structural Investigation Borehole, 32 Feet West of Wash N 33° 26.960' x W 112° 22.910' (GPS)*	Boring Equipment: *Mobile B - 51 With 8-Inch Hollow Stem Auger*
	Driller: *B. Burgess - ATL, Inc.*
Date of Boring: *6/24/02* Elevation of Boring: *Existing*	Logger: *B. Burgess - ATL, Inc.* Reviewed By: *D. Smith*

Graphical Log	Depth (Feet)	SOIL DESCRIPTION	SPT Blows/ft	Ring Blows/ft	Water Content %	Dry Density (pcf)
(hatched, 0–10.0)	0–10.0	*Light Brown, Lean CLAY (CL), Slightly Moist, Strong Reaction with HCL, Medium Dry Strength, Medium Plasticity with Moderate Cementation*				
	10.0	*(Bore Terminated At 10 Feet Below Existing Grade)* *(Hole Depth After Completeion of Boring Was 6 Feet Below Existing Grade)*				
	15.0					
	20.0					
	25.0					
	30.0					

Bore Stopped at 10 Feet Below Existing Grade	Ground water	Groundwater Observed	Initial Depth	24 Hour Depth
		NONE		

NOTE: THE ABOVE DATA FOR DESIGN PURPOSES ONLY.

The Stratification Lines Represent the Approximate Soil Boundaries And The In-Situ Transitions May Be Gradual

WOOD, PATEL AND ASSOCIATES
BULLARD WASH IMPROVEMENTS, PHASE II
Goodyear, Arizona

ATL

ATL Job No. *101015*
Bore No. *B - 16*

Boring Location: *Structural Investigation Borehole, 15 Feet West of Wash N 33° 25.774' x W 112° 22.958' (GPS)*

Boring Equipment: *Mobile B - 51 With 8-Inch Hollow Stem Auger*

Driller: *B. Burgess - ATL, Inc.*

Date of Boring: *6/24/02* Elevation of Boring: *Existing*

Logger: *B. Burgess - ATL, Inc.* Reviewed By: *D. Smith*

Graphical Log	Depth (Feet)	SOIL DESCRIPTION	SPT Blows/ft	Ring Blows/ft	Water Content %	Dry Density (pcf)
	0.0–5.0	*Light Brown, Lean Clay (CL), Slightly Moist, Strong Reaction, Medium Dense with HCL, Medium Dry Strength, Medium Plasticity with Moderate Cementation*				
	5.0–10.0	*Light Brown, Sandy SILT (ML), Slightly Moist, Strong Reaction, Medium Dense with HCL, Medium Dry Strength, Low Plasticity with Moderate Cementation*		18		
	10.0	*(Bore Terminated At 10 Feet Below Existing Grade)* *(Hole Depth After Completeion of Boring Was 7 Feet Below Existing Grade)*				

Depth scale: 5.0, 10.0, 15.0, 20.0, 25.0, 30.0

Bore Stopped at 10 Feet Below Existing Grade

Ground water	Groundwater Observed	Initial Depth	24 Hour Depth
	NONE		

NOTE: THE ABOVE DATA FOR DESIGN PURPOSES ONLY.

The Stratification Lines Represent the Approximate Soil Boundaries And The In-Situ Transitions May Be Gradual

ATL	WOOD, PATEL AND ASSOCIATES BULLARD WASH IMPROVEMENTS, PHASE II Goodyear, Arizona	ATL Job No. *101015* Bore No. *B - 17*

Boring Location: *Structural Investigation Borehole, 15 Feet East of Wash, N 33° 25.608' x W 112° 23.029' (GPS)*

Boring Equipment: *Mobile B - 51 With 8-Inch Hollow Stem Auger*

Driller: *B. Burgess - ATL, Inc.*

Date of Boring: *6/24/02* Elevation of Boring: *Existing*

Logger: *B. Burgess - ATL, Inc.* Reviewed By: *D. Smith*

Graphical Log	Depth (Feet)	SOIL DESCRIPTION	SPT Blows/ft	Ring Blows/ft	Water Content %	Dry Density (pcf)
	0.0–10.0	*Light Brown, Silty SAND (SM), Slightly Moist, Strong Reaction with HCL, Medium Dry Strength, Low Plasticity with Weak Cementation* *Note: At 8 Feet Increase in Sands*				
	5.0					
	10.0	*(Bore Terminated At 10 Feet Below Existing Grade)* *(Hole Depth After Completeion of Boring Was 7 Feet Below Existing Grade)*				
	15.0					
	20.0					
	25.0					
	30.0					

Bore Stopped at 10 Feet Below Existing Grade	Ground water	Groundwater Observed	Initial Depth	24 Hour Depth
		NONE		

NOTE: THE ABOVE DATA FOR DESIGN PURPOSES ONLY.

The Stratification Lines Represent the Approximate Soil Boundaries And The In-Situ Transitions May Be Gradual

ATL	WOOD, PATEL AND ASSOCIATES BULLARD WASH IMPROVEMENTS, PHASE II Goodyear, Arizona	ATL Job No. 101015 Bore No. B - 18

Boring Location: *Structural Investigation Borehole, 13 Feet East of Wash N 33° 25.480' x W 112° 23.022' (GPS)*	Boring Equipment: *Mobile B - 51 With 8-Inch Hollow Stem Auger*
	Driller: *B. Burgess - ATL, Inc.*
Date of Boring: *6/24/02* Elevation of Boring: *Existing*	Logger: *B. Burgess - ATL, Inc.* Reviewed By: *D. Smith*

Graphical Log	Depth (Feet)	SOIL DESCRIPTION	SPT Blows/ft	Ring Blows/ft	Water Content %	Dry Density (pcf)
		Light Brown, Sandy SILT (ML), Slightly Moist, Strong Reaction with HCL, Medium Dry Strength, Low Plasticity with Weak Cementation				
	5.0					
		Note: At 8 Feet Increase in Sands				
	10.0	*(Bore Terminated At 10 Feet Below Existing Grade)* *(Hole Depth After Completeion of Boring Was 8 Feet Below Existing Grade)*				
	15.0					
	20.0					
	25.0					
	30.0					

Bore Stopped at 10 Feet Below Existing Grade	Ground water	Groundwater Observed	Initial Depth	24 Hour Depth
		NONE		

NOTE: THE ABOVE DATA FOR DESIGN PURPOSES ONLY.

The Stratification Lines Represent the Approximate Soil Boundaries And The In-Situ Transitions May Be Gradual

WOOD, PATEL AND ASSOCIATES
BULLARD WASH IMPROVEMENTS, PHASE II
Goodyear, Arizona

ATL Job No. *101015*
Bore No. *B - 19*

Boring Location: *Structural Investigation Borehole, 14 Feet East of Wash, N 33° 25.335' x W 112° 23.019' (GPS)*

Boring Equipment: *Mobile B - 51 With 8-Inch Hollow Stem Auger*

Driller: *B. Burgess - ATL, Inc.*

Date of Boring: *6/24/02*   Elevation of Boring: *Existing*

Logger: *B. Burgess - ATL, Inc.*   Reviewed By: *D. Smith*

Graphical Log	Depth (Feet)	SOIL DESCRIPTION	SPT Blows/ft	Ring Blows/ft	Water Content %	Dry Density (pcf)
(hatched, 0–10.0)	0–10.0	*Light Brown, Lean Clay (CL), Slightly Moist, Strong Reaction with HCL, Medium Dry Strength, Medium Plasticity with Weak Cementation*				
	10.0	*(Bore Terminated At 10 Feet Below Existing Grade)* *(Hole Depth After Completeion of Boring Was 8 Feet Below Existing Grade)*				
	15.0					
	20.0					
	25.0					
	30.0					

Bore Stopped at 10 Feet Below Existing Grade	Ground water	Groundwater Observed	Initial Depth	24 Hour Depth
		NONE		

NOTE: THE ABOVE DATA FOR DESIGN PURPOSES ONLY.

The Stratification Lines Represent the Approximate Soil Boundaries And The In-Situ Transitions May Be Gradual

APPENDIX B

LABORATORY TEST RESULTS

ATL, INC.
Excellence In Quality

SUMMARY OF LABORATORY ANALYSIS

CLIENT: WOOD, PATEL AND ASSOCIATES DATE: 07/03/02

PROJECT: BULLARD WASH CHANNEL IMPROVEMENTS, PHASE II

LOCATION: GOODYEAR, AZ

MATERIAL: SEE BELOW SAMPLING DATE: 06/14, 15, 24, 25/02

REQUESTED BY: AMMI OSORIO ATL JOB NO.: 101015

BOREHOLE No.	DEPTH (Feet)	IN-SITU Moist %	USCS	LL	PI	SIEVE ANALYSIS - PERCENT PASSING												pH	Res ohm/cm
						200	100	50	40	30	16	10	4	3/8	3/4	1.5	3.0		
*B - 1	0 - 5	-	-	-	-	36.1	41	50	55	64	80	86	92	98	100	-	-	-	-
B - 1	5 - 10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	8.5	1141
B - 1	10 - 15	7.3	SC	22	14	31.6	39	51	59	66	79	87	93	98	100	-	-	-	-
B - 1	32 - 33	29.6	CL	45	19	68.8	76	82	85	86	88	90	95	97	100	-	-	-	-
B - 1	60 - 61	28.7	CL	35	8	87.4	95	98	98	99	100	-	-	-	-	-	-	-	-
B - 2	36 - 37	25.1	CL	35	12	75.7	89	97	99	99	100	-	-	-	-	-	-	-	-
B - 3	5 - 10	10.2	CL - ML	21	5	52.7	66	81	89	92	95	96	98	99	100	-	-	-	-
B - 3	25 - 26	8.5	SM	-	NP	15.7	20	25	30	35	51	62	78	88	95	100	-	-	-
B - 4	5 - 10	18.4	CL	34	17	82.3	89	93	95	97	98	99	100			-	-	8.1	597
B - 4	40 - 41	5.8	SW - SM	-	NP	9.6	13	18	21	24	30	36	50	62	82	100	-	-	-
*B - 5	7 - 12	-	-	-	-	63.4	74	83	87	90	93	94	96	98	100	-	-	-	-
B - 5	31 - 32	7.7	SW - SM	-	NP	11.0	15	30	44	53	65	70	78	84	89	100	-	-	-
*B - 8	5 - 10	-	-	-	-	58.3	69	80	85	89	94	96	99	100	-	-	-	-	-
B - 8	5 - 10	7.4	CL	28	13	54.5	65	77	82	87	92	95	98	99	100	-	-	-	-
B - 12	5 - 10	10.3	CL - ML	19	5	60.0	68	80	87	91	96	98	99	100	-	-	-	-	-
*B - 12	8 - 10	-	-	-	-	72.9	82	92	95	97	99	100	-	-	-	-	-	-	-
B - 15	8-10	-	-	28	10	-	-	-	-	-	-	-	-	-	-	-	-	8.0	671
B - 16	4 - 6	-	-	26	10	63.4	77	94	98	99	100	-	-	-	-	-	-	-	-
B - 16	5 - 10	12.5	ML	24	1	63.4	77	94	98	99	100	-	-	-	-	-	-	-	-
B - 17	5 - 10	5.0	SM	-	NP	24.9	33	50	67	79	91	95	98	99	100	-	-	-	-
*B - 17	8 - 10	-	-	-	-	36.8	47	65	76	86	93	96	98	100	-	-	-	-	-
B - 18	8 - 10	-	-	19	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-
B - 19	8 - 10	-	-	27	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-

* Hydrometer Analysis

HYDROMETER ANALYSIS
(ASTM D422)

CLIENT : Wood, Patel & Associates
2051 West Northern, Suite 100
Phoenix, AZ 85021

DATE : 07/09/02

LAB. NO.: 02-0740
JOB NO. : 101015
DATE RCVD: 06/25/02
SAMPLED BY: BB

PROJECT : Bullard Wash Channel Improvements, Phase II
MATERIAL: Light Brown, Clayey Sand (SC) with gravel
SAMPLE ID.: Bore Hole No. B-1, Depth: 0 - 5'

SAMPLE WT.(WBW-dry) = 50.6 (gm) SOIL PASSING #10 SIEVE = 85.6 %

SPECIFIC GRAVITY OF SOIL SAMPLE = 2.635

ELAPSED TIME (MIN)	TIME	TEMP. (oC)	CORR.(K) USING (TAB. 3)	HYDROMETER READING (WATER)	HYDROMETER READING (W/SOIL)	CORR. READING	EFFECTIVE DEPTH (cm)	PARTICLE SIZE (mm)	PERCENT FINER IN SUSPENSION
06/28/02 0	START 11:50 AM	22.2	0.01336	1.0028	1.0158	1.0130	12.1		35.4
2	11:52 AM	22.2	0.01336	1.0028	1.0128	1.0100	12.9	0.0340	27.3
5	11:55 AM	22.2	0.01336	1.0028	1.0120	1.0093	13.1	0.0216	25.2
15	12:05 PM	22.2	0.01336	1.0028	1.0118	1.0090	13.2	0.0125	24.5
30	12:20 PM	22.2	0.01336	1.0028	1.0108	1.0080	13.5	0.0089	21.8
60	12:50 PM	22.2	0.01336	1.0028	1.0103	1.0075	13.6	0.0064	20.4
250	04:00 PM	22.2	0.01336	1.0028	1.0102	1.0074	13.6	0.0031	20.2
06/29/02 1440	11:50 AM	22.2	0.01336	1.0028	1.0101	1.0073	13.6	0.0013	20.0

Remarks:

Respectfully Submitted:

Reviewed By: D.S.
Input By: AO

Miguel M. Cancino
Central Laboratory Manager

BullardWashPhase II\02-0740

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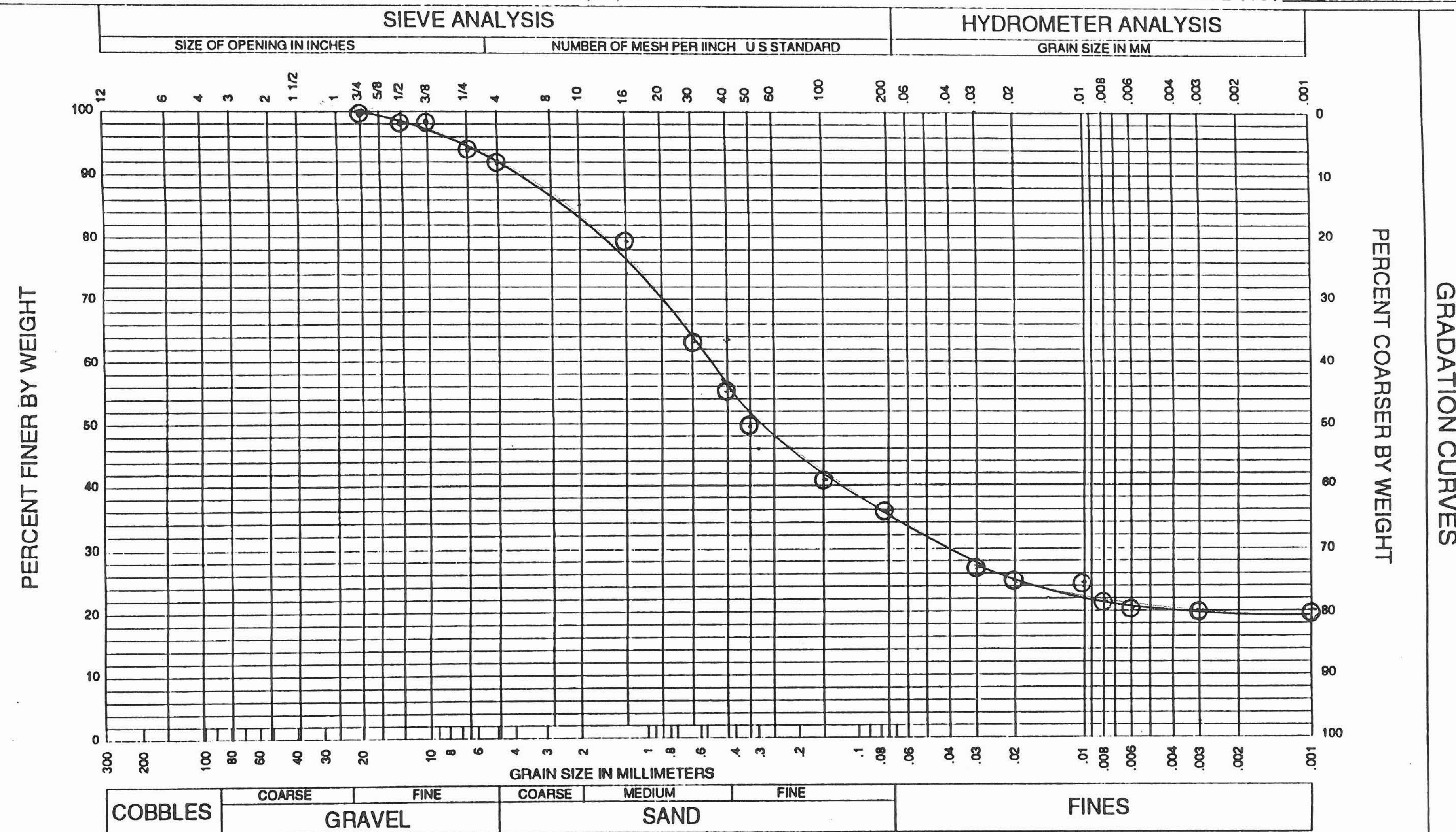
JOB NO. 101015

GRADATION CURVES



SAMPLE NO.	BORING NO.	DEPTH (in.)	CLASSIFICATION	MAT. W.C.	P.I.	L.L.	P.L.
740	B-1	0-60	Light brown, clayey SAND(SC) with gravel	-	-	-	-

HYDROMETER ANALYSIS
(ASTM D422)

CLIENT : Wood, Patel & Associates
2051 West Northern, Suite 100
Phoenix, AZ 85021

DATE : 07/09/02

LAB. NO.: 02-0739
JOB NO. : 101015
DATE RCVD: 06/25/02
SAMPLED BY: BB

PROJECT : Bullard Wash Channel Improvements, Phase II
MATERIAL: Brown, Sandy Lean CLAY (CL)
SAMPLE ID.: Bore Hole No. B-5, Depth: 7' - 12'

SAMPLE WT.(WBW-dry) = 50.9 (gm) SOIL PASSING #10 SIEVE = 94.1 %

SPECIFIC GRAVITY OF SOIL SAMPLE = 2.658

ELAPSED TIME (MIN)	TIME	TEMP. (oC)	CORR.(K) USING (TAB. 3)	HYDROMETER READING (WATER)	HYDROMETER READING (W/SOIL)	CORR. READING	EFFECTIVE DEPTH (cm)	PARTICLE SIZE (mm)	PERCENT FINER IN SUSPENSION
06/28/02 0	START 11:30 AM	22.2	0.01325	1.0028	1.0225	1.0198	10.3		58.5
2	11:32 AM	22.2	0.01325	1.0028	1.0160	1.0133	12.1	0.0325	39.3
5	11:35 AM	22.2	0.01325	1.0028	1.0153	1.0125	12.3	0.0207	37.0
15	11:45 AM	22.2	0.01325	1.0028	1.0145	1.0118	12.5	0.0121	34.8
30	12:00 PM	22.2	0.01325	1.0028	1.0133	1.0105	12.8	0.0087	31.1
60	12:30 PM	22.2	0.01325	1.0028	1.0123	1.0095	13.1	0.0062	28.2
250	03:30 PM	22.2	0.01325	1.0028	1.0115	1.0088	13.3	0.0031	25.9
06/29/02 1440	11:30 PM	22.2	0.01325	1.0028	1.0100	1.0073	13.6	0.0013	21.5

Remarks:

Reviewed By: DS.
Input By: AO

Respectfully Submitted:

Miguel M. Cancino
Central Laboratory Manager

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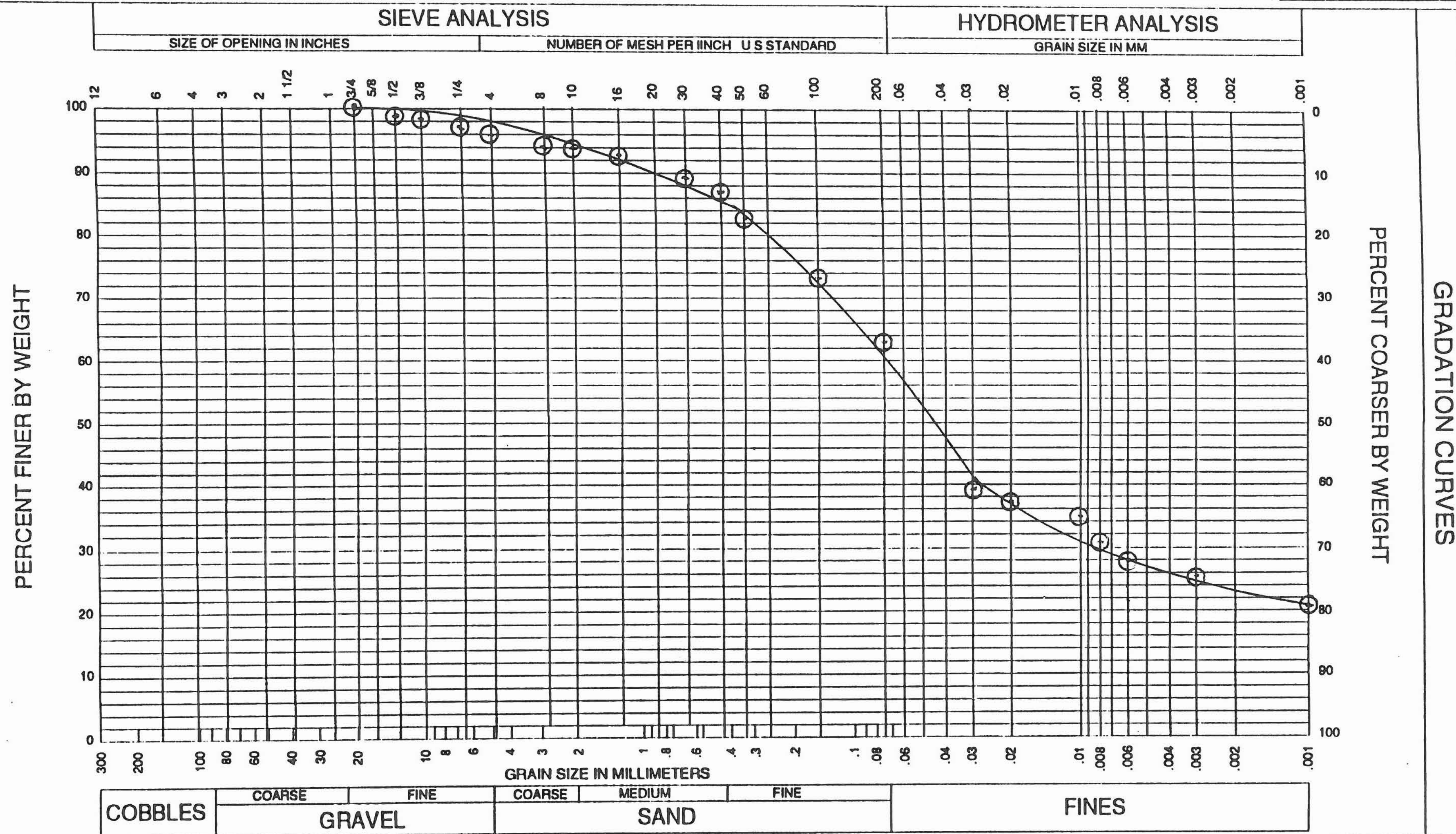
JOB NO. 101015

GRADATION CURVES



SAMPLE NO.	BORING NO.	DEPTH (in.)	CLASSIFICATION	MAT. W.C.	P.I.	L.L.	P.L.
739	B-5	84-144	Brown sandy lean CLAY(CL)	-	-	-	-

HYDROMETER ANALYSIS
(ASTM D422)

CLIENT : Wood, Patel & Associates
2051 West Northern, Suite 100
Phoenix, AZ 85021

DATE : 07/09/02

LAB. NO.: 02-0726
JOB NO. : 101015
DATE RCVD: 06/25/02
SAMPLED BY: BB

PROJECT : Bullard Wash Channel Improvements, Phase II
MATERIAL: Brown, Sandy Lean CLAY (CL)
SAMPLE ID.: Bore Hole No. B-8, Depth: 5' - 10'

SAMPLE WT.(WBW-dry) = 50.1 (gm) SOIL PASSING #10 SIEVE = 96.4 %

SPECIFIC GRAVITY OF SOIL SAMPLE = 2.699

ELAPSED TIME (MIN)	TIME	TEMP. (oC)	CORR.(K) USING (TAB. 3)	HYDROMETER READING		CORR. READING	EFFECTIVE DEPTH (cm)	PARTICLE SIZE (mm)	PERCENT FINER IN SUSPENSION
				(WATER)	(W/SOIL)				
06/27/02 0	START 09:25 AM	22.2	0.01309	1.0028	1.0138	1.0110	12.7		33.6
2	09:27 AM	22.2	0.01309	1.0028	1.0133	1.0105	12.8	0.0331	32.1
5	09:30 AM	22.2	0.01309	1.0028	1.0128	1.0100	12.9	0.0210	30.6
15	09:40 AM	22.2	0.01309	1.0028	1.0118	1.0090	13.2	0.0123	27.5
30	09:55 AM	22.2	0.01309	1.0028	1.0113	1.0085	13.3	0.0087	26.0
60	10:25 AM	22.2	0.01309	1.0028	1.0108	1.0080	13.5	0.0062	24.5
250	01:35 PM	22.2	0.01309	1.0028	1.0093	1.0065	13.8	0.0031	19.9
06/28/02 1440	09:25 AM	22.2	0.01309	1.0028	1.0080	1.0053	14.2	0.0013	16.0

Remarks:

Respectfully Submitted:

Reviewed By:
Input By: AO

Miguel M. Cancino
Central Laboratory Manager

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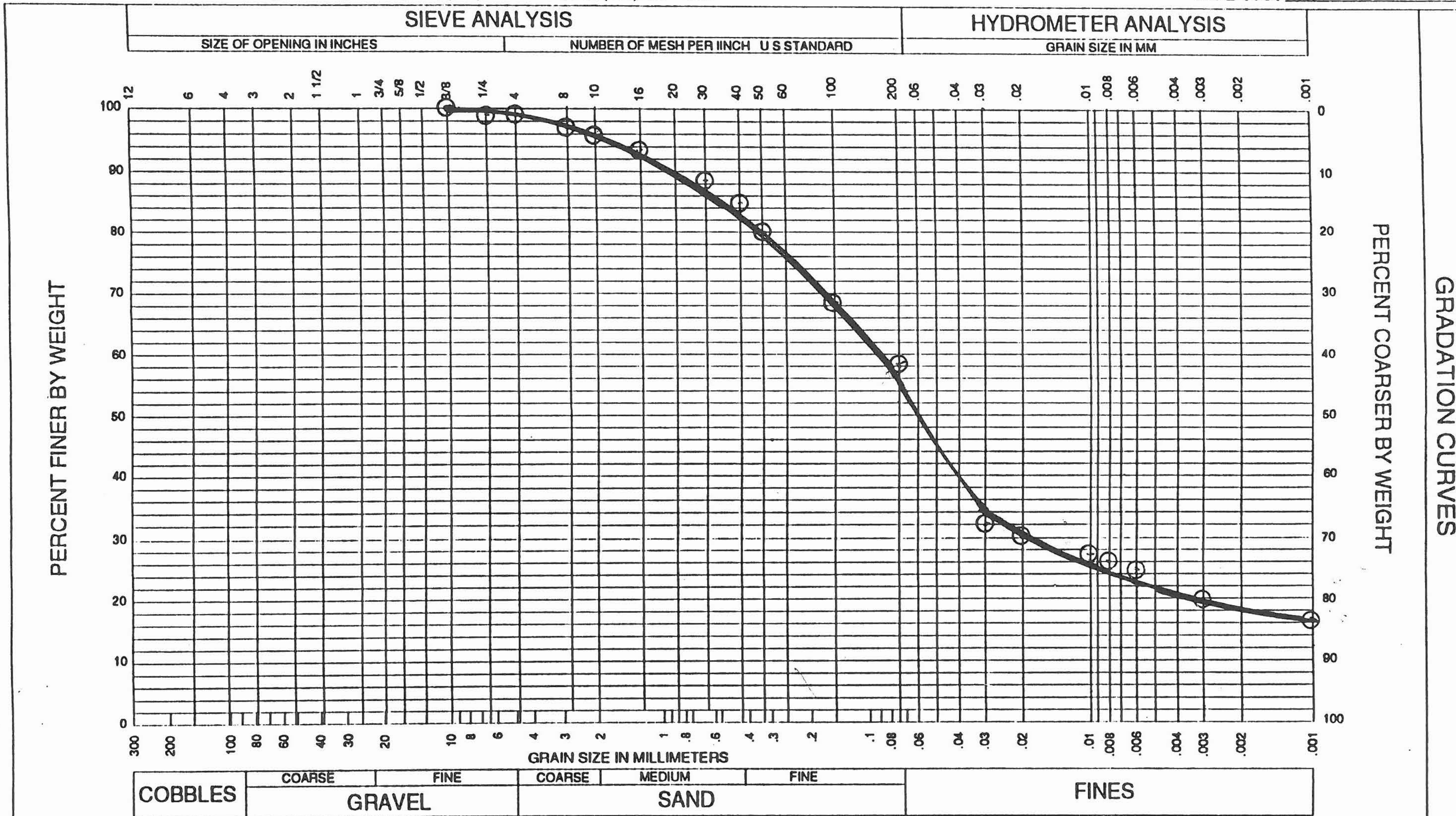
JOB NO. 101015



SAMPLE NO.	BORING NO.	DEPTH (in.)	CLASSIFICATION	MAT. W.C.	P.I.	L.L.	P.L.
726	B-8	60 - 120	Brown, sandy lean CLAY(CL)	7.4	12	35	23

HYDROMETER ANALYSIS
(ASTM D422)

CLIENT : Wood, Patel & Associates
2051 West Northern, Suite 100
Phoenix, AZ 85021

DATE : 07/09/02

LAB. NO.: 02-0725
JOB NO. : 101015
DATE RCVD: 06/25/02
SAMPLED BY: BB

PROJECT : Bullard Wash Channel Improvements, Phase II
MATERIAL: Brown, sandy, silty CLAY (CL-ML)
SAMPLE ID.: Bore Hole No. B-12, Depth: 8' - 10'

SAMPLE WT.(WBW-dry) = 45.8 (gm) SOIL PASSING #10 SIEVE = 100.0 %

SPECIFIC GRAVITY OF SOIL SAMPLE = 2.715

ELAPSED TIME (MIN)	TIME	TEMP. (oC)	CORR.(K) USING (TAB. 3)	HYDROMETER READING (WATER)	HYDROMETER READING (W/SOIL)	CORR. READING	EFFECTIVE DEPTH (cm)	PARTICLE SIZE (mm)	PERCENT FINER IN SUSPENSION
06/27/02 0	START 08:40 AM	22.2	0.01302	1.0028	1.0230	1.0203	10.2		70.0
2	08:42 AM	22.2	0.01302	1.0028	1.0190	1.0163	11.3	0.0309	56.2
5	08:45 AM	22.2	0.01302	1.0028	1.0185	1.0158	11.4	0.0197	54.4
15	08:55 AM	22.2	0.01302	1.0028	1.0178	1.0150	11.6	0.0114	51.8
30	09:10 AM	22.2	0.01302	1.0028	1.0158	1.0130	12.1	0.0083	44.9
60	09:40 AM	22.2	0.01302	1.0028	1.0148	1.0120	12.4	0.0059	41.5
250	12:50 PM	22.2	0.01302	1.0028	1.0128	1.0100	12.9	0.0030	34.6
06/28/02 1440	08:40 AM	22.2	0.01302	1.0028	1.0105	1.0078	13.5	0.0013	26.8

Remarks:

Respectfully Submitted:

Reviewed By:
Input By: AO

Miguel M. Cancino
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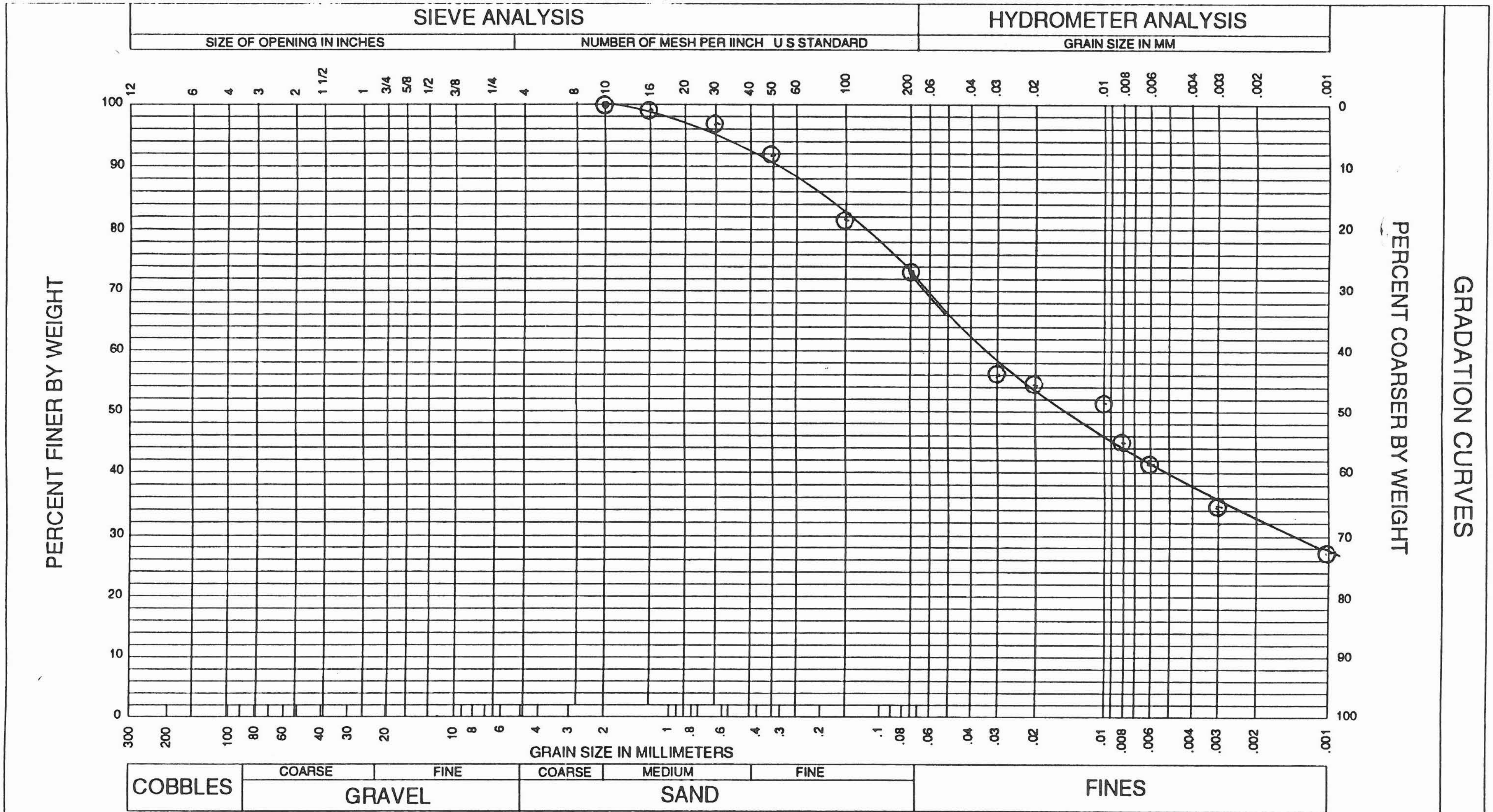
JOB NO. 101015



SAMPLE NO.	BORING NO.	DEPTH (in)	CLASSIFICATION	MAT. W.C.	P.I.	L.L.	P.L.
725	B-12	96 - 120	Brown, sandy,silty CLAY(CL-ML)	10.3	5	19	14

HYDROMETER ANALYSIS
(ASTM D422)

CLIENT : Wood, Patel & Associates
2051 West Northern, Suite 100
Phoenix, AZ 85021

DATE : 07/09/02

LAB. NO.: 02-0743
JOB NO. : 101015
DATE RCVD: 06/25/02
SAMPLED BY: BB

PROJECT : Bullard Wash Channel Improvements, Phase II
MATERIAL: Light Brown, Silty SAND (SM)
SAMPLE ID.: Bore Hole No. B-17,Depth: 8' - 10'

SAMPLE WT.(WBW-dry) = 97.5 (gm) SOIL PASSING #10 SIEVE = 95.9 %

SPECIFIC GRAVITY OF SOIL SAMPLE = 2.613

ELAPSED TIME (MIN)	TIME	TEMP. (oC)	CORR.(K) USING (TAB. 3)	HYDROMETER READING (WATER)	HYDROMETER READING (W/SOIL)	CORR. READING	EFFECTIVE DEPTH (cm)	PARTICLE SIZE (mm)	PERCENT FINER IN SUSPENSION
06/28/02 0	START 12:11 PM	22.2	0.01346	1.0028	1.0217	1.0190	10.5		30.3
2	12:13 PM	22.2	0.01346	1.0028	1.0180	1.0153	11.5	0.0323	24.3
5	12:16 PM	22.2	0.01346	1.0028	1.0168	1.0140	11.9	0.0207	22.3
15	12:26 PM	22.2	0.01346	1.0028	1.0150	1.0123	12.3	0.0122	19.5
30	12:41 PM	22.2	0.01346	1.0028	1.0148	1.0120	12.4	0.0086	19.1
60	01:11 PM	22.2	0.01346	1.0028	1.0138	1.0110	12.7	0.0062	17.5
250	04:21 PM	22.2	0.01346	1.0028	1.0120	1.0093	13.1	0.0031	14.7
06/29/02 1440	12:11 PM	22.2	0.01346	1.0028	1.0110	1.0083	13.4	0.0013	13.1

Remarks:

Respectfully Submitted:

Miguel M. Cancino
Central Laboratory Manager

Reviewed By:
Input By: AO

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Construction Quality Control / Geotechnical Consultants

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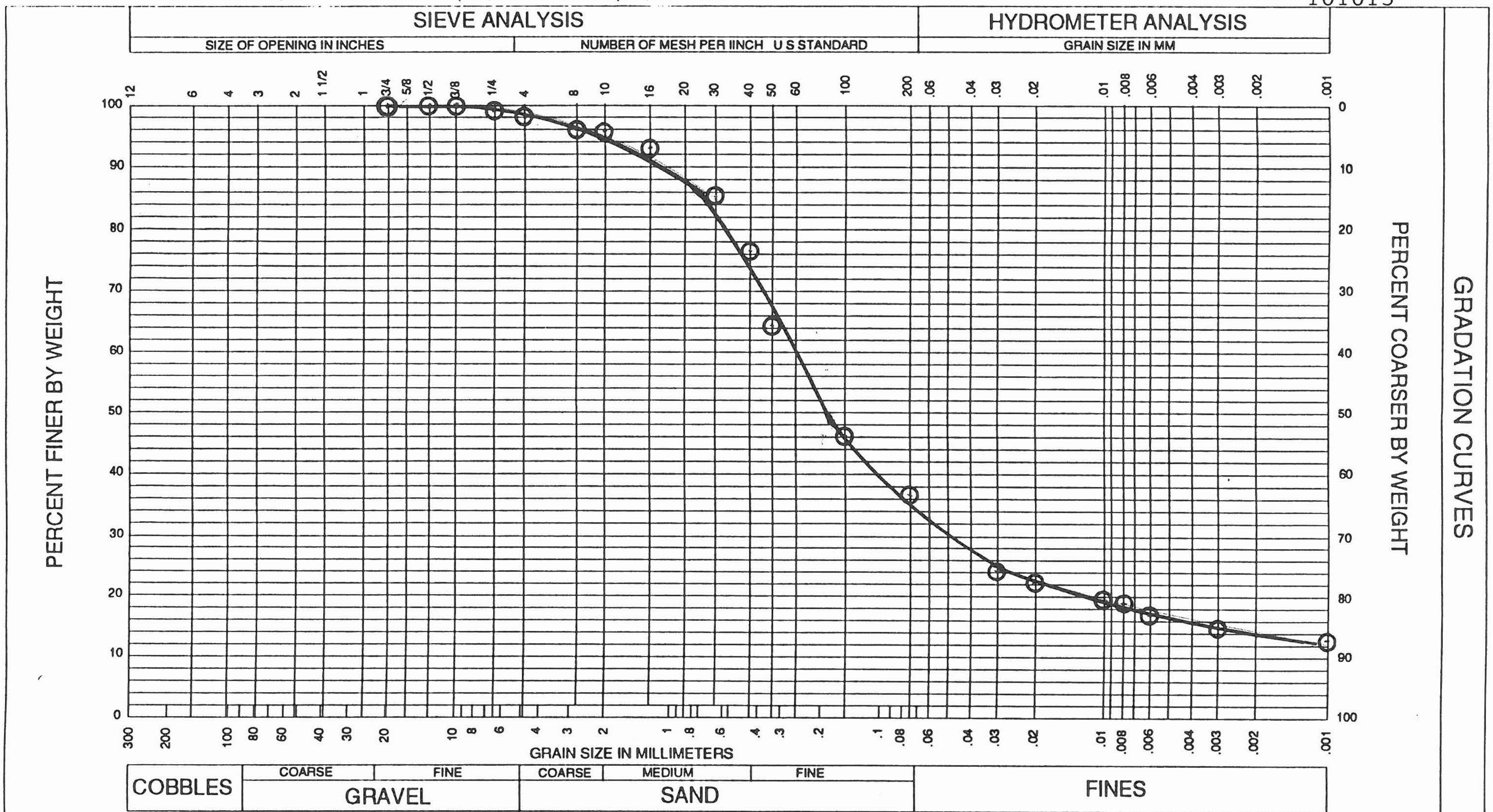
JOB NO. 101015



SAMPLE NO.	BORING NO.	DEPTH (ft)	CLASSIFICATION	MAT. W.C.	P.I.	L.L.	P.L.
743	B-17	96 - 120	Lightbrown, silty SAND(SM)	5.0	NP	-	NP

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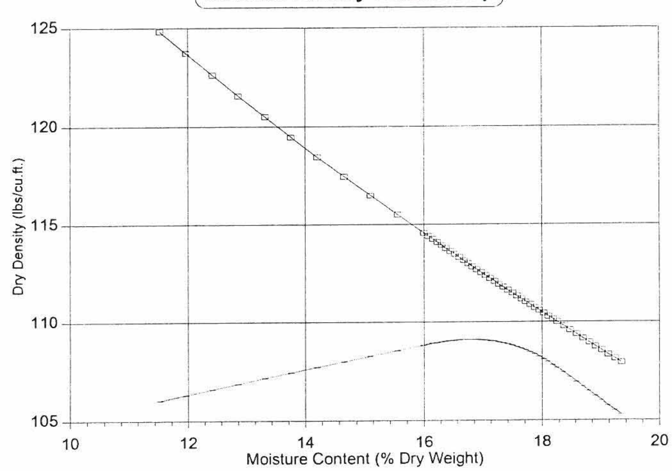
Excellence In Quality

Summary of Moisture Density Relationship Tests

Client:	Wood, Patel and Associates	Job No.	101015
Address:	2051 West Northern, Suite 100	Lab No.	02-0737
	Phoenix, AZ 85021	Type of Rammer:	Manual
		Sample Date:	06/21/02
Project:	Bullard Wash Channel Improvements	Material Description:	Light Brown, Sandy Silt
	Phase II	Material Source:	Bore Hole No.: B-18
Test Designation:	ASTM D698		Depth:5' - 10'
Test Method:	A	Report Date:	07/18/02
Tested By:	DR		



Bulk Specific Gravity for Rock Correction (+#4): 2.600 estimate
Specific Gravity Used For Zero Air Voids Curve Calculation: 2.600

Test No.	1	2	3	4
Dry Density (lbs/cu.ft.)	106.0	108.8	107.7	105.3
Moisture Content (%)	11.5	16.0	18.3	19.4

Maximum Dry Density (lbs/cu.ft.): **109.1**
Optimum Moisture Content (% of Dry Weight): **16.8**
Percent of Retained Oversized Particles:

Maximum Dry Density For Oversize Particles (D4718):
Corrected Moisture Content For Oversized Particles (D4718):

Remarks:

Respectfully Submitted:
ATL, INC.

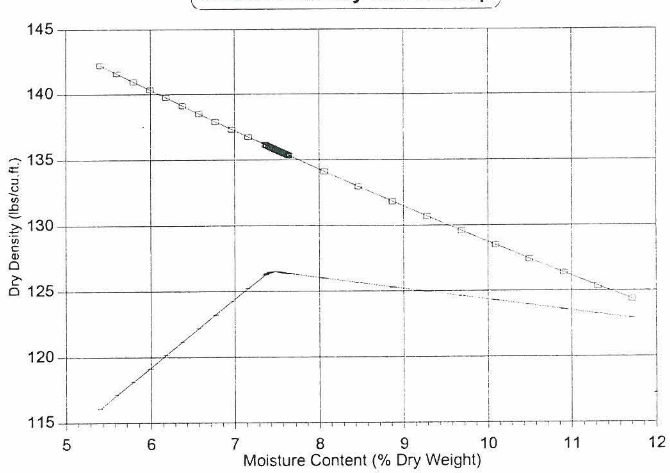
Miguel Cancino
Central Laboratory Manager

Reviewed by:

ATL, INC.
Excellence In Quality

Summary of Moisture Density Relationship Tests

Client:	Wood, Patel and Associates	Job No.	101015
Address:	2051 West Northern, Suite 100	Lab No.	02-0700
	Phoenix, AZ 85021	Type of Rammer:	Manual
		Sample Date:	06/14/02
Project:	Bullard Wash Channel Improvements	Material Description:	Brown, Silty Sand (SM)
	Phase II	Material Source:	Bore Hole No.: B-3
Test Designation:	ASTM D698		Depth: 25' - 30'
Test Method:	A	Report Date:	07/03/02
Tested By:	CH		



Bulk Specific Gravity for Rock Correction (+#4): 2.600 estimate
Specific Gravity Used For Zero Air Voids Curve Calculation: 2.600

Test No.	1	2	3	4
Dry Density (lbs/cu.ft.)	116.1	126.3	126.3	122.9
Moisture Content (%)	5.4	7.4	7.7	11.7

Maximum Dry Density (lbs/cu.ft.): **126.5**
Optimum Moisture Content (% of Dry Weight): **7.5**
Percent of Retained Oversized Particles:

Maximum Dry Density For Oversize Particles (D4718):
Corrected Moisture Content For Oversized Particles (D4718):

Remarks:

Respectfully Submitted:
ATL, INC.

Miguel Cancino
Central Laboratory Manager

Reviewed by:

ATL, INC.
Excellence In Quality

WOOD, PATEL & ASSOCIATES
BULLARD WASH CHANNEL IMPROVEMENTS PHASE II
GOODYEAR, ARIZONA
FCD 2001C023
ATL JOB NO. 101015

DRY UNIT WEIGHT

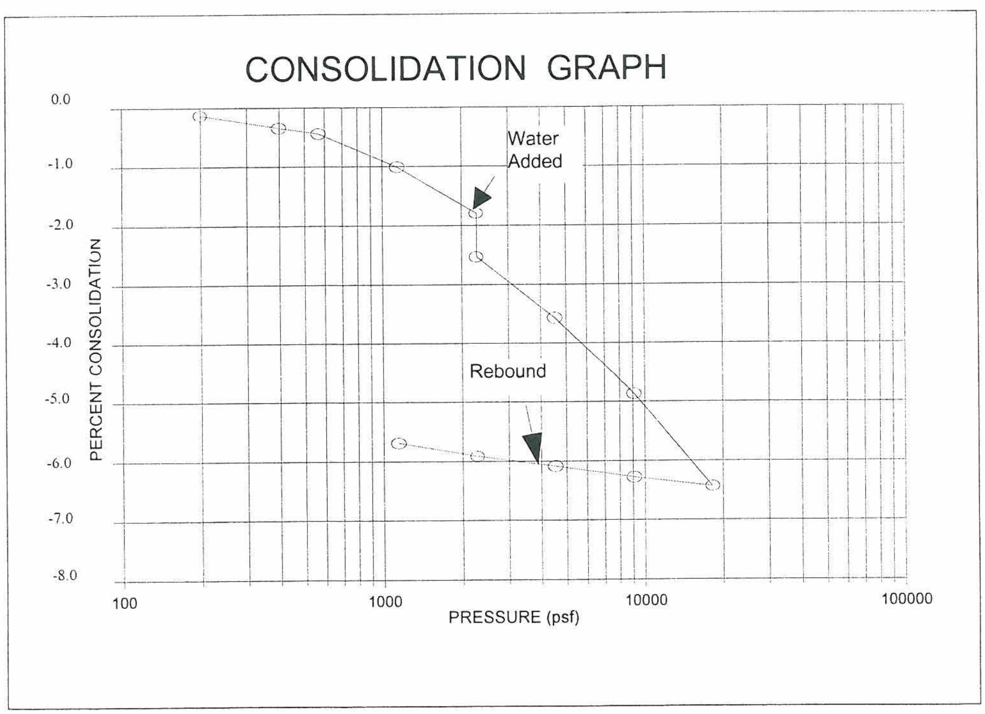
Boring No.	Sample Depth (ft.)	USCS	Dry Density (pcf)	Moisture Content (%)
B-12	5.0 - 6.0	CL-ML	100.6	14.7
B-16	5.0 - 6.0	ML	102.9	7.5

CONSOLIDATION TEST
(ASTM D-2435)

Client: Wood, Patel & Associates
Project Name : Bullard Wash Improvements, Phase II
Project No. : 101015
Initial Reading: 0.2000
Dry Density: 110.3 pcf
Moisture Content: Before: 10.9% After: 16.8%

Lab No.: 02-0702
Test Date: 06/19/02
Sample Location: Boring No.:B-3
Depth:10' - 11'
Soil Description: Brown, sandy, silty CLAY (CL-ML)

LOAD (tsf)	LOAD (psf)	DIAL READING	PERCENT CONSOLIDATION
0.05	100	0.2000	0.00
0.10	200	0.2013	-0.13
0.20	400	0.2034	-0.34
0.29	570	0.2044	-0.44
0.57	1140	0.2101	-1.01
1.14	2280	0.2180	-1.80
1.14	2280	0.2253	-2.53
2.28	4560	0.2357	-3.57
4.56	9120	0.2487	-4.87
9.12	18240	0.2643	-6.43
4.56	9120	0.2628	-6.28
2.28	4560	0.2609	-6.09
1.14	2280	0.2592	-5.92
0.57	1140	0.2569	-5.69



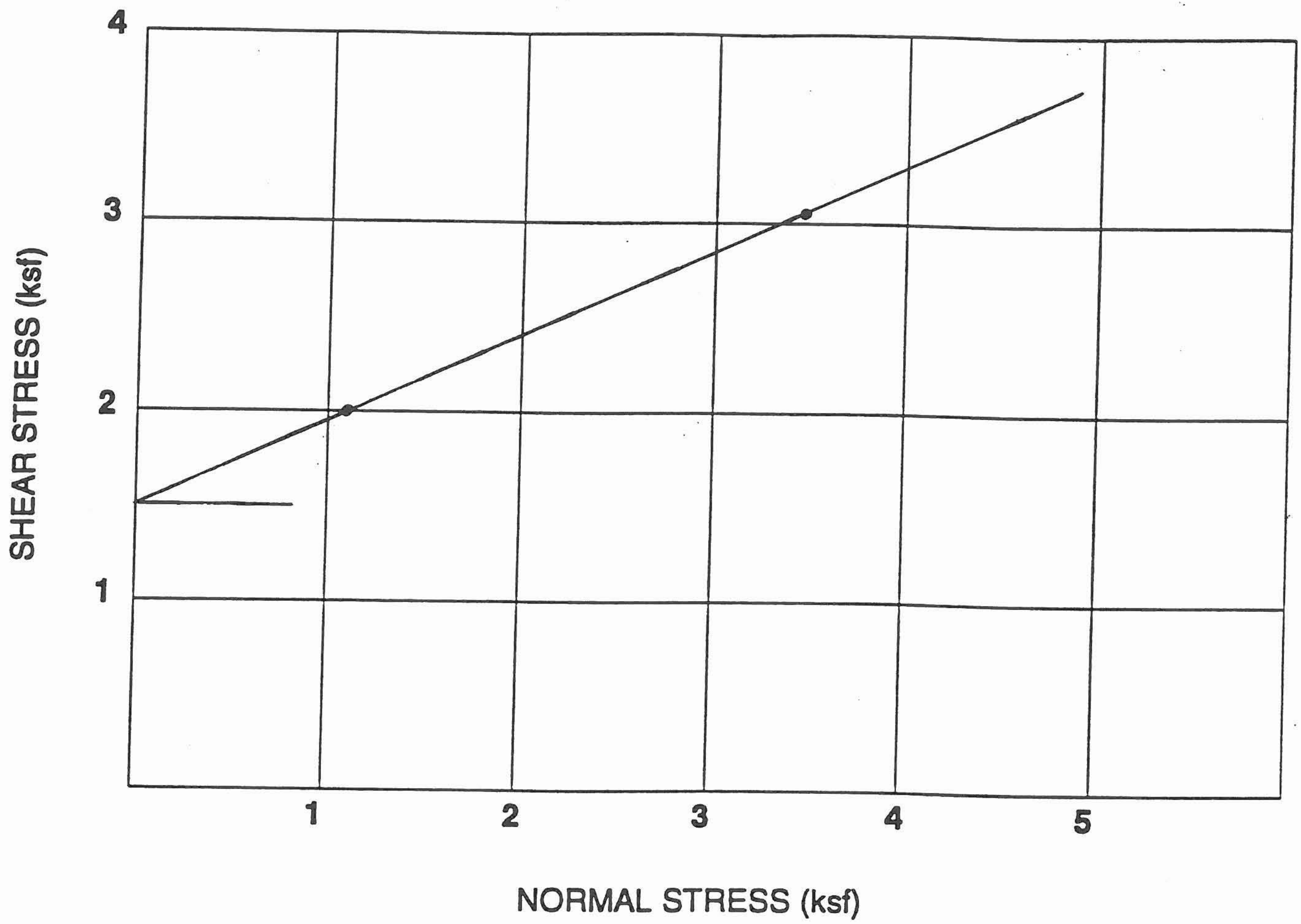
DS.

WOOD, PATEL & ASSOCIATES
BULLARD WASH CHANNEL IMPROVEMENTS, PHASE II
FCD 2001C023
ATL JOB NO. 101015

PERCENT SWELL TEST
(Surcharge = 100psf)

Test Location	Depth (Ft)	USCS	Surcharge (psf)	Dry Density (pcf)	Saturated Moisture (%)	Swell (%)
B-3	10.0 - 11.0	CL-ML	100	102.2	24.5	-*
B-18	5.0 -10.0	ML	100	102.3	23.8	0.98**

Note: *Sample tested consolidated 0.17% when inundated.
** Sample tested was remolded to 95% of the maximum dry density and 2% below the optimum moisture content determined from standard proctor analysis.

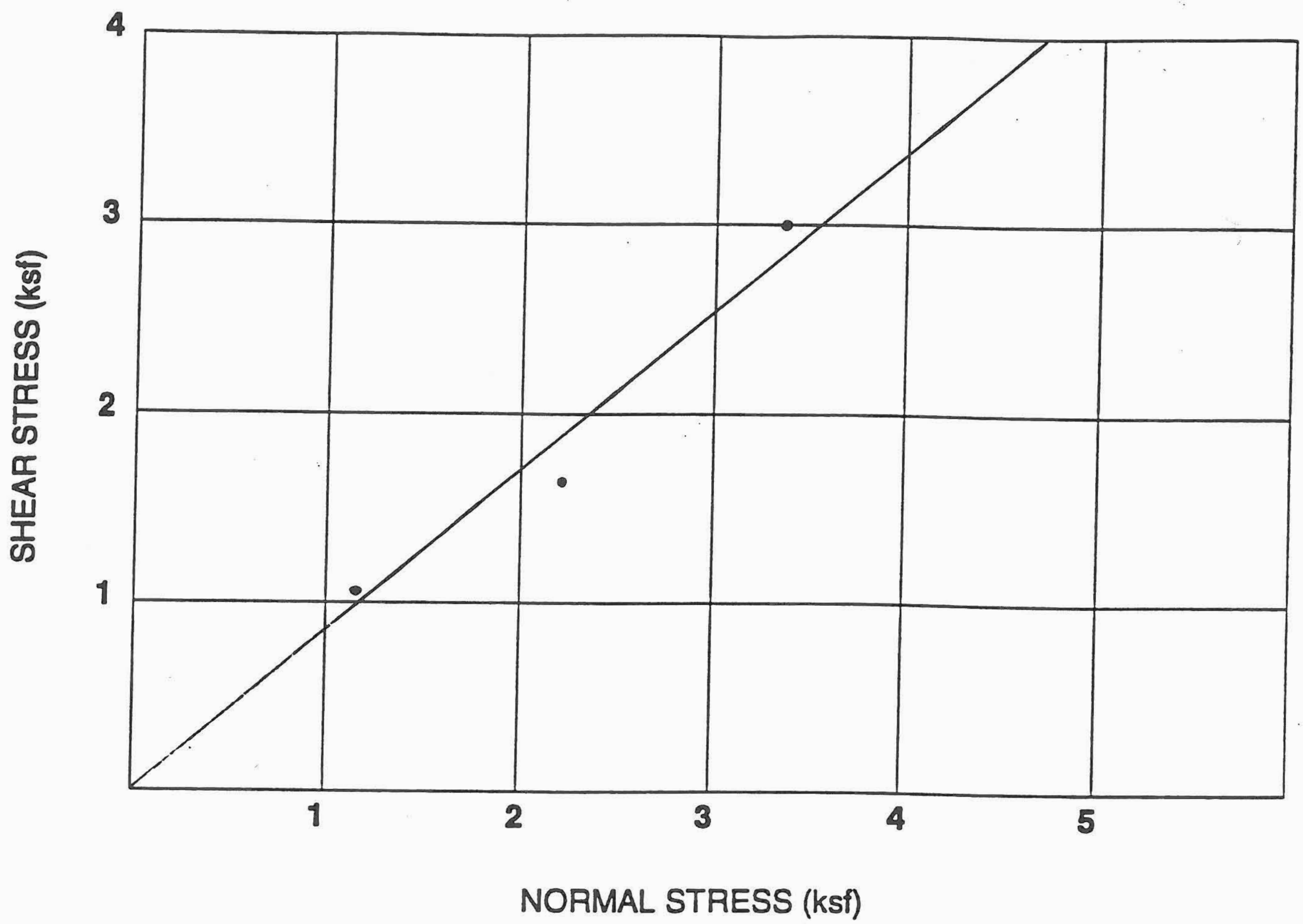


Boring or Test Pit no.	Depth (ft.)	USCS	Soil Description	Cohesive Strength (ksf)	Internal Friction Angle	Moisture Content (%)	Dry Density (pcf)
B-1	32-33	CL	Brown, sandy, Lean CLAY	1.50	32	26.4	93.6

DIRECT SHEAR TEST DATA

ATL Testing Laboratories

JOB NO. 101015



Boring or Test Pit no.	Depth (ft.)	USCS	Soil Description	Cohesive Strength (ksf)	Internal Friction Angle	Moisture Content (%)	Dry Density (pcf)
B-5	30-31	SW-SM	Brown, well - graded SAND (SW-SM) with silt and gravel	0	40	17.0	111.2

DIRECT SHEAR TEST DATA

ATL Testing Laboratories

JOB NO. 101015

IAS Laboratories

2515 East University Drive
Phoenix, Arizona
85034
(602) 273-7248

SOIL ANALYSIS REPORT

Today's Date: 7/19/2002
Grower: 101015
Submitted By: Dwayne Smith
Send Report To: ATL
Report Number: 6617586
Crop: Landscape
Date Received: 6/26/2002

VL = Very Low
L = Low
M = Medium
H = High
VH = Very High

Sender Sample Id	Depth	Lab #	pH	Calcium (Ca) PPM	Magnesium (Mg) PPM	Sodium (Na) PPM	Potash (K) PPM	Iron (Fe) PPM	Zinc (Zn) PPM	Manganese (Mn) PPM	Copper (Cu) PPM	Salinity (EC x K) dS/m	Nitrate Nitrogen (NO3-N) PPM	Phosphorus (Bicarb - Soluble P) PPM	Computed % Sodium (ESP)	Sulfur (SO4-S) PPM	Boron (B) PPM	Free Lime Level
B7	1"-12	724	8.2	5900 VH	480 VH	270 H	310 VH	.7 VL	.44 L	3.0 H	.26 M	2.7 M	45.0 H	7.7 L	3.3	22 VH	.72 L	High
B10	1"-12"	725	8.3	6900 VH	740 VH	640 VH	280 VH	.9 VL	.16 VL	1.4 M	.11 L	10.6 VH	230.0 VH	4.8 VL	6.3	240 VH	.88 L	High
B11	1"-12"	726	8.4	6800 VH	620 VH	570 VH	590 VH	2.0 L	.32 L	5.8 VH	.29 M	5.6 VH	56.0 VH	13.0 M	5.7	190 VH	1.3 M	High
B13	1"-12"	727	8.1	7300 VH	770 VH	770 VH	660 VH	1.9 L	.31 L	5.7 VH	.37 M	12.0 VH	250.0 VH	11.0 M	7.0	210 VH	1.3 M	High
B15	1"-12"	728	8.2	6700 VH	550 VH	290 H	480 VH	2.4 L	.35 L	5.1 VH	.39 M	4.4 H	100.0 VH	15.0 M	3.1	38 VH	.88 L	High
B18	1"-12"	729	8.1	7100 VH	630 VH	420 VH	500 VH	2.3 L	.39 L	5.0 VH	.37 M	7.0 VH	150.0 VH	11.0 M	4.2	93 VH	1.0 L	High

IAS Laboratories

2515 East University Drive
Phoenix, Arizona
85034
(602) 273-7248

SOIL FERTILITY RECOMMENDATIONS

Lb/1000 Sq Ft

Grower: 101015 Send To: ATL

Report No: 6617586 Date: 6/26/2002 Page: 2

												AMENDMENTS			
Sender Number	Crop	Nitrogen N	Phosphate P2O5	Potash K2O	Magnesium Mg	Sulfur S	Iron Fe	Zinc Zn	Manganese Mn	Copper Cu	Boron B	Elemental Sulfur	Gypsum	Lime	Leaching of Excess Salts

For all samples: Apply dispursul at 25 pounds per 1000 square feet and water in. (LEACH) This will dissolve some of the CaC03, lower pH and allow the sodium to be leached over time. As the pH lowers most of the micronutrients will become more available to the plants. Do not add any micronutrients at this time.
Do not add N to any of the above areas.
Lab# 724 and 725 Apply 5 lbs of Single Superphosphate per 1000 square feet and work into soil.
Once the leaching has been properly carried out the EC will lower to more acceptable levels.

APPENDIX C

PILE CAPACITY GRAPHS AND CALCULATIONS

APPENDIX D

RESEARCH ON SUBSIDENCE AND EARTH FISSURES

Land Subsidence, Earth Fissures Change Arizona's Landsc

by Joe Gelt

Mostly underground and out of sight, the effects of groundwater over-pumping and declining water tables are diff for many people to envision, much less conceptualize. The most apparent and tangible manifestation of excessive groundwater pumping seems to be the political and public policy debates the issue provokes. In other words, the obvious effect of groundwater overdraft in Arizona is the Groundwater Management Act.

With the increasing occurrence of land subsidence and resultant earth fissures in certain areas of the state, the consequences of dropping water tables become distinct, physical and sometimes dramatically visible. Land subsi and fissuring provide tangible evidence that the over withdrawal of groundwater has geological as well as public policy consequences.

Arizona, A Land of Subsidence

Subsidence and earth fissures are geological events that are accelerated by man through a long-term extraction of groundwater, and they represent a disruption of a natural equilibrium. Underlying groundwater is pumped and the settles and subsides. Under certain circumstances fissures then develop.

Using and eventually overusing its groundwater resources have been a way of life in Arizona. Colorful legends of Old West pale in comparison with this pump-and-consume legacy in explaining Arizona's growth and developme and its current level of civilization. Land subsidence and related problems are then consequences that cannot be ignored.

By some measures, Arizona's subsidence problem has been a long time coming, since the beginning of the centur About 1900 the state's groundwater resources began to be exploited, with withdrawals greatly increasing in the lat 1940s. The alluvial aquifer system continued to be a major source of water supplies through the boom years, until 1984 almost 196 million acre-feet had been withdrawn. Groundwater withdrawals were greatly exceeding recharg

As a result, the water table in various areas of the state dropped significantly, areas that may now be affected by l subsidence. For example, in two southern Arizona areas groundwater levels have dropped more than 500 feet. On area occurs southwest of Casa Grande near Stanfield, and the other is located south of Chandler near Chandler Heights.

South-central Arizona is the main area of the state affected by subsidence. The geological conditions of the area a such that an over pumping of the underlying stores of water can result in the settling of the land or subsidence. Th geological classification of this area of Arizona is basin and range.

This basin and range topography is an extensive swath of territory that extends from west Texas through southern New Mexico and the southwestern half of Arizona and into the Mojave desert. It includes almost all of Nevada, western Utah and up to southern Oregon. Within this area subsidence has been detected at various areas. Along w its occurrence in Arizona, where land-subsidence areas cover more than 3,120 square miles of land, subsidence h affected areas in Las Vegas, Nevada and Demming, New Mexico.

The occurrence of subsidence in south-central Arizona is a major concern because it is a core area of the state, wi major agricultural and urban centers. The Phoenix and Tucson metropolitan areas are located within this area, as as the agricultural production areas within Pinal and Maricopa Counties. This is an arid region of extensive groundwater pumping.

An Arizona Land Subsidence Committee was formed by Governor Babbitt in 1980 to address state concerns. The committee was made up of state and federal agencies including the Arizona Department of Water Resources (DW the Arizona Department of Transportation, the United States Geological Survey (USGS), and the Bureau of Reclamation (BuRec). The intent of the committee was to inventory subsidence zones and fissures and to investig related issues. The committee, which represented the only state-wide effort to address subsidence/fissure problem was not granted any appropriations.

Causes of Land Subsidence

There is obviously more to subsidence than meets the eye. What is seen at the surface when land settles and subsidence occurs is the end result of a process that begins deep underground, with the occurrence, use, and over of groundwater.

South-central Arizona consists of broad alluvial valleys or basins, bordered by mountainous terrain of igneous, metamorphic, and consolidated sedimentary rocks. The basins are broad and low sloping. Underneath are permea unconsolidated to moderately consolidated alluvium or loosely compacted alluvial sand and gravel. As much as 10,000 feet of alluvium might fill a basin. Here vast volumes of groundwater are stored. The groundwater occurs within the cracks and pore spaces of the alluvial fill.

As water is pumped from an aquifer, the water occupying the spaces between the rock particles is removed and th water level, described as the water table, drops. Without the water, the particles then become more tightly packed together. In other words, the particles compact and consolidate.

With the continued pumping of groundwater without adequate recharge, the sediments become increasingly compressed causing the land to settle or subside. This lowering is called land subsidence and is caused by the compaction of the aquifer. Subsidence occurs gradually and spreads over wide areas.

Different factors determine the occurrence and extent of land subsidence. A basic factor of course is groundwater withdrawal, but other factors also contribute to the situation. For example, when compressed, fine-grained sedime silt and clay compacts more than coarse-grained sediment composed of sand and gravel. Subsidence therefore is likely to be a problem in areas underlain by clay- bearing layers and where the water table has decreased 100 feet more.

Groundwater depletion is not the only cause of land subsidence. Subsidence also results from oil and gas withdra the removal of rock during underground mining operations, and the drainage of marshlands. In Arizona however l subsidence is associated chiefly with excessive groundwater withdrawal.

Causes of Earth Fissures

A related phenomenon, earth fissures are the most visible, and sometimes even spectacular manifestation of land subsidence. At one time not associated with the removal of underlying groundwater, fissures were once blamed o other natural geological forces.

Fissures usually are noticed first as land cracks or crevices, a break in the earth's surface. They can then grow considerably by water erosion. Gullies or trenches may be up to 50 feet deep and 10 feet wide, with the fissure extending hundreds of feet below the surface. The fissure may range in length from a few hundred feet to over 8 miles..The average length of a fissure is measured in hundreds of feet.

Fissures develop because of differentiated subsidence or compaction. In other words, fissures result when subside is not uniform over an area because of differences in geology and rates of groundwater pumping. As a result, a subsiding land mass may not settle smoothly and evenly like snow falling on a flat surface. Some areas may sink slightly deeper and at a different rate than other areas. Fissures may then result.

How the land settles depends upon characteristics of the underlying basin. The bedrock may include various irregularities such as ridges, hills or fault scarps that are completely covered by alluvial fill of sand, gravel, and cl The compaction of the alluvial fill over such bedrock features may be uneven and result in fissuring, especially if are less than 300 meters below the surface.

For example, land settling over areas of shallow bedrock will obviously not settle as deeply as a land mass underl by thick alluvial fill. Bedrock is found within basins at variable depths. It often occurs close to the mountain rang and, as a result, fissures commonly form along the margins of a subsiding basin. Here the alluvial soil pulls away the mountains at the basin's edge because of uneven settling.

Fissuring may result from other conditions as well. A variation in the type and thickness of the alluvium might ex the occurrence of fissuring. These alluvium characteristics may vary within a basin. Also variations in water-level decline can be a factor to explain fissuring.

Fissures begin as tension cracks below the earth's surface. They first become visible above ground as slight, hairli cracks or a line of holes. Flowing water either above or below the surface enlarges the opening, and eventually its surface covering or roof collapses exposing the fissure. The crevice traps surface water drainage and erodes into a deeper and wider gully or trench, until it becomes a prominent feature of the landscape.

The crevices or cracks of the fissures act as a sort of furrow for seeds to settle into and germinate. Vegetation the grows. Sometimes creosote bushes line the edge of a fissure making it especially prominent in aerial photographs where the vegetation shows as a dark outline of the fissure.

Once fissuring begins in an area the process tends to continue, increasing in number and length, with fissures for adjacent and parallel to older fissures. Fissures spread at uneven speeds and in uncertain directions growing or branching out, sometimes forming complex patterns of multiple fissuring extending for miles.

Fissures are not to be confused with arroyos or washes, legendary land crevices of western regions. Arroyos are formed by surface runoff and provide natural drainage. Fissures result from land subsidence and often cut across normal drainage patterns, often running perpendicular to them. Surface flow in fissures may move laterally, but al sinks downward, possibly into the groundwater table. Also, unlike arroyos, earth fissures extend deep in the grou

Subsidence and Fissure Locations in Arizona

Subsidence and fissures were at one time perceived to be strictly agricultural problems, the consequences of an ar extensive use of groundwater. For example, subsidence has affected over hundreds of square miles in the Arizona agricultural areas of Eloy, Picacho, Maricopa, and Stanfield.

Urban centers meanwhile grew and expanded and, as a result, also began to experience land subsidence problems This was not just because cities were pumping great stores of groundwater. As urban areas expanded, they someti reached into former agricultural areas, lands possibly already prone to subsidence and fissuring.

This type of development is still occurring. New developments continue to be built in outlying areas, often with a water-consuming golf course as a central feature. Cities may thus be ensuring a future land subsidence problem. officials believe subsidence will become an increasingly serious problem in urban areas, unless groundwater pum is more carefully controlled.

Subsidence was first detected in Arizona in 1948 near Eloy in the lower Santa Cruz basin. Follow-up studies foun that subsidence was an ongoing phenomenon in the Eloy area. About 675 square miles of the area were determine be affected by subsidence by 1977. Subsidence of about 12.5 feet had occurred in the Eloy area by this date, with more than 15 feet of subsidence evident by 1985. The Eloy area is the center of subsidence activity in the state.

Stanfield, which is located about 30 miles northwest of Eloy, was also identified as a major subsidence site. By 1 about 425 square miles in the Stanfield area were affected by subsidence. Subsidence in the area measured 11.8 f this time.

Within the Salt River Valley are various locations where subsidence is occurring. In the Queen Creek-Apache Junction area about 230 square miles had subsided more than three feet by 1977. Near Luke Air Force Base west Phoenix and in the western part of the Salt River Valley 140 square miles also had subsided more than three feet 1977. At an area east of Mesa 5.2 feet of subsidence was measured. Subsidence has also been recorded in the Par Valley area in eastern Salt River Valley where land has subsided as much as five feet between 1965 and 1982.

Other Arizona areas affected by subsidence include: northwestern Avra Valley near Red Rock; Harquahala Plains areas northwest and southeast of Willcox; Bowie and San Simon areas; a location near Tonopah in the lower-Hassayampa area; and the Gila Bend basin.

Subsidence in the Upper Santa Cruz basin is of special concern because it is an area of extensive groundwater pumping to support municipal, agricultural and industrial activities. It is also the location of a major Arizona metropolitan area, Tucson.

Where subsidence occurs, fissures are a possible occurrence. Not a wide-ranging phenomenon, fissures are know occur in only six U.S. states. And among these states, Arizona has the dubious distinction of having the greatest number of earth fissures caused by groundwater withdrawal. Some authorities even claim Arizona ranks first in t world in this regard.

Arizona's first recorded fissure was observed in 1927 near Picacho. Since that time, with increased pumping of groundwater, fissuring has intensified in several south-central basins in Arizona. Another landmark in the history Arizona fissures occurred in 1980 when a 429-foot fissure opened in a northeast Phoenix construction site. This the first to occur in a nonagricultural, densely populated area and the first in the Phoenix area.

Since the 1950s the occurrence of fissures has greatly increased, with hundreds now identified in the alluvial basi southern Maricopa, western Pinal, western Pima, and northwestern Cochise Counties. Most fissures however are found in Pinal and Maricopa counties.

In Arizona, and indeed in the world, the lower Santa Cruz basin is the site of the greatest concentration of earth fissures. This is an area where a sizable groundwater level drop was measured and significant subsidence recorde Fissures occur in the desert by the west side of the Picacho Mountains, the east side of the Casa Grande Mountain and south of the Sacaton Mountains. Fissures have formed west of Stanfield, and along the southwest side of the Cruz Flats. Fissures are also located near Marana, 25 miles north of Tucson.

Studies indicate that no fissures existed along the Casa Grande Mountains, southeast of Casa Grande in 1949. In the existence of a single fissure was demonstrated. By 1980 there were 50 fissures, with some in areas formerly cultivated. This area also has the distinction of having the longest fissure zone in Arizona. An unusually extensiv ten-mile long fissure system is located in the lower Santa Cruz basin, east of the town of Picacho in Pinal County.

Earth fissures have been identified also in other areas where groundwater depletion is of concern, including Harquahala Plains; McMullen, Salt River, and Avra Valleys; and the Willcox and San Simon basins.

Problems Caused by Subsidence and Fissures

Subsidence and land fissures, which are slow and gradual developments, do not pose the type of hazards associat with sudden and catastrophic natural events like floods and earthquakes. Looking across an expanse of subsiding a viewer may not perceive any evidence of the settling land mass. The most pronounced effect might be increased erosion near mountains.

Place man-made structures and projects on that expanse of land-- works designed for specific elevations and gradients--and subsidence is likely to take a toll. Damages that result from subsidence and fissures often are costl disruptive.

For example, subsidence can be costly to farmers in a number of ways. Irrigation ditches and canals might be bro as land settles. Uneven and irregular subsidence could alter the slope of previously leveled fields, disrupting the fl of irrigation water. Fields may then have to be releveled, as had to be done in the western Salt River Valley, the l Santa Cruz basin, and the Willcox basin.

A developing fissure cutting across an irrigated field may cause sections of land to be taken out of production and abandoned. The crevice remains as a hazard to people, livestock and wildlife.

The effect of subsidence on well casings can be curious as well as destructive. As land subsides, casings from dee wells may seem to rise into the air, as if they were growing from the ground. The casing is not rising, of course, b the earth is sinking. Well cases may also collapse under the pressure of subsidence necessitating expensive repair even the replacement of wells. Large irrigation wells can cost from $100,000 to $200,000.

Land surveyors experience difficulties because of subsidence. They may have difficulty closing traverses in certai areas of the state. Bench marks in subsidence areas may have settled while those on bedrock may not have. Surve data quickly become obsolete. Expensive releveling may be needed.

Urban areas are especially vulnerable to the effects of subsidence. Cities are dense of population, with clusters of buildings and facilities. Also within urban areas are the varied projects and structures--bridges, highways, electric power lines, underground pipes, etc.--that make up the urban infrastructure. There is therefore much to damage in movement of a land mass, even the gradual settlement of subsidence.

For example, subsidence may necessitate repairs to streets and highways and could result in the rupture of water mains, sewer lines and gas pipes. Building foundations might crack. More frequent and costly maintenance may b required. Those structures that cover large areas or have height are especially vulnerable. Any system that depend gravity flow could be disrupted if differentiated subsidence shifts the gradient. For example, a change in the gradi of a sewer line or storm drain could interrupt flow causing it to reverse or clog. Such an event occurred in northea Phoenix where the gradient of sewer lines decreased due to subsidence. Also subsidence might cause gravity flow aqueducts to overflow. Costly new designs may have to be worked out for such systems to accommodate the thre subsidence.

Railroads, earthen dams, wastewater-treatment facilities and canals also are vulnerable to damage from subsidenc Any structure built across the path of a fissure likely will suffer serious damage.

Groundwater pollution also is concern. Earth fissures may be quite deep, possibly extending to the water table. Surface flow and its possible contaminants--chemicals, animal waste, etc.--may therefore have a direct channel to water table, without percolating through the unsaturated zone for filtration. That fissures often are used as conven sites to dump trash and refuse compounds the potential threat to groundwater quality.

Finally, it is worth emphasizing that land subsidence and the damage and destruction they cause should not be interpreted merely by their effects on humans, their activities and structures.

Even if land subsidence were to occur in the remoteness of the desert, unnoticed and posing no threat to humans, still is an ominous occurrence. Once again humans have seriously disrupted a natural process and caused severe environmental damage. This is the most formidable consequence of land subsidence.

Subsidence and fissures are therefore forces to be reckoned with. Now nearing completion, the CAP project was designed, constructed and is being maintained to prevent damage from subsidence and fissures. Meanwhile, as mentioned, subsidence is a relatively new phenomenon to some Arizona cities. For example, the extent of its occurrence in Tucson is currently being studied, with its possible effects interpreted.

Subsidence, Fissures and the CAP Canal

CAP offers a case study of coping with subsidence and fissures. Never before in Arizona has such a complex manmade project reached across such an extensive area of the state, 335 miles from Lake Havasu to Tucson. This territory includes areas of groundwater overdraft, areas susceptible to subsidence and fissures. The project consist concrete-lined canals, siphons, tunnels, pumping plants, and pipelines.

The U.S. Bureau of Reclamation (BuRec) identified various possible causes of disruption to the CAP system. Alo with floods and fire, earth fissures and subsidence were events to be carefully considered when designing, constructing, and operating the CAP.

BuRec and the U.S. Geologic Survey began geologic studies in 1977 to determine the hydrogeologic conditions associated with land subsidence and earth fissuring. The studies were to determine the expected subsidence that C design would need to accommodate and to identify areas of fissure hazards.

Also, work was to be done to devise ways to monitor future land subsidence along the CAP route. The investigati included field reconnaissance and mapping, test drilling, borehole instrumentation, and geophysical surveys. Subsidence predictions were worked out for the aqueduct route for the 50-year period ending in the year 2035, an range from four inches to over 15 feet on the Salt-Gila Aqueduct and from about two feet to almost eight feet on t Tucson Aqueduct.

With subsidence predicted and expected, engineering design techniques were needed to mitigate any resulting ad effects. Such techniques included additional canal freeboard, reinforced concrete lining, overbuilt overchutes, trapezoidal road crossings, and modified check structures. Each represents a method to protect CAP operations fr serious disruption because of subsidence.

For example, additional canal freeboard is constructed in areas of subsidence concern. This means that in such ar the canal is built with a margin of ten feet from the surface of the water to the top of the canal lining. If the canal settles, the banks are protected and the flow is maintained.

Because of the potential of fissures to cause serious disruptions to CAP flow, project operations also include caref monitoring and emergency mitigation of fissures. Early detection and treatment of fissures are essential to ensure safety and continued operation of the CAP aqueduct system.

Early surface traces of fissures and subsurface irregularities are carefully mapped, with regular monitoring to determine fissure growth and direction, especially if toward CAP structures. Studies have identified existing fissu located within about two miles of the canal alignment, and potential fissure hazard zones are defined.

With fissure zones identified, a strategy of avoidance can be implemented. The CAP route was planned to bypass known areas of subsidence and fissures. For example, east of the town of Picacho a ten-mile long fissure zone exi To avoid this zone the canal was routed along the base of the Picacho Mountains, northwest of Picacho Peak.

Despite its rerouting, the canal unavoidably traverses some fissure hazard areas. One area is in Avra Valley, abou miles northwest of Tucson. Another area of concern is in Apache Junction in the Phoenix metropolitan area. The Basin is another area where subsidence and fissuring have threatened the CAP aqueduct.

Thus far nine fissures have necessitated corrective measures on the CAP system. The strategies in place to cope threatening fissures include filling in and bridging the fissure with gravel. This method however has proven to be limited success. The most effective method has combined sealing the fissure with rerouting drainage away from it Surface flows therefore can not enter the fissure, and it is unlikely to erode into a large destructive gully.

In areas threatened by fissures the canal lining has been reinforced with steel. If a fissure occurs, the canal lining supports itself until repairs are made. This design was tested in the Cortaro area when a large fissure opened up beneath the canal. Repairs were able to be made without the canal collapsing.

To date the main CAP canal has not suffered any serious consequences from fissuring and subsidence. This is ma because sufficient funding and trained personnel have been available to cope with any developing and threatening situation. These advantages are not usually available to operators of offshoot or lateral canals. As a result, the mo serious fissuring problems have occurred in canals leading from the main aqueduct. Such problems have develop along the Santa Rosa canal and Maricopa-Stanfield Water District canals.

Tucson and Subsidence

A recent study indicated that the subsidence rate in parts of the Tucson basin is increasing. If this, in fact, is occur then the event might presage a development expected by some geologists; i.e., subsidence as a growing problem i urban areas in Arizona.

Subsidence has been detected in certain urban areas of the state. It has occurred for example in sections of the Ph metropolitan area. And even some of the subsidence in the Casa Grande area may be attributable to urban groundwater use. That subsidence is occurring in Tucson has been recognized for a period of time. The concern n is that the Tucson subsidence rate is increasing. The damage and disruption to be expected from extensive subsid occurring in a large metropolitan area thus gain importance as an issue.

Research has demonstrated that between 1947 and 1981, the Tucson basin ground surface dropped 3 millimeters (twelve-hundreds of an inch) for every meter of water loss. Recent research conducted by John S. Sumner, Unive of Arizona professor emeritus of geosciences, and graduate student Michael A. Hatch indicates that between 198 1991 the surface of the Tucson Basin dropped an average of 24 millimeters (about an inch) for every drop of one meter in the water table, with subsidence ranging from half an inch to 2 inches. The water table under Tucson has been dropping about one meter or over three feet a year since the 1940s.

Hatch points out that if the average subsidence rate in the Tucson basin of a half-inch to two inches per year conti for the next 30 years, much of the basin will settle about a foot during that time. Some areas might even subside u four feet.

Sumner and Hatch further suggest that the subsidence rate may be increasing because of a loss of elasticity within basin, the result of various subsurface developments. Because of the consistent groundwater pumping within the the water table might have dropped below the clay layers. Without the water, the clay particles are compressed m tightly by the weight of the overlying rocks, and their water storage capacity is thus permanently reduced. Subsid would then be inelastic because the sinking of the ground surface is permanent. Recharge would not reverse the process.

It is generally agreed that more research is needed to confirm the above findings. Meanwhile geologists speculate about various possible consequences of subsidence occurring in the Tucson Basin. Some believe that if subsidenc general and uniform throughout the area, disruptions will be very minimal. Others believe that inelastic subsidenc fact is occurring and eventually will result in fissures developing in areas of Tucson.

Predicting, Identifying and Monitoring Subsidence, Fissuring

Subsidence and earth fissures are problems not easily halted. Efforts are needed therefore to predict their occurre as well as monitor their development to ensure that people and their projects remain out of harm's way. Much pioneering work in this area is being done in Arizona.

Predicting and interpreting areas of subsidence were essential when planning the CAP route. This was done by us test wells and geophysical surveys to establish soil profiles to measure the settlement of subsurface soils within a area. This determines the extent to which the soils are dewatered and therefore susceptible to compaction. Well records of the areas also were examined to ascertain a history of pumpage. Also, the history of subsidence in the a was researched by reviewing benchmark placements. The future occurrence of subsidence then was estimated thr analysis.

The Global Positioning System is another method to monitor subsidence. GPS uses satellites to fix the latitude, longitude and elevation of a point. Results are compared with previous readings to determine the rate of land subsidence. GPS enables quick and accurate positioning to within a fraction of an inch. The method is relatively recent however. As a result, sometimes long-term survey records do not exist to compare with recent GPS readin

UA geoscientist John S. Sumner is using GPS to monitor subsidence within the Tucson Basin. CAP officials look eventually using GPS to monitor subsidence along the entire canal route. Meanwhile, traditional surveying metho are presently converted to GPS.

Although readily apparent when open at the surface, fissures are difficult to predict and identify at an early stage i their development. Horizontal extensometers are tools for accomplishing this complex task. An extensometer is essentially a micrometer hooked to two wires, each attached to a stationary post. The stretching and contracting o wires is measured to interpret tensions.

Vertical extensometers are placed beneath the ground in the bottom of wells in areas with geological conditions favorable to the formation of fissures. In such areas soils may be settling into bedrock, and the process produces tension. Extensometers measure the tension in the soil to interpret the probability and development of fissures. Th devices are installed at 24 sites in southern Arizona including sites in Tucson, Casa Grande, the Eloy area, Avra Valley and Pinal County.

Aerial photography is a basic and fairly reliable method to identify new fissures and monitor existing ones. This strategy was the focus of a joint effort between the BuRec and the Arizona Geological Survey. Photographs were taken periodically of certain areas and compared with earlier images to determine fissure growth. Although useful this method is limited because complete photographic records of certain fissure areas are not available.

Other methods are more experimental. Charles E. Glass, UA associate professor of mining and engineering, is working on physical models to predict subsidence and fissures. The work is still at the research stage. Michael Pegnam assisted by Aaron Glass--both are students of Glass--modeled three Arizona basins, with fairly accurate results. Glass hopes eventually to develop a model of the Tucson basin.

USGS geologists also believe that acoustic emission surveys are a promising method for predicting fissures along CAP canal, although no work has been done thus far with the method. As tension or tensile stress builds up in the ground, micronoise or acoustic signatures are emitted. Listening posts could be installed about every ten feet alon canal to provide data points for monitoring or listening to the emissions. The growth of a fissure could then be tracked.

Conclusion

An important water issue in Arizona is the use and overuse of groundwater. The implicit, sometimes explicit mes of the groundwater laws, regulations and conservation campaigns is that we need to take care of our groundwater resources to ensure the continued growth and development of the state. Much less is heard about managing groundwater to avoid land subsidence and earth fissures.

In fact, the groundwater issue is discussed in terms that suggest that the threatened consequences of groundwater overuse is temporary and redeemable. Groundwater is described as overdrawn calling to mind a checking account could be put to right with additional cash deposits. And groundwater recharge can replenish depleting aquifers. S yield is achievable when an equilibrium is reached between recharge and withdrawal. What is suggested is that th groundwater situation is a temporary condition that can be fixed. And in some cases this might be true.

Yet the fact remains that relatively large portions of the state have subsided due to excessive groundwater pumpin And with subsidence often comes fissuring. Fissures slice across lands causing environmental damage and threate structures and disrupting human activities. These are assuredly not temporary effects. Fissures pose threats to bot agricultural and urban areas.

The implementation of the Groundwater Management Act and the completion of the CAP project are to relieve th state of its reliance on groundwater reserves. These endeavors should indeed help reduce the occurrence of subsid and fissures, but their beneficial effects are limited to certain areas of the state and, further, will take time to work Meanwhile subsidence and fissures continue to be a concern.

Many scientists and officials stress the need for more research to be done to better understand the occurrence of subsidence and fissuring. This then will lead to better tracking of such occurrences, from predicting and early identification to monitoring and remedial actions.

The writer thanks all the people who contributed information to this newsletter, especially the following: Sam Ba Bureau of Reclamation; Mike Carpenter, U.S. Geological Survey; Larry Fellows, Arizona Geological Survey; Ch Glass, University of Arizona; Herbert Schumann, USGS.; John S. Sumner, UA; and Greg Wallace, Arizona Department of Water Resources.

The ideas and opinions expressed in the newsletter do not necessarily reflect the views of any of the above people

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LAND SUBSIDENCE AND EARTH-FISSURE HAZARDS NEAR LUKE AIR FORCE BASE, ARIZONA

Herbert H. Schumann (U.S. Geological Survey, Tempe, Arizona)

Land subsidence and earth-fissure hazards near Luke Air Force Base are being investigated by the U.S. Geological Survey in cooperation with the U.S. Air Force. The main objectives of the investigation include the evaluation of land subsidence and earth-fissure hazards and the characterization of the surface- and subsurface-hydrogeologic conditions that may control the movement of contaminants toward and through the alluvial-aquifer system on and near the base. (See Ward and others, and Blodgett abstracts, for similar studies at Edwards Air Force Base). Differential land subsidence and resultant earth fissures have damaged buildings, roads, railroads, water wells, irrigation canals, and flood-control structures on or near the base, which is about 20 mi west of Phoenix, Arizona (fig. 1).

Large-scale pumping of ground water, mainly to irrigate crops in the surrounding area, has caused aquifer hydraulic heads measured in wells to decline more than 300 ft throughout much of the area. Ground-water depletion has caused the aquifer materials to compact and by 1991 had resulted in as much as 18 ft of land subsidence (fig 2). In August 1992, a Global Positioning System (GPS) satellite survey measured more than 17 ft of land subsidence northwest of the base (fig. 3). (See Ikehara #1, #2, and Pool #2 abstracts for GPS applications in land-subsidence investigations). Areas of maximum land subsidence correspond to areas of maximum hydraulic-head decline within the alluvial-aquifer system.

Large tensional breaks in the alluvial sediments, locally known as earth cracks or earth fissures, are caused by differential land subsidence. (See Haneberg and Helm abstracts for other possible mechanisms of earth-fissure formation). Earth-fissure zones as much as 2 mi long occur on the periphery of the areas of maximum land subsidence on three sides of the base (fig. 2). The earth fissures act as drains and are capable of capturing large volumes of surface runoff. When the fissures capture surface flows, the fissures enlarge by rapid erosion of the sides, by slumping, and by piping along the trend of the fissures. Such erosion can produce open fissure gullies as much as 15 ft deep and 30 to 40 ft wide in local areas. However, the fissures extend to depths far below the bottom of the fissure gullies and thus can provide vertical conduits for rapid downward movement of contaminants toward the water table. Part of the surface drainage from the south side of the base is captured by existing earth fissures.

The flood hazard on the base has been adversely affected by land subsidence. The gradient, or slope, of the Dysart Drain, which is a major flood-control channel along the north side of the base, has been reversed by differential land subsidence, and the carrying capacity of the drain and other flood-control structures has been greatly reduced (fig. 2). On September 20, 1992, a high-intensity storm produced about 4 in. of rain immediately north of the base and resulted in extensive flooding on the base. Floodwater overtopped the Dysart Drain and spilled onto the runways, into the aircraft parking areas, and into the base-housing area. The flooding closed the base for 3 days, inundated more than 100 homes, and generally disrupted base operations. Preliminary estimates of flood damage exceed $3 million.

Urbanization, together with commercial and industrial development, has occurred near the base in recent years. Any leakage of contaminants from the base into the nearby river channels or into the underlying body of ground water could affect the water resources of the area.

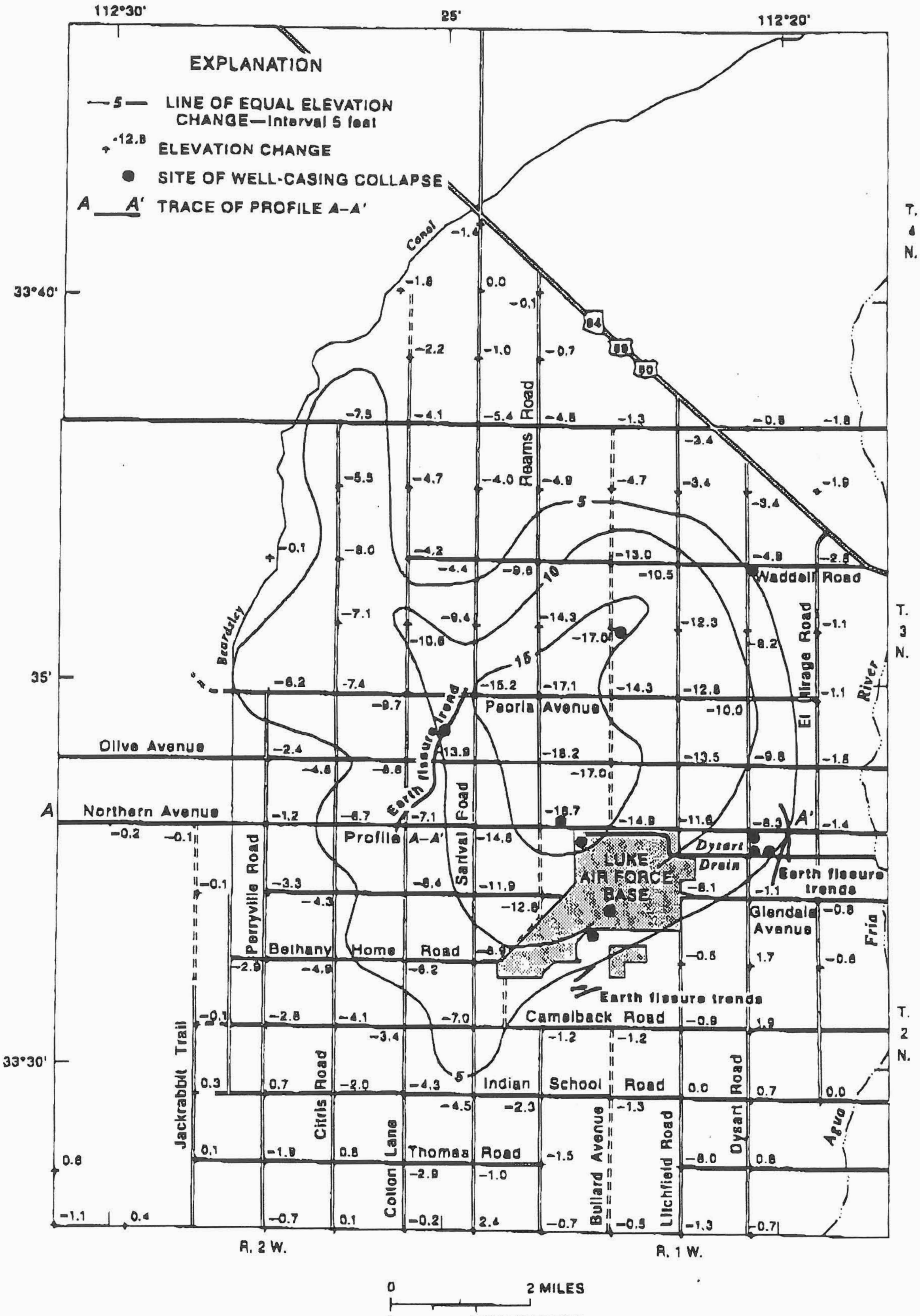

Figure 2. Land subsidence in part of the western Salt River Valley, 1957–1991.

Arizona Geological Survey

Center for Land Subsidence and Earth Fissure Information

The purpose of the Center is to answer requests for information, refer the public to appropriate agencies for assistance, and investigate subsidence areas and earth fissures. The ultimate objective is to identify areas that have potential for subsidence and related problems in the future. A number of governmental agencies have responsibilities that require them to know the location of subsiding areas and associated fissures. Geologist Ray Harris coordinates CLASEFI activities.

Earth fissures are tension cracks that result from land subsidence, which is caused most commonly by groundw withdrawal, oil extraction, dissolution of soluble rocks and underground mining. In Arizona, land subsidence and earth fissures are common in large alluvial basins where extensive groundwater pumping has lowered water tabl as much as 600 hundred feet. Subsidence can cause flooding of lowered areas, and can change drainage gradients and directions, thereby disrupting storm drains, sewers, and canals. Earth fissures can cause significa damage to structures such as buildings, roads, pipelines, and aqueducts. Fissures can provide a conduit for surf pollution to reach aquifers. Land subsidence and earth fissures are serious geologic hazards and their impacts w increase as Arizona's population grows.

Earth fissures have been found in Arizona in the following areas:

- Avra Valley
- Picacho Basin
- Casa Grande Basin
- Mesa-Chandler area
- Apache Junction area
- Queen Creek-Chandler Heights area
- Tempe- Paradise Valley area
- West Phoenix-Luke AFB area
- Harquahala Valley
- McMullen Valley
- Willcox-Kansas Settlement area
- Bowie-San Simon area

Subsidence and Earth Fissure Information

On-line publications and links are available at the AZGS earth fissure links page.

Publications about subsidence and earth fissures available for sale at AZGS.

To report an earth fissure:

Contact CLASEFI Arizona Geological Survey, 416 West Congress, #100, Tucson, AZ 85701 Phone (520) 770-3500, fax (520) 770-3505

For information about groundwater level monitoring, water quality, or other water-relat matters, contact:

Arizona Department of Water Resources 500 North third Street, Phoenix, Arizona, 85004 Phone (602) 417-2400

Tucson Water 310 West Alameda, Tucson, Arizona, 85701 Water Quality Information (520) 791-4227

U.S. Geological Survey, Water Resources Division

Tucson Office: 520 N. Park Avenue, Suite 221, Tucson, AZ 85719 (On University of Arizona campus, corner of Park and 6th Street) Phone : (520) 670-6671, Fax : (520) 670-5592 Office Hours : 7:30 am to 4:00 pm

Tempe Office: 1545 West University Dr., Tempe, AZ 85281 Phone : (602) 379-3086, Fax : (602) 379-3138 Office Hours : 7:30 am to 4:00 pm

Flagstaff Office: 2255 N. Gemini Drive, Flagstaff, AZ 86001 Phone : (520) 556-7136, Fax : (520) 556-7169 Office Hours : 07:30 am to 4:00 pm

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FIELDNOTES
From The Arizona
Bureau Of Geology And Mineral Technology

Volume 14 No. 3 | Earth Sciences and Mineral Resources in Arizona | Fall 1984

A VIEW OF SUBSIDENCE

by Carl C. Winikka
Assistant State Engineer
Arizona Department of Transportation

Figure 1. Giant earth fissure near Chandler Heights, Arizona. Earth fissures begin as tiny cracks, but become enlarged by water erosion and collapse of adjacent soils. This fissure is related to subsidence due to ground-water withdrawal. Photo taken on October 21, 1983 by Larry D. Fellows.

INTRODUCTION

Subsidence, the gradual settling or sinking of the earth's surface, is occurring in many areas of Arizona as a result of declining ground-water levels. Rates of subsidence have exceeded 0.6 foot per year and earth fissures, or cracks in the earth's surface, are proliferating (Figures 1, 2, and 3). In some areas, the total amount of subsidence has increased from 12.5 feet, measured in 1977, to about 16 feet.

Subsidence can be caused by natural geologic processes or by man's activities, such as the removal of subsurface fluids. In Arizona, subsidence is mostly due to large-scale withdrawal of ground water from subsurface reservoirs. The fluid pressure of ground water partially supports the material above. As the water is pumped out, that support is lost, causing compaction of the grains of earth material and lowering, or subsidence, of the earth's crust.

Earth fissures usually form around the margins of subsiding areas and may be related to distribution and thickness of basin-fill sands and gravels, buried bedrock topography, or other factors. It is not possible to predict specifically where fissures will form. It may be possible, however, to identify zones where fissures *might* form.

Land-elevation changes caused by subsidence can be determined by repeated, precise, survey leveling to fixed reference points or bench marks. Bench marks are usually brass caps encased in concrete and set a few inches above the ground surface. Precise surveys determine elevations of bench marks within the subsiding area by comparing them with stable bench marks set in bedrock *near* the subsiding area. Reference bench marks must remain stable to provide an accurate, common base for all measurements; therefore, they are located in bedrock.

Problems related to subsidence, especially differential subsidence and the formation of earth fissures, have been known for years. The issue itself is complex; numerous papers have been published to explain causes, identify problems, and offer solutions. A list of papers that describe specific subsidence areas and problems in Arizona is included at the end of this article.

It is not the purpose of this article to summarize or describe the extent of subsidence throughout Arizona, although a plan for monitoring subsidence in the State is discussed. This article does, however, describe the results of the National Geodetic Survey (NGS) precise leveling conducted in the Phoenix metropolitan area from 1980 through 1981 (Winikka, 1981). It also identifies subsidence areas and discusses uses of the NGS level datum.

THE PHOENIX AREA

The NGS Level Line

The 1980-81 NGS retracement of the 1967 NGS level line in Arizona was done as a segment of the current network of NGS transcontinental leveling, which extends through all States from coast to coast. In the Phoenix area, where several subsidence areas were crossed, numerous new bench marks were established in bedrock to preserve the precise leveling results. Consequently, more convenient stable elevations are now available to all users, particularly those who measure or monitor subsidence. The 1980-81 NGS leveling identified and measured subsidence that had occurred since 1967.

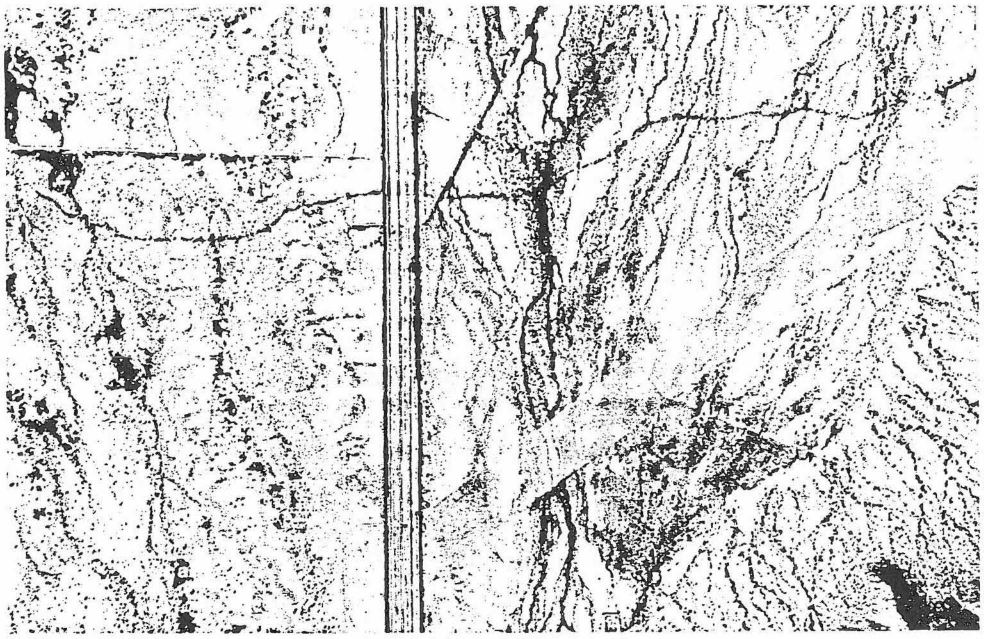

Figure 2. Aerial view of earth fissure crossing Interstate Highway 10 (I-10) between the town of Picacho and Picacho Peak. Photo taken on December 9, 1963 by the Arizona Department of Transportation.

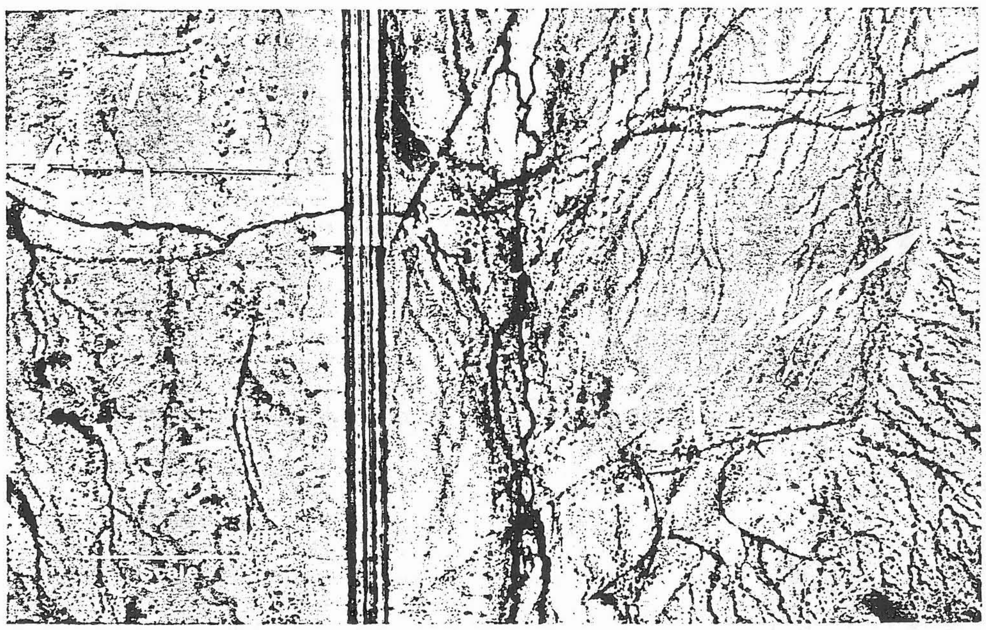

Figure 3. Aerial view of same area shown in Figure 2, taken 14 years later. Proliferation of earth fissures is indicated by arrows. Note that subsequent fissuring near the original fissure is all on the basin (west) side. Other fissuring, which may be due to buried bedrock topography, is evident to the east. Photo taken on January 9, 1978 by the Arizona Department of Transportation.

Final NGS elevations will not be available until the transcontinental leveling network is adjusted to account for numerous, influencing factors. The need to utilize the NGS leveling results, however, was great in the Phoenix area. To fill this need, the Arizona Department of Transportation (ADOT) used the NGS field information to make an accurate, preliminary, least-squares adjustment, which held NGS elevations previously established on bench marks in bedrock.

Because many bench marks set in 1967 and earlier years had been destroyed, new marks were set during 1980 and 1981 to establish a bench mark approximately every mile. Additional stable bench marks were established in rock to preserve ties to the NGS level datum for subsequent surveys. Enduring, subsiding bench marks, however, are equally important for continuity in subsidence monitoring. Figure 4 shows the location of the NGS level line through metropolitan Phoenix, the bench marks in bedrock, and the areas of measured subsidence.

Subsidence Areas

The greatest subsidence directly measured in the Phoenix area has occurred in the vicinity of U.S. Highway 60 and Bush Highway/Power Road. From 1948 to 1981, more than 5 feet of subsidence were measured just east of the junction, and several other points in the vicinity had subsided from 1 to 4 feet. The maximum subsidence rate in this area is approximately 0.2 foot per year. By indirect measurement, subsidence greater than 6 feet was determined to have occurred from 1943 to 1981 along Power Road, 1/2 mile south of U.S. Highway 60 at NGS bench mark W281. Because W281 was destroyed sometime between 1967 and 1970 and reset in 1970, a gap in information existed. The measured subsidence value was added to the projected value for the 1967-70 time period to obtain the total measure of subsidence.

The next highest measure of subsidence was obtained west of Phoenix along the Beardsley Canal, from U.S. Highway 60 south to the junction of Perryville Road and McDowell Road. Total subsidence from 1948 to 1981 exceeded 4 feet at the Beardsley Canal near both Bell Road and Peoria Avenue. Analysis of subsidence rates along the Beardsley Canal shows an increase in the annual rate at each of six bench marks north of Glendale Avenue. The approximate annual rate of 0.08 foot from 1948 to 1967 increased by 50 percent to 0.12 foot from 1967 to 1981. From Glendale Avenue south, on the other hand, the subsidence rate *decreased* at each of four bench marks. The approximate annual rate of 0.10 foot decreased by 50 percent to 0.05 foot during the corresponding time periods (Table 1). Although the definite cause of this variation in subsidence rates is currently unknown, the difference is most likely due to a change in ground-water pumping influenced by dewatered alluvial material.

Other areas in which subsidence was measured include the following:

(1) Along the Arizona Canal where it crosses the Salt River Indian Reservation (maximum 1948-81 measurement is 0.9 foot at Dobson Road and at Mesa Drive);

(2) Along portions of Beardsley Road from I-17 west (maximum 1967-81 measurement is 0.45 foot at 83rd Avenue); and

(3) Along I-17 from the Arizona Canal north to Beardsley Road (maximum 1967-81 measurement is 0.28 foot at Thunderbird Road).

Although subsidence measurements are given for the specific areas listed above, subsidence was measurable only where reliable bench marks were recovered. Many bench marks had been destroyed during the rapid growth and development in the Phoenix area; thus, a tie to past leveling information was lost. To either side of the level line, subsidence exceeding the values listed above is very probable.

Uses of the NGS Datum

In the Phoenix area, the establishment of NGS bench marks, especially those set in

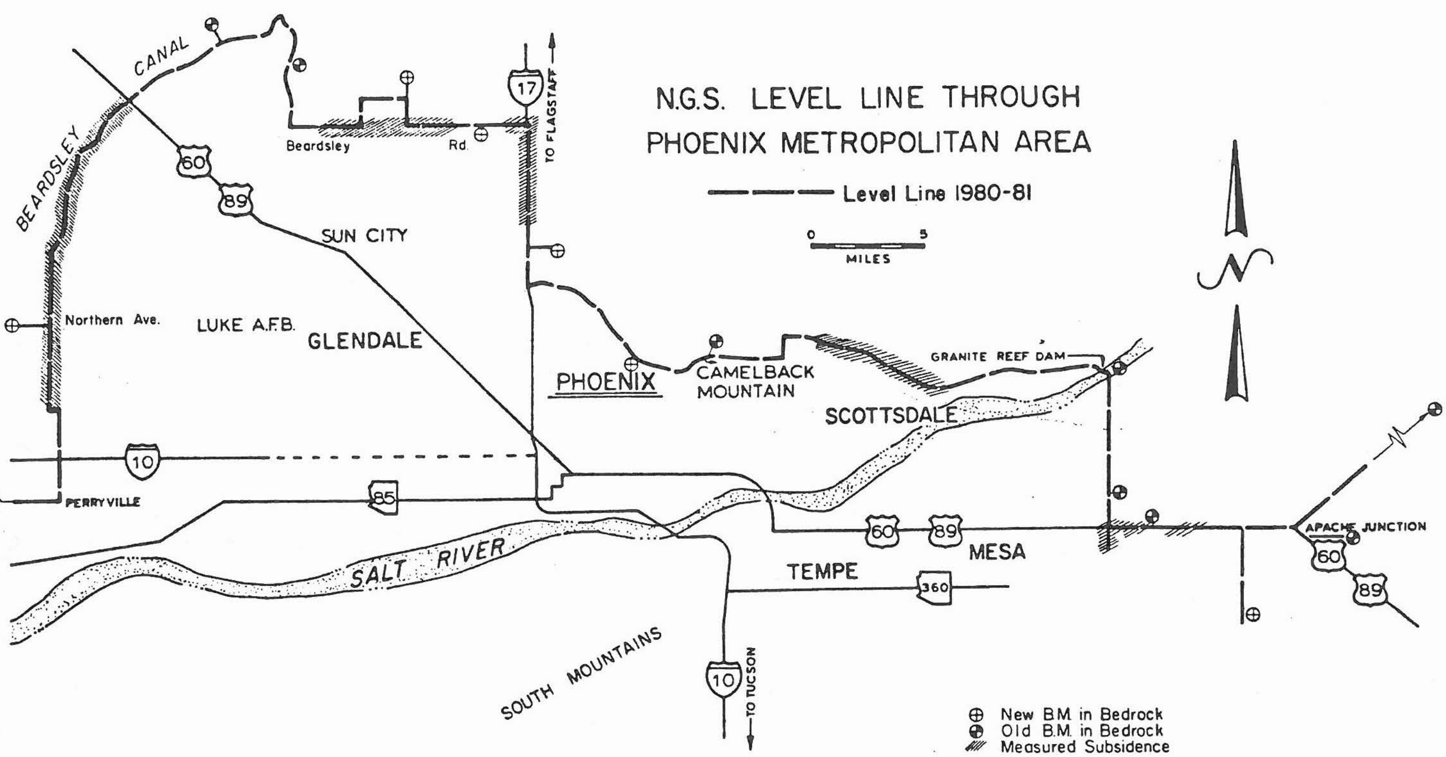

Figure 4. Location of the NGS level line run through Phoenix area during 1980-81. Old and new bench marks established in bedrock are shown, as well as areas of measured subsidence.

stable rock, has enabled the ADOT and others to detect and monitor subsidence for various purposes.

The U.S. Bureau of Reclamation (USBR) annually runs control levels along the Central Arizona Project (CAP) aqueduct to detect and monitor subsidence. West of Apache Junction, the design of the aqueduct accommodates subsidence in areas crossed by the structure. Monitoring provided essential information used in the design and will continue after the aqueduct becomes operational.

The Arizona Department of Transportation periodically runs a level circuit that includes the future extension of the Superstition Freeway east of Power Road. The freeway and its extension cross several areas of subsidence, including one that is also crossed by the CAP aqueduct. In this instance, common bench marks are used by the ADOT and USBR to obtain more frequent data from this critical area.

The city of Phoenix is experiencing subsidence-related problems with several sewer lines in Paradise Valley, where more than 3 feet of subsidence were measured and monitored from 1965 to 1982 (Harmon, 1982). Phoenix has recently engaged a geotechnical engineering consultant to analyze the problems and suggest solutions in this area, where the annual subsidence rate has reached 0.35 foot. All leveling to monitor subsidence is tied to NGS bedrock bench marks. Use of this consistent datum is particularly important because elevations and grades affect the capacity of the sewer system, which presently drains by gravity.

The city of Gilbert is planning to extend its sewer system considerably east of present development to accommodate future needs. A consulting firm on the project has used recent, precise, ADOT levels that rely upon NGS bench marks. These levels, which extend from the Superstition Freeway south along Power Road to Germann Road, have confirmed that approximately 3 feet of subsidence have occurred. Because this amount of subsidence, as well as the projected subsidence rate, was significant, city officials decided to alter the plan for the wastewater collection system.

Without question, the new NGS datum in the Phoenix area is becoming the base accepted by all levels of government and several private firms. The older level datums will still be used indefinitely, even though their inadequacy for subsidence monitoring is evident. Lines begun and ended within a subsiding area are of questionable value because they are not tied to stable, nonsubsiding bedrock. Measurements become even more inaccurate if the lines are tied to bench marks that have subsided at different rates. A precise level line with bedrock ties, such as the NGS line through the Phoenix region, is invaluable for conducting surveys in subsiding areas.

Table 1. Subsidence along the Beardsley Canal.

Bench mark	Crossroad	Total Subsidence (ft) 1948-67	1967-81	1948-81	Rate (ft/yr) 1948-67	1967-81
R265	Union Hills	1.171	1.237	2.408	0.0616	0.0884
Q265	Bell Road	1.887	2.186	4.073	0.0993	0.1561
P265	Greenway Road	1.932	(bench mark destroyed)		0.1017	—
N265	Waddell Road	1.919	(bench mark destroyed)		0.1010	—
M265	Cactus	1.706	1.598	3.304	0.0898	0.1141
L265	Peoria	1.578	2.513	4.091	0.0830	0.1795
K265	Olive	1.207	1.081	2.288	0.0635	0.0772
J265	Northern	1.244	1.304	2.548	0.0655	0.0931
H265	Glendale	2.067	1.189	3.256	0.1088	0.0849
G265	Bethany Home	1.433	0.469	1.902	0.0754	0.0335
F265	Camelback	2.152	0.633	2.785	0.1133	0.0452
E265	Indian School	1.866	0.581	2.447	0.0982	0.0411

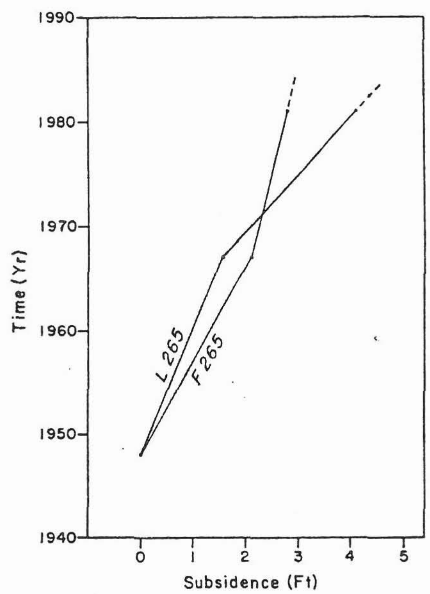

Figure 5. Total subsidence and subsidence rate changes for bench marks L265 (Peoria) and F265 (Camelback), listed in Table 1. Note that the subsidence rate for each bench mark increases until 1967, after which the rate for L265 accelerates, whereas the rate for F265 *decreases*. This graph illustrates that subsidence rates are not static.

THE TUCSON AREA

Within the Tucson metropolitan area, subsidence due to ground-water declines has begun (Strange, 1983). In some sections, the water table has been lowered by more than 100 feet, the magnitude at which subsidence can be expected to commence. The U.S. Geological Survey is conducting a study of aquifer compaction in the Tucson area. Survey geologists have installed seven compaction recorders in wells to detect subsidence in the upper 1,000 feet of the earth's surface. To date, the highest subsidence rate that has been measured is approximately 0.02 foot per year.

Results of NGS leveling through the area show a maximum subsidence of 0.4 foot, a measurement that was obtained by comparing the 1951 results with the 1980 results. This subsidence occurred at a bench mark between Davis Monthan Air Force Base and Interstate 10.

SUBSIDENCE RATES

As the above examples suggest, for the planning and design of civil-works projects, the subsidence rate is at least as important as the total amount of subsidence. Subsidence in Arizona is not static, but changes both in rate and locus. Continued subsidence, particularly at increasing rates, proves that the problem cannot be ignored. Until recently, subsidence was a phenomenon that lacked impact. As subsidence increases in developed areas, however, its importance will also increase.

As bench marks in subsiding areas are identified and subsidence rates are recorded, the dynamics of continuing movement are conveyed to users. By knowing locations, amounts, and rates of subsidence, users will have a rational basis for decisions to use or reject the use of subsiding bench marks.

Total subsidence and the subsidence rate are well illustrated by simply plotting subsidence against time at an appropriate scale (Figure 5).

A SUBSIDENCE-MONITORING PLAN

Spurred by the NGS leveling results in the Phoenix area and the realization that severe subsidence and earth fissures are occurring in Arizona, the Arizona Mapping Advisory Committee and its member agencies recognized the need for a statewide plan to monitor subsidence. At the request of Governor Bruce Babbitt, the National Geodetic Survey prepared the plan, which was completed in 1983 (Strange, 1983). The plan was the result of a comprehensive effort by the NGS and the interagency Ad Hoc Land-Subsidence Committee of the State. The committee, which was chaired by a representative of the Arizona Department of Water Resources, included members from State, Federal, and local government groups, universities, and private industry. Although the plan still lacks operational funds, copies are available for purchase from the NGS.

The NGS Global Positioning System (GPS), which utilizes satellites and geodetic receivers, was recommended in the subsidence plan. The system was recently tested to evaluate its possible use in Arizona. Numerous bench marks, subsiding as well as stable, were measured. Leveling to most of these bench marks to determine present elevations was done for comparison. If the GPS results yield elevations accurate to within 0.2 foot, as expected, this system may prove to be an efficient monitor of subsidence.

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NORTH MTN
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GLENDALE
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Papago AA
West End
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Avondale Farm Labor Supply Center
Tolleson
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SOUTHERN PACIFIC
Goodyear
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Cashion
Sky Harbor
Union School
Salt River
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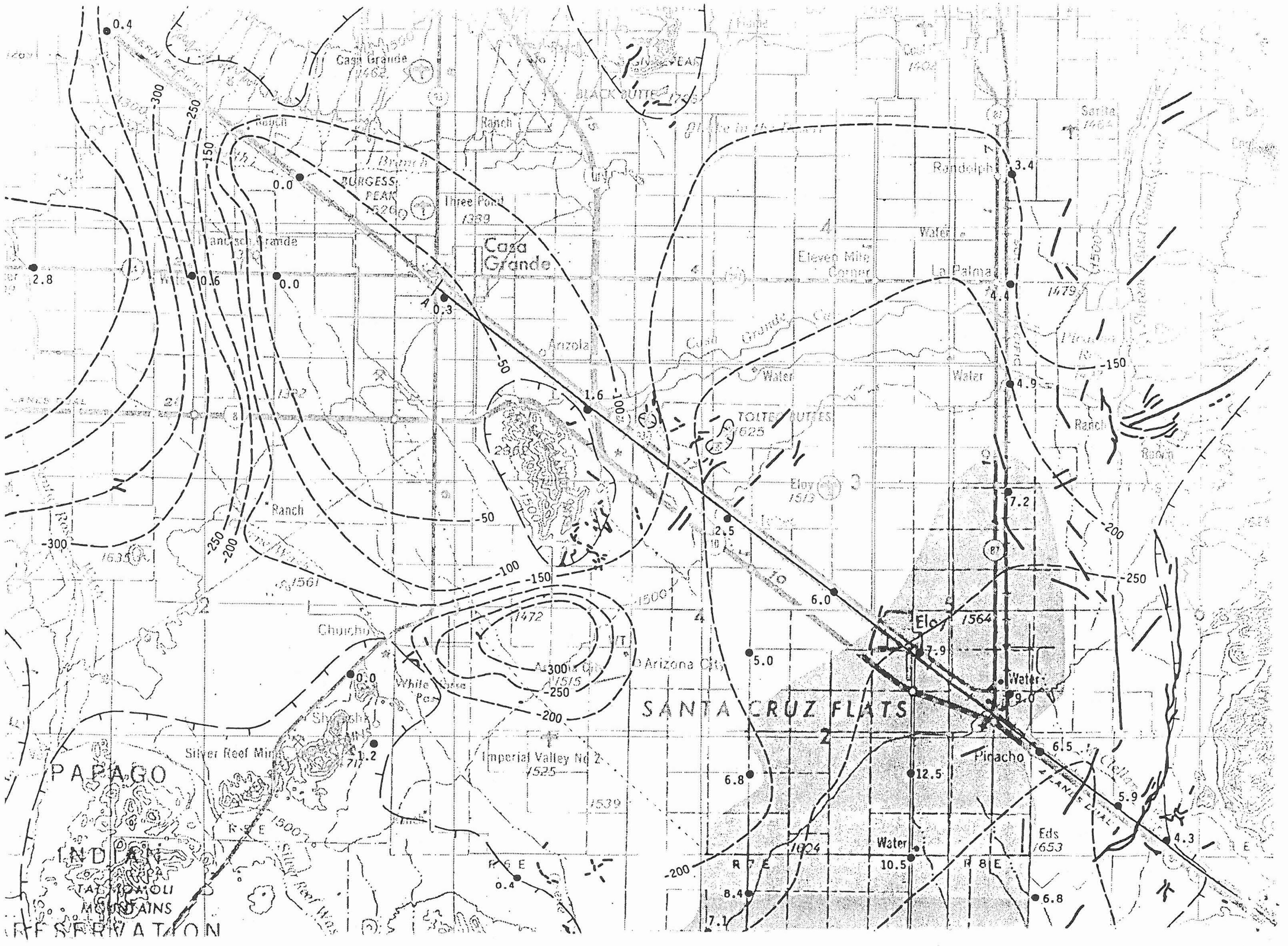
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EARTH FISSURES AND LAND SUBSIDEN

by Michael K. Larson and Troy L. Péwé

INTRODUCTION

Earth fissures—long, narrow, eroded tension cracks associated with land subsidence caused by ground-water withdrawal—have formed during the past 50 years in alluvial basins of southern and south-central Arizona (Leonard, 1929; Schumann, 1974; Laney, Raymond, and Winikka, C.W., 1978; Peirce, 1979; Jachens and Holzer, 1982). Until recently, the fissure hazard has been confined to outlying agricultural areas. In January 1980 a 400-foot-long fissure opened in Paradise Valley at a residential construction site of northeast Phoenix. This fissure is the first known occurrence in a densely populated, non-agricultural area of the state, and the first in the city of Phoenix.

Land subsidence and earth fissures pose serious problems for urban areas, with the potential for widespread damage to manmade structures. Well failure is a dramatic manifestation of subsidence as the casing collapses or the well head protrudes above the ground. Canals designed for gravity flow may overflow as a result of local sags and gradient reversals. Water and sewer mains that also depend on gravity flow may reverse flow or clog, and in extreme cases rupture, because of altered gradients. Subsidence may also necessitate new designs of storm drainage systems, and expensive, repeated levelings of benchmarks, resulting in obsolete surveying data. Fissures may directly damage buildings, roads, and other architectural structures. However, even without ground failure, differential subsidence in and of itself may cause damage to structures large in area or height.

Our recently completed study (Péwé and Larson, 1982) outlines in detail the problems of ground-water withdrawal, land subsidence, and earth fissuring in northeast Phoenix (Figure 1). The research consisted of a detailed gravity survey supplemented by geologic mapping, precise, repeated land surveying, and interpretation of well records. The city of Phoenix Engineering Department has provided logistical support, partial funding for the project, and has published the final report.

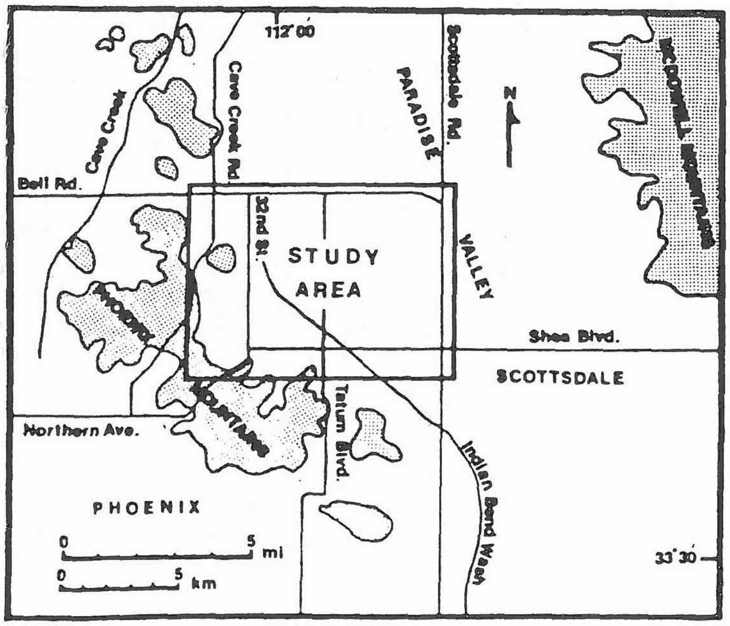

Figure 1. Map of Paradise Valley with study area outlined.

THE PHOENIX FISSURE

The fissure at 40th Street and Lupine Avenue opened 400 feet in an east-west direction, marked by hairline cracks, small open holes, and a linear opening 15 feet long, and as much as 8 feet deep and 15 inches wide (Figure 2). No vertical offset was observed; the fissure appeared to be an example of a tensional break. The crack appeared after locally heavy rains on the weekend of January 19, 1980. Such fissures have been commonly reported after rain showers or application of irrigation water, apparently because the cracks first open below the surface, only to be eroded later by downward percolation of the surface water. At the 40th Street construction site, the overlying soil cover had been scraped off, exposing the subterranean crack, and the collecting of rainwater in a retention basin eroded the large main cavity. The temporary halting of construction, modification of plans, hiring of consultants, and other expenses incurred as a result of the fissure are estimated by the owners of the subdivision to have cost them approximately $500,000.

HISTORY OF GROUNDWATER DEVELOPMENT AND LAND SUBSIDENCE

Water levels remained nearly constant in the study area prior to about 1950, generally within 250 feet of the surface. Increased pumpage in relatively unproductive aquifers has caused rapid water-level decline, particularly in two areas where ground-water has dropped more than 300 feet from its original level. These "cones of depression" are centered halfway between Greenway and Bell Roads at 44th Street and near 56th Street and Thunderbird Road. Withdrawals of ground water are many times the natural recharge rate, and this overdraft has resulted in depletion of thin aquifers peripheral to the mountains, and loss of supply to shallow wells. More wells will certainly become dry as pumping in the area continues.

Since the mid-50s, water levels have declined, resulting in current water depths of more than 500 feet. Subsidence apparently began about a decade later in the vicinity of 52nd Street and Thunderbird Road after water levels declined from 100 feet to 150 feet. Since 1970 the subsidence bowl has increased in size at an average rate of two square miles per year, with early expansion predominantly in a westerly direction, and more recent expansion toward the north and east.

As of March 1982, the maximum subsidence measured was 3.44 feet at 56th Street and Thunderbird Road (Figure 3), near the center of the southern cone of water-level depression. At the assumed center of the subsidence area (or subsidence "bowl") 0.5 miles to the southwest (Figure 3), there is indirect evidence from topographic and land survey data for as much as 5 feet of subsidence. Harmon (1982) noted that the subsidence rate has increased to the south, particularly at 56th Street and Cactus

:E HAZARDS IN NORTHEAST PHOENIX

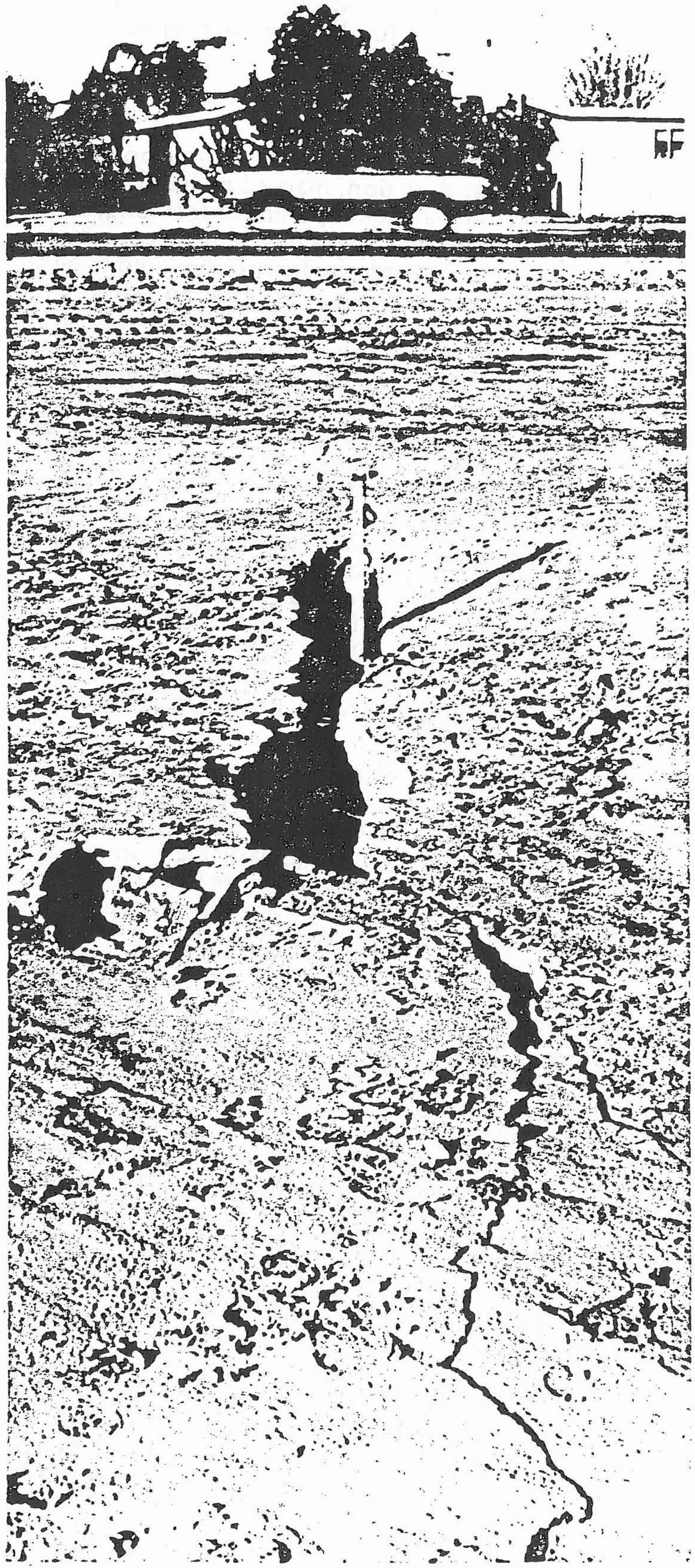

Figure 2. Earth crack in construction area at Lupine Avenue and 40th Street, Phoenix, Arizona. View is west toward 40th Street. Photo by Troy L. Péwé, No. 4484, January 27, 1980.

Road, and Tatum Boulevard and Cholla Street, where the ground is subsiding 4-5 inches per year. This occurrence may represent a southward shift in the center of the subsidence bowl.

The growth of the subsidence bowl suggests that it will expand farther, particularly toward the north and east; subsidence has been measured to the east in the city of Scottsdale. The extent of land subsidence to the south into the town of Paradise Valley, however, is not known. There is insuffecent data on compaction and material properties of the subsurface to fully evaluate the potential of future land subsidence in northeast Phoenix; however, given known thicknesses of alluvium and present subsidence rates near the center of the subsidence bowl, more than 9 feet of land subsidence is possible if this area is completely dewatered.

The apparent lack of significant subsidence near the northern cone of depression of water levels may be due to the slow draining of the 200-foot-thick clay layer. Greater subsidence in this area will probably occur as water level reach the base of the clay unit.

SUBSURFACE CONDITIONS

Well-drilling records and gravity data provide the basi for a depth to bedrock map (Figure 4). The map shows the relationship of past and potential land subsidence and earth fissuring to the buried bedrock topography.

The underground bedrock slopes gently toward the northeast from the Phoenix Mountains. The inner part of this area is buried less than 500 feet, and extends at least 2.5 miles into the Paradise Valley basin, with a series of hills and ridges with relief of 100-300 feet (Figure 4). The buried bedrock features follow the same NE-SW direction as the foliation and topographic expression in the adjacent Phoenix Mountains. One can visualize the buried bedrock topography as that which would exist if the present Papago Park (three miles SE of the Phoenix Mountains) were buried beneath 300-500 feet of silt, sand, and gravel.

Bordering the inner surface, is an outer, more deeply buried, low-relief topography, sloping gently northeastward at a depth of 500-1,000 feet. A major NW-SE basin and range fault separates this gently sloping surface from thick deposits of consolidated sediments.

The subsurface geologic conditions control patterns of water-level decline and land subsidence. Maximum subsidence and water-level decline have been on the deeper outer surface; whereas minimal subsidence and little or no water has been obtained from wells drilled on the shallow buried inner surface. Subsidence generally increases wherever the thickness of alluvium increases.

Gravity data indicate that a small bedrock hill underlies the fissure at a depth of about 150 feet, with at least 100 feet of relief (Figure 5C). Differential compaction induced by dewatering of sediments across this buried knoll was sufficient to cause ground failure. Continued differential subsidence has been measured (April 1981 to April 198 along 40th Street between Shea Boulevard and Cactus Road, with as much as 0.17 feet of subsidence south of the fissure (Figure 5B). The striking similarity between th-

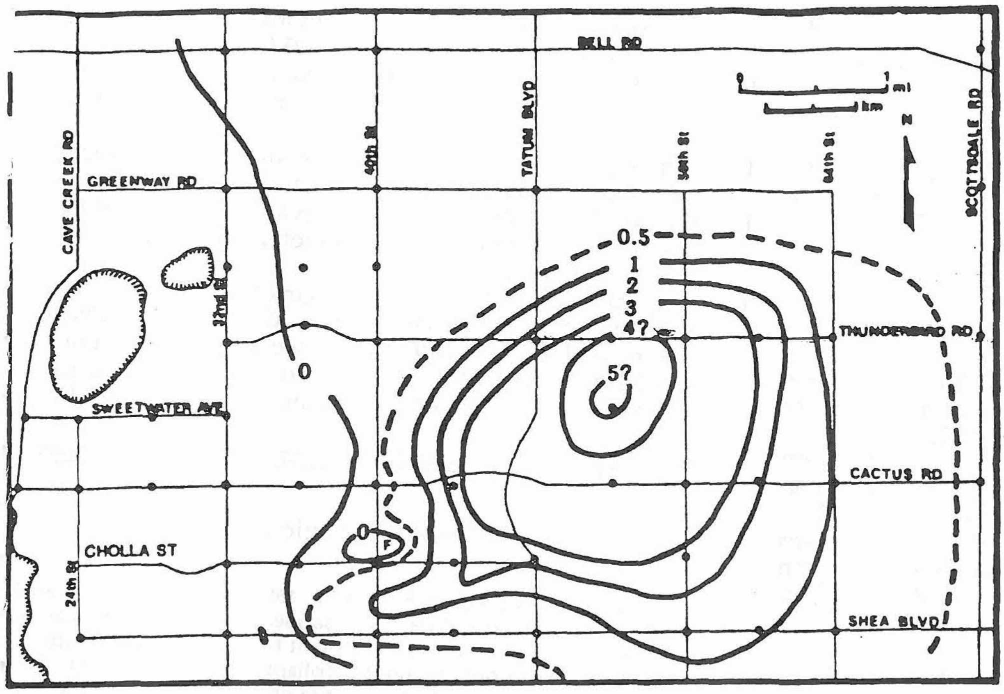

Figure 3. Land subsidence (in feet), northeast Phoenix from 1962-1982. "F" indicates location of fissure. Dots indicate locations of city benchmarks.

subsidence curve and an interpreted depth-to-bedrock profile along 40th Street supports the argument that fissuring is associated with the crests of buried hills. On the basis of the subsidence profile, theoretical calculations and computer modeling by Michael Larson (Figure 5A) and Dr. Donal Ragan at Arizona State University Department of Geology indicate that the stress in the sediments over the inferred buried hill was sufficient to crack the ground surface in 1980.

Measured differential subsidence and calculated horizontal strain strongly suggest a reopening of the entire fissure. Continued displacement is indicated by small cracks that have lengthened and become more numerous in the newly constructed paved road and concrete wall across the original fissure trace. On the basis of detailed gravity traverses, a future westward extension of the fissure is probable, with less than 600 feet of eastward extension possible. Several fissures subparallel to the original could form in the vicinity of 40th Street and Lupine Avenue.

The history of fissured basins in southern Arizona bears ample evidence that the initial fissure is later followed by complex patterns of multiple fissuring. In northeast Phoenix, future fissuring may be localized in three geological settings: 1) buried bedrock topographic highs, 2) at the hinge line of subsiding areas controlled by bedrock depth, and 3) buried fault scarps. Gravity data suggest there are several buried hills between 30th and 42nd Streets, with a high probability of fissuring, particularly near those hills directly north of the fissure (Figure 4). Another area of potential fissuring is near the hinge line of subsidence between Shea Boulevard and the Phoenix Mountains east of 34th Street. Differential subsidence and fissuring are also possible across an inferred buried basin and range fault scarp in the eastern part of the study area; however, because most water-level decline and land subsidence has occurred on the upthrown rather than the downthrown fault block, fissuring seems less likely in this area at the present time.

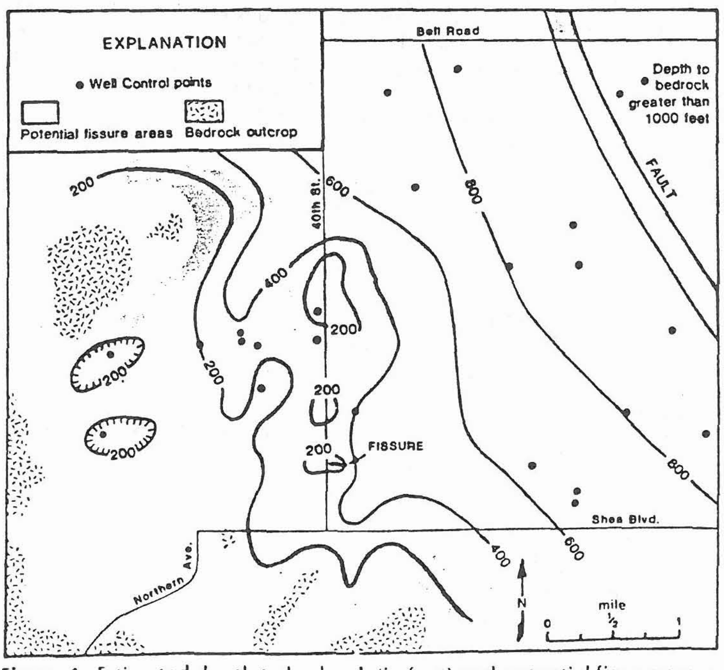

Figure 4. Estimated depth to bedrock (in feet) and potential fissure areas, northeast Phoenix. Contour interval 200 feet.

CONCLUSIONS

Studies such as that of the northeast Phoenix area permit a better understanding of earth fissures and land subsidence phenomena. Hydrogeological and geophysical methods are now available to delimit specific areas where there is a high potential for problems due to fissuring and land subsidence. Many of these methods have been applied to the northeast Phoenix study, but as land subsidence and water-level decline continue, ongoing monitoring is necessary in order to anticipate future problems.

Similar studies could prove timely elsewhere in south central Arizona, because of the widespread distribution of ground-water development in similar geologic settings. Cooperation of city, state, and federal governments and public education is essential if problems associated with water-level decline, land subsidence, and earth fissures are to be resolved.

For a copy of the report, make checks payable for $25.00 ($26.00 if mailed) to the City of Phoenix. Requests are taken by David Harmon, Assistant City Engineer, City of Phoenix Engineering Department, 125 East Washington St., Phoenix, AZ 85004.

CITED REFERENCES

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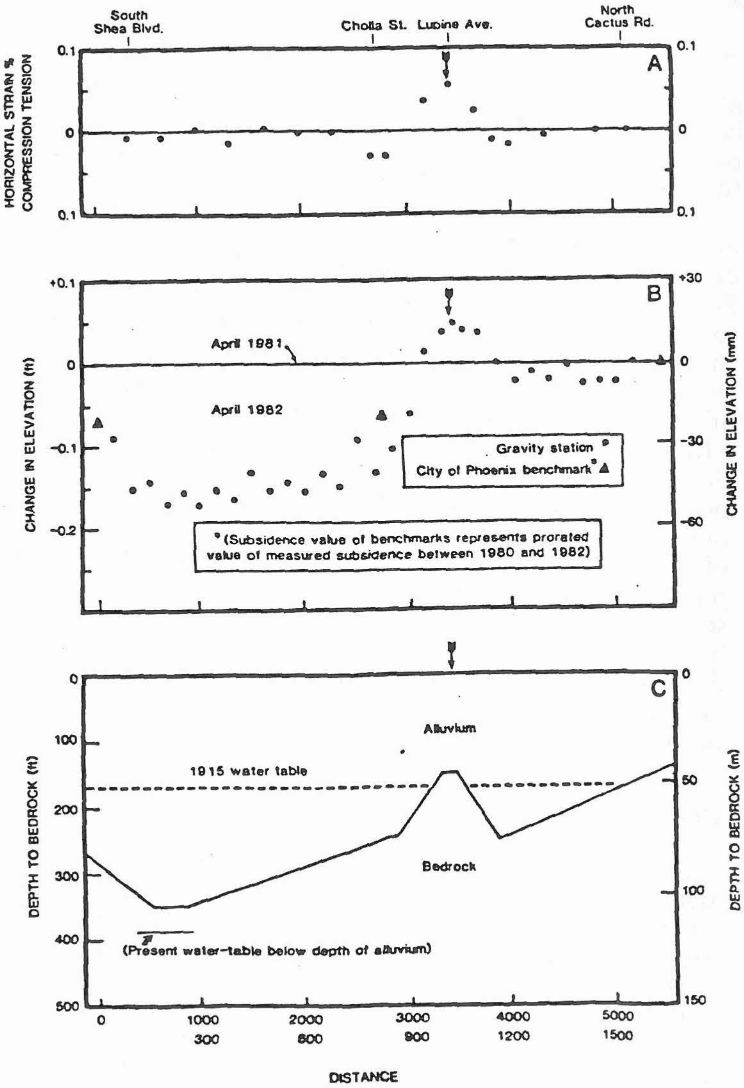


Figure 5. Surface strain, land subsidence, and depth to bedrock, 40th Street from Shea Boulevard to Cactus Road.

5A. Computed horizontal surface strain (1980) at time of fissuring.

5B. Land subsidence from April 1981 to April 1982.

5C. Interpreted depth to bedrock based on gravity data.

KRAKATAU—A Geologic Cataclysm

One hundred years ago, on August 27, 1883, the island of Krakatau exploded; then, after several days, it disappeared into the Sunda Strait near Java and Sumatra. A volcano, dormant for 203 years, had erupted, causing the two-mile-long island to collapse into the sea. All that remained after the explosion was a caldera or basin, five miles wide and more than 700 feet deep.

The volcanic blast, equal to 100-150 megatons of explosives, was heard 3,000 miles away. Seismic waves traveled several times around the earth in both directions. Four cubic miles of ash and pumice was spewed into the atmosphere (about 60 times the ejecta produced by Mount St. Helens during the early 1980s). Two islands adjacent to Krakatau were covered by 45 feet of ash and pumice, then overlain by 180 feet of lava. The heavier fallout ash blanketed 180,000 square miles; the airborne ash drifted in the stratosphere for many months, causing vivid sky scapes around the world. A sulfate/dust layer remained in the atmosphere for over five years, combining with ozone and precipitation to create a 'greenhouse' effect. As a result, a portion of solar heat was prevented from reaching the surface of the earth, and lower average surface temperatures occurred.

Loss of life from the eruption and the accompanying tsunami (the great sea wave that destroyed 300 villages and thousands of ships) is estimated to have been between 36,000 and 100,000 people.

Just as the mythical Phoenix arose from its own ashes, Anak Krakatau (child of Krakatau) first emerged as a new cone in 1927, and has since produced 30 small eruptions. Anak Krakatau is one of 500 known active volcanoes in the world today. Three of the six worst volcanic disasters in the world since the beginning of the 16th century have occurred in Indonesia (Kelut in 1586, Tambora in 1815, and Krakatau in 1883). In order of the most active volcanic history, Indonesia ranks first, Japan, second, and the United States, third.

ANNOUNCEMENT

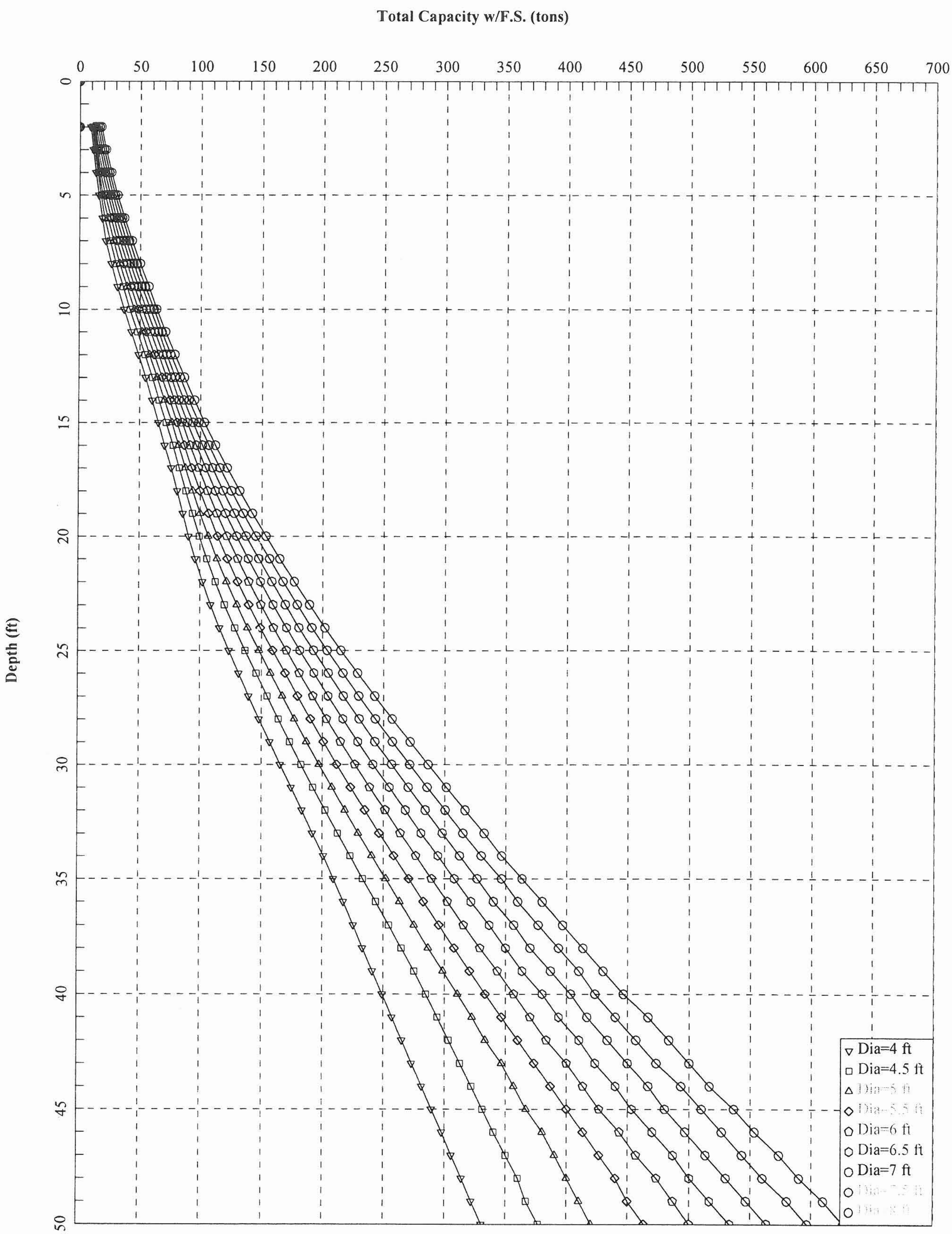
Daniel N. Miller, Jr., resigned from his position as Assistant Secretary for Energy and Minerals at the Department of the Interior at the end of May 1983. He had occupied that position since May 1981.

In his capacity as Assistant Secretary, Miller headed up the U.S. Geological Survey, the U.S. Bureau of Mines, the Office of Surface Mining, and most recently, the Mineral Management Service.

Prior to joining Secretary Watt's team, Miller served 12 years as State Geologist of Wyoming and Director of the Wyoming Geological Survey. He also spent 11 years as Senior Exploration Geologist in the petroleum industry.

Miller will reside in Coeur d'Alene, Idaho, where he will establish a consulting service.

YUMA ROAD



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Depth (ft)
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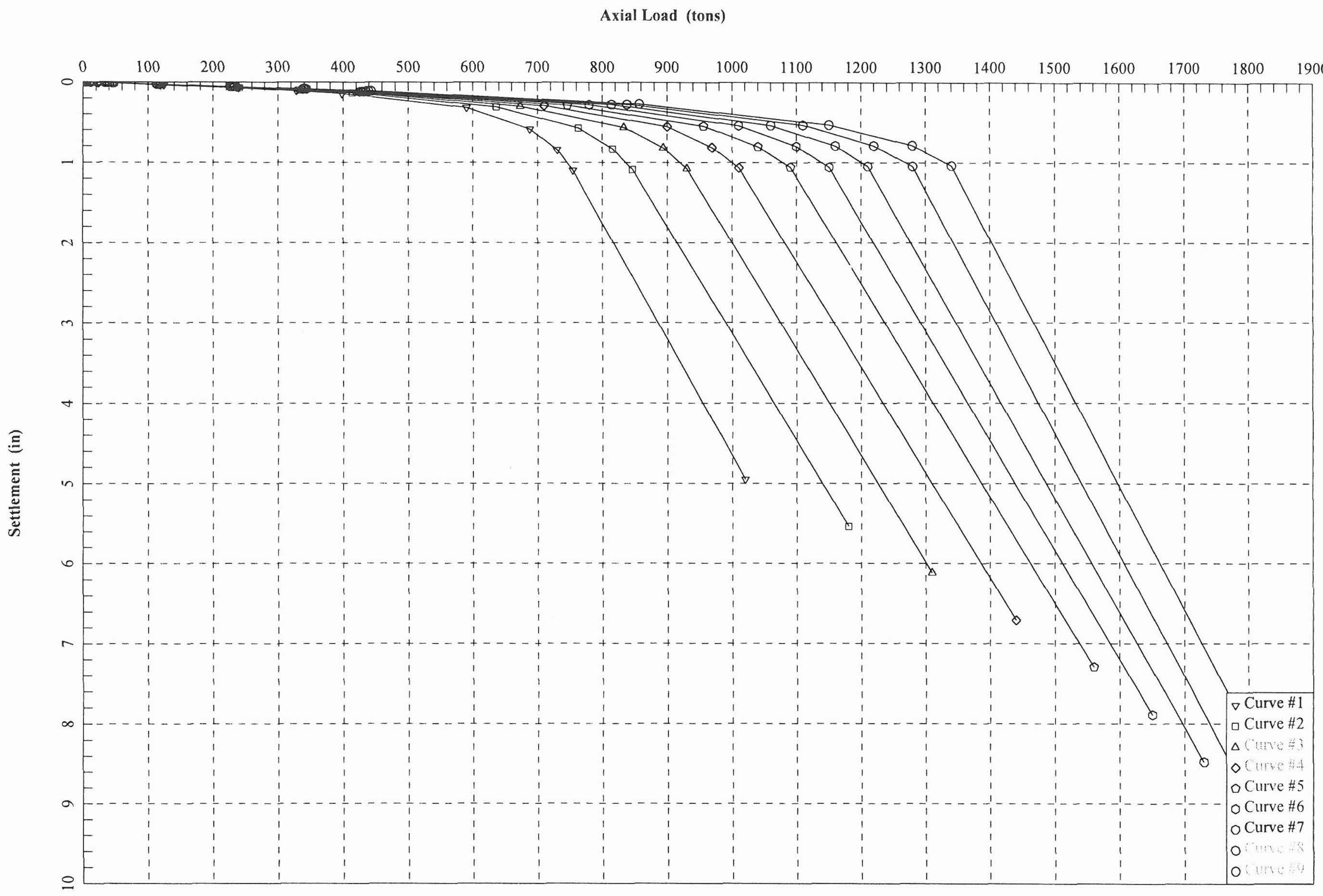
Dia=4 ft
Dia=4.5 ft
Dia=6 ft
Dia=6.5 ft
Dia=7 ft

Yuma Street


Axial Load (tons)
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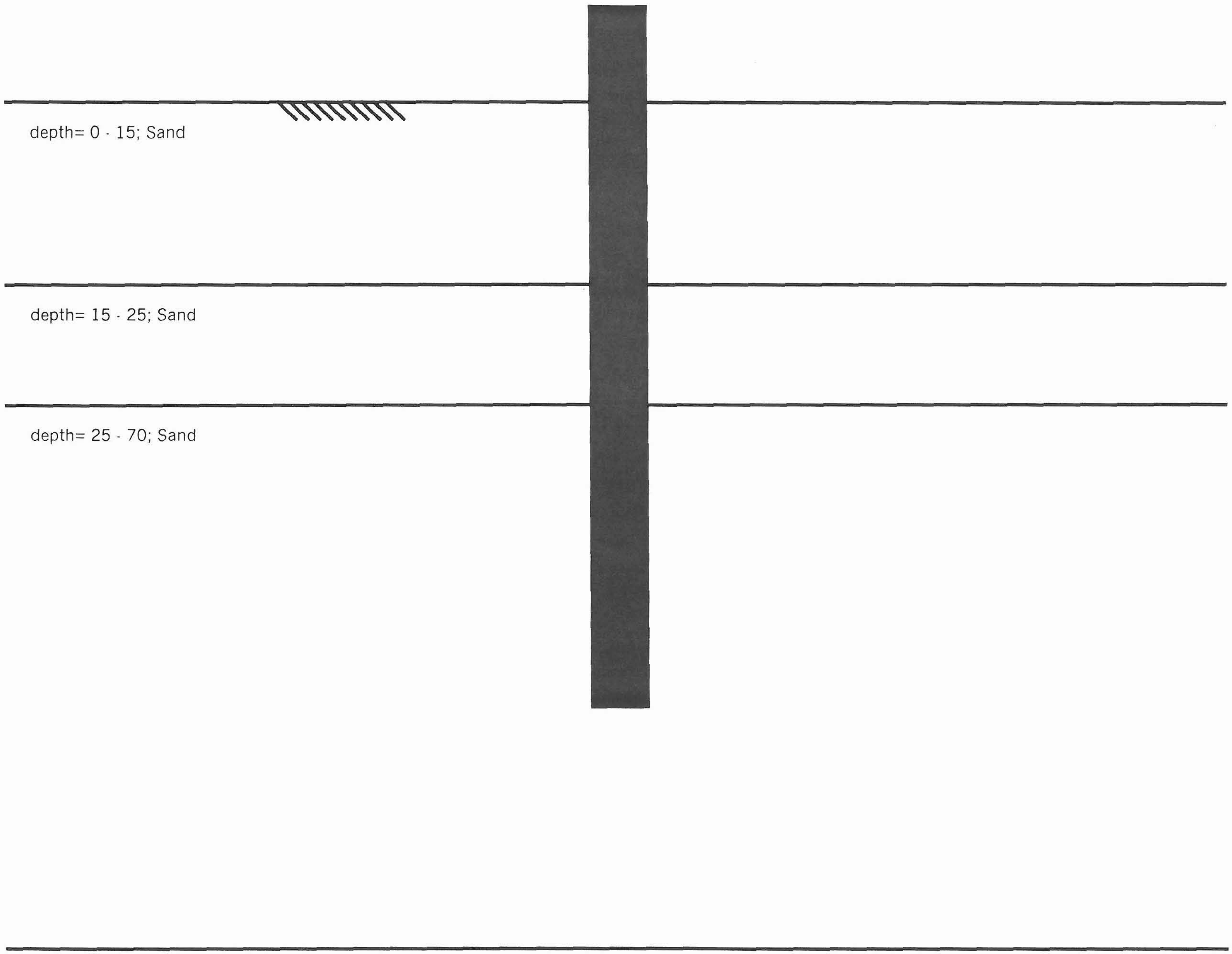
100
200
300
400
500
600
700
800
900
1000
1100
1200
1300
1400
1500
1600
1700
1800
1900
Settlement (in)
0
1
2
3
4
5
6
7
8
9
10
Curve #1
Curve #2
Curve #3
Curve #4
Curve #5
Curve #6
Curve #7
Curve #8
Curve #9

Yuma Street


depth= 0 - 15; Sand
depth= 15 - 25; Sand
depth= 25 - 70; Sand

VERTICALLY LOADED DRILLED SHAFT ANALYSIS PROGRAM SHAFT
VERSION 4.0 (C) COPYRIGHT ENSOFT,INC. 1989,1993,1995,1998,2001

Bullard Wash Phase II - Yuma Street

PROPOSED DEPTH = 50.0 FT

NUMBER OF LAYERS = 3

WATER TABLE DEPTH = 55.0 FT.

FACTOR OF SAFETY APPLIED TO THE TOTAL ULTIMATE CAPACITY = 3.0
0

FACTOR OF SAFETY APPLIED TO THE ULTIMATE BASE CAPACITY = 3.00

SOIL INFORMATION

LAYER NO 1----SAND

AT THE TOP

SKIN FRICTION COEFFICIENT- BETA = .120E+
01
UNDRAINED SHEAR STRENGTH, LB/SQ FT = .000E+
00
INTERNAL FRICTION ANGLE, DEG. = .340E+
02
BLOWS PER FOOT FROM STANDARD PENETRATION TEST = .000E+
00
SOIL UNIT WEIGHT, LB/CU FT = .115E+
03
MAXIMUM LOAD TRANSFER FOR SOIL, LB/SQ FT = .400E+
04
DEPTH, FT = .000E+

00

AT THE BOTTOM

SKIN FRICTION COEFFICIENT- BETA = .977E+
00
UNDRAINED SHEAR STRENGTH, LB/SQ FT = .000E+
00
INTERNAL FRICTION ANGLE, DEG. = .340E+
02
BLOWS PER FOOT FROM STANDARD PENETRATION TEST = .000E+
00
SOIL UNIT WEIGHT, LB/CU FT = .115E+
03
MAXIMUM LOAD TRANSFER FOR SOIL, LB/SQ FT = .400E+
04
DEPTH, FT = .150E+
02

LAYER NO 2----SAND

AT THE TOP

SKIN FRICTION COEFFICIENT- BETA = .977E+
00
UNDRAINED SHEAR STRENGTH, LB/SQ FT = .000E+
00
INTERNAL FRICTION ANGLE, DEG. = .360E+
02
BLOWS PER FOOT FROM STANDARD PENETRATION TEST = .000E+
00
SOIL UNIT WEIGHT, LB/CU FT = .118E+
03
MAXIMUM LOAD TRANSFER FOR SOIL, LB/SQ FT = .400E+
04
DEPTH, FT = .150E+
02

AT THE BOTTOM

SKIN FRICTION COEFFICIENT- BETA = .825E+
00
UNDRAINED SHEAR STRENGTH, LB/SQ FT = .000E+
00
INTERNAL FRICTION ANGLE, DEG. = .360E+

02
BLOWS PER FOOT FROM STANDARD PENETRATION TEST = .000E+
00
SOIL UNIT WEIGHT, LB/CU FT = .118E+
03
MAXIMUM LOAD TRANSFER FOR SOIL, LB/SQ FT = .400E+
04
DEPTH, FT = .250E+
02

LAYER NO 3----SAND

AT THE TOP

SKIN FRICTION COEFFICIENT- BETA = .825E+
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UNDRAINED SHEAR STRENGTH, LB/SQ FT = .000E+
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INTERNAL FRICTION ANGLE, DEG. = .000E+
00
BLOWS PER FOOT FROM STANDARD PENETRATION TEST = .220E+
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SOIL UNIT WEIGHT, LB/CU FT = .118E+
03
MAXIMUM LOAD TRANSFER FOR SOIL, LB/SQ FT = .400E+
04
DEPTH, FT = .250E+
02

AT THE BOTTOM

SKIN FRICTION COEFFICIENT- BETA = .371E+
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UNDRAINED SHEAR STRENGTH, LB/SQ FT = .000E+
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INTERNAL FRICTION ANGLE, DEG. = .000E+
00
BLOWS PER FOOT FROM STANDARD PENETRATION TEST = .500E+
02
SOIL UNIT WEIGHT, LB/CU FT = .118E+
03
MAXIMUM LOAD TRANSFER FOR SOIL, LB/SQ FT = .400E+
04
DEPTH, FT = .700E+
02

DRILLED SHAFT INFORMATION

DIAMETER OF STEM	=	4.000	FT.
DIAMETER OF BASE	=	4.000	FT.
END OF STEM TO BASE	=	.000	FT.
ANGLE OF BELL	=	.000	DEG.
IGNORED TOP PORTION	=	.000	FT.
IGNORED BOTTOM PORTION	=	.000	FT.
AREA OF ONE PERCENT STEEL	=	18.098	SQ.IN.
ELASTIC MODULUS, Ec	=	.350E+07	LB/SQ IN
VOLUME OF UNDERREAM	=	.000	CU.YDS.

PREDICTED RESULTS

QS = ULTIMATE SIDE RESISTANCE;
QB = ULTIMATE BASE RESISTANCE;
WT = WEIGHT OF DRILLED SHAFT (FOR UPLIFT CAPACITY ONLY);
QU = TOTAL ULTIMATE RESISTANCE;
QBD = TOTAL ALLOWABLE LOAD USING A FACTOR OF SAFETY APPLIED TO THE ULTIMATE BASE RESISTANCE;
QDN = TOTAL ALLOWABLE LOAD USING FACTORS OF SAFETY APPLIED TO THE ULTIMATE SIDE RESISTANCE AND THE ULTIMATE BASE RESISTANCE.

LENGTH (FEET)	VOLUME (CU.YDS)	QS (TONS)	QB (TONS)	QU (TONS)	QBD (TONS)	QDN (TONS)	QU/VOLUME (TONS/CU.YDS)
1.0	.47	.87	21.68	22.54	8.09	7.51	48.43
2.0	.93	2.60	25.03	27.63	10.94	9.21	29.68
3.0	1.40	5.20	28.38	33.58	14.66	11.19	24.05
4.0	1.86	8.67	31.73	40.40	19.25	13.47	21.70
5.0	2.33	13.00	35.08	48.08	24.70	16.03	20.66
6.0	2.79	18.07	38.43	56.51	30.88	18.84	20.23

7.0	3.26	23.85	41.79	65.64	37.78	21.88	20.14
8.0	3.72	30.32	49.16	79.48	46.70	26.49	21.34
9.0	4.19	37.44	57.23	94.67	56.52	31.56	22.60
10.0	4.65	45.19	66.03	111.23	67.20	37.08	23.89
11.0	5.12	53.56	75.59	129.14	78.75	43.05	25.22
12.0	5.59	62.51	84.13	146.64	90.55	48.88	26.25
13.0	6.05	72.03	91.59	163.62	102.56	54.54	27.04
14.0	6.52	82.09	97.88	179.97	114.72	59.99	27.62
15.0	6.98	92.69	102.90	195.59	126.99	65.20	28.01
16.0	7.45	103.81	107.93	211.74	139.78	70.58	28.43
17.0	7.91	115.43	112.96	228.39	153.08	76.13	28.86
18.0	8.38	127.54	115.01	242.55	165.88	80.85	28.95
19.0	8.84	140.13	117.09	257.22	179.16	85.74	29.08
20.0	9.31	153.17	119.28	272.45	192.93	90.82	29.27
21.0	9.78	166.64	121.65	288.29	207.19	96.10	29.49
22.0	10.24	180.54	125.61	306.15	222.41	102.05	29.90
23.0	10.71	194.84	131.09	325.93	238.53	108.64	30.44
24.0	11.17	209.52	138.00	347.52	255.52	115.84	31.11
25.0	11.64	224.58	146.25	370.83	273.33	123.61	31.87
26.0	12.10	240.00	154.72	394.73	291.58	131.58	32.62
27.0	12.57	255.76	163.44	419.20	310.24	139.73	33.35
28.0	13.03	271.85	172.39	444.24	329.32	148.08	34.08
29.0	13.50	288.26	181.57	469.83	348.78	156.61	34.80
30.0	13.96	304.96	190.99	495.95	368.63	165.32	35.52

31.0	14.43	321.95	200.64	522.60	388.83	174.20	36.22
32.0	14.90	339.22	210.53	549.75	409.39	183.25	36.91
33.0	15.36	356.74	219.75	576.49	429.99	192.16	37.53
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37.0	17.22	429.17	247.56	676.73	511.69	225.58	39.29
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39.0	18.15	466.61	257.24	723.84	552.35	241.28	39.87
40.0	18.62	485.59	261.93	747.52	572.90	249.17	40.15
41.0	19.08	504.74	266.62	771.36	593.61	257.12	40.42
42.0	19.55	524.03	271.31	795.34	614.46	265.11	40.68
43.0	20.02	543.45	276.00	819.46	635.45	273.15	40.94
44.0	20.48	563.01	280.70	843.70	656.57	281.23	41.19
45.0	20.95	582.67	285.39	868.06	677.80	289.35	41.44
46.0	21.41	602.44	290.08	892.52	699.13	297.51	41.68
47.0	21.88	622.30	294.77	917.07	720.56	305.69	41.92
48.0	22.34	642.24	299.46	941.70	742.06	313.90	42.15
49.0	22.81	662.25	304.16	966.40	763.63	322.13	42.37
50.0	23.27	682.31	308.85	991.16	785.26	330.39	42.59

TOP LOAD	TOP MOVEMENT	TIP LOAD	TIP MOVEMENT
ton	IN.	ton	IN.
.4958E+00	.1561E-03	.2252E-01	.1000E-03
.4958E+01	.1561E-02	.2252E+00	.1000E-02

.1240E+02	.3903E-02	.5630E+00	.2500E-02
.2479E+02	.7807E-02	.1126E+01	.5000E-02
.3719E+02	.1171E-01	.1689E+01	.7500E-02
.4958E+02	.1561E-01	.2252E+01	.1000E-01
.1243E+03	.3906E-01	.5630E+01	.2500E-01
.2387E+03	.7733E-01	.1126E+02	.5000E-01
.3280E+03	.1127E+00	.1689E+02	.7500E-01
.3979E+03	.1464E+00	.2252E+02	.1000E+00
.5901E+03	.3214E+00	.5624E+02	.2500E+00
.6875E+03	.5870E+00	.1102E+03	.5000E+00
.7297E+03	.8450E+00	.1528E+03	.7500E+00
.7542E+03	.1100E+01	.1777E+03	.1000E+01
.1022E+04	.4951E+01	.4509E+03	.4800E+01

DRILLED SHAFT INFORMATION

DIAMETER OF STEM	=	4.500	FT.
DIAMETER OF BASE	=	4.500	FT.
END OF STEM TO BASE	=	.000	FT.
ANGLE OF BELL	=	.000	DEG.
IGNORED TOP PORTION	=	.000	FT.
IGNORED BOTTOM PORTION	=	.000	FT.
AREA OF ONE PERCENT STEEL	=	22.905	SQ.IN.
ELASTIC MODULUS, Ec	=	.350E+07	LB/SQ IN
VOLUME OF UNDERREAM	=	.000	CU.YDS.

PREDICTED RESULTS

QS = ULTIMATE SIDE RESISTANCE;
QB = ULTIMATE BASE RESISTANCE;
WT = WEIGHT OF DRILLED SHAFT (FOR UPLIFT CAPACITY ONLY);
QU = TOTAL ULTIMATE RESISTANCE;
QBD = TOTAL ALLOWABLE LOAD USING A FACTOR OF SAFETY APPLIED TO THE ULTIMATE BASE RESISTANCE;
QDN = TOTAL ALLOWABLE LOAD USING FACTORS OF SAFETY APPLIED TO THE ULTIMATE SIDE RESISTANCE AND THE ULTIMATE BASE RESISTANCE.

LENGTH (FEET)	VOLUME (CU.YDS)	QS (TONS)	QB (TONS)	QU (TONS)	QBD (TONS)	QDN (TONS)	QU/VOLUME (TONS/CU.YDS)

1.0	.59	.98	24.62	25.60	9.18	8.53	43.45
2.0	1.18	2.93	28.12	31.04	12.30	10.35	26.35
3.0	1.77	5.85	31.61	37.46	16.39	12.49	21.20
4.0	2.36	9.76	35.10	44.86	21.46	14.95	19.03
5.0	2.95	14.63	38.59	53.22	27.49	17.74	18.07
6.0	3.53	20.33	42.08	62.41	34.36	20.80	17.66
7.0	4.12	26.83	49.25	76.08	43.25	25.36	18.45
8.0	4.71	34.11	57.01	91.12	53.11	30.37	19.33
9.0	5.30	42.12	65.40	107.52	63.92	35.84	20.28
10.0	5.89	50.84	74.43	125.27	75.65	41.76	21.26
11.0	6.48	60.25	83.38	143.64	88.05	47.88	22.16
12.0	7.07	70.32	91.52	161.84	100.83	53.95	22.89
13.0	7.66	81.03	98.75	179.78	113.95	59.93	23.47
14.0	8.25	92.36	105.02	197.38	127.36	65.79	23.93
15.0	8.84	104.27	110.26	214.53	141.03	71.51	24.28
16.0	9.43	116.78	115.50	232.28	155.28	77.43	24.64
17.0	10.02	129.86	118.01	247.87	169.20	82.62	24.75
18.0	10.60	143.49	120.59	264.08	183.68	88.03	24.90
19.0	11.19	157.65	123.29	280.93	198.74	93.64	25.10
20.0	11.78	172.31	126.18	298.49	214.37	99.50	25.33
21.0	12.37	187.47	129.87	317.35	230.76	105.78	25.65
22.0	12.96	203.10	134.93	338.03	248.08	112.68	26.08
23.0	13.55	219.19	141.28	360.47	266.29	120.16	26.60
24.0	14.14	235.71	148.86	384.58	285.34	128.19	27.20

25.0	14.73	252.66	157.60	410.25	305.19	136.75	27.86
26.0	15.32	270.00	166.57	436.58	325.53	145.53	28.50
27.0	15.91	287.73	175.79	463.53	346.33	154.51	29.14
28.0	16.50	305.84	185.26	491.09	367.59	163.70	29.77
29.0	17.08	324.29	194.97	519.26	389.28	173.09	30.39
30.0	17.67	343.08	204.92	548.00	411.39	182.67	31.01
31.0	18.26	362.20	215.12	577.32	433.90	192.44	31.61
32.0	18.85	381.62	225.56	607.18	456.81	202.39	32.21
33.0	19.44	401.33	236.25	637.58	480.08	212.53	32.80
34.0	20.03	421.32	247.18	668.50	503.72	222.83	33.37
35.0	20.62	441.58	258.36	699.93	527.69	233.31	33.95
36.0	21.21	462.08	269.78	731.85	552.00	243.95	34.51
37.0	21.80	482.81	280.53	763.35	576.33	254.45	35.02
38.0	22.39	503.77	290.51	794.28	600.61	264.76	35.48
39.0	22.98	524.93	299.57	824.51	624.79	274.84	35.89
40.0	23.57	546.29	307.60	853.89	648.82	284.63	36.24
41.0	24.15	567.83	314.63	882.46	672.70	294.15	36.53
42.0	24.74	589.53	320.90	910.43	696.50	303.48	36.80
43.0	25.33	611.39	326.66	938.05	720.27	312.68	37.03
44.0	25.92	633.38	332.16	965.54	744.10	321.85	37.25
45.0	26.51	655.51	337.66	993.17	768.06	331.06	37.46
46.0	27.10	677.74	343.16	1020.90	792.13	340.30	37.67
47.0	27.69	700.09	348.66	1048.74	816.30	349.58	37.88
48.0	28.28	722.52	354.16	1076.67	840.57	358.89	38.07

49.0	28.87	745.03	359.66	1104.68	864.91	368.23	38.27
50.0	29.46	767.60	365.15	1132.76	889.32	377.59	38.46

TOP LOAD	TOP MOVEMENT	TIP LOAD	TIP MOVEMENT
ton	IN.	ton	IN.
.4856E+00	.1439E-03	.2367E-01	.1000E-03
.4856E+01	.1439E-02	.2367E+00	.1000E-02
.1214E+02	.3597E-02	.5917E+00	.2500E-02
.2428E+02	.7195E-02	.1183E+01	.5000E-02
.3642E+02	.1079E-01	.1775E+01	.7500E-02
.4856E+02	.1439E-01	.2367E+01	.1000E-01
.1217E+03	.3599E-01	.5917E+01	.2500E-01
.2406E+03	.7187E-01	.1183E+02	.5000E-01
.3311E+03	.1053E+00	.1775E+02	.7500E-01
.4143E+03	.1382E+00	.2367E+02	.1000E+00
.6355E+03	.3106E+00	.5917E+02	.2500E+00
.7631E+03	.5759E+00	.1168E+03	.5000E+00
.8161E+03	.8337E+00	.1657E+03	.7500E+00
.8457E+03	.1088E+01	.1970E+03	.1000E+01
.1175E+04	.5538E+01	.5331E+03	.5400E+01

DRILLED SHAFT INFORMATION

DIAMETER OF STEM	=	5.000	FT.
DIAMETER OF BASE	=	5.000	FT.
END OF STEM TO BASE	=	.000	FT.
ANGLE OF BELL	=	.000	DEG.
IGNORED TOP PORTION	=	.000	FT.
IGNORED BOTTOM PORTION	=	.000	FT.
AREA OF ONE PERCENT STEEL	=	28.278	SQ.IN.
ELASTIC MODULUS, Ec	=	.350E+07	LB/SQ IN
VOLUME OF UNDERREAM	=	.000	CU.YDS.

PREDICTED RESULTS

QS = ULTIMATE SIDE RESISTANCE;
QB = ULTIMATE BASE RESISTANCE;

WT = WEIGHT OF DRILLED SHAFT (FOR UPLIFT CAPACITY ONLY);
QU = TOTAL ULTIMATE RESISTANCE;
QBD = TOTAL ALLOWABLE LOAD USING A FACTOR OF SAFETY APPLIED TO THE ULTIMATE BASE RESISTANCE;
QDN = TOTAL ALLOWABLE LOAD USING FACTORS OF SAFETY APPLIED TO THE ULTIMATE SIDE RESISTANCE AND THE ULTIMATE BASE RESISTANCE.

LENGTH (FEET)	VOLUME (CU.YDS)	QS (TONS)	QB (TONS)	QU (TONS)	QBD (TONS)	QDN (TONS)	QU/VOLUME (TONS/CU.YDS)
1.0	.73	1.08	26.65	27.73	9.97	9.24	38.13
2.0	1.45	3.25	30.14	33.39	13.30	11.13	22.95
3.0	2.18	6.50	33.63	40.13	17.71	13.38	18.39
4.0	2.91	10.84	37.12	47.96	23.21	15.99	16.49
5.0	3.64	16.25	40.61	56.86	29.79	18.95	15.64
6.0	4.36	22.59	47.34	69.93	38.37	23.31	16.02
7.0	5.09	29.82	54.56	84.38	48.00	28.13	16.57
8.0	5.82	37.90	62.30	100.19	58.66	33.40	17.22
9.0	6.55	46.80	70.57	117.36	70.32	39.12	17.93
10.0	7.27	56.49	79.39	135.88	82.95	45.29	18.68
11.0	8.00	66.95	87.60	154.55	96.15	51.52	19.32
12.0	8.73	78.14	95.15	173.29	109.86	57.76	19.86
13.0	9.46	90.04	101.99	192.03	124.03	64.01	20.31
14.0	10.18	102.62	108.05	210.67	138.64	70.22	20.69
15.0	10.91	115.86	113.29	229.15	153.62	76.38	21.00
16.0	11.64	129.76	116.14	245.89	168.47	81.96	21.13
17.0	12.36	144.29	119.05	263.34	183.97	87.78	21.30
18.0	13.09	159.43	122.10	281.53	200.13	93.84	21.50

19.0	13.82	175.16	125.32	300.49	216.94	100.16	21.74
20.0	14.55	191.46	128.80	320.26	234.39	106.75	22.02
21.0	15.27	208.30	133.45	341.75	252.78	113.92	22.38
22.0	16.00	225.67	139.23	364.90	272.08	121.63	22.81
23.0	16.73	243.55	146.10	389.65	292.25	129.88	23.29
24.0	17.46	261.91	154.01	415.91	313.24	138.64	23.83
25.0	18.18	280.73	162.88	443.61	335.02	147.87	24.40
26.0	18.91	300.00	172.00	472.00	357.34	157.33	24.96
27.0	19.64	319.71	181.36	501.07	380.16	167.02	25.52
28.0	20.36	339.82	190.97	530.79	403.47	176.93	26.06
29.0	21.09	360.32	200.82	561.14	427.26	187.05	26.60
30.0	21.82	381.20	210.91	592.12	451.51	197.37	27.14
31.0	22.55	402.44	221.25	623.69	476.19	207.90	27.66
32.0	23.27	424.02	231.84	655.86	501.30	218.62	28.18
33.0	24.00	445.92	242.67	688.59	526.81	229.53	28.69
34.0	24.73	468.14	253.74	721.88	552.72	240.63	29.19
35.0	25.46	490.64	265.06	755.70	578.99	251.90	29.69
36.0	26.18	513.42	276.62	790.04	605.63	263.35	30.17
37.0	26.91	536.46	288.42	824.88	632.60	274.96	30.65
38.0	27.64	559.75	300.47	860.22	659.90	286.74	31.12
39.0	28.37	583.26	312.77	896.03	687.52	298.68	31.59
40.0	29.09	606.99	325.31	932.30	715.43	310.77	32.05
41.0	29.82	630.92	337.22	968.14	743.33	322.71	32.47
42.0	30.55	655.03	348.41	1003.44	771.17	334.48	32.85

43.0	31.27	679.32	358.75	1038.07	798.90	346.02	33.19
44.0	32.00	703.76	368.14	1071.90	826.47	357.30	33.49
45.0	32.73	728.34	376.46	1104.80	853.83	368.27	33.76
46.0	33.46	753.05	383.92	1136.97	881.02	378.99	33.98
47.0	34.18	777.87	390.71	1168.58	908.11	389.53	34.19
48.0	34.91	802.80	397.04	1199.84	935.14	399.95	34.37
49.0	35.64	827.81	403.15	1230.96	962.19	410.32	34.54
50.0	36.37	852.89	409.26	1262.15	989.31	420.72	34.71

TOP LOAD	TOP MOVEMENT	TIP LOAD	TIP MOVEMENT
ton	IN.	ton	IN.
.4776E+00	.1352E-03	.2387E-01	.1000E-03
.4776E+01	.1352E-02	.2387E+00	.1000E-02
.1194E+02	.3380E-02	.5968E+00	.2500E-02
.2388E+02	.6760E-02	.1194E+01	.5000E-02
.3582E+02	.1014E-01	.1791E+01	.7500E-02
.4776E+02	.1352E-01	.2387E+01	.1000E-01
.1196E+03	.3381E-01	.5968E+01	.2500E-01
.2390E+03	.6762E-01	.1194E+02	.5000E-01
.3340E+03	.9984E-01	.1791E+02	.7500E-01
.4212E+03	.1314E+00	.2387E+02	.1000E+00
.6734E+03	.3019E+00	.5968E+02	.2500E+00
.8333E+03	.5667E+00	.1180E+03	.5000E+00
.8939E+03	.8237E+00	.1698E+03	.7500E+00
.9300E+03	.1078E+01	.2091E+03	.1000E+01
.1311E+04	.6125E+01	.5975E+03	.6000E+01

DRILLED SHAFT INFORMATION

DIAMETER OF STEM	=	5.500	FT.
DIAMETER OF BASE	=	5.500	FT.
END OF STEM TO BASE	=	.000	FT.
ANGLE OF BELL	=	.000	DEG.
IGNORED TOP PORTION	=	.000	FT.
IGNORED BOTTOM PORTION	=	.000	FT.

AREA OF ONE PERCENT STEEL = 34.216 SQ.IN.
ELASTIC MODULUS, Ec = .350E+07 LB/SQ IN
VOLUME OF UNDERREAM = .000 CU.YDS.

PREDICTED RESULTS

QS = ULTIMATE SIDE RESISTANCE;
QB = ULTIMATE BASE RESISTANCE;
WT = WEIGHT OF DRILLED SHAFT (FOR UPLIFT CAPACITY ONLY);
QU = TOTAL ULTIMATE RESISTANCE;
QBD = TOTAL ALLOWABLE LOAD USING A FACTOR OF SAFETY APPLIED TO THE ULTIMATE BASE RESISTANCE;
QDN = TOTAL ALLOWABLE LOAD USING FACTORS OF SAFETY APPLIED TO THE ULTIMATE SIDE RESISTANCE AND THE ULTIMATE BASE RESISTANCE.

LENGTH (FEET)	VOLUME (CU.YDS)	QS (TONS)	QB (TONS)	QU (TONS)	QBD (TONS)	QDN (TONS)	QU/VOLUME (TONS/CU.YDS)
1.0	.88	1.19	28.69	29.88	10.76	9.96	33.96
2.0	1.76	3.58	32.18	35.76	14.30	11.92	20.32
3.0	2.64	7.15	35.67	42.83	19.05	14.28	16.22
4.0	3.52	11.92	39.17	51.09	24.98	17.03	14.51
5.0	4.40	17.88	45.57	63.45	33.07	21.15	14.42
6.0	5.28	24.85	52.40	77.25	42.32	25.75	14.63
7.0	6.16	32.80	59.68	92.47	52.69	30.82	15.01
8.0	7.04	41.69	67.40	109.09	64.15	36.36	15.49
9.0	7.92	51.48	75.60	127.08	76.68	42.36	16.04
10.0	8.80	62.14	83.80	145.94	90.07	48.65	16.58
11.0	9.68	73.64	91.49	165.14	104.14	55.05	17.06
12.0	10.56	85.95	98.64	184.60	118.83	61.53	17.48

13.0	11.44	99.04	105.20	204.24	134.11	68.08	17.85
14.0	12.32	112.88	111.12	224.00	149.92	74.67	18.18
15.0	13.20	127.44	114.20	241.65	165.51	80.55	18.31
16.0	14.08	142.73	117.37	260.10	181.85	86.70	18.47
17.0	14.96	158.72	120.66	279.37	198.94	93.12	18.67
18.0	15.84	175.37	124.13	299.50	216.75	99.83	18.91
19.0	16.72	192.68	127.83	320.50	235.29	106.83	19.17
20.0	17.60	210.61	132.17	342.77	254.66	114.26	19.47
21.0	18.48	229.13	137.52	366.66	274.97	122.22	19.84
22.0	19.36	248.24	143.86	392.10	296.19	130.70	20.25
23.0	20.24	267.90	151.14	419.04	318.28	139.68	20.70
24.0	21.12	288.10	159.32	447.41	341.20	149.14	21.18
25.0	22.00	308.80	168.33	477.14	364.91	159.05	21.69
26.0	22.88	330.00	177.59	507.60	389.20	169.20	22.18
27.0	23.76	351.68	187.10	538.77	414.04	179.59	22.67
28.0	24.64	373.80	196.85	570.65	439.41	190.22	23.16
29.0	25.52	396.35	206.84	603.20	465.30	201.07	23.63
30.0	26.40	419.32	217.08	636.40	491.68	212.13	24.10
31.0	27.28	442.68	227.56	670.25	518.54	223.42	24.57
32.0	28.16	466.42	238.29	704.71	545.85	234.90	25.02
33.0	29.04	490.52	249.26	739.78	573.60	246.59	25.47
34.0	29.92	514.95	260.48	775.43	601.78	258.48	25.92
35.0	30.80	539.70	271.94	811.64	630.35	270.55	26.35
36.0	31.68	564.76	283.64	848.41	659.31	282.80	26.78

37.0	32.56	590.11	295.59	885.70	688.64	295.23	27.20
38.0	33.44	615.72	307.79	923.51	718.32	307.84	27.62
39.0	34.32	641.59	320.22	961.81	748.33	320.60	28.02
40.0	35.20	667.69	332.91	1000.59	778.66	333.53	28.42
41.0	36.08	694.01	345.83	1039.84	809.29	346.61	28.82
42.0	36.96	720.54	359.00	1079.54	840.20	359.85	29.21
43.0	37.84	747.25	372.42	1119.67	871.39	373.22	29.59
44.0	38.72	774.13	386.08	1160.21	902.83	386.74	29.96
45.0	39.60	801.17	399.14	1200.31	934.22	400.10	30.31
46.0	40.48	828.35	411.50	1239.85	965.52	413.28	30.63
47.0	41.36	855.66	423.06	1278.72	996.68	426.24	30.92
48.0	42.24	883.08	433.73	1316.81	1027.65	438.94	31.17
49.0	43.12	910.59	443.40	1353.99	1058.39	451.33	31.40
50.0	44.00	938.18	452.11	1390.29	1088.88	463.43	31.60

TOP LOAD	TOP MOVEMENT	TIP LOAD	TIP MOVEMENT
ton	IN.	ton	IN.
.4716E+00	.1289E-03	.2398E-01	.1000E-03
.4716E+01	.1289E-02	.2398E+00	.1000E-02
.1179E+02	.3222E-02	.5994E+00	.2500E-02
.2358E+02	.6444E-02	.1199E+01	.5000E-02
.3537E+02	.9666E-02	.1798E+01	.7500E-02
.4716E+02	.1289E-01	.2398E+01	.1000E-01
.1180E+03	.3222E-01	.5994E+01	.2500E-01
.2362E+03	.6446E-01	.1199E+02	.5000E-01
.3379E+03	.9583E-01	.1798E+02	.7500E-01
.4246E+03	.1262E+00	.2398E+02	.1000E+00
.7104E+03	.2952E+00	.5994E+02	.2500E+00
.9001E+03	.5592E+00	.1187E+03	.5000E+00
.9694E+03	.8156E+00	.1732E+03	.7500E+00
.1014E+04	.1070E+01	.2203E+03	.1000E+01

.1445E+04 .6714E+01 .6601E+03 .6600E+01

DRILLED SHAFT INFORMATION

DIAMETER OF STEM	=	6.000	FT.
DIAMETER OF BASE	=	6.000	FT.
END OF STEM TO BASE	=	.000	FT.
ANGLE OF BELL	=	.000	DEG.
IGNORED TOP PORTION	=	.000	FT.
IGNORED BOTTOM PORTION	=	.000	FT.
AREA OF ONE PERCENT STEEL	=	40.720	SQ.IN.
ELASTIC MODULUS, Ec	=	.350E+07	LB/SQ IN
VOLUME OF UNDERREAM	=	.000	CU.YDS.

PREDICTED RESULTS

QS = ULTIMATE SIDE RESISTANCE;
QB = ULTIMATE BASE RESISTANCE;
WT = WEIGHT OF DRILLED SHAFT (FOR UPLIFT CAPACITY ONLY);
QU = TOTAL ULTIMATE RESISTANCE;
QBD = TOTAL ALLOWABLE LOAD USING A FACTOR OF SAFETY APPLIED TO THE ULTIMATE BASE RESISTANCE;
QDN = TOTAL ALLOWABLE LOAD USING FACTORS OF SAFETY APPLIED TO THE ULTIMATE SIDE RESISTANCE AND THE ULTIMATE BASE RESISTANCE.

LENGTH (FEET)	VOLUME (CU.YDS)	QS (TONS)	QB (TONS)	QU (TONS)	QBD (TONS)	QDN (TONS)	QU/VOLUME (TONS/CU.YDS)
1.0	1.05	1.30	30.72	32.02	11.54	10.67	30.57
2.0	2.09	3.90	34.21	38.11	15.30	12.70	18.19
3.0	3.14	7.80	37.70	45.50	20.37	15.17	14.48
4.0	4.19	13.01	43.82	56.83	27.62	18.94	13.57
5.0	5.24	19.50	50.31	69.81	36.27	23.27	13.33
6.0	6.28	27.11	57.18	84.29	46.17	28.10	13.41

7.0	7.33	35.78	64.44	100.22	57.26	33.41	13.67
8.0	8.38	45.48	72.11	117.58	69.51	39.19	14.03
9.0	9.43	56.16	80.19	136.35	82.89	45.45	14.47
10.0	10.47	67.79	87.90	155.69	97.09	51.90	14.86
11.0	11.52	80.34	95.18	175.52	112.06	58.51	15.24
12.0	12.57	93.77	102.01	195.78	127.77	65.26	15.58
13.0	13.62	108.04	108.35	216.40	144.16	72.13	15.89
14.0	14.66	123.14	112.21	235.35	160.55	78.45	16.05
15.0	15.71	139.03	115.59	254.62	177.56	84.87	16.21
16.0	16.76	155.71	119.09	274.80	195.41	91.60	16.40
17.0	17.80	173.15	122.77	295.91	214.07	98.64	16.62
18.0	18.85	191.32	126.66	317.97	233.54	105.99	16.87
19.0	19.90	210.19	130.81	341.00	253.80	113.67	17.14
20.0	20.95	229.75	135.87	365.62	275.04	121.87	17.45
21.0	21.99	249.96	141.81	391.77	297.23	130.59	17.81
22.0	23.04	270.81	148.61	419.42	320.34	139.81	18.20
23.0	24.09	292.26	156.24	448.50	344.34	149.50	18.62
24.0	25.14	314.29	164.66	478.94	369.17	159.65	19.05
25.0	26.18	336.88	173.82	510.69	394.82	170.23	19.50
26.0	27.23	360.00	183.22	543.22	421.08	181.07	19.95
27.0	28.28	383.65	192.87	576.51	447.93	192.17	20.39
28.0	29.33	407.78	202.76	610.54	475.37	203.51	20.82
29.0	30.37	432.39	212.89	645.28	503.35	215.09	21.25
30.0	31.42	457.44	223.27	680.72	531.87	226.91	21.67

31.0	32.47	482.93	233.90	716.83	560.89	238.94	22.08
32.0	33.51	508.82	244.77	753.59	590.41	251.20	22.49
33.0	34.56	535.11	255.88	790.99	620.40	263.66	22.89
34.0	35.61	561.76	267.24	829.00	650.84	276.33	23.28
35.0	36.66	588.77	278.84	867.61	681.71	289.20	23.67
36.0	37.70	616.10	290.69	906.79	713.00	302.26	24.05
37.0	38.75	643.75	302.78	946.53	744.68	315.51	24.43
38.0	39.80	671.70	315.11	986.81	776.73	328.94	24.79
39.0	40.85	699.91	327.69	1027.60	809.14	342.53	25.16
40.0	41.89	728.39	340.52	1068.90	841.89	356.30	25.51
41.0	42.94	757.10	353.58	1110.69	874.96	370.23	25.87
42.0	43.99	786.04	366.90	1152.94	908.34	384.31	26.21
43.0	45.04	815.18	380.45	1195.63	942.00	398.54	26.55
44.0	46.08	844.51	394.25	1238.76	975.93	412.92	26.88
45.0	47.13	874.01	408.30	1282.31	1010.11	427.44	27.21
46.0	48.18	903.66	422.59	1326.25	1044.52	442.08	27.53
47.0	49.22	933.45	437.13	1370.57	1079.16	456.86	27.84
48.0	50.27	963.36	451.90	1415.26	1113.99	471.75	28.15
49.0	51.32	993.37	466.11	1459.47	1148.74	486.49	28.44
50.0	52.37	1023.47	479.64	1503.11	1183.35	501.04	28.70

TOP LOAD	TOP MOVEMENT	TIP LOAD	TIP MOVEMENT
ton	IN.	ton	IN.
.4663E+00	.1241E-03	.2332E-01	.1000E-03
.4663E+01	.1241E-02	.2332E+00	.1000E-02

.1166E+02	.3102E-02	.5829E+00	.2500E-02
.2331E+02	.6203E-02	.1166E+01	.5000E-02
.3497E+02	.9305E-02	.1749E+01	.7500E-02
.4663E+02	.1241E-01	.2332E+01	.1000E-01
.1166E+03	.3102E-01	.5829E+01	.2500E-01
.2335E+03	.6204E-01	.1166E+02	.5000E-01
.3418E+03	.9273E-01	.1749E+02	.7500E-01
.4277E+03	.1222E+00	.2332E+02	.1000E+00
.7458E+03	.2897E+00	.5829E+02	.2500E+00
.9563E+03	.5525E+00	.1156E+03	.5000E+00
.1036E+04	.8084E+00	.1711E+03	.7500E+00
.1085E+04	.1062E+01	.2177E+03	.1000E+01
.1557E+04	.7303E+01	.7003E+03	.7200E+01

DRILLED SHAFT INFORMATION

```
DIAMETER OF STEM           =    6.500  FT.
DIAMETER OF BASE           =    6.500  FT.
END OF STEM TO BASE        =     .000  FT.
ANGLE OF BELL              =     .000  DEG.
IGNORED TOP PORTION        =     .000  FT.
IGNORED BOTTOM PORTION     =     .000  FT.
AREA OF ONE PERCENT STEEL  =   47.790  SQ.IN.
ELASTIC MODULUS, Ec        =  .350E+07 LB/SQ IN
VOLUME OF UNDERREAM        =     .000  CU.YDS.
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PREDICTED RESULTS

```
QS     = ULTIMATE SIDE RESISTANCE;
QB     = ULTIMATE BASE RESISTANCE;
WT     = WEIGHT OF DRILLED SHAFT (FOR UPLIFT CAPACITY ONLY);
QU     = TOTAL ULTIMATE RESISTANCE;
QBD    = TOTAL ALLOWABLE LOAD USING A FACTOR OF SAFETY
         APPLIED TO THE ULTIMATE BASE RESISTANCE;
QDN    = TOTAL ALLOWABLE LOAD USING FACTORS OF SAFETY
         APPLIED TO THE ULTIMATE SIDE RESISTANCE AND
         THE ULTIMATE BASE RESISTANCE.
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     LENGTH   VOLUME      QS        QB        QU        QBD        QDN
 QU/VOLUME
      (FEET)   (CU.YDS) (TONS)    (TONS)    (TONS)    (TONS)     (TONS)    (
TONS/CU.YDS)
```

1.0	1.23	1.41	32.76	34.17	12.33	11.39	27.80
2.0	2.46	4.23	36.25	40.48	16.31	13.49	16.47
3.0	3.69	8.46	42.16	50.61	22.51	16.87	13.73
4.0	4.92	14.09	48.39	62.48	30.22	20.83	12.71
5.0	6.15	21.13	54.95	76.08	39.44	25.36	12.38
6.0	7.37	29.37	61.86	91.22	49.98	30.41	12.37
7.0	8.60	38.76	69.12	107.88	61.80	35.96	12.54
8.0	9.83	49.26	76.75	126.01	74.85	42.00	12.82
9.0	11.06	60.84	84.41	145.25	88.97	48.42	13.13
10.0	12.29	73.44	91.75	165.19	104.02	55.06	13.44
11.0	13.52	87.03	98.73	185.77	119.94	61.92	13.74
12.0	14.75	101.58	105.33	206.91	136.69	68.97	14.03
13.0	15.98	117.05	109.72	226.77	153.62	75.59	14.19
14.0	17.21	133.40	113.74	247.15	171.32	82.38	14.36
15.0	18.44	150.62	117.41	268.02	189.75	89.34	14.54
16.0	19.67	168.68	121.24	289.92	209.10	96.64	14.74
17.0	20.90	187.57	125.27	312.84	229.33	104.28	14.97
18.0	22.12	207.26	129.55	336.80	250.44	112.27	15.22
19.0	23.35	227.71	134.36	362.07	272.50	120.69	15.50
20.0	24.58	248.90	139.99	388.89	295.56	129.63	15.82
21.0	25.81	270.79	146.41	417.21	319.60	139.07	16.16
22.0	27.04	293.37	153.60	446.97	344.57	148.99	16.53
23.0	28.27	316.61	161.53	478.13	370.45	159.38	16.91
24.0	29.50	340.48	170.16	510.63	397.20	170.21	17.31

25.0	30.73	364.95	179.46	544.41	424.77	181.47	17.72
26.0	31.96	390.00	189.00	579.01	453.01	193.00	18.12
27.0	33.19	415.62	198.79	614.41	481.88	204.80	18.51
28.0	34.42	441.76	208.83	650.59	511.37	216.86	18.90
29.0	35.65	468.42	219.11	687.53	541.45	229.18	19.29
30.0	36.87	495.56	229.63	725.19	572.11	241.73	19.67
31.0	38.10	523.17	240.40	763.57	603.31	254.52	20.04
32.0	39.33	551.23	251.41	802.64	635.03	267.55	20.41
33.0	40.56	579.70	262.67	842.37	667.26	280.79	20.77
34.0	41.79	608.58	274.17	882.74	699.97	294.25	21.12
35.0	43.02	637.83	285.91	923.75	733.14	307.92	21.47
36.0	44.25	667.45	297.90	965.35	766.75	321.78	21.82
37.0	45.48	697.40	310.14	1007.54	800.78	335.85	22.15
38.0	46.71	727.67	322.61	1050.28	835.21	350.09	22.49
39.0	47.94	758.24	335.34	1093.58	870.02	364.53	22.81
40.0	49.17	789.09	348.30	1137.39	905.19	379.13	23.13
41.0	50.40	820.19	361.52	1181.71	940.70	393.90	23.45
42.0	51.62	851.54	374.97	1226.51	976.53	408.84	23.76
43.0	52.85	883.11	388.67	1271.78	1012.67	423.93	24.06
44.0	54.08	914.88	402.62	1317.50	1049.09	439.17	24.36
45.0	55.31	946.84	416.80	1363.65	1085.78	454.55	24.65
46.0	56.54	978.96	431.24	1410.20	1122.71	470.07	24.94
47.0	57.77	1011.23	445.92	1457.15	1159.87	485.72	25.22
48.0	59.00	1043.64	460.84	1504.47	1197.25	501.49	25.50

49.0	60.23	1076.15	476.00	1552.15	1234.82	517.38	25.77
50.0	61.46	1108.76	491.41	1600.17	1272.56	533.39	26.04

TOP LOAD	TOP MOVEMENT	TIP LOAD	TIP MOVEMENT
ton	IN.	ton	IN.
.4613E+00	.1203E-03	.2205E-01	.1000E-03
.4613E+01	.1203E-02	.2205E+00	.1000E-02
.1153E+02	.3008E-02	.5513E+00	.2500E-02
.2307E+02	.6016E-02	.1103E+01	.5000E-02
.3460E+02	.9023E-02	.1654E+01	.7500E-02
.4613E+02	.1203E-01	.2205E+01	.1000E-01
.1153E+03	.3008E-01	.5513E+01	.2500E-01
.2309E+03	.6016E-01	.1103E+02	.5000E-01
.3445E+03	.9021E-01	.1654E+02	.7500E-01
.4308E+03	.1191E+00	.2205E+02	.1000E+00
.7799E+03	.2853E+00	.5513E+02	.2500E+00
.1009E+04	.5468E+00	.1096E+03	.5000E+00
.1097E+04	.8022E+00	.1631E+03	.7500E+00
.1149E+04	.1056E+01	.2083E+03	.1000E+01
.1645E+04	.7892E+01	.7175E+03	.7800E+01

DRILLED SHAFT INFORMATION

DIAMETER OF STEM	=	7.000	FT.
DIAMETER OF BASE	=	7.000	FT.
END OF STEM TO BASE	=	.000	FT.
ANGLE OF BELL	=	.000	DEG.
IGNORED TOP PORTION	=	.000	FT.
IGNORED BOTTOM PORTION	=	.000	FT.
AREA OF ONE PERCENT STEEL	=	55.425	SQ.IN.
ELASTIC MODULUS, Ec	=	.350E+07	LB/SQ IN
VOLUME OF UNDERREAM	=	.000	CU.YDS.

PREDICTED RESULTS

QS = ULTIMATE SIDE RESISTANCE;
QB = ULTIMATE BASE RESISTANCE;

WT = WEIGHT OF DRILLED SHAFT (FOR UPLIFT CAPACITY ONLY);
QU = TOTAL ULTIMATE RESISTANCE;
QBD = TOTAL ALLOWABLE LOAD USING A FACTOR OF SAFETY APPLIED TO THE ULTIMATE BASE RESISTANCE;
QDN = TOTAL ALLOWABLE LOAD USING FACTORS OF SAFETY APPLIED TO THE ULTIMATE SIDE RESISTANCE AND THE ULTIMATE BASE RESISTANCE.

LENGTH (FEET)	VOLUME (CU.YDS)	QS (TONS)	QB (TONS)	QU (TONS)	QBD (TONS)	QDN (TONS)	QU/VOLUME (TONS/CU.YDS)
1.0	1.43	1.52	34.79	36.30	13.11	12.10	25.47
2.0	2.85	4.55	40.49	45.05	18.05	15.02	15.80
3.0	4.28	9.11	46.49	55.59	24.60	18.53	13.00
4.0	5.70	15.18	52.78	67.96	32.77	22.65	11.92
5.0	7.13	22.75	59.37	82.13	42.54	27.38	11.52
6.0	8.55	31.62	66.28	97.91	53.72	32.64	11.45
7.0	9.98	41.74	73.52	115.26	66.25	38.42	11.55
8.0	11.40	53.05	81.08	134.14	80.08	44.71	11.76
9.0	12.83	65.52	88.40	153.91	94.98	51.30	12.00
10.0	14.26	79.09	95.44	174.52	110.90	58.17	12.24
11.0	15.68	93.73	102.17	195.90	127.78	65.30	12.49
12.0	17.11	109.39	106.93	216.32	145.04	72.11	12.65
13.0	18.53	126.05	111.42	237.47	163.19	79.16	12.81
14.0	19.96	143.67	115.64	259.31	182.21	86.44	12.99
15.0	21.38	162.20	119.61	281.81	202.07	93.94	13.18
16.0	22.81	181.66	123.76	305.42	222.91	101.81	13.39
17.0	24.23	202.00	128.15	330.15	244.72	110.05	13.62
18.0	25.66	223.20	132.80	356.00	267.47	118.67	13.87

19.0	27.09	245.23	138.19	383.41	291.29	127.80	14.16
20.0	28.51	268.04	144.31	412.35	316.15	137.45	14.46
21.0	29.94	291.62	151.14	442.77	342.01	147.59	14.79
22.0	31.36	315.94	158.67	474.61	368.83	158.20	15.13
23.0	32.79	340.96	166.86	507.83	396.59	169.28	15.49
24.0	34.21	366.67	175.70	542.37	425.23	180.79	15.85
25.0	35.64	393.02	185.14	578.16	454.74	192.72	16.22
26.0	37.06	420.01	194.83	614.83	484.95	204.94	16.59
27.0	38.49	447.59	204.76	652.35	515.84	217.45	16.95
28.0	39.92	475.74	214.94	690.68	547.39	230.23	17.30
29.0	41.34	504.45	225.36	729.81	579.57	243.27	17.65
30.0	42.77	533.68	236.02	769.71	612.36	256.57	18.00
31.0	44.19	563.42	246.93	810.35	645.73	270.12	18.34
32.0	45.62	593.63	258.09	851.71	679.66	283.90	18.67
33.0	47.04	624.29	269.48	893.78	714.12	297.93	19.00
34.0	48.47	655.39	281.13	936.52	749.10	312.17	19.32
35.0	49.89	686.90	293.01	979.91	784.57	326.64	19.64
36.0	51.32	718.79	305.14	1023.93	820.50	341.31	19.95
37.0	52.74	751.04	317.52	1068.57	856.89	356.19	20.26
38.0	54.17	783.64	330.14	1113.78	893.69	371.26	20.56
39.0	55.60	816.57	343.00	1159.57	930.90	386.52	20.86
40.0	57.02	849.79	356.11	1205.90	968.49	401.97	21.15
41.0	58.45	883.29	369.47	1252.75	1006.44	417.58	21.43
42.0	59.87	917.05	383.06	1300.11	1044.73	433.37	21.71

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       43.0     61.30    951.04    396.91   1347.95   1083.35    449.32
   21.99
       44.0     62.72    985.26    410.99   1396.25   1122.26    465.42
   22.26
       45.0     64.15   1019.67    425.32   1445.00   1161.45    481.67
   22.53
       46.0     65.57   1054.27    439.90   1494.17   1200.90    498.06
   22.79
       47.0     67.00   1089.02    454.72   1543.74   1240.59    514.58
   23.04
       48.0     68.43   1123.92    469.78   1593.70   1280.51    531.23
   23.29
       49.0     69.85   1158.93    485.09   1644.02   1320.63    548.01
   23.54
       50.0     71.28   1194.05    500.64   1694.69   1360.93    564.90
   23.78
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TOP LOAD	TOP MOVEMENT	TIP LOAD	TIP MOVEMENT
ton	IN.	ton	IN.
.4573E+00	.1174E-03	.2086E-01	.1000E-03
.4573E+01	.1174E-02	.2086E+00	.1000E-02
.1143E+02	.2934E-02	.5215E+00	.2500E-02
.2286E+02	.5869E-02	.1043E+01	.5000E-02
.3429E+02	.8803E-02	.1565E+01	.7500E-02
.4573E+02	.1174E-01	.2086E+01	.1000E-01
.1143E+03	.2934E-01	.5215E+01	.2500E-01
.2288E+03	.5869E-01	.1043E+02	.5000E-01
.3432E+03	.8804E-01	.1565E+02	.7500E-01
.4345E+03	.1166E+00	.2086E+02	.1000E+00
.8141E+03	.2816E+00	.5215E+02	.2500E+00
.1062E+04	.5422E+00	.1038E+03	.5000E+00
.1158E+04	.7971E+00	.1545E+03	.7500E+00
.1214E+04	.1050E+01	.1994E+03	.1000E+01
.1730E+04	.8483E+01	.7309E+03	.8400E+01

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DRILLED SHAFT INFORMATION
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 DIAMETER OF STEM          =    7.500  FT.
 DIAMETER OF BASE          =    7.500  FT.
 END OF STEM TO BASE       =     .000  FT.
 ANGLE OF BELL             =     .000  DEG.
 IGNORED TOP PORTION       =     .000  FT.
 IGNORED BOTTOM PORTION    =     .000  FT.
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AREA OF ONE PERCENT STEEL =    63.625  SQ.IN.
ELASTIC MODULUS, Ec       =  .350E+07 LB/SQ IN
VOLUME OF UNDERREAM       =      .000  CU.YDS.
```

PREDICTED RESULTS

```
QS    = ULTIMATE SIDE RESISTANCE;
QB    = ULTIMATE BASE RESISTANCE;
WT    = WEIGHT OF DRILLED SHAFT (FOR UPLIFT CAPACITY ONLY);
QU    = TOTAL ULTIMATE RESISTANCE;
QBD   = TOTAL ALLOWABLE LOAD USING A FACTOR OF SAFETY
        APPLIED TO THE ULTIMATE BASE RESISTANCE;
QDN   = TOTAL ALLOWABLE LOAD USING FACTORS OF SAFETY
        APPLIED TO THE ULTIMATE SIDE RESISTANCE AND
        THE ULTIMATE BASE RESISTANCE.
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LENGTH (FEET)	VOLUME (CU.YDS)	QS (TONS)	QB (TONS)	QU (TONS)	QBD (TONS)	QDN (TONS)	QU/VOLUME (TONS/CU.YDS)
1.0	1.64	1.63	38.89	40.52	14.59	13.51	24.76
2.0	3.27	4.88	44.70	49.58	19.78	16.53	15.15
3.0	4.91	9.76	50.77	60.53	26.68	20.18	12.33
4.0	6.55	16.26	57.12	73.38	35.30	24.46	11.21
5.0	8.18	24.38	63.75	88.13	45.63	29.38	10.77
6.0	9.82	33.88	70.67	104.55	57.44	34.85	10.65
7.0	11.46	44.72	77.88	122.61	70.68	40.87	10.70
8.0	13.09	56.84	85.15	141.99	85.23	47.33	10.85
9.0	14.73	70.20	92.20	162.39	100.93	54.13	11.03
10.0	16.36	84.74	99.00	183.74	117.74	61.25	11.23
11.0	18.00	100.42	104.02	204.44	135.09	68.15	11.36
12.0	19.64	117.21	108.84	226.04	153.49	75.35	11.51

13.0	21.27	135.06	113.46	248.51	172.87	82.84	11.68
14.0	22.91	153.93	117.89	271.82	193.22	90.61	11.86
15.0	24.55	173.79	122.14	295.93	214.50	98.64	12.06
16.0	26.18	194.63	126.61	321.25	236.84	107.08	12.27
17.0	27.82	216.43	131.33	347.76	260.21	115.92	12.50
18.0	29.46	239.15	136.52	375.66	284.65	125.22	12.75
19.0	31.09	262.74	142.38	405.13	310.20	135.04	13.03
20.0	32.73	287.19	148.92	436.11	336.83	145.37	13.32
21.0	34.37	312.45	156.11	468.56	364.49	156.19	13.63
22.0	36.00	338.51	163.93	502.44	393.15	167.48	13.96
23.0	37.64	365.32	172.36	537.68	422.77	179.23	14.29
24.0	39.28	392.86	181.39	574.25	453.32	191.42	14.62
25.0	40.91	421.10	190.98	612.07	484.75	204.02	14.96
26.0	42.55	450.01	200.81	650.81	516.94	216.94	15.30
27.0	44.18	479.56	210.88	690.44	549.85	230.15	15.63
28.0	45.82	509.73	221.20	730.93	583.46	243.64	15.95
29.0	47.46	540.48	231.76	772.25	617.74	257.42	16.27
30.0	49.09	571.80	242.57	814.38	652.66	271.46	16.59
31.0	50.73	603.66	253.62	857.29	688.20	285.76	16.90
32.0	52.37	636.03	264.92	900.95	724.34	300.32	17.20
33.0	54.00	668.89	276.46	945.35	761.04	315.12	17.51
34.0	55.64	702.20	288.25	990.45	798.29	330.15	17.80
35.0	57.28	735.96	300.28	1036.24	836.05	345.41	18.09
36.0	58.91	770.13	312.55	1082.68	874.31	360.89	18.38

37.0	60.55	804.69	325.07	1129.76	913.05	376.59	18.66
38.0	62.19	839.62	337.83	1177.45	952.23	392.48	18.93
39.0	63.82	874.89	350.84	1225.73	991.84	408.58	19.21
40.0	65.46	910.48	364.09	1274.58	1031.85	424.86	19.47
41.0	67.09	946.38	377.59	1323.97	1072.24	441.32	19.73
42.0	68.73	982.55	391.33	1373.88	1112.99	457.96	19.99
43.0	70.37	1018.98	405.32	1424.29	1154.08	474.76	20.24
44.0	72.00	1055.64	419.54	1475.18	1195.48	491.73	20.49
45.0	73.64	1092.51	434.02	1526.53	1237.18	508.84	20.73
46.0	75.28	1129.57	448.74	1578.31	1279.15	526.10	20.97
47.0	76.91	1166.81	463.70	1630.51	1321.38	543.50	21.20
48.0	78.55	1204.20	478.91	1683.10	1363.83	561.03	21.43
49.0	80.19	1241.71	494.36	1736.07	1406.50	578.69	21.65
50.0	81.82	1279.34	510.05	1789.39	1449.35	596.46	21.87

TOP LOAD	TOP MOVEMENT	TIP LOAD	TIP MOVEMENT
ton	IN.	ton	IN.
.4539E+00	.1150E-03	.1984E-01	.1000E-03
.4539E+01	.1150E-02	.1984E+00	.1000E-02
.1135E+02	.2876E-02	.4959E+00	.2500E-02
.2270E+02	.5751E-02	.9918E+00	.5000E-02
.3404E+02	.8627E-02	.1488E+01	.7500E-02
.4539E+02	.1150E-01	.1984E+01	.1000E-01
.1135E+03	.2876E-01	.4959E+01	.2500E-01
.2270E+03	.5752E-01	.9918E+01	.5000E-01
.3407E+03	.8628E-01	.1488E+02	.7500E-01
.4387E+03	.1146E+00	.1984E+02	.1000E+00
.8378E+03	.2782E+00	.4959E+02	.2500E+00
.1105E+04	.5380E+00	.9889E+02	.5000E+00
.1219E+04	.7929E+00	.1471E+03	.7500E+00
.1276E+04	.1046E+01	.1918E+03	.1000E+01

.1815E+04	.9075E+01	.7447E+03	.9000E+01

DRILLED SHAFT INFORMATION

DIAMETER OF STEM	=	8.000	FT.
DIAMETER OF BASE	=	8.000	FT.
END OF STEM TO BASE	=	.000	FT.
ANGLE OF BELL	=	.000	DEG.
IGNORED TOP PORTION	=	.000	FT.
IGNORED BOTTOM PORTION	=	.000	FT.
AREA OF ONE PERCENT STEEL	=	72.392	SQ.IN.
ELASTIC MODULUS, Ec	=	.350E+07	LB/SQ IN
VOLUME OF UNDERREAM	=	.000	CU.YDS.

PREDICTED RESULTS

QS = ULTIMATE SIDE RESISTANCE;
QB = ULTIMATE BASE RESISTANCE;
WT = WEIGHT OF DRILLED SHAFT (FOR UPLIFT CAPACITY ONLY);
QU = TOTAL ULTIMATE RESISTANCE;
QBD = TOTAL ALLOWABLE LOAD USING A FACTOR OF SAFETY APPLIED TO THE ULTIMATE BASE RESISTANCE;
QDN = TOTAL ALLOWABLE LOAD USING FACTORS OF SAFETY APPLIED TO THE ULTIMATE SIDE RESISTANCE AND THE ULTIMATE BASE RESISTANCE.

LENGTH (FEET)	VOLUME (CU.YDS)	QS (TONS)	QB (TONS)	QU (TONS)	QBD (TONS)	QDN (TONS)	QU/VOLUME (TONS/CU.YDS)
1.0	1.86	1.73	42.92	44.65	16.04	14.88	23.98
2.0	3.72	5.20	48.80	54.00	21.47	18.00	14.50
3.0	5.59	10.41	54.92	65.33	28.71	21.78	11.70
4.0	7.45	17.34	61.30	78.64	37.78	26.21	10.56
5.0	9.31	26.00	67.94	93.94	48.65	31.31	10.09
6.0	11.17	36.14	74.84	110.99	61.09	37.00	9.93

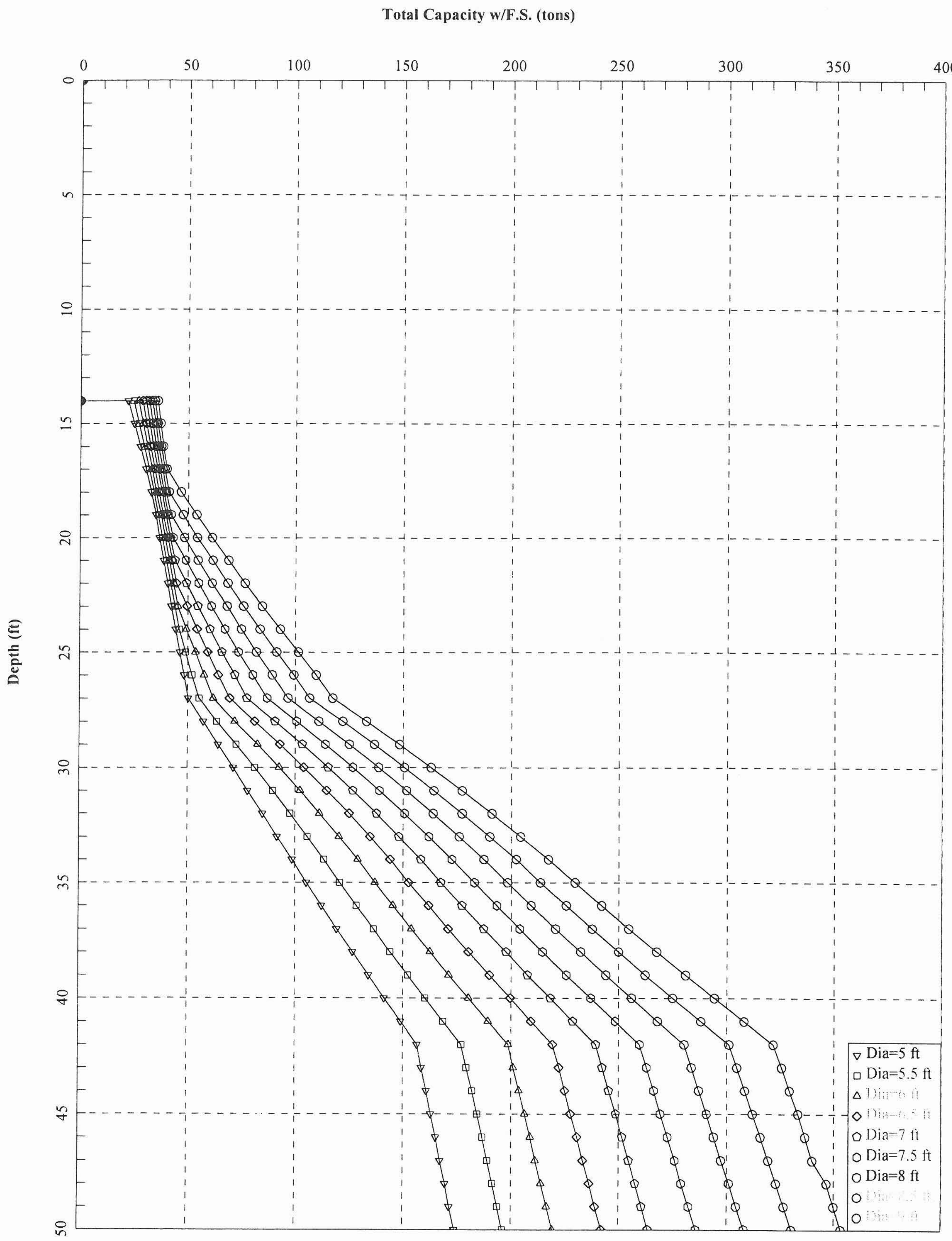
7.0	13.03	47.70	82.02	129.73	75.05	43.24	9.95
8.0	14.90	60.63	89.03	149.67	90.31	49.89	10.05
9.0	16.76	74.88	95.86	170.73	106.83	56.91	10.19
10.0	18.62	90.39	101.05	191.44	124.07	63.81	10.28
11.0	20.48	107.12	106.10	213.21	142.48	71.07	10.41
12.0	22.34	125.02	111.01	236.03	162.02	78.68	10.56
13.0	24.21	144.06	115.79	259.85	182.66	86.62	10.74
14.0	26.07	164.19	120.44	284.63	204.34	94.88	10.92
15.0	27.93	185.37	124.99	310.36	227.04	103.45	11.11
16.0	29.79	207.61	129.76	337.37	250.86	112.46	11.32
17.0	31.65	230.86	134.80	365.66	275.79	121.89	11.55
18.0	33.51	255.09	140.46	395.55	301.91	131.85	11.80
19.0	35.38	280.26	146.75	427.01	329.18	142.34	12.07
20.0	37.24	306.34	153.66	459.99	357.55	153.33	12.35
21.0	39.10	333.28	161.17	494.45	387.01	164.82	12.65
22.0	40.96	361.08	169.26	530.33	417.49	176.78	12.95
23.0	42.82	389.67	177.92	567.59	448.98	189.20	13.25
24.0	44.69	419.05	187.13	606.17	481.42	202.06	13.57
25.0	46.55	449.17	196.85	646.02	514.79	215.34	13.88
26.0	48.41	480.01	206.83	686.83	548.95	228.94	14.19
27.0	50.27	511.53	217.04	728.57	583.88	242.86	14.49
28.0	52.13	543.71	227.50	771.21	619.54	257.07	14.79
29.0	54.00	576.52	238.21	814.73	655.92	271.58	15.09
30.0	55.86	609.92	249.16	859.08	692.98	286.36	15.38

31.0	57.72	643.91	260.35	904.26	730.69	301.42	15.67
32.0	59.58	678.43	271.79	950.23	769.03	316.74	15.95
33.0	61.44	713.48	283.48	996.95	807.97	332.32	16.23
34.0	63.31	749.02	295.40	1044.42	847.49	348.14	16.50
35.0	65.17	785.02	307.58	1092.60	887.55	364.20	16.77
36.0	67.03	821.47	319.99	1141.46	928.14	380.49	17.03
37.0	68.89	858.34	332.65	1190.99	969.22	397.00	17.29
38.0	70.75	895.59	345.56	1241.15	1010.78	413.72	17.54
39.0	72.62	933.22	358.71	1291.92	1052.79	430.64	17.79
40.0	74.48	971.18	372.10	1343.28	1095.22	447.76	18.04
41.0	76.34	1009.47	385.74	1395.21	1138.05	465.07	18.28
42.0	78.20	1048.05	399.62	1447.67	1181.26	482.56	18.51
43.0	80.06	1086.91	413.75	1500.66	1224.82	500.22	18.74
44.0	81.92	1126.01	428.12	1554.13	1268.72	518.04	18.97
45.0	83.79	1165.34	442.74	1608.08	1312.92	536.03	19.19
46.0	85.65	1204.88	457.60	1662.47	1357.41	554.16	19.41
47.0	87.51	1244.60	472.70	1717.30	1402.16	572.43	19.62
48.0	89.37	1284.47	488.05	1772.52	1447.16	590.84	19.83
49.0	91.23	1324.49	503.64	1828.13	1492.37	609.38	20.04
50.0	93.10	1364.63	519.48	1884.10	1537.79	628.03	20.24

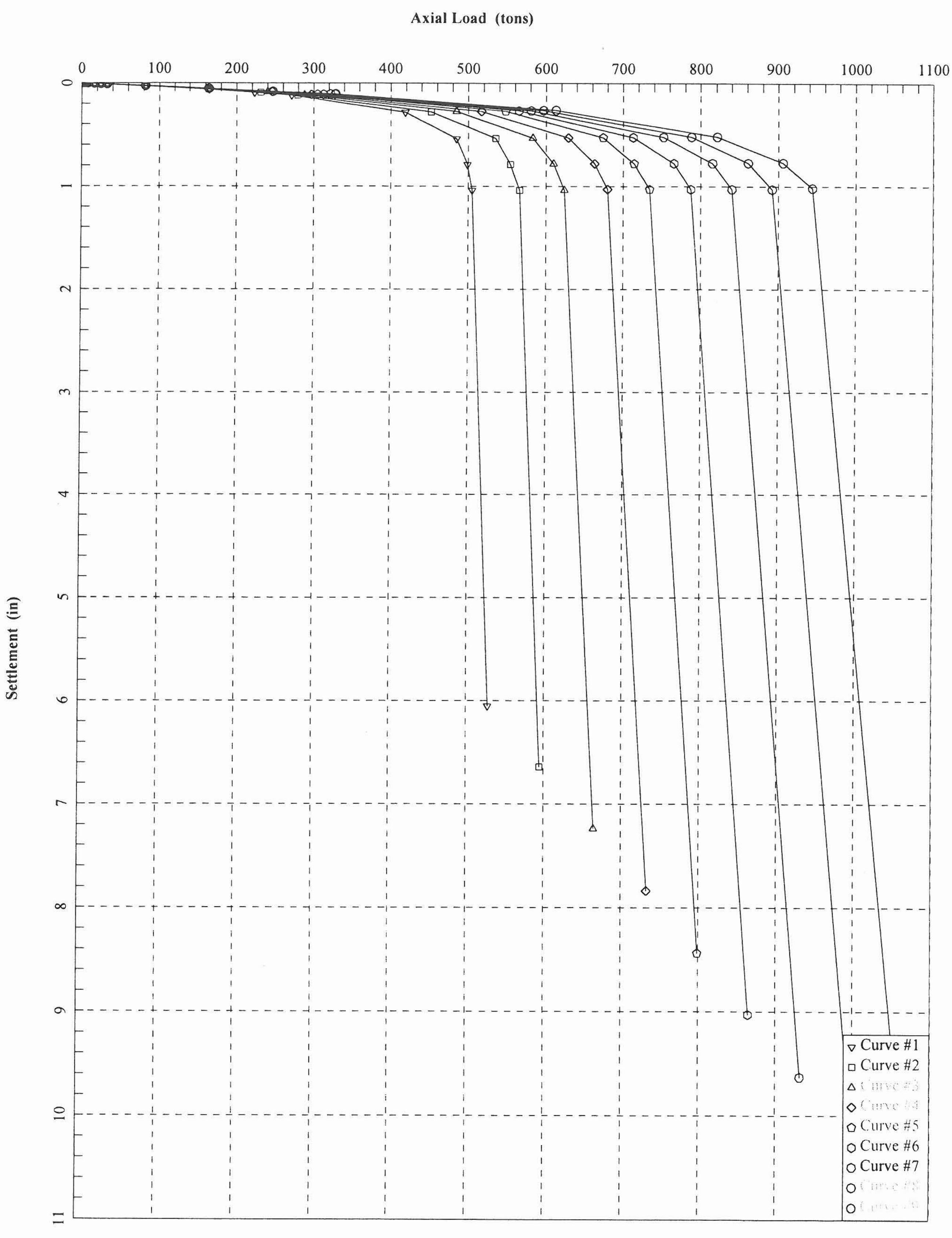
TOP LOAD	TOP MOVEMENT	TIP LOAD	TIP MOVEMENT
ton	IN.	ton	IN.
.4512E+00	.1131E-03	.1894E-01	.1000E-03
.4512E+01	.1131E-02	.1894E+00	.1000E-02

.1128E+02	.2828E-02	.4735E+00	.2500E-02
.2256E+02	.5657E-02	.9470E+00	.5000E-02
.3384E+02	.8485E-02	.1420E+01	.7500E-02
.4512E+02	.1131E-01	.1894E+01	.1000E-01
.1128E+03	.2828E-01	.4735E+01	.2500E-01
.2256E+03	.5657E-01	.9470E+01	.5000E-01
.3386E+03	.8485E-01	.1420E+02	.7500E-01
.4433E+03	.1129E+00	.1894E+02	.1000E+00
.8569E+03	.2753E+00	.4735E+02	.2500E+00
.1146E+04	.5345E+00	.9459E+02	.5000E+00
.1280E+04	.7893E+00	.1406E+03	.7500E+00
.1338E+04	.1042E+01	.1853E+03	.1000E+01
.1900E+04	.9669E+01	.7584E+03	.9600E+01

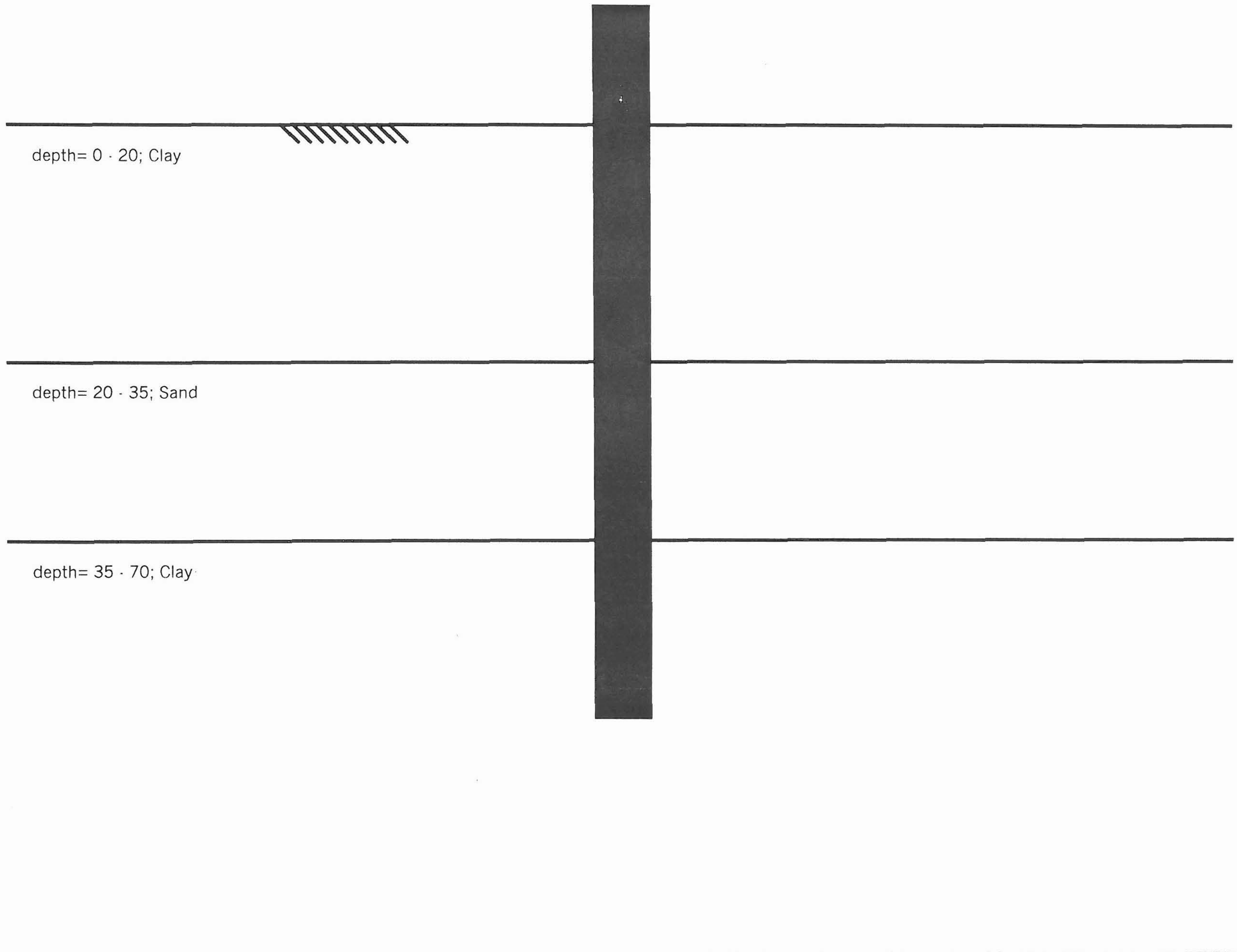
VAN BUREN STREET


Total Capacity w/F.S. (tons)
0
50
100
150
200
250
300
350
400
Depth (ft)
0
5
10
15
20
25
30
35
40
45
50
Dia=5 ft
Dia=5.5 ft
Dia=7 ft
Dia=7.5 ft
Dia=8 ft

Van Buren St.


Axial Load (tons)
0
100
200
300
400
500
600
700
800
900
1000
1100
Settlement (in)
0
1
2
3
4
5
6
7
8
9
10
11
Curve #1
Curve #2
Curve #5
Curve #6
Curve #7

Van Buren St.


depth= 0 - 20; Clay
depth= 20 - 35; Sand
depth= 35 - 70; Clay

```
VERTICALLY LOADED DRILLED SHAFT ANALYSIS PROGRAM SHAFT
VERSION 4.0 (C) COPYRIGHT ENSOFT,INC. 1989,1993,1995,1998,2001

     Bullard Wash Phase II - Van Buren St.


     PROPOSED DEPTH =      50.0 FT
     ----------------


     NUMBER OF LAYERS =    3
     ------------------


     WATER TABLE DEPTH =      47.0 FT.
     -------------------


     FACTOR OF SAFETY APPLIED TO THE TOTAL ULTIMATE CAPACITY = 3.0
0
     -------------------------------------------------------
     FACTOR OF SAFETY APPLIED TO THE ULTIMATE BASE CAPACITY = 3.00
     ------------------------------------------------------


     SOIL INFORMATION
     ---------------

     LAYER NO 1----CLAY

       AT THE TOP

       STRENGTH REDUCTION FACTOR-ALPHA                      =  .550E+
00
       END BEARING COEFFICIENT-Nc                           =  .600E+
01
       UNDRAINED SHEAR STRENGTH, LB/SQ FT                   =  .500E+
03
       INTERNAL FRICTION ANGLE, DEG.                        =  .000E+
00
       BLOWS PER FOOT FROM STANDARD PENETRATION TEST        =  .000E+
00
       SOIL UNIT WEIGHT, LB/CU FT                           =  .118E+
03
       MAXIMUM LOAD TRANSFER FOR SOIL, LB/SQ FT             =  .640E+
```

04
DEPTH, FT = .000E+
00

AT THE BOTTOM

STRENGTH REDUCTION FACTOR-ALPHA = .550E+
00
END BEARING COEFFICIENT-Nc = .900E+
01
UNDRAINED SHEAR STRENGTH, LB/SQ FT = .500E+
03
INTERNAL FRICTION ANGLE, DEG. = .000E+
00
BLOWS PER FOOT FROM STANDARD PENETRATION TEST = .000E+
00
SOIL UNIT WEIGHT, LB/CU FT = .118E+
03
MAXIMUM LOAD TRANSFER FOR SOIL, LB/SQ FT = .640E+
04
DEPTH, FT = .200E+
02

LAYER NO 2----SAND

AT THE TOP

SKIN FRICTION COEFFICIENT- BETA = .896E+
00
UNDRAINED SHEAR STRENGTH, LB/SQ FT = .000E+
00
INTERNAL FRICTION ANGLE, DEG. = .340E+
02
BLOWS PER FOOT FROM STANDARD PENETRATION TEST = .000E+
00
SOIL UNIT WEIGHT, LB/CU FT = .120E+
03
MAXIMUM LOAD TRANSFER FOR SOIL, LB/SQ FT = .400E+
04
DEPTH, FT = .200E+
02

AT THE BOTTOM

SKIN FRICTION COEFFICIENT- BETA = .701E+

00

UNDRAINED SHEAR STRENGTH, LB/SQ FT = .000E+
00
INTERNAL FRICTION ANGLE, DEG. = .340E+
02
BLOWS PER FOOT FROM STANDARD PENETRATION TEST = .000E+
00
SOIL UNIT WEIGHT, LB/CU FT = .120E+
03
MAXIMUM LOAD TRANSFER FOR SOIL, LB/SQ FT = .400E+
04
DEPTH, FT = .350E+
02

LAYER NO 3----CLAY

AT THE TOP

STRENGTH REDUCTION FACTOR-ALPHA = .550E+
00
END BEARING COEFFICIENT-Nc = .900E+
01
UNDRAINED SHEAR STRENGTH, LB/SQ FT = .150E+
04
INTERNAL FRICTION ANGLE, DEG. = .000E+
00
BLOWS PER FOOT FROM STANDARD PENETRATION TEST = .000E+
00
SOIL UNIT WEIGHT, LB/CU FT = .108E+
03
MAXIMUM LOAD TRANSFER FOR SOIL, LB/SQ FT = .640E+
04
DEPTH, FT = .350E+
02

AT THE BOTTOM

STRENGTH REDUCTION FACTOR-ALPHA = .550E+
00
END BEARING COEFFICIENT-Nc = .900E+
01
UNDRAINED SHEAR STRENGTH, LB/SQ FT = .150E+
04
INTERNAL FRICTION ANGLE, DEG. = .000E+
00
BLOWS PER FOOT FROM STANDARD PENETRATION TEST = .000E+

00
SOIL UNIT WEIGHT, LB/CU FT = .108E+
03
MAXIMUM LOAD TRANSFER FOR SOIL, LB/SQ FT = .640E+
04
DEPTH, FT = .700E+
02

DRILLED SHAFT INFORMATION

DIAMETER OF STEM	=	5.000	FT.
DIAMETER OF BASE	=	5.000	FT.
END OF STEM TO BASE	=	.000	FT.
ANGLE OF BELL	=	.000	DEG.
IGNORED TOP PORTION	=	5.000	FT.
IGNORED BOTTOM PORTION	=	7.000	FT.
AREA OF ONE PERCENT STEEL	=	28.278	SQ.IN.
ELASTIC MODULUS, Ec	=	.350E+07	LB/SQ IN
VOLUME OF UNDERREAM	=	.000	CU.YDS.

PREDICTED RESULTS

QS = ULTIMATE SIDE RESISTANCE;
QB = ULTIMATE BASE RESISTANCE;
WT = WEIGHT OF DRILLED SHAFT (FOR UPLIFT CAPACITY ONLY);
QU = TOTAL ULTIMATE RESISTANCE;
QBD = TOTAL ALLOWABLE LOAD USING A FACTOR OF SAFETY APPLIED TO THE ULTIMATE BASE RESISTANCE;
QDN = TOTAL ALLOWABLE LOAD USING FACTORS OF SAFETY APPLIED TO THE ULTIMATE SIDE RESISTANCE AND THE ULTIMATE BASE RESISTANCE.

LENGTH (FEET)	VOLUME (CU.YDS)	QS (TONS)	QB (TONS)	QU (TONS)	QBD (TONS)	QDN (TONS)	QU/VOLUME (TONS/CU.YDS)
13.0	9.46	2.16	55.66	57.82	20.71	19.27	6.12
14.0	10.18	4.32	61.63	65.95	24.86	21.98	6.48

15.0	10.91	6.48	68.30	74.78	29.25	24.93	6.85
16.0	11.64	8.64	74.51	83.15	33.48	27.72	7.15
17.0	12.36	10.80	80.17	90.97	37.52	30.32	7.36
18.0	13.09	12.96	85.19	98.15	41.36	32.72	7.50
19.0	13.82	15.12	89.49	104.61	44.95	34.87	7.57
20.0	14.55	17.28	92.99	110.27	48.28	36.76	7.58
21.0	15.27	19.44	96.48	115.92	51.60	38.64	7.59
22.0	16.00	21.60	99.97	121.57	54.92	40.52	7.60
23.0	16.73	23.76	103.46	127.22	58.25	42.41	7.61
24.0	17.46	25.92	106.95	132.87	61.57	44.29	7.61
25.0	18.18	28.08	110.44	138.52	64.90	46.17	7.62
26.0	18.91	30.24	114.73	144.97	68.48	48.32	7.67
27.0	19.64	32.40	118.68	151.08	71.96	50.36	7.69
28.0	20.36	49.57	122.27	171.84	90.33	57.28	8.44
29.0	21.09	67.27	125.45	192.72	109.09	64.24	9.14
30.0	21.82	85.49	128.18	213.67	128.22	71.22	9.79
31.0	22.55	104.20	130.15	234.35	147.58	78.12	10.39
32.0	23.27	123.38	131.46	254.84	167.20	84.95	10.95
33.0	24.00	143.02	132.23	275.24	187.09	91.75	11.47
34.0	24.73	163.09	132.55	295.64	207.27	98.55	11.96
35.0	25.46	183.58	132.55	316.13	227.76	105.38	12.42
36.0	26.18	204.46	132.55	337.02	248.65	112.34	12.87
37.0	26.91	225.73	132.55	358.28	269.92	119.43	13.31
38.0	27.64	247.36	132.55	379.92	291.55	126.64	13.75

39.0	28.37	269.34	132.55	401.90	313.53	133.97	14.17
40.0	29.09	291.65	132.55	424.20	335.83	141.40	14.58
41.0	29.82	314.27	132.55	446.82	358.46	148.94	14.98
42.0	30.55	337.19	132.55	469.74	381.37	156.58	15.38
43.0	31.27	343.67	132.55	476.22	387.85	158.74	15.23
44.0	32.00	350.15	132.55	482.70	394.33	160.90	15.08
45.0	32.73	356.63	132.55	489.18	400.81	163.06	14.95
46.0	33.46	363.11	132.55	495.66	407.29	165.22	14.82
47.0	34.18	369.59	132.55	502.14	413.77	167.38	14.69
48.0	34.91	376.07	132.55	508.62	420.26	169.54	14.57
49.0	35.64	382.55	132.55	515.10	426.74	171.70	14.45
50.0	36.37	389.03	132.55	521.58	433.22	173.86	14.34

TOP LOAD	TOP MOVEMENT	TIP LOAD	TIP MOVEME NT
ton	IN.	ton	IN.
.3286E+00	.1257E-03	.1745E-01	.1000E-03
.3286E+01	.1257E-02	.1745E+00	.1000E-02
.8215E+01	.3142E-02	.4363E+00	.2500E-02
.1643E+02	.6284E-02	.8726E+00	.5000E-02
.2465E+02	.9426E-02	.1309E+01	.7500E-02
.3286E+02	.1257E-01	.1745E+01	.1000E-01
.8223E+02	.3142E-01	.4363E+01	.2500E-01
.1646E+03	.6286E-01	.8726E+01	.5000E-01
.2229E+03	.9254E-01	.1309E+02	.7500E-01
.2705E+03	.1213E+00	.1745E+02	.1000E+00
.4188E+03	.2838E+00	.4363E+02	.2500E+00
.4851E+03	.5397E+00	.6694E+02	.5000E+00
.4992E+03	.7915E+00	.8351E+02	.7500E+00
.5048E+03	.1043E+01	.9643E+02	.1000E+01
.5276E+03	.6046E+01	.1314E+03	.6000E+01

DRILLED SHAFT INFORMATION

DIAMETER OF STEM	=	5.500	FT.
DIAMETER OF BASE	=	5.500	FT.
END OF STEM TO BASE	=	.000	FT.
ANGLE OF BELL	=	.000	DEG.
IGNORED TOP PORTION	=	5.000	FT.
IGNORED BOTTOM PORTION	=	7.000	FT.
AREA OF ONE PERCENT STEEL	=	34.216	SQ.IN.
ELASTIC MODULUS, Ec	=	.350E+07	LB/SQ IN
VOLUME OF UNDERREAM	=	.000	CU.YDS.

PREDICTED RESULTS

QS = ULTIMATE SIDE RESISTANCE;
QB = ULTIMATE BASE RESISTANCE;
WT = WEIGHT OF DRILLED SHAFT (FOR UPLIFT CAPACITY ONLY);
QU = TOTAL ULTIMATE RESISTANCE;
QBD = TOTAL ALLOWABLE LOAD USING A FACTOR OF SAFETY APPLIED TO THE ULTIMATE BASE RESISTANCE;
QDN = TOTAL ALLOWABLE LOAD USING FACTORS OF SAFETY APPLIED TO THE ULTIMATE SIDE RESISTANCE AND THE ULTIMATE BASE RESISTANCE.

LENGTH (FEET)	VOLUME (CU.YDS)	QS (TONS)	QB (TONS)	QU (TONS)	QBD (TONS)	QDN (TONS)	QU/VOLUME (TONS/CU.YDS)
13.0	11.44	2.38	64.28	66.66	23.80	22.22	5.83
14.0	12.32	4.75	69.03	73.79	27.76	24.60	5.99
15.0	13.20	7.13	73.98	81.11	31.79	27.04	6.14
16.0	14.08	9.50	78.77	88.28	35.76	29.43	6.27
17.0	14.96	11.88	83.34	95.22	39.66	31.74	6.36
18.0	15.84	14.26	87.62	101.88	43.46	33.96	6.43
19.0	16.72	16.63	91.54	108.17	47.15	36.06	6.47
20.0	17.60	19.01	95.03	114.04	50.69	38.01	6.48

21.0	18.48	21.39	98.52	119.91	54.23	39.97	6.49
22.0	19.36	23.76	102.01	125.78	57.77	41.93	6.50
23.0	20.24	26.14	105.51	131.64	61.31	43.88	6.50
24.0	21.12	28.51	109.00	137.51	64.85	45.84	6.51
25.0	22.00	30.89	116.11	147.00	69.59	49.00	6.68
26.0	22.88	33.27	123.16	156.42	74.32	52.14	6.84
27.0	23.76	35.64	130.11	165.76	79.01	55.25	6.98
28.0	24.64	54.53	136.95	191.47	100.18	63.82	7.77
29.0	25.52	74.00	143.63	217.63	121.88	72.54	8.53
30.0	26.40	94.04	149.52	243.55	143.88	81.18	9.23
31.0	27.28	114.62	154.05	268.67	165.97	89.56	9.85
32.0	28.16	135.72	157.31	293.03	188.15	97.68	10.41
33.0	29.04	157.32	159.39	316.71	210.45	105.57	10.91
34.0	29.92	179.40	160.39	339.79	232.86	113.26	11.36
35.0	30.80	201.93	160.39	362.32	255.40	120.77	11.76
36.0	31.68	224.91	160.39	385.30	278.37	128.43	12.16
37.0	32.56	248.30	160.39	408.69	301.77	136.23	12.55
38.0	33.44	272.10	160.39	432.49	325.56	144.16	12.93
39.0	34.32	296.28	160.39	456.67	349.74	152.22	13.31
40.0	35.20	320.82	160.39	481.20	374.28	160.40	13.67
41.0	36.08	345.70	160.39	506.09	399.16	168.70	14.03
42.0	36.96	370.91	160.39	531.30	424.37	177.10	14.37
43.0	37.84	378.04	160.39	538.43	431.50	179.48	14.23
44.0	38.72	385.16	160.39	545.55	438.63	181.85	14.09

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    45.0     39.60    392.29    160.39    552.68    445.76    184.23
 13.96
    46.0     40.48    399.42    160.39    559.81    452.88    186.60
 13.83
    47.0     41.36    406.55    160.39    566.94    460.01    188.98
 13.71
    48.0     42.24    413.68    160.39    574.07    467.14    191.36
 13.59
    49.0     43.12    420.81    160.39    581.20    474.27    193.73
 13.48
    50.0     44.00    427.93    160.39    588.32    481.40    196.11
 13.37
```

TOP LOAD	TOP MOVEMENT	TIP LOAD	TIP MOVEMENT
ton	IN.	ton	IN.
.3284E+00	.1213E-03	.1920E-01	.1000E-03
.3284E+01	.1213E-02	.1920E+00	.1000E-02
.8210E+01	.3033E-02	.4800E+00	.2500E-02
.1642E+02	.6066E-02	.9599E+00	.5000E-02
.2463E+02	.9099E-02	.1440E+01	.7500E-02
.3284E+02	.1213E-01	.1920E+01	.1000E-01
.8212E+02	.3033E-01	.4800E+01	.2500E-01
.1645E+03	.6067E-01	.9599E+01	.5000E-01
.2313E+03	.9011E-01	.1440E+02	.7500E-01
.2792E+03	.1183E+00	.1920E+02	.1000E+00
.4518E+03	.2802E+00	.4800E+02	.2500E+00
.5350E+03	.5364E+00	.7699E+02	.5000E+00
.5545E+03	.7882E+00	.9594E+02	.7500E+00
.5657E+03	.1040E+01	.1127E+03	.1000E+01
.5948E+03	.6643E+01	.1589E+03	.6600E+01

DRILLED SHAFT INFORMATION

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DIAMETER OF STEM           =     6.000  FT.
DIAMETER OF BASE           =     6.000  FT.
END OF STEM TO BASE        =      .000  FT.
ANGLE OF BELL              =      .000  DEG.
IGNORED TOP PORTION        =     5.000  FT.
IGNORED BOTTOM PORTION     =     7.000  FT.
AREA OF ONE PERCENT STEEL  =    40.720  SQ.IN.
ELASTIC MODULUS, Ec        =  .350E+07  LB/SQ IN
VOLUME OF UNDERREAM        =      .000  CU.YDS.
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PREDICTED RESULTS

QS = ULTIMATE SIDE RESISTANCE;
QB = ULTIMATE BASE RESISTANCE;
WT = WEIGHT OF DRILLED SHAFT (FOR UPLIFT CAPACITY ONLY);
QU = TOTAL ULTIMATE RESISTANCE;
QBD = TOTAL ALLOWABLE LOAD USING A FACTOR OF SAFETY APPLIED TO THE ULTIMATE BASE RESISTANCE;
QDN = TOTAL ALLOWABLE LOAD USING FACTORS OF SAFETY APPLIED TO THE ULTIMATE SIDE RESISTANCE AND THE ULTIMATE BASE RESISTANCE.

LENGTH (FEET)	VOLUME (CU.YDS)	QS (TONS)	QB (TONS)	QU (TONS)	QBD (TONS)	QDN (TONS)	QU/VOLUME (TONS/CU.YDS)
13.0	13.62	2.59	71.63	74.22	26.47	24.74	5.45
14.0	14.66	5.18	75.14	80.32	30.23	26.77	5.48
15.0	15.71	7.78	78.78	86.55	34.04	28.85	5.51
16.0	16.76	10.37	82.49	92.86	37.87	30.95	5.54
17.0	17.80	12.96	86.23	99.19	41.70	33.06	5.57
18.0	18.85	15.55	89.94	105.49	45.53	35.16	5.60
19.0	19.90	18.15	93.56	111.71	49.33	37.24	5.61
20.0	20.95	20.74	97.05	117.79	53.09	39.26	5.62
21.0	21.99	23.33	100.55	123.88	56.84	41.29	5.63
22.0	23.04	25.92	104.04	129.96	60.60	43.32	5.64
23.0	24.09	28.51	107.53	136.04	64.36	45.35	5.65
24.0	25.14	31.11	117.16	148.27	70.16	49.42	5.90
25.0	26.18	33.70	126.94	160.63	76.01	53.54	6.13
26.0	27.23	36.29	136.83	173.12	81.90	57.71	6.36

27.0	28.28	38.88	146.82	185.70	87.82	61.90	6.57
28.0	29.33	59.49	156.87	216.35	111.77	72.12	7.38
29.0	30.37	80.73	166.97	247.69	136.38	82.56	8.16
30.0	31.42	102.59	175.19	277.78	160.98	92.59	8.84
31.0	32.47	125.04	181.62	306.65	185.58	102.22	9.44
32.0	33.51	148.06	186.32	334.38	210.16	111.46	9.98
33.0	34.56	171.62	189.38	361.00	234.75	120.33	10.45
34.0	35.61	195.70	190.88	386.58	259.33	128.86	10.86
35.0	36.66	220.29	190.88	411.17	283.92	137.06	11.22
36.0	37.70	245.36	190.88	436.23	308.98	145.41	11.57
37.0	38.75	270.88	190.88	461.75	334.50	153.92	11.92
38.0	39.80	296.84	190.88	487.71	360.46	162.57	12.25
39.0	40.85	323.21	190.88	514.09	386.84	171.36	12.59
40.0	41.89	349.98	190.88	540.86	413.61	180.29	12.91
41.0	42.94	377.13	190.88	568.00	440.75	189.33	13.23
42.0	43.99	404.63	190.88	595.50	468.25	198.50	13.54
43.0	45.04	412.40	190.88	603.28	476.03	201.09	13.40
44.0	46.08	420.18	190.88	611.06	483.80	203.69	13.26
45.0	47.13	427.96	190.88	618.83	491.58	206.28	13.13
46.0	48.18	435.73	190.88	626.61	499.36	208.87	13.01
47.0	49.22	443.51	190.88	634.39	507.13	211.46	12.89
48.0	50.27	451.28	190.88	642.16	514.91	214.05	12.77
49.0	51.32	459.06	190.88	649.94	522.69	216.65	12.66
50.0	52.37	466.84	190.88	657.71	530.46	219.24	12.56

TOP LOAD ton	TOP MOVEMENT IN.	TIP LOAD ton	TIP MOVEME NT IN.
.3287E+00	.1180E-03	.2094E-01	.1000E-03
.3287E+01	.1180E-02	.2094E+00	.1000E-02
.8216E+01	.2950E-02	.5236E+00	.2500E-02
.1643E+02	.5900E-02	.1047E+01	.5000E-02
.2465E+02	.8851E-02	.1571E+01	.7500E-02
.3287E+02	.1180E-01	.2094E+01	.1000E-01
.8216E+02	.2950E-01	.5236E+01	.2500E-01
.1645E+03	.5901E-01	.1047E+02	.5000E-01
.2399E+03	.8821E-01	.1571E+02	.7500E-01
.2882E+03	.1159E+00	.2094E+02	.1000E+00
.4849E+03	.2773E+00	.5236E+02	.2500E+00
.5827E+03	.5334E+00	.8764E+02	.5000E+00
.6098E+03	.7855E+00	.1091E+03	.7500E+00
.6241E+03	.1037E+01	.1277E+03	.1000E+01
.6646E+03	.7241E+01	.1892E+03	.7200E+01

DRILLED SHAFT INFORMATION

DIAMETER OF STEM	=	6.500	FT.
DIAMETER OF BASE	=	6.500	FT.
END OF STEM TO BASE	=	.000	FT.
ANGLE OF BELL	=	.000	DEG.
IGNORED TOP PORTION	=	5.000	FT.
IGNORED BOTTOM PORTION	=	7.000	FT.
AREA OF ONE PERCENT STEEL	=	47.790	SQ.IN.
ELASTIC MODULUS, Ec	=	.350E+07	LB/SQ IN
VOLUME OF UNDERREAM	=	.000	CU.YDS.

PREDICTED RESULTS

QS = ULTIMATE SIDE RESISTANCE;
QB = ULTIMATE BASE RESISTANCE;
WT = WEIGHT OF DRILLED SHAFT (FOR UPLIFT CAPACITY ONLY);
QU = TOTAL ULTIMATE RESISTANCE;
QBD = TOTAL ALLOWABLE LOAD USING A FACTOR OF SAFETY APPLIED TO THE ULTIMATE BASE RESISTANCE;

QDN = TOTAL ALLOWABLE LOAD USING FACTORS OF SAFETY APPLIED TO THE ULTIMATE SIDE RESISTANCE AND THE ULTIMATE BASE RESISTANCE.

LENGTH (FEET)	VOLUME (CU.YDS)	QS (TONS)	QB (TONS)	QU (TONS)	QBD (TONS)	QDN (TONS)	QU/VOLUME (TONS/CU.YDS)
13.0	15.98	2.81	78.00	80.81	28.81	26.94	5.06
14.0	17.21	5.62	80.33	85.94	32.39	28.65	4.99
15.0	18.44	8.42	82.95	91.38	36.08	30.46	4.96
16.0	19.67	11.23	85.84	97.07	39.85	32.36	4.94
17.0	20.90	14.04	88.94	102.98	43.69	34.33	4.93
18.0	22.12	16.85	92.21	109.06	47.58	36.35	4.93
19.0	23.35	19.66	95.61	115.27	51.53	38.42	4.94
20.0	24.58	22.47	99.10	121.56	55.50	40.52	4.95
21.0	25.81	25.27	102.59	127.86	59.47	42.62	4.95
22.0	27.04	28.08	106.08	134.16	63.44	44.72	4.96
23.0	28.27	30.89	117.71	148.60	70.13	49.53	5.26
24.0	29.50	33.70	129.61	163.31	76.90	54.44	5.54
25.0	30.73	36.51	141.77	178.28	83.76	59.43	5.80
26.0	31.96	39.31	154.17	193.49	90.70	64.50	6.05
27.0	33.19	42.12	166.78	208.91	97.72	69.64	6.29
28.0	34.42	64.44	179.59	244.03	124.31	81.34	7.09
29.0	35.65	87.46	191.40	278.86	151.26	92.95	7.82
30.0	36.87	111.14	201.09	312.22	178.16	104.07	8.47
31.0	38.10	135.46	208.71	344.16	205.03	114.72	9.03
32.0	39.33	160.39	214.32	374.71	231.83	124.90	9.53

33.0	40.56	185.92	218.00	403.92	258.59	134.64	9.96
34.0	41.79	212.01	219.81	431.82	285.28	143.94	10.33
35.0	43.02	238.65	219.81	458.46	311.92	152.82	10.66
36.0	44.25	265.80	219.81	485.61	339.07	161.87	10.97
37.0	45.48	293.45	219.81	513.26	366.72	171.09	11.29
38.0	46.71	321.57	219.81	541.38	394.84	180.46	11.59
39.0	47.94	350.15	219.81	569.95	423.41	189.98	11.89
40.0	49.17	379.15	219.81	598.95	452.42	199.65	12.18
41.0	50.40	408.55	219.81	628.36	481.82	209.45	12.47
42.0	51.62	438.35	219.81	658.15	511.61	219.38	12.75
43.0	52.85	446.77	219.81	666.58	520.04	222.19	12.61
44.0	54.08	455.19	219.81	675.00	528.46	225.00	12.48
45.0	55.31	463.62	219.81	683.43	536.89	227.81	12.36
46.0	56.54	472.04	219.81	691.85	545.31	230.62	12.24
47.0	57.77	480.47	219.81	700.28	553.74	233.43	12.12
48.0	59.00	488.89	219.81	708.70	562.16	236.23	12.01
49.0	60.23	497.32	219.81	717.13	570.59	239.04	11.91
50.0	61.46	505.74	219.81	725.55	579.01	241.85	11.81

TOP LOAD	TOP MOVEMENT	TIP LOAD	TIP MOVEMENT
ton	IN.	ton	IN.
.3288E+00	.1154E-03	.2226E-01	.1000E-03
.3288E+01	.1154E-02	.2226E+00	.1000E-02
.8219E+01	.2885E-02	.5566E+00	.2500E-02
.1644E+02	.5770E-02	.1113E+01	.5000E-02
.2466E+02	.8655E-02	.1670E+01	.7500E-02
.3288E+02	.1154E-01	.2226E+01	.1000E-01

.8219E+02	.2885E-01	.5566E+01	.2500E-01
.1645E+03	.5771E-01	.1113E+02	.5000E-01
.2460E+03	.8655E-01	.1670E+02	.7500E-01
.2968E+03	.1140E+00	.2226E+02	.1000E+00
.5169E+03	.2748E+00	.5566E+02	.2500E+00
.6290E+03	.5308E+00	.9705E+02	.5000E+00
.6632E+03	.7829E+00	.1203E+03	.7500E+00
.6803E+03	.1034E+01	.1405E+03	.1000E+01
.7329E+03	.7839E+01	.2178E+03	.7800E+01

DRILLED SHAFT INFORMATION

DIAMETER OF STEM	=	7.000	FT.
DIAMETER OF BASE	=	7.000	FT.
END OF STEM TO BASE	=	.000	FT.
ANGLE OF BELL	=	.000	DEG.
IGNORED TOP PORTION	=	5.000	FT.
IGNORED BOTTOM PORTION	=	7.000	FT.
AREA OF ONE PERCENT STEEL	=	55.425	SQ.IN.
ELASTIC MODULUS, Ec	=	.350E+07	LB/SQ IN
VOLUME OF UNDERREAM	=	.000	CU.YDS.

PREDICTED RESULTS

QS = ULTIMATE SIDE RESISTANCE;
QB = ULTIMATE BASE RESISTANCE;
WT = WEIGHT OF DRILLED SHAFT (FOR UPLIFT CAPACITY ONLY);
QU = TOTAL ULTIMATE RESISTANCE;
QBD = TOTAL ALLOWABLE LOAD USING A FACTOR OF SAFETY APPLIED TO THE ULTIMATE BASE RESISTANCE;
QDN = TOTAL ALLOWABLE LOAD USING FACTORS OF SAFETY APPLIED TO THE ULTIMATE SIDE RESISTANCE AND THE ULTIMATE BASE RESISTANCE.

LENGTH (FEET)	VOLUME (CU.YDS)	QS (TONS)	QB (TONS)	QU (TONS)	QBD (TONS)	QDN (TONS)	QU/VOLUME (TONS/CU.YDS)
13.0	18.53	3.02	83.41	86.44	30.83	28.81	4.66
14.0	19.96	6.05	84.82	90.87	34.32	30.29	4.55

15.0	21.38	9.07	86.65	95.73	37.96	31.91	4.48
16.0	22.81	12.10	88.89	100.98	41.73	33.66	4.43
17.0	24.23	15.12	91.48	106.60	45.61	35.53	4.40
18.0	25.66	18.15	94.41	112.55	49.61	37.52	4.39
19.0	27.09	21.17	97.63	118.80	53.71	39.60	4.39
20.0	28.51	24.19	101.13	125.32	57.90	41.77	4.40
21.0	29.94	27.22	104.62	131.83	62.09	43.94	4.40
22.0	31.36	30.24	117.67	147.92	69.47	49.31	4.72
23.0	32.79	33.27	131.09	164.36	76.96	54.79	5.01
24.0	34.21	36.29	144.85	181.14	84.57	60.38	5.29
25.0	35.64	39.31	158.94	198.25	92.29	66.08	5.56
26.0	37.06	42.34	173.33	215.67	100.11	71.89	5.82
27.0	38.49	45.36	188.00	233.37	108.03	77.79	6.06
28.0	39.92	69.40	202.95	272.35	137.05	90.78	6.82
29.0	41.34	94.18	215.59	309.77	166.05	103.26	7.49
30.0	42.77	119.68	225.99	345.67	195.01	115.22	8.08
31.0	44.19	145.88	234.19	380.07	223.94	126.69	8.60
32.0	45.62	172.73	240.27	413.00	252.82	137.67	9.05
33.0	47.04	200.22	244.26	444.48	281.64	148.16	9.45
34.0	48.47	228.32	246.23	474.55	310.40	158.18	9.79
35.0	49.89	257.01	246.23	503.23	339.08	167.74	10.09
36.0	51.32	286.25	246.23	532.48	368.32	177.49	10.38
37.0	52.74	316.02	246.23	562.25	398.10	187.42	10.66
38.0	54.17	346.31	246.23	592.54	428.39	197.51	10.94

39.0	55.60	377.08	246.23	623.31	459.16	207.77	11.21
40.0	57.02	408.31	246.23	654.54	490.39	218.18	11.48
41.0	58.45	439.98	246.23	686.21	522.06	228.74	11.74
42.0	59.87	472.06	246.23	718.29	554.14	239.43	12.00
43.0	61.30	481.14	246.23	727.36	563.21	242.45	11.87
44.0	62.72	490.21	246.23	736.44	572.29	245.48	11.74
45.0	64.15	499.28	246.23	745.51	581.36	248.50	11.62
46.0	65.57	508.35	246.23	754.58	590.43	251.53	11.51
47.0	67.00	517.43	246.23	763.65	599.50	254.55	11.40
48.0	68.43	526.50	246.23	772.73	608.58	257.58	11.29
49.0	69.85	535.57	246.23	781.80	617.65	260.60	11.19
50.0	71.28	544.64	246.23	790.87	626.72	263.62	11.10

TOP LOAD	TOP MOVEMENT	TIP LOAD	TIP MOVEMENT
ton	IN.	ton	IN.
.3287E+00	.1133E-03	.2316E-01	.1000E-03
.3287E+01	.1133E-02	.2316E+00	.1000E-02
.8217E+01	.2833E-02	.5789E+00	.2500E-02
.1643E+02	.5666E-02	.1158E+01	.5000E-02
.2465E+02	.8498E-02	.1737E+01	.7500E-02
.3287E+02	.1133E-01	.2316E+01	.1000E-01
.8217E+02	.2833E-01	.5789E+01	.2500E-01
.1644E+03	.5666E-01	.1158E+02	.5000E-01
.2467E+03	.8499E-01	.1737E+02	.7500E-01
.3050E+03	.1124E+00	.2316E+02	.1000E+00
.5475E+03	.2726E+00	.5789E+02	.2500E+00
.6738E+03	.5285E+00	.1050E+03	.5000E+00
.7142E+03	.7806E+00	.1292E+03	.7500E+00
.7343E+03	.1032E+01	.1510E+03	.1000E+01
.7987E+03	.8436E+01	.2440E+03	.8400E+01

DRILLED SHAFT INFORMATION

DIAMETER OF STEM	=	7.500	FT.
DIAMETER OF BASE	=	7.500	FT.
END OF STEM TO BASE	=	.000	FT.
ANGLE OF BELL	=	.000	DEG.
IGNORED TOP PORTION	=	5.000	FT.
IGNORED BOTTOM PORTION	=	7.000	FT.
AREA OF ONE PERCENT STEEL	=	63.625	SQ.IN.
ELASTIC MODULUS, Ec	=	.350E+07	LB/SQ IN
VOLUME OF UNDERREAM	=	.000	CU.YDS.

PREDICTED RESULTS

QS = ULTIMATE SIDE RESISTANCE;
QB = ULTIMATE BASE RESISTANCE;
WT = WEIGHT OF DRILLED SHAFT (FOR UPLIFT CAPACITY ONLY);
QU = TOTAL ULTIMATE RESISTANCE;
QBD = TOTAL ALLOWABLE LOAD USING A FACTOR OF SAFETY APPLIED TO THE ULTIMATE BASE RESISTANCE;
QDN = TOTAL ALLOWABLE LOAD USING FACTORS OF SAFETY APPLIED TO THE ULTIMATE SIDE RESISTANCE AND THE ULTIMATE BASE RESISTANCE.

LENGTH (FEET)	VOLUME (CU.YDS)	QS (TONS)	QB (TONS)	QU (TONS)	QBD (TONS)	QDN (TONS)	QU/VOLUME (TONS/CU.YDS)
13.0	21.27	3.24	88.21	91.45	32.64	30.48	4.30
14.0	22.91	6.48	88.86	95.34	36.10	31.78	4.16
15.0	24.55	9.72	90.06	99.78	39.74	33.26	4.06
16.0	26.18	12.96	91.76	104.72	43.55	34.91	4.00
17.0	27.82	16.20	93.95	110.15	47.52	36.72	3.96
18.0	29.46	19.44	96.60	116.04	51.64	38.68	3.94
19.0	31.09	22.68	99.68	122.36	55.91	40.79	3.94
20.0	32.73	25.92	103.17	129.09	60.31	43.03	3.94

21.0	34.37	29.16	117.55	146.71	68.34	48.90	4.27
22.0	36.00	32.40	132.35	164.75	76.52	54.92	4.58
23.0	37.64	35.64	147.55	183.20	84.83	61.07	4.87
24.0	39.28	38.88	163.15	202.03	93.27	67.34	5.14
25.0	40.91	42.12	179.12	221.25	101.83	73.75	5.41
26.0	42.55	45.36	195.46	240.82	110.51	80.27	5.66
27.0	44.18	48.60	212.13	260.73	119.31	86.91	5.90
28.0	45.82	74.36	227.77	302.12	150.28	100.71	6.59
29.0	47.46	100.91	241.03	341.94	181.25	113.98	7.21
30.0	49.09	128.23	251.96	380.19	212.22	126.73	7.74
31.0	50.73	156.30	260.60	416.90	243.16	138.97	8.22
32.0	52.37	185.07	267.02	452.09	274.08	150.70	8.63
33.0	54.00	214.52	271.24	485.77	304.94	161.92	9.00
34.0	55.64	244.63	273.33	517.96	335.74	172.65	9.31
35.0	57.28	275.36	273.33	548.70	366.48	182.90	9.58
36.0	58.91	306.69	273.33	580.03	397.81	193.34	9.85
37.0	60.55	338.60	273.33	611.93	429.71	203.98	10.11
38.0	62.19	371.05	273.33	644.38	462.16	214.79	10.36
39.0	63.82	404.01	273.33	677.35	495.13	225.78	10.61
40.0	65.46	437.48	273.33	710.81	528.59	236.94	10.86
41.0	67.09	471.41	273.33	744.74	562.52	248.25	11.10
42.0	68.73	505.78	273.33	779.12	596.89	259.71	11.34
43.0	70.37	515.50	273.33	788.84	606.61	262.95	11.21
44.0	72.00	525.22	273.33	798.56	616.34	266.19	11.09

45.0	73.64	534.94	273.33	808.28	626.06	269.43	10.98
46.0	75.28	544.67	273.33	818.00	635.78	272.67	10.87
47.0	76.91	554.39	273.33	827.72	645.50	275.91	10.76
48.0	78.55	564.11	273.33	837.44	655.22	279.15	10.66
49.0	80.19	573.83	273.33	847.16	664.94	282.39	10.56
50.0	81.82	583.55	273.33	856.88	674.66	285.63	10.47

TOP LOAD	TOP MOVEMENT	TIP LOAD	TIP MOVEMENT
ton	IN.	ton	IN.
.3287E+00	.1116E-03	.2399E-01	.1000E-03
.3287E+01	.1116E-02	.2399E+00	.1000E-02
.8218E+01	.2791E-02	.5998E+00	.2500E-02
.1644E+02	.5581E-02	.1200E+01	.5000E-02
.2465E+02	.8372E-02	.1799E+01	.7500E-02
.3287E+02	.1116E-01	.2399E+01	.1000E-01
.8218E+02	.2791E-01	.5998E+01	.2500E-01
.1644E+03	.5581E-01	.1200E+02	.5000E-01
.2467E+03	.8372E-01	.1799E+02	.7500E-01
.3133E+03	.1111E+00	.2399E+02	.1000E+00
.5655E+03	.2703E+00	.5998E+02	.2500E+00
.7129E+03	.5263E+00	.1130E+03	.5000E+00
.7653E+03	.7785E+00	.1380E+03	.7500E+00
.7870E+03	.1030E+01	.1616E+03	.1000E+01
.8652E+03	.9034E+01	.2709E+03	.9000E+01

DRILLED SHAFT INFORMATION

DIAMETER OF STEM	=	8.000	FT.
DIAMETER OF BASE	=	8.000	FT.
END OF STEM TO BASE	=	.000	FT.
ANGLE OF BELL	=	.000	DEG.
IGNORED TOP PORTION	=	5.000	FT.
IGNORED BOTTOM PORTION	=	7.000	FT.
AREA OF ONE PERCENT STEEL	=	72.392	SQ.IN.
ELASTIC MODULUS, Ec	=	.350E+07	LB/SQ IN
VOLUME OF UNDERREAM	=	.000	CU.YDS.

PREDICTED RESULTS

QS = ULTIMATE SIDE RESISTANCE;
QB = ULTIMATE BASE RESISTANCE;
WT = WEIGHT OF DRILLED SHAFT (FOR UPLIFT CAPACITY ONLY);
QU = TOTAL ULTIMATE RESISTANCE;
QBD = TOTAL ALLOWABLE LOAD USING A FACTOR OF SAFETY APPLIED TO THE ULTIMATE BASE RESISTANCE;
QDN = TOTAL ALLOWABLE LOAD USING FACTORS OF SAFETY APPLIED TO THE ULTIMATE SIDE RESISTANCE AND THE ULTIMATE BASE RESISTANCE.

LENGTH (FEET)	VOLUME (CU.YDS)	QS (TONS)	QB (TONS)	QU (TONS)	QBD (TONS)	QDN (TONS)	QU/VOLUME (TONS/CU.YDS)
13.0	24.21	3.46	92.43	95.89	34.27	31.96	3.96
14.0	26.07	6.91	92.49	99.40	37.74	33.13	3.81
15.0	27.93	10.37	93.17	103.54	41.42	34.51	3.71
16.0	29.79	13.82	94.45	108.27	45.31	36.09	3.63
17.0	31.65	17.28	96.31	113.59	49.39	37.86	3.59
18.0	33.51	20.74	98.74	119.47	53.65	39.82	3.56
19.0	35.38	24.19	101.71	125.90	58.10	41.97	3.56
20.0	37.24	27.65	117.22	144.87	66.72	48.29	3.89
21.0	39.10	31.11	133.20	164.30	75.51	54.77	4.20
22.0	40.96	34.56	149.63	184.19	84.44	61.40	4.50
23.0	42.82	38.02	166.51	204.52	93.52	68.17	4.78
24.0	44.69	41.47	183.80	225.28	102.74	75.09	5.04
25.0	46.55	44.93	201.52	246.45	112.10	82.15	5.29
26.0	48.41	48.39	219.62	268.01	121.59	89.34	5.54

27.0	50.27	51.84	238.11	289.96	131.21	96.65	5.77
28.0	52.13	79.31	254.15	333.46	164.03	111.15	6.40
29.0	54.00	107.64	267.76	375.40	196.89	125.13	6.95
30.0	55.86	136.78	279.00	415.78	229.78	138.59	7.44
31.0	57.72	166.72	287.91	454.63	262.69	151.54	7.88
32.0	59.58	197.41	294.53	491.93	295.58	163.98	8.26
33.0	61.44	228.82	298.90	527.72	328.46	175.91	8.59
34.0	63.31	260.94	301.06	562.00	361.29	187.33	8.88
35.0	65.17	293.72	301.06	594.78	394.07	198.26	9.13
36.0	67.03	327.14	301.06	628.20	427.49	209.40	9.37
37.0	68.89	361.17	301.06	662.23	461.52	220.74	9.61
38.0	70.75	395.78	301.06	696.84	496.14	232.28	9.85
39.0	72.62	430.95	301.06	732.01	531.30	244.00	10.08
40.0	74.48	466.64	301.06	767.70	566.99	255.90	10.31
41.0	76.34	502.83	301.06	803.89	603.19	267.96	10.53
42.0	78.20	539.50	301.06	840.56	639.86	280.19	10.75
43.0	80.06	549.87	301.06	850.93	650.22	283.64	10.63
44.0	81.92	560.24	301.06	861.30	660.59	287.10	10.51
45.0	83.79	570.61	301.06	871.67	670.96	290.56	10.40
46.0	85.65	580.98	301.06	882.04	681.33	294.01	10.30
47.0	87.51	591.34	301.06	892.41	691.70	297.47	10.20
48.0	89.37	601.71	301.06	902.77	702.07	300.92	10.10
49.0	91.23	612.08	301.06	913.14	712.44	304.38	10.01
50.0	93.10	622.45	301.06	923.51	722.80	307.84	9.92

TOP LOAD	TOP MOVEMENT	TIP LOAD	TIP MOVEME NT
ton	IN.	ton	IN.
.3288E+00	.1102E-03	.2477E-01	.1000E-03
.3288E+01	.1102E-02	.2477E+00	.1000E-02
.8221E+01	.2756E-02	.6194E+00	.2500E-02
.1644E+02	.5512E-02	.1239E+01	.5000E-02
.2466E+02	.8268E-02	.1858E+01	.7500E-02
.3288E+02	.1102E-01	.2477E+01	.1000E-01
.8221E+02	.2756E-01	.6194E+01	.2500E-01
.1644E+03	.5512E-01	.1239E+02	.5000E-01
.2468E+03	.8268E-01	.1858E+02	.7500E-01
.3216E+03	.1100E+00	.2477E+02	.1000E+00
.5813E+03	.2684E+00	.6194E+02	.2500E+00
.7515E+03	.5244E+00	.1210E+03	.5000E+00
.8149E+03	.7767E+00	.1469E+03	.7500E+00
.8397E+03	.1028E+01	.1721E+03	.1000E+01
.9323E+03	.9633E+01	.2984E+03	.9600E+01

DRILLED SHAFT INFORMATION

DIAMETER OF STEM	=	8.500	FT.
DIAMETER OF BASE	=	8.500	FT.
END OF STEM TO BASE	=	.000	FT.
ANGLE OF BELL	=	.000	DEG.
IGNORED TOP PORTION	=	5.000	FT.
IGNORED BOTTOM PORTION	=	7.000	FT.
AREA OF ONE PERCENT STEEL	=	81.723	SQ.IN.
ELASTIC MODULUS, Ec	=	.350E+07	LB/SQ IN
VOLUME OF UNDERREAM	=	.000	CU.YDS.

PREDICTED RESULTS

QS = ULTIMATE SIDE RESISTANCE;
QB = ULTIMATE BASE RESISTANCE;
WT = WEIGHT OF DRILLED SHAFT (FOR UPLIFT CAPACITY ONLY);
QU = TOTAL ULTIMATE RESISTANCE;
QBD = TOTAL ALLOWABLE LOAD USING A FACTOR OF SAFETY
APPLIED TO THE ULTIMATE BASE RESISTANCE;

QDN = TOTAL ALLOWABLE LOAD USING FACTORS OF SAFETY APPLIED TO THE ULTIMATE SIDE RESISTANCE AND THE ULTIMATE BASE RESISTANCE.

LENGTH (FEET)	VOLUME (CU.YDS)	QS (TONS)	QB (TONS)	QU (TONS)	QBD (TONS)	QDN (TONS)	QU/VOLUME (TONS/CU.YDS)
13.0	27.33	3.67	96.33	100.00	35.78	33.33	3.66
14.0	29.43	7.34	95.88	103.23	39.31	34.41	3.51
15.0	31.53	11.02	96.13	107.14	43.06	35.71	3.40
16.0	33.63	14.69	97.05	111.74	47.04	37.25	3.32
17.0	35.73	18.36	98.64	117.00	51.24	39.00	3.27
18.0	37.83	22.03	100.88	122.91	55.66	40.97	3.25
19.0	39.94	25.71	116.84	142.55	64.65	47.52	3.57
20.0	42.04	29.38	133.93	163.31	74.02	54.44	3.88
21.0	44.14	33.05	151.50	184.55	83.55	61.52	4.18
22.0	46.24	36.72	169.56	206.28	93.24	68.76	4.46
23.0	48.34	40.39	188.08	228.47	103.09	76.16	4.73
24.0	50.45	44.07	207.05	251.12	113.08	83.71	4.98
25.0	52.55	47.74	226.47	274.21	123.23	91.40	5.22
26.0	54.65	51.41	246.31	297.72	133.51	99.24	5.45
27.0	56.75	55.08	265.11	320.19	143.45	106.73	5.64
28.0	58.85	84.27	281.43	365.70	178.08	121.90	6.21
29.0	60.96	114.36	295.31	409.68	212.80	136.56	6.72
30.0	63.06	145.33	306.78	452.11	247.59	150.70	7.17
31.0	65.16	177.14	315.88	493.02	282.43	164.34	7.57
32.0	67.26	209.74	322.65	532.40	317.30	177.47	7.92

33.0	69.36	243.13	327.13	570.26	352.17	190.09	8.22
34.0	71.47	277.25	329.35	606.60	387.03	202.20	8.49
35.0	73.57	312.08	329.35	641.43	421.86	213.81	8.72
36.0	75.67	347.59	329.35	676.94	457.37	225.65	8.95
37.0	77.77	383.74	329.35	713.09	493.53	237.70	9.17
38.0	79.87	420.52	329.35	749.87	530.30	249.96	9.39
39.0	81.98	457.88	329.35	787.23	567.67	262.41	9.60
40.0	84.08	495.81	329.35	825.16	605.59	275.05	9.81
41.0	86.18	534.26	329.35	863.61	644.04	287.87	10.02
42.0	88.28	573.22	329.35	902.57	683.00	300.86	10.22
43.0	90.38	584.24	329.35	913.59	694.02	304.53	10.11
44.0	92.49	595.25	329.35	924.60	705.04	308.20	10.00
45.0	94.59	606.27	329.35	935.62	716.05	311.87	9.89
46.0	96.69	617.29	329.35	946.64	727.07	315.55	9.79
47.0	98.79	628.30	329.35	957.65	738.09	319.22	9.69
48.0	100.89	639.32	329.35	968.67	749.10	322.89	9.60
49.0	103.00	650.34	329.35	979.69	760.12	326.56	9.51
50.0	105.10	661.35	329.35	990.70	771.14	330.23	9.43

TOP LOAD	TOP MOVEMENT	TIP LOAD	TIP MOVEMENT
ton	IN.	ton	IN.
.3290E+00	.1091E-03	.2551E-01	.1000E-03
.3290E+01	.1091E-02	.2551E+00	.1000E-02
.8225E+01	.2727E-02	.6377E+00	.2500E-02
.1645E+02	.5455E-02	.1275E+01	.5000E-02
.2468E+02	.8182E-02	.1913E+01	.7500E-02
.3290E+02	.1091E-01	.2551E+01	.1000E-01

.8225E+02	.2727E-01	.6377E+01	.2500E-01
.1645E+03	.5455E-01	.1275E+02	.5000E-01
.2469E+03	.8182E-01	.1913E+02	.7500E-01
.3284E+03	.1091E+00	.2551E+02	.1000E+00
.5971E+03	.2667E+00	.6377E+02	.2500E+00
.7885E+03	.5227E+00	.1275E+03	.5000E+00
.8607E+03	.7750E+00	.1557E+03	.7500E+00
.8921E+03	.1026E+01	.1823E+03	.1000E+01
.1000E+04	.1023E+02	.3264E+03	.1020E+02

DRILLED SHAFT INFORMATION

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DIAMETER OF STEM              =    9.000  FT.
DIAMETER OF BASE              =    9.000  FT.
END OF STEM TO BASE           =     .000  FT.
ANGLE OF BELL                 =     .000  DEG.
IGNORED TOP PORTION           =    5.000  FT.
IGNORED BOTTOM PORTION        =    7.000  FT.
AREA OF ONE PERCENT STEEL     =   91.621  SQ.IN.
ELASTIC MODULUS, Ec           = .350E+07  LB/SQ IN
VOLUME OF UNDERREAM           =     .000  CU.YDS.
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PREDICTED RESULTS

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QS      = ULTIMATE SIDE RESISTANCE;
QB      = ULTIMATE BASE RESISTANCE;
WT      = WEIGHT OF DRILLED SHAFT (FOR UPLIFT CAPACITY ONLY);
QU      = TOTAL ULTIMATE RESISTANCE;
QBD     = TOTAL ALLOWABLE LOAD USING A FACTOR OF SAFETY
          APPLIED TO THE ULTIMATE BASE RESISTANCE;
QDN     = TOTAL ALLOWABLE LOAD USING FACTORS OF SAFETY
          APPLIED TO THE ULTIMATE SIDE RESISTANCE AND
          THE ULTIMATE BASE RESISTANCE.
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LENGTH (FEET)	VOLUME (CU.YDS)	QS (TONS)	QB (TONS)	QU (TONS)	QBD (TONS)	QDN (TONS)	QU/VOLUME (TONS/CU.YDS)
13.0	30.63	3.89	99.79	103.68	37.15	34.56	3.38
14.0	32.99	7.78	98.95	106.73	40.76	35.58	3.23

15.0	35.35	11.66	98.85	110.52	44.62	36.84	3.13
16.0	37.70	15.55	99.50	115.05	48.72	38.35	3.05
17.0	40.06	19.44	100.88	120.32	53.07	40.11	3.00
18.0	42.42	23.33	116.99	140.32	62.33	46.77	3.31
19.0	44.77	27.22	134.35	161.56	72.00	53.85	3.61
20.0	47.13	31.11	152.90	184.01	82.07	61.34	3.90
21.0	49.49	34.99	171.96	206.96	92.32	68.99	4.18
22.0	51.84	38.88	191.52	230.40	102.72	76.80	4.44
23.0	54.20	42.77	211.56	254.33	113.29	84.78	4.69
24.0	56.56	46.66	232.07	278.73	124.02	92.91	4.93
25.0	58.91	50.55	253.04	303.59	134.89	101.20	5.15
26.0	61.27	54.44	274.46	328.90	145.92	109.63	5.37
27.0	63.63	58.32	293.37	351.69	156.11	117.23	5.53
28.0	65.98	89.23	309.80	399.03	192.49	133.01	6.05
29.0	68.34	121.09	323.78	444.87	229.02	148.29	6.51
30.0	70.69	153.88	335.35	489.23	265.66	163.08	6.92
31.0	73.05	187.56	344.54	532.09	302.40	177.36	7.28
32.0	75.41	222.08	351.38	573.46	339.21	191.15	7.60
33.0	77.76	257.43	355.90	613.33	376.06	204.44	7.89
34.0	80.12	293.56	358.15	651.71	412.94	217.24	8.13
35.0	82.48	330.44	358.15	688.59	449.82	229.53	8.35
36.0	84.83	368.03	358.15	726.19	487.42	242.06	8.56
37.0	87.19	406.32	358.15	764.47	525.70	254.82	8.77
38.0	89.55	445.26	358.15	803.41	564.64	267.80	8.97

39.0	91.90	484.82	358.15	842.97	604.20	280.99	9.17
40.0	94.26	524.97	358.15	883.12	644.35	294.37	9.37
41.0	96.62	565.69	358.15	923.84	685.07	307.95	9.56
42.0	98.97	606.94	358.15	965.09	726.32	321.70	9.75
43.0	101.33	618.60	358.15	976.76	737.99	325.59	9.64
44.0	103.69	630.27	358.15	988.42	749.65	329.47	9.53
45.0	106.04	641.93	358.15	1000.08	761.32	333.36	9.43
46.0	108.40	653.60	358.15	1011.75	772.98	337.25	9.33
47.0	110.76	665.26	358.15	1023.41	784.65	341.14	9.24
48.0	113.11	676.93	358.15	1035.08	796.31	345.03	9.15
49.0	115.47	688.59	358.15	1046.74	807.98	348.91	9.07
50.0	117.82	700.26	358.15	1058.41	819.64	352.80	8.98

TOP LOAD	TOP MOVEMENT	TIP LOAD	TIP MOVEMENT
ton	IN.	ton	IN.
.3292E+00	.1081E-03	.2620E-01	.1000E-03
.3292E+01	.1081E-02	.2620E+00	.1000E-02
.8231E+01	.2703E-02	.6550E+00	.2500E-02
.1646E+02	.5406E-02	.1310E+01	.5000E-02
.2469E+02	.8110E-02	.1965E+01	.7500E-02
.3292E+02	.1081E-01	.2620E+01	.1000E-01
.8231E+02	.2703E-01	.6550E+01	.2500E-01
.1646E+03	.5406E-01	.1310E+02	.5000E-01
.2470E+03	.8110E-01	.1965E+02	.7500E-01
.3294E+03	.1081E+00	.2620E+02	.1000E+00
.6128E+03	.2653E+00	.6550E+02	.2500E+00
.8207E+03	.5211E+00	.1310E+03	.5000E+00
.9065E+03	.7735E+00	.1645E+03	.7500E+00
.9438E+03	.1025E+01	.1918E+03	.1000E+01
.1068E+04	.1083E+02	.3549E+03	.1080E+02