REPORT

# GEOTECHNICAL INVESTIGATION AND RECOMMENDATIONS

## Tres Lomas Groundwater Seep

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**September 2, 2010** **103-92518**

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# 1.0 INTRODUCTION

This report presents the results of the hydrogeologic and geotechnical engineering study performed by Golder Associates Inc. (Golder) for Pima County Regional Wastewater Reclamation Department (RWRD) at the Tres Lomas Groundwater Seepage Project located in the northeast of Tucson, Pima County, Arizona (the site). The site is located in Section 22, Township 13 South, Range 15 East; GSRM, Pima County Board District No. 4.

Golder's study had three primary objectives as described in the RWRD's Request for Proposal issued on March 30, 2010:

1. Evaluate subsurface soil and groundwater conditions to assess the hydrogeologic and geotechnical conditions in the area,
2. Evaluate surface soil and groundwater conditions to estimate the hydraulic conductivity of the sewer trench backfill sections and the surrounding native areas.
3. Perform a geotechnical investigation to evaluate interpretations proposed by prior investigations.

This report has been prepared in accordance with our approved proposal dated March 30, 2010. (Golder, 2010). Golder's scope of work was further described in our March 30, 2010 proposal letter. Notice to proceed was given by Mr. David Logue, P.E. of RWRD on April 21, 2010.

## 1.1 Project Overview

The project site, shown in Figure 1, is located in the Tres Lomas North Subdivision in the northeast portion of the Tucson Metropolitan area, southwest of the intersection of Snyder and Houghton Roads. The area under investigation has surface expressions of seeping groundwater that has been independently investigated by both Tucson Water and a private consultant funded by the local residents. The project limits defined by a rectangular area with its southwest corner at the intersection of East Moenkopi Trail and East Walnut Tree Drive and extend to the north approximately 350 feet along Moenkopi Trail and to the east approximately 330 feet to the east on Walnut Tree Drive. At the request of RWRD additional investigations were performed along the sewer alignment at the intersection of Bidahochi Drive and Summer Trail.

## 1.2 Scope of Services

Golder's scope of services discussed in this report includes Tasks 1 to 3 above. Specifically, these services included site reconnaissance by a geotechnical engineer and a hydrogeologist, a subsurface investigation program, laboratory testing, and engineering analysis. A more detailed description of each of these tasks follows:

- Site reconnaissance by a field engineer and a hydrogeologist to assess the distribution of the seepage region.

- Additional Site inspections by a field engineer that included locating boreholes and pothole locations at the project site, under the direction of RWRD, and contacting Arizona Bluestake for locating utilities within the public easement.
- A field investigation supervised by a geological engineer and a hydrogeologist that included four boreholes and two potholes along the alignment of the project limits as established by RWRD.
- Laboratory testing of representative samples collected during the preliminary subsurface investigation program was conducted to establish material classification, material geotechnical properties, and the groundwater chemical composition to assist in evaluating the site conditions and the potential source(s) of the water. The results of the laboratory testing program are discussed in Section 3.3. Laboratory test data are included as Appendix B.
- Preparing this report summarizing the results and recommendations of the hydrogeological and geotechnical study.

Golder performed these tasks under contract to Pima County Field Engineering Division, Regional Wastewater Reclamation Department. The work was performed under Purchase Order No. 10041288.

# 2.0 REGIONAL GEOLOGY

## 2.1 General Overview

The project site is located in the northeastern portion of the Tucson Metropolitan Area in the Tucson Basin, approximately one mile south of the Santa Catalina Mountain massif. The Tucson basin is bordered on the north and east by the Santa Catalina, Tanque Verde, and Rincon Mountains. Their shape reflects their metamorphic core complex structure, and is depicted by a series of broad west-southwest-trending and plunging open folds comprising the layers of the granitic Catalina gneiss assemblage. The mountain ranges and their structures were formed during periods of intrusion, metamorphism, folding, thrust and detachment faulting that is estimated to have started in Late Cretaceous or early Tertiary time and continued through late Tertiary time. (Pashley, 1966)

The region has experienced intense faulting and folding. It has been suggested that the upper plate is composed of folded rocks that were formed by displacement along the Catalina fault. At many places the upper plate is composed of the Tinaja beds of probable middle and late Tertiary age. The lower Tinaja beds consist of red to light-gray, firmly to very firmly cemented, interbedded conglomerate, sandstone, and mudstone. Beds of massive gypsum, interbedded with the mudstone, have also been observed in the lower Tinaja. In addition, several thin beds of mud cracked limestone and thicker beds of white volcanic ash have been observed in these sediments (Pashley, 1966). Mudstone and gypsum, which distinguish the lower Tinaja beds from other Tinaja units, indicate a low energy playa environment situated near the center of a closed ancestral depositional basin. Upper Tinaja beds were deposited along the edges of the ranges after the basin-mountain complex had reached their approximate present configuration. These sediments are composed of gneissic pebbles derived from the nearby mountains and of material eroded from the lower and middle Tinaja beds involved in the uplift. The beds consist of sand and gravel deposited along the edge of the ranges as alluvial fans and merge near the center of the basin with fine-grained playa deposits. (Pashley, 1966)

The close of the Tinaja depositional period was marked by normal faulting and erosion within the piedmont area. The erosion carved the Tinaja surface across the Tinaja beds, and formed narrow bedrock pediments along the edges of the ranges. In late Tertiary and early Quaternary time, during and after the formation of the Tinaja surface, the basin-fill deposits were laid down in a closed basin as alluvial fans that at one time extended from the steep fronts of the ranges to the center of the basin where they merged with fine-grained deposits and reached thicknesses in excess of 700 feet. (Pashley, 1966)

In middle Quaternary time the formation of a drainage outlet in the northwest corner of the basin resulted in increased stream gradients and the start of basin erosion. This resulted in the present drainage system, the formation of several broad pediments, and the removal of alluvial fans from along the mountain edges. (Pashley, 1966)

## 2.2 Stratigraphy and Structure

As discussed above, much of the margin of the present Tucson Basin, (area along the edges of the Santa Catalina Mountains) is underlain directly by Tinaja beds. These deposits are complexly interlayered, tilted, faulted, and jointed conglomerate, sandstone, and mudstone and exhibit a great range of induration, color, and composition and represent an older or ancestral basin fill sedimentary complex. The Tinaja beds are tilted and broken by faults with displacement measured in the tens to thousands of feet, which divided the units into a series of tilted fault blocks. The beds in the individual blocks, separated by these major faults, are broken by numerous smaller faults showing displacement ranging from a few inches to a few feet.

The Tinaja beds were buried over most of their present extent by younger undeformed deposits, which are usually referred to collectively as recent basin-fill deposits. These recent basin fill sediments represent the present day Tucson basin stratigraphic assemblage. Subsequent erosion has removed much of the cover of basin-fill deposits and exposed the underlying Tinaja beds along the margins of the current Tucson basin and in the central part of the Tucson Basin the Tinaja beds are buried by the recent basin-fill.

Along the margins of the basin, groundwater wells that tap the Tinaja beds generally have lower specific capacities than wells that yield water from the younger basin-fill deposits, thus indicating that the young basin-fill deposits are more permeable than the Tinaja beds. The ability to distinguish between the basin-fill deposits and the Tinaja beds in outcrops and well cuttings and determination of the thickness and aerial distribution of these two units are therefore critical to an overall evaluation of the groundwater supplies of the Tucson basin. (Pashley, 1966)

Based on geologic mapping provided by the Arizona Geological Survey (Open-File Report 89-2, 1989) the Tinaja beds located in the vicinity of the project site and may be affecting the groundwater flow in the Tres Lomas area.

## 2.3 Near Surface Deposits

A soil report of the area, based on soil units mapped by the United States Department of Agriculture Natural Conservation Services (NRCS), is provided in Appendix C (Soil Survey Staff, 2009). According to information contained in the this report, surface soils in the upper 5 feet in the affected subdivision areas include the Haywook-Sahuarita complex consisting of fan terrace deposits derived from granite and are also mixed with recent alluvium. This soil series has a high capacity to transmit water with k-values ranging from $1.69 \times 10^{-3}$ cm/s to $4.23 \times 10^{-3}$ cm/s. The Pantano-Granolite complex has been mapped in the western and southern portions of the Tres Lomas North Subdivision and has also been mapped to the east of the project site. This soil complex correlates with the mapped exposures of the lower Tinaja beds that have been discussed in previous sections of this report. These soils have a distinct maroon color and fine bedding and are readily distinguishable from younger alluvial deposits. They are potentially

subject to shrink-swell processes. They are further characterized by their very low k values. A soil survey map of the site is attached as Figure 3.

## 3.0 GEOTECHNICAL INVESTIGATION PROGRAM

Golder performed the field investigation in two phases. Phase 1 was the pothole investigation and was performed on May 18, 2010. Phase 2 of the investigation consisted of drilling four boreholes and was conducted on May 26, 2010. Both investigations are described in detail in Sections 3.1 and 3.2, respectively. The laboratory analysis of representative samples is discussed in Section 3.3. A site plan with borehole and test pit locations is provided on Figure 2. A summary of the borehole and test pit locations is provided in Table 1 (below).

**TABLE 1**

**BOREHOLE AND POTHOLE LOCATIONS**

| Borehole/Pothole Identification | Latitude | Longitude | Exploration Depth (feet) |
|---|---|---|---|
| B-1 | 32.290973 | 110.795847 | 8.0 |
| B-2 | 32.292063 | 110.796581 | 11.5 |
| B-3 | 32.290855 | 110.795931 | 7.0 |
| B-4 | 32.290973 | 110.795847 | 11.5 |
| PH-1 | 32.290883 | 110.797133 | 4.0 |
| PH-2 | 32.290894 | 110.797022 | 3.0 |
| PH-3 | 32.288011 | 110.796941 | 10.0 |

### 3.1 Pothole Investigation

Three potholes were excavated at the project site on May 18, 2010. The location of the potholes was directed by RWRD to investigate the type of material that was used as trench backfill during the construction of the sewerline. The three locations were located within the trench alignment at each location. The potholing was performed by Geomechanics Southwest, Inc (GSI) of Tucson Arizona. The potholing was performed utilizing an air knife powered by an air compressor while the excavated soil was extracted by a vacuum pump that stored the cuttings in a chamber within the vacuum.

The excavations were performed at 0.5– to 1-foot intervals so as not to have excess soil in the excavation vessel and to allow observation of the excavated materials. The air knife eroded the soil in the excavation and once a grab sample had been retrieved and analyzed, the soil was extracted using the vacuum.

All samples collected were placed and sealed in plastic bags. Selected samples were sent to Speedie and Associates Inc in Tucson, Arizona for geotechnical testing.

### 3.2 Geotechnical Boreholes

Four boreholes were drilled at the project site. The locations of the boreholes were directed by RWRD prior to the drilling investigation. The boreholes were drilled to depths ranging from 7 to 11 feet below ground surface (bgs), and were advanced using a CME-75 truck mounted drill rig provided by GSI of Tucson, Arizona. The boreholes were drilled with 3.25-inch inside diameter (ID) and 7.626-inch outside diameter (OD) hollow-stem auger backfilled with the excavated drill cuttings upon completion.

Samples were collected using a Standard Penetration Test (SPT) split-spoon sampler at 2.5- and 5-foot intervals. This split spoon sampler consists of a 2-inch OD, 1.4-inch ID split-barrel shaft that is driven a total of 18 inches into the soil at the bottom of the borehole. Soil is retained inside the split-barrel shaft (without rings or liner) and the soil is visually classified by the field engineer. SPTs were in general accordance with American Society for Testing and Materials (ASTM) Method D1586 standards. The split-spoon sampler was driven 18 inches into the soil with a 140-pound automatic hammer, freely falling from a height of 30 inches. The number of blows required for each 6 inches of penetration was recorded. The number of blows required to advance the sampler the last 12 inches is the penetration resistance N value, or blowcount, and provides a quantitative measure of the relative density of cohesionless soils, or the consistency of cohesive soils. The N value recorded for each SPT is shown on the borehole logs in Appendix A.

A 2.5-inch OD, split-spoon sampler was also used to sample soils where a larger sample quantity was required, or where in-place soil density w s to be measured. The sampling method was similar to the SPT, but because of the larger diameter of this sampler, blow counts were typically higher than those obtained with the SPT sampler and they should not directly be equated to SPT blow counts.

The SPTs conducted using the CME-75 drill rig were performed with a CME automatic hammer, which has an efficiency of approximately 85 to 95 percent of the theoretical free-fall energy (DSO-99-03, 1999). This high efficiency was considered for this project when the SPT was used to derive geotechnical parameters. For example, corrections between soil relative density and the SPT typically use N values standardized to 60 percent energy efficiency. Therefore, use of these correlations using the SPT results from the project boreholes require that N values be corrected by multiplying by a factor of approximately 85/60 prior to use.

All soil samples collected with the split-spoon sampler were placed and sealed in plastic bags. Selected samples from the investigation were sent to the Golder Geomechanics laboratory in Lakewood, Colorado and to Speedie in Tucson, Arizona, for geotechnical testing.

Golder personnel were present throughout the field investigation to observe the drilling operations, conduct SPTs, assist in sampling, and prepare descriptive logs of the boreholes. The soils encountered in these boreholes were visually logged in the field by the Golder engineer in general accordance with ASTM Method D2488, Standard Recommended Practice for Description of Soils (Visual-Manual Procedure). The soil descriptions based on the field classification were recorded on the borehole logs (Appendix A).

## 3.3 Geotechnical Laboratory Testing

Laboratory testing was performed by Golder, Speedie, and Turner Laboratories, Inc. (Turner) of Tucson, Arizona, on representative, bulk, and relatively undisturbed samples to:

- substantiate field classifications, and
- provide engineering parameters necessary for the hydrogeological and geotechnical analysis.

The laboratory testing included grain-size analysis, Atterberg Limits tests (plasticity), hydraulic conductivity, standard proctor, dry unit weight, and moisture content determination. Tests were performed in accordance with the standard test procedures listed in Table 2. The laboratory test data are in Appendix B. In accordance with ASTM Method D 2487, the field classification of soil samples were updated on the borehole and pothole logs, where appropriate.

## TABLE 2

## GEOTECHNICAL TEST METHODS APPLIED TO REPRESENTATIVE SOIL SAMPLES

| Geotechnical Test | Test Procedure |
|---|---|
| Moisture Content | ASTM D2216 |
| Sieve (grain–size) Analysis | ASTM D422 |
| Atterberg Limits (soil plasticity) | ASTM D4318 |
| Dry Unit Weight | ASTM D2937 |
| Standard Proctor | ASTM D698 |
| Hydraulic Conductivity | ASTM D5084 |

Hydraulic conductivity tests (ASTM D5058) were performed on two samples. The results of the laboratory test results are presented below in Table 3:

## TABLE 3

## FLEX-WALL PERMEABILITY (HYDRAULIC CONDUCTIVITY) TEST RESULTS

| Sample Number | Dry Density (pcf) | Moisture (%) | Ave. Permeability (cm/sec) |
|---|---|---|---|
| B-1 (1 to 5 ft) | 105.8 | 9.3 | $7.7 \times 10^{-5}$ |
| B-2 (7.5 to 10 ft) | 104.7 | 11.9 | $1.2 \times 10^{-4}$ |

Based on these results, the clayey sand in the trench backfill material has a slightly lower conductivity than the clayey sand in the native soil conditions.

Sieve analysis and soil plasticity tests indicate that the alluvial soils are predominantly clayey sand, with percent passing the No. 200 sieve (silt and clay fraction) ranging from 16 to 48 percent with an average value of 30. The plasticity index of the fines ranged from 15 percent to 40 percent with an average value of 29 percent and the liquid limit ranged from 32 to percent to 63 percent with an average value of 44.

The groundwater collected from the potholes was also tested for multiple chemical constituents. Several tests were performed on the two water samples that were collected from PH-1 and PH-2. Amongst the tests performed, the total dissolved solids (TDS) for residue and filterable results ranged from 4,800 to

5,300 mg/L, nitrogen, ammonia and nitrates were non-detectable, below 1.0 and 0.5 mg/L, respectively. Sulfate contents for both samples were 2,000 mg/L and the chloride content ranged from 460 to 600 mg/L.

# 4.0 INTERPRETED SUBSURFACE CONDITIOINS

## 4.1 Site Conditions

The areas of the site that appear to have been affected by the groundwater seepage are occupied by residential lots with existing single home residences. The roads in the subdivision are all paved with asphaltic concrete. The pavement located in the vicinity of the intersection of Moenkopi Trail and Walnut Tree Drive has developed significant alligator cracks and appears to be disintegrating in a few areas. The topography in the area generally slopes to the southwest. The vegetation mainly consists of mesquite and palo verde trees with scattered shrubs and desert grasses. There are three drainage channels in the vicinity of the project limits, as shown in Figure 1. All three channels flow south as one unit to the Tanque Verde Creek. To the northwest of the site, Bear Creek flows into the Sabino Creek and further south, the wash that flows south of the site confluences with the Sabino Creek and drains south to the Tanque Verde Creek.

## 4.2 Soil Stratigraphy

A summary description of the subsurface materials encountered in each of the four boreholes is provided below.

- **Borehole B-1:** The borehole was located adjacent to the existing sewerline, approximately 6 feet south of the manhole within bounds that were expected to be part of the existing sewerline trench. Measurements from the manhole showed that the top of the sewerline was approximately 9 feet below ground surface (bgs). The borehole encountered approximately 3-inches of asphaltic concrete overlying 7.5 feet of medium dense to loose clayey sand with gravel. The clayey sand was further characterized as brown with medium plasticity fines and consisting of fine to coarse sand with fine to coarse angular to sub-angular gravel. The clayey sand increased in moisture content with depth, gradually transitioning from moist to very moist.
- **Borehole B-2:** The borehole was located approximately 18 feet west of Borehole B-1 in native soil conditions. The borehole encountered medium dense to very dense clayey sand with varying amounts of gravel from the surface to 11.5 feet consisting of medium plasticity fines, fine to coarse sand, and fine to coarse angular to sub-angular gravel. The borehole was terminated at 11.5 feet bgs when wet clayey sand with gravel was encountered from 10 to 11.5 feet. The clayey sand at 10 feet was further classified as very dense with medium plasticity fines, fine to coarse sand, angular to sub-angular fine to coarse sand. Upon completion, the borehole was left open for approximately 1 hour after which the water level was measured. Approximately 12-inches of standing water was measured in the borehole prior to backfilling.
- **Borehole B-3:** The borehole was located approximately 5 feet west of the existing sewer manhole. Measurements from the manhole showed that the top of the sewerline was approximately 8.5 feet bgs. The borehole encountered approximately 7 feet of loose to very loose clayey sand with gravel. The clayey sand was further classified as moist to very moist consisting of medium plasticity fines with fine to coarse sand, and fine to coarse angular gravel. The borehole was terminated at 7 feet bgs.
- **Borehole B-4:** The borehole was located approximately 50 feet northeast of Borehole B-3, in native soil conditions. The borehole encountered 7.5 feet of stiff to very stiff sandy lean clay with medium plasticity fines. The clay was further characterized as damp to moist, brown and consisting of fine to coarse sand and fine angular gravel.

Underlying the clay, the borehole encountered approximately 2.5 feet of brown to reddish brown medium dense clayey sand. The sand was further characterized as moist with medium plasticity fine, fine to coarse sand, and fine angular gravel. At 10 feet bgs, the borehole encountered medium dense well graded sand with gravel consisting of fine to coarse sand, and fine to coarse gravel. Groundwater was encountered at 10 feet. The borehole was terminated at 11.5 feet bgs. Upon completion, the borehole was left open for approximately 1 hour after which the water level was measured. Approximately 12-inches of standing water was measured in the borehole prior to backfilling.

## 4.3 Pothole Explorations

A summary description of the subsurface materials encountered in each exploration is provided below. Additional details are provided on the pothole logs:

- **Pothole PH-1:** The borehole was located approximately 20 feet south of the exiting manhole at the intersection on Moenkopi Trail and Walnut Tree Drive along the utility easement alignment. The pothole encountered approximately 1.5 feet of brown, loose to medium dense clayey sand. Underlying the upper sand, the excavation encountered 2.5 feet of very soft gray to tan sandy lean clay. The clay was very moist, eventually transitioning into a wet zone at 4 feet. The excavation was left open for 40 minutes before a water measurement was recorded. Approximately 12 inches of water had accumulated in the 8-inch diameter hole. A water sample was collected for analysis and the borehole was backfilled.
- **Pothole PH-2:** The borehole was located approximately 20 feet east of the PH-01 to investigate the subsurface conditions in the native areas outside the sewerline trench. The excavation encountered half a foot of medium dense to dense clayey sand with gravel, underlain by 1.5 feet of loose to medium dense clayey sand. The upper clayey sand was brown with medium plasticity fines and fine to coarse sand. From 3- to 4-feet bgs, the pothole encountered grayish white and tan sandy lean. The layer was further characterized as very soft and wet. The excavation was left open for approximately 30 minutes prior to measuring the water level. Approximately 5-inches of water had collected in the 8-inch diameter excavation.
- **Pothole PH-3:** The borehole was located approximately 20 feet northwest of the existing manhole at the intersection of Bidahochi Drive and Summer Trail. Based on the measurements performed in the field, the top of the sewerline was expected to be at approximately 11.0 feet bgs. The pothole encountered approximately 10 feet of sandy clay with varying amounts of gravel. The clayey sand was further described as moderate brown, damp with medium plasticity fines, fine to coarse sand, and fine to coarse sub-angular to sub-rounded gravel. The potholes was terminated at 10 feet bgs.

## 4.4 Groundwater

Based upon review of Tucson Basin and Avra Valley Depth to Water Maps (City of Tucson, 2005), regional groundwater is typically within deep, basin fill deposits at the project site. Arizona Department of Water Resources records from 2000 indicate that regional groundwater is present at an estimated depth ranging from 50 to 100 feet below the existing ground surface in surrounding areas.

Groundwater was observed in Boreholes B-2 and B-4 at 10 feet bgs. Groundwater was also observed in Potholes PH-1 and PH-2 at 4 feet bgs.

# 5.0 FINDINGS

## 5.1 Hydraulic Conductivity of Site Conditions

Golder performed two hydraulic conductivity tests (ASTM D 5084) on two samples from Boreholes B-1 and B-2. The tests were performed to assess the hydraulic conductivity of the soil used in the trench backfill and in the native soil conditions. Both boreholes encountered clayey sand with gravel, although the soil in Borehole B-2 appeared contain higher gravel content than the soil used as trench backfill. This could be attributed to the fact the backfill material was screened prior to placement when the sewerline was constructed.

The hydraulic conductivity for the material from B-1 (K) was 7.7 x $10^{-5}$ centimeters per second (cm/s), and the K value for the B-2 sample was 1.2 x $10^{-4}$ cm/s. Based on these results, the clayey sand in the trench backfill material has a slightly lower, but similar hydraulic conductivity as the clayey sand in the native soil conditions. It is therefore unlikely that the groundwater seeping through site will be preferentially transmitted through the sewerline trenches rather than through the native material at similar unit weights.

## 5.2 Hydrogeologic Interpretation

Based on the site geology that has been discussed in Section 2, and the site location at the margins of the Tucson Basin, Golder expects that the site surface geology is a relatively thin veneer of the younger basin fill deposits that are directly overlying conglomerate, sandstone, and mudstone beds of the Tinaja Formation. The Tinaja units are tilted and broken by normal faults of variable displacement which divided the underlying units into a series of tilted fault blocks. Consequently, the thickness of the overlying basin fill deposits will vary significantly throughout the area. Based on information provided in the NRCS (2009) soil survey and the discussion in Section 2, the younger basin fill deposits are more permeable that the Tinaja beds which generally have low to moderate capacities to transmit water.

Using the model summarized above, we hypothesize that shallow groundwater from up-gradient infiltration will travel within the more permeable and younger basin fill sediments. Once this groundwater encounters the underlying low permeability Tinaja beds it may either become perched or diverted. Where the static water level profile (phreatic surface) intersects the ground surface, groundwater will daylight in the form of seeps and small springs. This scenario is likely present at the project site, where some of the residences were constructed on the younger basin-fill sediments which are underlain at shallow depth by the less permeable Tinaja units. The efflorescent precipitates (white powder) that are present at the surface seeps are evaporated salt residues that were leached out of the underlying Tinaja by groundwater interaction with the evaporate sequences in the Tinaja. The efflorescent precipitates are the sulfate and sodium salts that have been deposited at the surface as the groundwater evaporates.

The pothole excavations performed at the site revealed that water was encountered in the excavations within the trench boundaries and outside the limits of the sewerline. Water was also encountered in

Boreholes B-2 and B-4 that were drilled outside the limits of the sewerline trench. This observation suggests that the groundwater is seeping regionally through basin fill deposits and does not preferentially select the sewer line trench or trench backfill material.

## 6.0 CLOSING

This report has been prepared for the exclusive use of Pima County Regional Wastewater Reclamation Department and its staff and consultants for specific application for the Tres Lomas North Subdivision project site as described in this report.

The findings, conclusions, and recommendations presented in this report were prepared in accordance with generally accepted hydrogeologic and geotechnical engineering practices within the area at the time this study was performed. No warranty, either expressed or implied, is made. Golder's field investigation program was based on the preliminary site plan provided to Golder at the time of the field investigation. Golder should review the final site map to verify that the soil boreholes were properly located. Appendix D. contains further detailed information regarding the proper use and interpretation of this report.

The client has the responsibility to see that all parties are made aware of this report in its entirety. This report contains information that may be useful in the preparation of contract specifications and contractor cost estimates if necessary. However, this report is not written as a specification document and may not contain sufficient information for this use without proper modification.

Respectfully submitted,

**GOLDER ASSOCIATES INC.**

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## 7.0 REFERENCES

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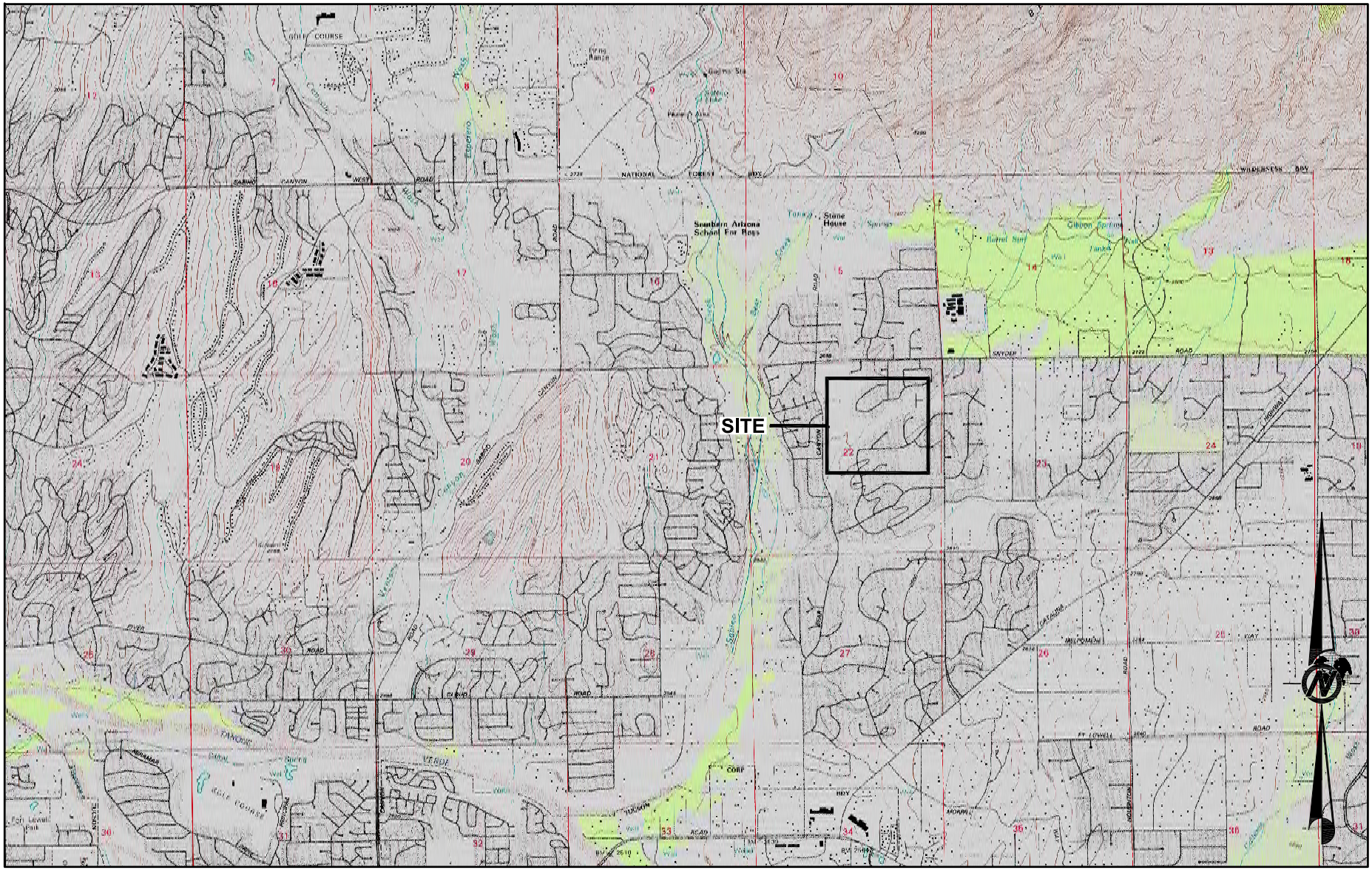
# FIGURES

Drawing file: K:\2010 Projects\103-92518 Tres Lomas\10392518A001.dwg Aug 31, 2010 - 2:47pm



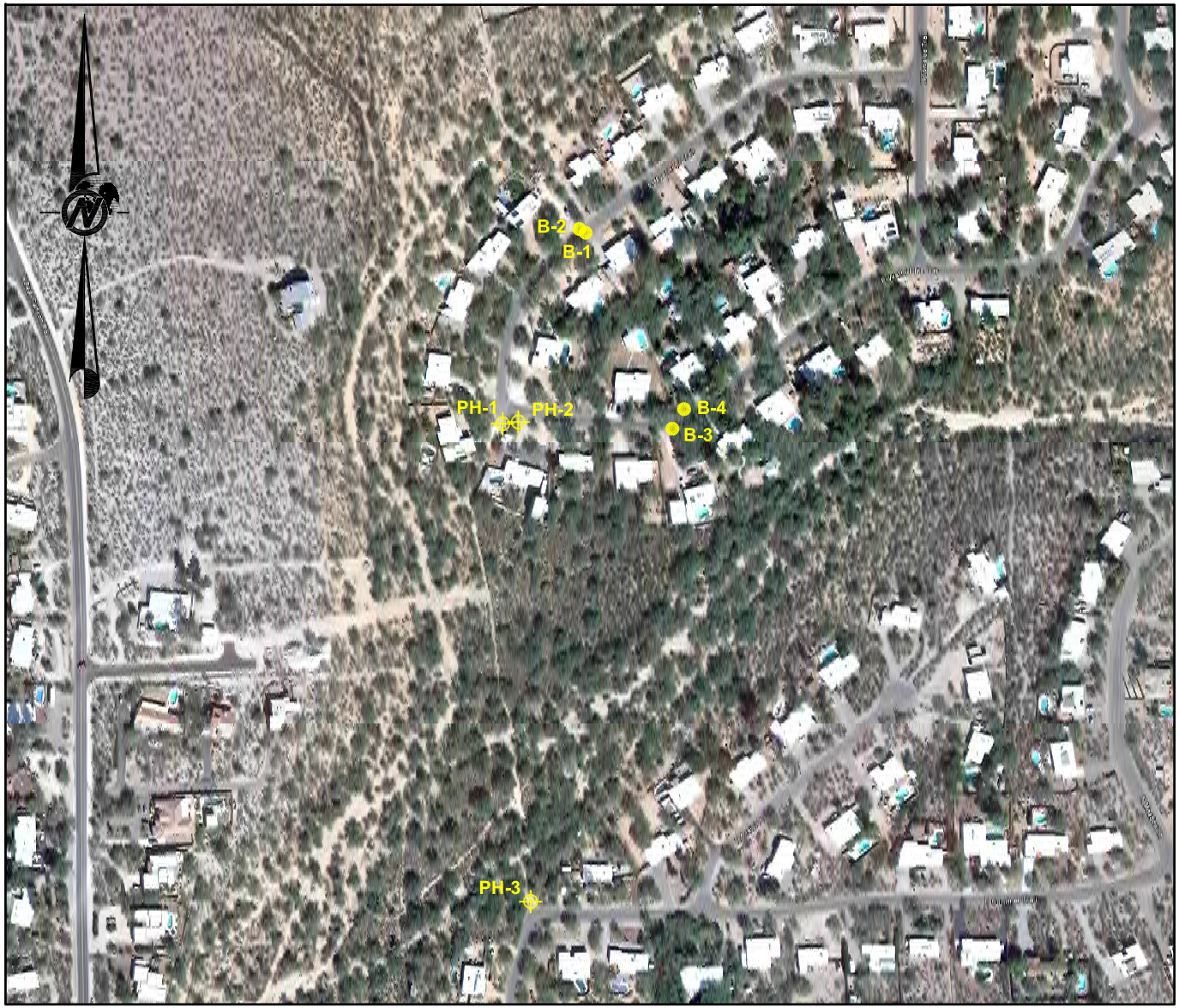

SOURCE: USGS 7.5 MINUTE TOPOGRAPHIC QUADRANGLE MAP "SABINO CANYON, AZ", 1992.

4000 0 4000

SCALE 1" to 4000' FEET

| PROJECT | TITLE | | | | |
|---|---|---|---|---|---|
| PIMA COUNTY<br>REGIONAL WASTEWATER RECLAMATION DEPARTMENT<br>TRES LOMAS GROUNDWATER SEEPAGE PROJECT<br>PIMA COUNTY, ARIZONA | **SITE LOCATION MAP** | Golder Associates | PROJECT No. 103-92518 | FILE No. 10392518A001 | |
| | | | DESIGN CM 06/29/10 | SCALE AS SHOWN | REV. A |
| | | | CADD NIL 06/29/10 | **FIGURE 1** | |
| | | | CHECK CM 06/30/10 | | |
| | | | REVIEW MLP 06/30/10 | | |

Drawing file: K:\2010 Projects\103-92518 Tres Lomas\10392518A002.dwg Aug 31, 2010 - 2:46pm




SOURCE: NOVEMBER 21, 2009 IMAGERY © GOOGLE 2010.

## LEGEND

B-1 BOREHOLE

PH-1 POTHOLE

## BOREHOLE LOCATIONS

| ID | LATITUDE | LONGITUDE |
|---|---|---|
| B-1 | 32° 17' 31.29" N | 110° 47' 47.55" W |
| B-2 | 32° 17' 31.37" N | 110° 47' 47.71" W |
| B-3 | 32° 17' 27.08" N | 110° 47' 45.35" W |
| B-4 | 32° 17' 27.50" N | 110° 47' 45.05" W |

## POTHOLE LOCATIONS

| ID | LATITUDE | LONGITUDE |
|---|---|---|
| PH-1 | 32° 17' 27.18" N | 110° 47' 49.68" W |
| PH-2 | 32° 17' 27.22" N | 110° 47' 49.28" W |
| PH-3 | 32° 17' 16.84" N | 110° 47' 48.99" W |

PROJECT

PIMA COUNTY
REGIONAL WASTEWATER RECLAMATION DEPARTMENT
TRES LOMAS GROUNDWATER SEEPAGE PROJECT
PIMA COUNTY, ARIZONA

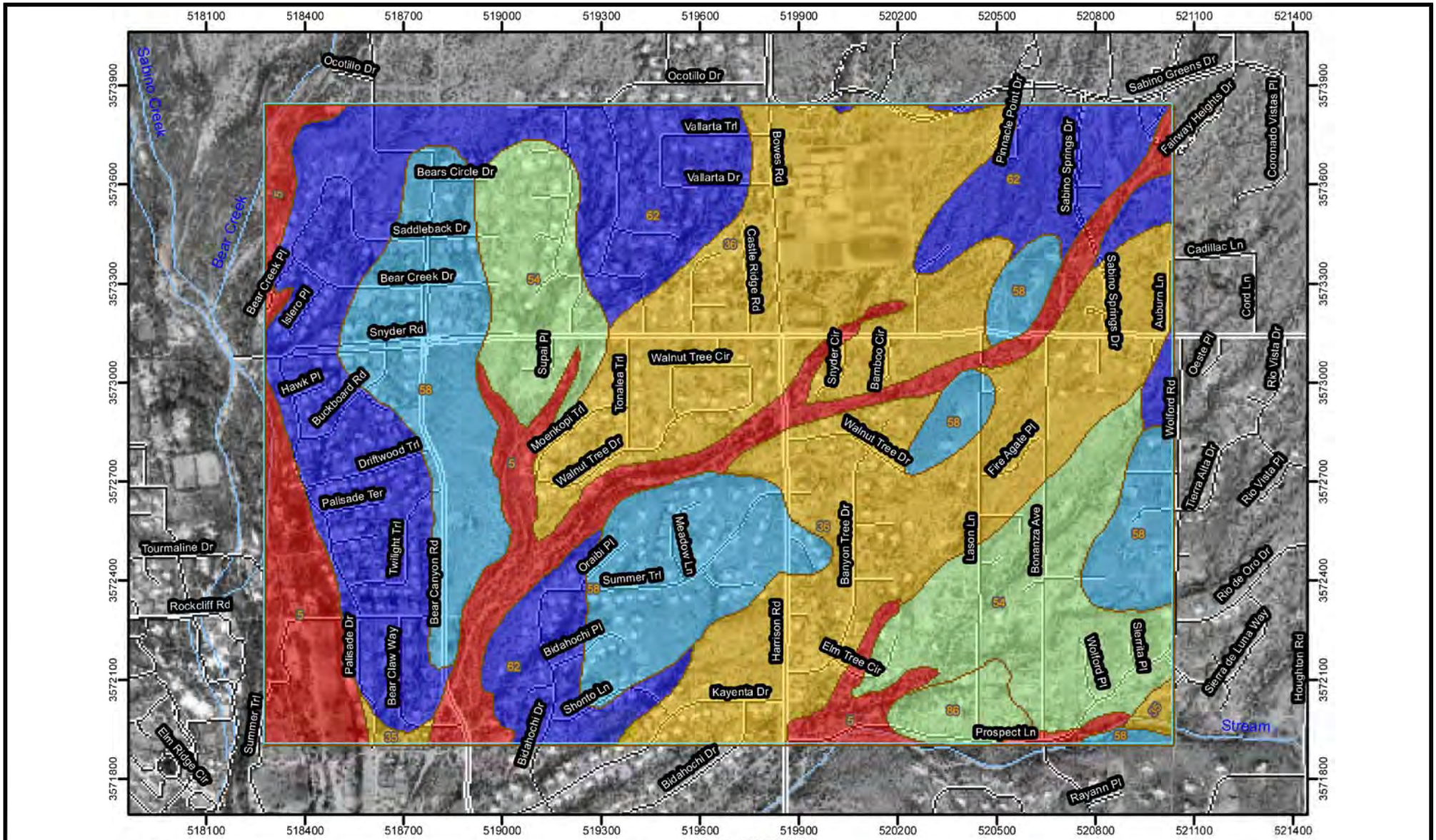
TITLE

**BOREHOLE AND POTHOLE LOCATION MAP**

Golder Associates

| | | | | |
|---|---|---|---|---|
| PROJECT No. | | 103-92518 | FILE No. | 10392518A002 |
| DESIGN | CM | 06/29/10 | SCALE N.T.S. | REV. A |
| CADD | NIL | 06/29/10 | **FIGURE 2** | |
| CHECK | CM | 06/30/10 | | |
| REVIEW | MLP | 06/30/10 | | |

Drawing file: K:\2010 Projects\103-92518 Tres Lomas\10392518A003.dwg Aug 31, 2010 - 2:48pm




SOURCE: UNITED STATES DEPARTMENT OF AGRICULTURE (USDA), NATIONAL COOPERATIVE SOIL SURVEY, 2009

| PROJECT | TITLE | | |
|---|---|---|---|
| PIMA COUNTY<br>REGIONAL WASTEWATER RECLAMATION DEPARTMENT<br>TRES LOMAS GROUNDWATER SEEPAGE PROJECT<br>PIMA COUNTY, ARIZONA | **SOIL SURVEY MAP** | Golder Associates | |

| | | | | |
|---|---|---|---|---|
| PROJECT No. | | 103-92518 | FILE No. | 10392518A003 |
| DESIGN | CM | 06/29/10 | SCALE AS SHOWN | REV. A |
| CADD | NIL | 06/29/10 | **FIGURE 3** | |
| CHECK | CM | 06/30/10 | | |
| REVIEW | MLP | 06/30/10 | | |

# APPENDIX A

# LOGS OF SOIL BOREHOLES AND POTHOLES

# REPORT OF BOREHOLE: Key

SHEET: 1 OF 1

PROJECT NO.: 103-92518
CLIENT: (Pima County)
PROJECT: Tres Lomas
LOGGED: CDM DATE:
CHECKED: DATE:

LOCATION: Tres Lomas North Subdiv.
AZ STATE PLANE: N: , E:
ELEVATION: ft. AMSL
INCLINATION: -90

DRILLING CONTRACTOR:
DRILL RIG:
DRILLING METHOD:
SAMPLE HAMMER WEIGHT:
SAMPLE HAMMER DROP:

| DEPTH feet | LAYER ELEVATION | WATER | SAMPLE NUMBER | SAMPLE TYPE | BLOWS PER SIX INCHES | BLOWS PER FOOT (N) | RECOVERY / ATTEMP (IN.) | GRAPHIC LOG | USCS | Sample Description consistency or density, color, grain size, MAJOR COMPONENT, minor components, moisture. | Comments | MOISTURE (%) | DRY DENSITY (pcf) | ADDITIONAL LAB TESTING |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | | | | | | | | | | Material Description<br>Range of Proportion:<br>-trace: 0 - 5%<br>-little: 5 - 12%<br>-some or (y, ey): 12 - 30%<br>-and: 30 - 50%<br><br>Blows Per Six Inches<br>Number of sample hammer blows required to drive the sampler six inches, or recorded number of blows to drive the sampler the specified distance (e.g. 50/4" = 50 hammer blows to drive the sampler four inches).<br><br>Blows Per Foot<br>Number of sample hammer blows required to drive the sampler twelve inches. Resolved using the final twelve inches of the sample or the amount of penetration upon sample refusal (50 blow counts).<br><br>Sample Types | | | | |
| | | | 1 | | | | 6 / 6 | | | Bag Grab - Collect the auger cuttings in a quart bag at the respective depth. | | | | |
| | | | 2 | | 4<br>5<br>6 | 11 | 18 / 17 | | | Standard Penetration Test - Full penetration with 17 of 18 inches recovered. | | | | |
| 10 | | | 3 | | 50/4"<br>-<br>- | 50/4" | 4 / 3 | | | Standard Penetration Test - Refusal at 4 inches, 3 of 4 inches recovered. | | | | |
| | | | 4 | | 14<br>13<br>9 | 22 | 18 / 16 | | | Modified California Samples (Barrel Ring Sampler - (2.5" O.D.)) | | | | |
| 15 | | | | | | | | | | Additional Lab Testing<br><br>AL = Atterberg Limit<br>MC = Moisture Content<br>MD = Moisture Density<br>ND = Natural Density<br>SA = Sieve Analysis | | | | |
| 20 | | | | | | | | | | | | | | |

Report of borehole must be read in conjunction with accompanying notes and abbreviations

# REPORT OF BOREHOLE: B-1

SHEET: 1 OF 1

PROJECT NO.: 103-92518
CLIENT: (Pima County)
PROJECT: Tres Lomas
LOGGED: CDM DATE: 5/26/10
CHECKED: DGA DATE: 8/31/10

LOCATION: 6 ft South of manhole on Moenkopi Tr.
AZ STATE PLANE: N: 32.292024, E: -110.796542
ELEVATION: ft. AMSL
INCLINATION: -90

DRILLING CONTRACTOR: Dafoe Excavating
DRILL RIG: CME - 75
DRILLING METHOD: HSA 3.75" I.D.
SAMPLE HAMMER WEIGHT: 140 lbs.
SAMPLE HAMMER DROP: 30 inches

| DEPTH feet | LAYER ELEVATION | WATER | SAMPLE NUMBER | SAMPLE TYPE | BLOWS PER SIX INCHES | BLOWS PER FOOT (N) | RECOVERY / ATTEMP (IN.) | GRAPHIC LOG | USCS | Sample Description consistency or density, color, grain size, MAJOR COMPONENT, minor components, moisture. | Comments | MOISTURE (%) | DRY DENSITY (pcf) | ADDITIONAL LAB TESTING |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | | | | | | | | | ASPHALT | Asphaltic Concrete (AC) | | | | |
| | | | 1<br>2 | | 17<br>15 | 32 | 12 / 12<br>/ | | SC | **Clayey SAND with Gravel [Trench Backfill]:** Brown, medium plasticity, fine to coarse sand, fine to coarse angular to sub-angular gravel, maximum particle size 1", medium dense to very loose, moist to very moist. | | | | |
| 5 | | | 3 | | 4<br>3 | 7 | 12 / 12 | | | | | 12.5 | 97.5 | |
| | | | 5 | | 1<br>1 | 2 | 8 / 12 | | | | | | | |
| | 8.0 | | | | | | | | | Bottom of borehole = 8.0 feet<br>Borehole was backfilled with cuttings. | Projected Top of Sewrline = 9.0 feet | | | |

Report of borehole must be read in conjunction with accompanying notes and abbreviations

# REPORT OF BOREHOLE: B-2

Golder Associates

SHEET: 1 OF 1

PROJECT NO.: 103-92518
CLIENT: (Pima County)
PROJECT: Tres Lomas
LOGGED: CDM DATE: 5/26/10
CHECKED: DGA DATE: 8/31/10

LOCATION: West shoulder of Moenkopi Tr.
AZ STATE PLANE: N: 32.292063, E: -110.796581
ELEVATION: ft. AMSL
INCLINATION: -90

DRILLING CONTRACTOR: Dafoe Excavating
DRILL RIG: CME - 75
DRILLING METHOD: HSA 3.75" I.D.
SAMPLE HAMMER WEIGHT: 140 lbs.
SAMPLE HAMMER DROP: 30 inches

| DEPTH feet | LAYER ELEVATION | WATER | SAMPLE NUMBER | SAMPLE TYPE | BLOWS PER SIX INCHES | BLOWS PER FOOT (N) | RECOVERY / ATTEMP (IN.) | GRAPHIC LOG | USCS | Sample Description consistency or density, color, grain size, MAJOR COMPONENT, minor components, moisture. | Comments | MOISTURE (%) | DRY DENSITY (pcf) | ADDITIONAL LAB TESTING |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | | | 1 | | | | / | | | Clayey **SAND with Gravel [Native]:** Brown, medium plasticity, fine to coarse sand, fine to coarse angular to sub-angular gravel, maximum particle size 0.25", damp, medium dense to dense. | | 4.1 | | |
| | | | 2 | | 7<br>25 | 32 | 10 / 12 | | | | | 10.4 | 103.8 | |
| 5 | | | 3<br>4 | | 4<br>4<br>10 | 14 | 8 / 12<br>/ | | SC | Moderate brown, medium dense. | | | | |
| | | | 5 | | 16<br>17<br>20 | 37 | 10 / 18 | | | Light brown, dense, maximum particle size 1". | | | | |
| 10 | 10.0 | | 6 | | 19<br>16<br>36 | 52 | 12 / 18 | | SC | Clayey **SAND with Gravel:** Light brown, medium plasticity. fine to coarse sand, fine to coarse angular to sub-angular gravel, maximum particle size 0.25", very dense, wet. | After an hour of drilling to 10-feet, 12" of standing water was measured in the borehole. | 11.8 | | |
| | 11.5 | | | | | | | | | Bottom of borehole = 11.5 ft.<br>Borehole was backfilled with cuttings. | | | | |

Report of borehole must be read in conjunction with accompanying notes and abbreviations

# REPORT OF BOREHOLE: B-3

Golder Associates

SHEET: 1 OF 1

PROJECT NO.: 103-92518
CLIENT: (Pima County)
PROJECT: Tres Lomas
LOGGED: CDM DATE: 5/26/10
CHECKED: DGA DATE: 8/31/10

LOCATION: 5 ft East of existing sewer manhole.
AZ STATE PLANE: N: 32.290855, E: -110.795931
ELEVATION: ft. AMSL
INCLINATION: -90

DRILLING CONTRACTOR: Dafoe Excavating
DRILL RIG: CME - 75
DRILLING METHOD: HSA 3.75" I.D.
SAMPLE HAMMER WEIGHT: 140 lbs.
SAMPLE HAMMER DROP: 30 inches

| DEPTH feet | LAYER ELEVATION | WATER | SAMPLE NUMBER | SAMPLE TYPE | BLOWS PER SIX INCHES | BLOWS PER FOOT (N) | RECOVERY / ATTEMP (IN.) | GRAPHIC LOG | USCS | Sample Description consistency or density, color, grain size, MAJOR COMPONENT, minor components, moisture. | Comments | MOISTURE (%) | DRY DENSITY (pcf) | ADDITIONAL LAB TESTING |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | | | 1 | | | | / | | SC | **Clayey SAND with Gravel [Trench Backfill]:** Brown, medium plasticity, fine to coarse sand, fine angular to sub-angular gravel, loose to very loose, maximum particle size 1", moist to very moist. Maximum particle size 0.5". | | | | |
| | | | 2 | | 5<br>5 | 10 | 10 / 12 | | | | | | | |
| | | | 3 | | 2<br>3 | 5 | 10 / 12 | | | | | 13.7 | 97.1 | |
| 5 | | | 4 | | 1<br>1 | 2 | 3 / 12 | | | Light brown, maximum particle size 0.25", very loose. | | | | |
| | 7.0 | | | | | | | | | Bottom of borehole = 7.0 feet<br>Borehole was backfilled with cuttings. | Estimated depth to top of sewer was 8.5 feet to top of pipe. | | | |

Report of borehole must be read in conjunction with accompanying notes and abbreviations

# REPORT OF BOREHOLE: B-4

SHEET: 1 OF 1

PROJECT NO.: 103-92518
CLIENT: (Pima County)
PROJECT: Tres Lomas
LOGGED: CDM DATE: 5/26/10
CHECKED: DGA DATE: 8/31/10

LOCATION: 39 ft NE of sewer manhole @ 9180
AZ STATE PLANE: N: 32.290973, E: -110.795847
ELEVATION: ft. AMSL
INCLINATION: -90

DRILLING CONTRACTOR: Dafoe Excavating
DRILL RIG: CME - 75
DRILLING METHOD: HSA 3.75" I.D.
SAMPLE HAMMER WEIGHT: 140 lbs.
SAMPLE HAMMER DROP: 30 inches

| DEPTH feet | LAYER ELEVATION | WATER | SAMPLE NUMBER | SAMPLE TYPE | BLOWS PER SIX INCHES | BLOWS PER FOOT (N) | RECOVERY / ATTEMP (IN.) | GRAPHIC LOG | USCS | Sample Description consistency or density, color, grain size, MAJOR COMPONENT, minor components, moisture. | Comments | MOISTURE (%) | DRY DENSITY (pcf) | ADDITIONAL LAB TESTING |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | | | 1<br>2 | | 7<br>10 | 17 | /<br>12 / 12 | | CL | **Sandy Lean CLAY [Native]:** Brown, medium plasticity, fine to coarse sand, fine angular gravel, stiff to very stiff, maximum particle size 0.25", damp to moist. | | 16.0 | 105.9 | |
| 5 | | | 3<br>4 | | 10<br>12<br>12 | 24 | 8 / 18<br>/ | | | Light brown, maximum particle size 0.5". | | | | |
| | 7.5 | | 5<br>6 | | 4<br>8<br>8 | 16 | 10 / 18<br>/ | | SC | **Clayey SAND, trace gravel:** Brown to reddish brown, medium plasticity, fine to coarse sand, trace fine gravel, medium dense, maximum particle size 0.25", moist. | | 18.3 | | |
| 10 | 10.0 | | 7 | | 6<br>6<br>8 | 14 | 14 / 18 | | SW | **Well-graded SAND with gravel:** Brown, fine to coarse sand, fine to coarse angular to sub-angular gravel, maximum particle size 0.25", medium dense, wet. | After an hour of drilling to 10-feet, 12" of standing water was measured in the borehole. | | | |
| | 11.5 | | | | | | | | | Bottom of borehole = 11.5 ft.<br>Borehole was backfilled with cuttings. | | | | |

Report of borehole must be read in conjunction with accompanying notes and abbreviations

# REPORT OF BOREHOLE: PH-1

Golder Associates

SHEET: 1 OF 1

PROJECT NO.: 103-92518
CLIENT: (Pima County)
PROJECT: Tres Lomas
LOGGED: CDM DATE: 5/18/10
CHECKED: DGA DATE: 8/31/10

LOCATION: 20 feet south of manhole
AZ STATE PLANE: N: 32.290883, E: -110.797133
ELEVATION: ft. AMSL
INCLINATION: -90

DRILLING CONTRACTOR: GSI
DRILL RIG:
DRILLING METHOD: Air Knife & Vacuum
SAMPLE HAMMER WEIGHT:
SAMPLE HAMMER DROP:

| DEPTH feet | LAYER ELEVATION | WATER | SAMPLE NUMBER | SAMPLE TYPE | BLOWS PER SIX INCHES | BLOWS PER FOOT (N) | RECOVERY / ATTEMP (IN.) | GRAPHIC LOG | USCS | Sample Description consistency or density, color, grain size, MAJOR COMPONENT, minor components, moisture. | Comments | MOISTURE (%) | DRY DENSITY (pcf) | ADDITIONAL LAB TESTING |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | | | | | | | | | SC | **Clayey SAND, trace Gravel [Trench Backfill]:** Reddish-brown, medium plasticity fines, fine to coarse sand, fine angular gravel, damp to moist, loose to medium dense. | | | | |
| | 1.5 | | 1 | | | | 12 / 12 | | CL | **Sandy Lean CLAY:** Grayish brown to tan, medium to high plasticity, fine to coarse sand, very moist to wet, very soft | Pothole accumulated 12" of water after 40 min. | 23.3 | | SA AL |
| | 4.0 | | | | | | | | | Bottom of Pothole = 4.0 feet<br>Pothole backfilled with excavated cuttings. | | | | |

Report of borehole must be read in conjunction with accompanying notes and abbreviations

# REPORT OF BOREHOLE: PH-2

Golder Associates

SHEET: 1 OF 1

PROJECT NO.: 103-92518
CLIENT: (Pima County)
PROJECT: Tres Lomas
LOGGED: CDM DATE: 5/18/10
CHECKED: DGA DATE: 8/31/10

LOCATION: 20 feet west of PH-1
AZ STATE PLANE: N: 32.290894, E: -110.797022
ELEVATION: ft. AMSL
INCLINATION: -90

DRILLING CONTRACTOR: GSI
DRILL RIG:
DRILLING METHOD: Air Knife & Vacuum
SAMPLE HAMMER WEIGHT:
SAMPLE HAMMER DROP:

| DEPTH feet | LAYER ELEVATION | WATER | SAMPLE NUMBER | SAMPLE TYPE | BLOWS PER SIX INCHES | BLOWS PER FOOT (N) | RECOVERY / ATTEMP (IN.) | GRAPHIC LOG | USCS | Sample Description consistency or density, color, grain size, MAJOR COMPONENT, minor components, moisture. | Comments | MOISTURE (%) | DRY DENSITY (pcf) | ADDITIONAL LAB TESTING |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | | | 1 | | | | 12 / 12 | | SC | **Clayey SAND with Gravel [Native]:** Brown, medium plasticity, fine to coarse sand, fine to coarse angular to sub-angular gravel, damp, medium dense to dense. | | | | |
| | 2.0 | | 2 | | | | 12 / 12 | | CL | **Sandy Lean Clay:** Brown, medium plasticity, fine to coarse sand, trace gravel, wet, very soft. | Pothole accumulated 5" of standing water after 30 min. | | | |
| | 3.0 | | | | | | | | | Bottom of Pothole = 3.0 feet<br>Pothole backfilled with soil cuttings. | | | | |

Report of borehole must be read in conjunction with accompanying notes and abbreviations

# REPORT OF BOREHOLE: PH-3

Golder Associates



PROJECT NO.: 103-92518
CLIENT: (Pima County)
PROJECT: Tres Lomas
LOGGED: CDM DATE: 5/18/10
CHECKED: DGA DATE: 8/31/10

LOCATION: 20 feet north-east of manhole
AZ STATE PLANE: N: 32.288011, E: -110.7969
ELEVATION: ft. AMSL
INCLINATION: -90

DRILLING CONTRACTOR: GSI
DRILL RIG:
DRILLING METHOD: Air Knife & Vacuum
SAMPLE HAMMER WEIGHT:
SAMPLE HAMMER DROP:

| DEPTH feet | LAYER ELEVATION | WATER | SAMPLE NUMBER | SAMPLE TYPE | BLOWS PER SIX INCHES | BLOWS PER FOOT (N) | RECOVERY / ATTEMP (IN.) | GRAPHIC LOG | USCS | Sample Description consistency or density, color, grain size, MAJOR COMPONENT, minor components, moisture. | Comments | MOISTURE (%) | DRY DENSITY (pcf) | ADDITIONAL LAB TESTING |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | | | 1 | | | | 60 / 60 | | | **Clayey SAND with Gravel [Trench Backfill]:** Brown, low to medium plasticity, fine to coarse sand, fine to coarse gravel, damp to moist, medium dense to dense. | | | | |
| 5 | | | 2 | | | | 60 / 60 | | SC | | | | | |
| 10 | 10.0 | | | | | | | | | Bottom of Pothole = 10.0 feet.<br>Pothole backfilled with soil cuttings.<br>No groundwater was encountered in the pothole. | | | | |

# APPENDIX B
# LABORATORY TEST RESULTS

# APPENDIX B
# GEOTECHNICAL LABORATORY TESTING
# SUMMARY SHEET

**Project:** Tres Lomas Groundwater Seepage
**Client:** Pima County
**Project #:** 103-92518

**Dates of Sampling:** May 18 & 26, 2010
**Results Received:** June 18, 2010
**Laboratory:** Speedie and Associates, Inc Tucson

| Borehole No. | Depth (feet) | Sample Type | USCS Soil Class. | In-Situ Properties | | Flex Wall Permeability Test | | | Classification | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Dry Density (pcf) | Moisture (%) | Dry Density (pcf) | Moisture (%) | Ave. perm. (cm/sec) | Grain Size Distribution (Percent Passing) | | | | | | | | | | | | | | | | Atterberg Limits | | |
| | | | | | | | | | 11/2" | 1" | 3/4" | 1/2" | 3/8" | 1/4" | #4 | #8 | #10 | #16 | #30 | #40 | #50 | #100 | #200 | LL[1] | PL | PI[1] |
| BH-01 | 5.0 | Ring | SC | 97.5 | 12.5 | -- | -- | -- | | | | | | | | | | | | | | | | | | | |
| B-01 | 1 to 5 | Bulk | SC | | | 105.8 | 9.3 | $7.7 \times 10^{-5}$ | | | | | | | | | | | | | | | | | | | |
| BH-02 | 1.0 | Ring | SC | 103.8 | 10.4 | -- | -- | -- | | | | | | | | | | | | | | | | | | | |
| BH-02 | 1 to 5 | Bag | SC | -- | 4.1 | -- | -- | -- | 100 | 100 | 97 | 94 | 92 | 87 | 83 | 71 | 68 | 59 | 50 | 46 | 44 | 35 | 28 | 32 | 17 | 15 |
| B-02 | 7 to 10 | Bulk | SC | | | 104.7 | 11.9 | $1.2 \times 10^{-4}$ | | | | | | | | | | | | | | | | | | | |
| BH-02 | 10 | Bag | SC | -- | 11.8 | -- | -- | -- | 100 | 100 | 100 | 100 | 96 | 89 | 84 | 73 | 67 | 54 | 38 | 33 | 33 | 22 | 17 | 34 | 18 | 16 |
| BH-03 | 4.5 | Ring | SC | 97.1 | 13.7 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| BH-04 | 1.0 | Ring | CL | 105.9 | 16.0 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| BH-04 | 7.5 to 10 | Bag | SC | -- | 18.3 | -- | -- | -- | 100 | 100 | 100 | 100 | 98 | 96 | 95 | 92 | 90 | 84 | 68 | 58 | 51 | 35 | 29 | 49 | 18 | 31 |
| PH-01 | 1.5 | Bag | SC | -- | 23.3 | -- | -- | -- | 100 | 100 | 100 | 99 | 99 | 95 | 93 | 88 | 86 | 80 | 70 | 67 | 66 | 55 | 48 | 63 | 23 | 40 |

**NOTES:**
1. -- Not tested
2. A Liquid Limit (LL) of NV and a Plasticity Index (PI) of NP indicates the material is non-viscous and non-plastic respectively.
3. ND: Not Dtected at or above the PQL
4. PQL: Practical Quantitation Limit



Golder Associates

**TABLE 1**
**Tres Lomas/Ground Water Seepage Project/Lab Testing**
**SUMMARY OF FLEXIBLE-WALL PERMEABILITY TEST RESULTS**

| Sample Number | Sample Length (cm) | Sample Diameter (cm) | Sample Dry Density (pcf) | Maximum Dry Density (pcf) | Compaction (%) | Initial Moisture (%) | Optimum Moisture (%) | Effective Stress (psi) | Back Pressure (psi) | Gradient | Average Permeability (cm/sec) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| B-1 @ 1-5 ft | 9.38 | 7.30 | 105.8 | 105.0 | 100.8% | 9.3 | 10.6 | 5 | 80 | 2 | $7.7X10^{-5}$ |
| B-2 @ 7.5-10 ft | 9.39 | 7.30 | 104.7 | 105.0 | 99.7% | 11.9 | 10.6 | 5 | 80 | 1 | $1.2X10^{-4}$ |
| | | | | | | | | | | | |
| | | | | | | | | | | | |
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FLOW PUMP #1

# FLEXIBLE WALL PERMEABILITY
## ASTM D 5084
## METHOD D, CONSTANT RATE OF FLOW

| | | | | | |
|---|---|---|---|---|---|
| PROJECT TITLE | Tres Lomas/Ground Water Seepage Proj | | BOARD # | 1 | |
| PROJECT NUMBER | 103-92518.003 | | CELL # | aa | |
| SAMPLE ID | B-1 @ 1-5 ft | -- | Flow Pump Speed | 3 | |
| SAMPLE TYPE | Remold | | Technician | BDM | |

COMMENTS
1. Water used as permeant
2. Specific gravity is assumed
3. Requested remold parameters: 105 pcf @ 10% mc

**Sample Data, Initial**

| | | | |
|---|---|---|---|
| Height, cm | 9.38 | B-Value, f | 95.0 |
| Diameter, cm | 7.30 | Cell Pres. | 85.0 |
| Area, cm² | 41.85 | Bot. Pres. | 80.0 |
| Volume, cm³ | 392.59 | Top Pres. | 80.0 |
| Mass, g | 727.70 | Eff. Stress | 5.0 |
| Moisture Content, % | 9.3 | Head, max. | 16 |
| Dry Density, pcf | 105.8 | Head, min. | 16 |
| Spec. Gravity | 2.70 | Max. Grad. | 1.71 |
| Volume Solids, cm³ | 246.50 | Min. Grad. | 1.71 |
| Volume Voids, cm³ | 146.09 | | |
| Void Ratio | 0.59 | | |
| Saturation, % | 42.5% | | |

**Sample Data, Final**

| | |
|---|---|
| Height, cm | 9.23 |
| Diameter, cm | 7.29 |
| Area, cm² | 41.74 |
| Volume, cm³ | 385.25 |
| Mass, g | 786.94 |
| Moisture Content,% | 18.0 |
| Dry Density, pcf | 108.1 |
| Volume Solids, cm³ | 247.10 |
| Volume Voids, cm³ | 138.15 |
| Void Ratio | 0.56 |
| Saturation, % | 86.7% |

| WATER CONTENTS | | Trimmings Initial | Sample Final |
|---|---|---|---|
| Wt Soil & Tare, i | g | 223.34 | 887.0 |
| Wt Soil & Tare, f | g | 207.17 | 767.35 |
| Wt Tare | g | 33.98 | 100.66 |
| Wt Moisture Lost | g | 16.17 | 119.68 |
| Wt Dry Soil | g | 173.19 | 666.69 |
| Water Content | % | 9.3% | 18.0% |

DESCRIPTION
--

Flow Pump Rate 5.50E-03 cm³/sec

| DATE/TIME | | dt (min) | TEMP (°C) | Speed (1-12) | Speed Coeff. | DH (cm) | L (cm) | A (cm²) | i Gradient | q cm³/sec | v (cm/sec) | Permeability (cm/sec) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 6/25/10 | 8:45 | | | | | | | | | | | |
| 6/25/10 | 9:00 | 15 | 20.7 | 3 | 1 | 16 | 9.38 | 41.85 | 1.71 | 5.5E-03 | 1.3E-04 | 7.7E-05 |

PERMEABILITY REPORTED AS ** 7.7E-05 cm/sec **

DATE 6/25/2010
REVIEW JEO

FLOW PUMP #1

# FLEXIBLE WALL PERMEABILITY
## ASTM D 5084
## METHOD D, CONSTANT RATE OF FLOW

| | | | |
|---|---|---|---|
| PROJECT TITLE | Tres Lomas/Ground Water Seepage Proj | BOARD # | 9 |
| PROJECT NUMBER | 103-92518.003 | CELL # | 5 |
| SAMPLE ID | B-2 @ 7.5-10 ft -- | Flow Pump Speed | 3 |
| SAMPLE TYPE | Remold | Technician | BDM |

COMMENTS
1. Water used as permeant
2. Specific gravity is assumed
3. Requested remold parameters: 105 pcf @ 10% mc

**Sample Data, Initial**

| | | | |
|---|---|---|---|
| Height, cm | 9.39 | B-Value, f | 96.0 |
| Diameter, cm | 7.30 | Cell Pres. | 85.0 |
| Area, cm² | 41.85 | Bot. Pres. | 80.0 |
| Volume, cm³ | 393.01 | Top Pres. | 80.0 |
| Mass, g | 737.60 | Eff. Stress | 5.0 |
| Moisture Content, % | 11.9 | Head, max. | 10 |
| Dry Density, pcf | 104.7 | Head, min. | 10 |
| Spec. Gravity | 2.70 | Max. Grad. | 1.06 |
| Volume Solids, cm³ | 244.24 | Min. Grad. | 1.06 |
| Volume Voids, cm³ | 148.77 | | |
| Void Ratio | 0.61 | | |
| Saturation, % | 52.5% | | |

**Sample Data, Final**

| | |
|---|---|
| Height, cm | 9.24 |
| Diameter, cm | 7.30 |
| Area, cm² | 41.85 |
| Volume, cm³ | 386.73 |
| Mass, g | 788.95 |
| Moisture Content,% | 19.3 |
| Dry Density, pcf | 106.7 |
| Volume Solids, cm³ | 244.97 |
| Volume Voids, cm³ | 141.76 |
| Void Ratio | 0.58 |
| Saturation, % | 90.0% |

| WATER CONTENTS | | Trimmings Initial | Sample Final |
|---|---|---|---|
| Wt Soil & Tare, i | g | 258.25 | 871.3 |
| Wt Soil & Tare, f | g | 234.01 | 743.84 |
| Wt Tare | g | 29.50 | 82.97 |
| Wt Moisture Lost | g | 24.24 | 127.42 |
| Wt Dry Soil | g | 204.51 | 660.87 |
| Water Content | % | 11.9% | 19.3% |

DESCRIPTION
--

Flow Pump Rate 5.50E-03 cm³/sec

| DATE/TIME | | dt (min) | TEMP (°C) | Speed (1-12) | Speed Coeff. | DH (cm) | L (cm) | A (cm²) | i Gradient | q cm³/sec | v (cm/sec) | Permeability (cm/sec) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 6/25/10 | 9:45 | | | | | | | | | | | |
| 6/25/10 | 10:00 | 15 | 20.7 | 3 | 1 | 10 | 9.39 | 41.85 | 1.06 | 5.5E-03 | 1.3E-04 | 1.2E-04 |

PERMEABILITY REPORTED AS ** 1.2E-04 cm/sec **

DATE 6/25/2010
REVIEW JEO

SPEEDIE AND ASSOCIATES
Geotechnical • Environmental • Materials Engineers
3125 E. 47TH STREET • TUCSON, ARIZONA 85713

**LABORATORY REPORT**

# Physical Properties of Soil and Aggregate

Client: Golder Associates, Inc.
ATTN: Chushi Mwewa
4730 N. Oracle Rd. Suite 210
Tucson, AZ 85705

Project No. 100652TT
Lab No. 337283
Field No. 1
Report Date: 6-17-2010

Project: Tres Lomas
Location: Arizona
Material: Soil — Sampled By: Client — Date: 6-10-2010
Source: Borings — Submitted By: DWH — Date: 6-11-2010
Supplier: n/a — Authorized By: Client — Date: 6-11-2010
Sample Location: B-1 Ring 5.0'

SIEVE ANALYSIS - ASTM C 136 & D 1140 or D 6913

| SIEVE SIZE in/mm | CUMULATIVE % PASSING | PROJECT SPECIFICATION |
|---|---|---|
| 6" / 150 | NT | |
| 3" / 75 | NT | |
| 2½" / 62.5 | NT | |
| 2" / 50 | NT | |
| 1½" / 37.5 | NT | |
| 1" / 25 | NT | |
| 3/4" / 19 | NT | |
| ½" / 12.5 | NT | |
| 3/8" / 9.5 | NT | |
| 1/4" / 6.3 | NT | |
| #4 / 4.75 | NT | |
| #8 / 2.36 | NT | |
| #10 / 2.00 | NT | |
| #16 / 1.18 | NT | |
| #30 / .600 | NT | |
| #40 / .425 | NT | |
| #50 / .300 | NT | |
| #100 / .150 | NT | |
| #200 / .075 | NT | |

Comments: NT denotes material not tested for this property.

* denotes material out of specification.

| | |
|---|---|
| % Gravel | |
| % Sand | |
| % Silt/clay | |

ADDITIONAL TESTING

| PHYSICAL PROPERTIES | TEST RESULTS | TARGET/ SPECIFICATION |
|---|---|---|
| IN PLACE MOISTURE & DENSITY OF SOIL , ASTM D2937 | | |
| In Place Dry Density (pcf) | 97.5 | |
| In Place Moisture Content (%) | 12.5 | |

Laboratory test results reported herein apply only to the specific sample on which the test was run. The above services and report were performed pursuant to the terms and conditions of the agreement or proposal, if any, between SA and client. SA warrants that this work was performed under the appropriate standard of care, including the skill and judgement that is reasonably expected from similarly situated professionals. No other warranty, guaranty, or representation, either express or implied is included or intended.

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**LABORATORY REPORT**

## Physical Properties of Soil and Aggregate

Client: Golder Associates, Inc.
ATTN: Chushi Mwewa
4730 N. Oracle Rd. Suite 210
Tucson, AZ 85705

Project No. 100652TT
Lab No. 337284
Field No. 2
Report Date: 6-17-2010

Project: Tres Lomas
Location: Arizona
Material: Soil — Sampled By: Client — Date: 6-10-2010
Source: Borings — Submitted By: DWH — Date: 6-11-2010
Supplier: n/a — Authorized By: Client — Date: 6-11-2010
Sample Location: B-2 Ring 1.0'

SIEVE ANALYSIS - ASTM C 136 & D 1140 or D 6913

| SIEVE SIZE in/mm | CUMULATIVE % PASSING | PROJECT SPECIFICATION |
|---|---|---|
| 6" / 150 | NT | |
| 3" / 75 | NT | |
| 2½" / 62.5 | NT | |
| 2" / 50 | NT | |
| 1½" / 37.5 | NT | |
| 1" / 25 | NT | |
| 3/4" / 19 | NT | |
| ½" / 12.5 | NT | |
| 3/8" / 9.5 | NT | |
| 1/4" / 6.3 | NT | |
| #4 / 4.75 | NT | |
| #8 / 2.36 | NT | |
| #10 / 2.00 | NT | |
| #16 / 1.18 | NT | |
| #30 / .600 | NT | |
| #40 / .425 | NT | |
| #50 / .300 | NT | |
| #100 / .150 | NT | |
| #200 / .075 | NT | |

Comments: NT denotes material not tested for this property.

* denotes material out of specification.

| | |
|---|---|
| % Gravel | |
| % Sand | |
| % Silt/clay | |

ADDITIONAL TESTING

| PHYSICAL PROPERTIES | TEST RESULTS | TARGET/ SPECIFICATION |
|---|---|---|
| IN PLACE MOISTURE & DENSITY OF SOIL , ASTM D2937 | | |
| In Place Dry Density (pcf) | 103.8 | |
| In Place Moisture Content (%) | 10.4 | |

Laboratory test results reported herein apply only to the specific sample on which the test was run. The above services and report were performed pursuant to the terms and conditions of the agreement or proposal, if any, between SA and client. SA warrants that this work was performed under the appropriate standard of care, including the skill and judgement that is reasonably expected from similarly situated professionals. No other warranty, guaranty, or representation, either express or implied is included or intended.

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**LABORATORY REPORT**

# Physical Properties of Soil and Aggregate

Client: Golder Associates, Inc.
ATTN: Chushi Mwewa
4730 N. Oracle Rd. Suite 210
Tucson, AZ 85705

Project No. 100652TT
Lab No. 337288
Field No. 6
Report Date: 6-17-2010

Project: Tres Lomas
Location: Arizona
Material: Soil — Sampled By: Client — Date: 6-10-2010
Source: Borings — Submitted By: DWH — Date: 6-11-2010
Supplier: n/a — Authorized By: Client — Date: 6-11-2010
Sample Location: B-2 bag 1' to 5'

SIEVE ANALYSIS - ASTM C 136 & D 1140 or D 6913

| SIEVE SIZE in/mm | CUMULATIVE % PASSING | PROJECT SPECIFICATION |
|---|---|---|
| 6" / 150 | 100 | |
| 3" / 75 | 100 | |
| 2½" / 62.5 | 100 | |
| 2" / 50 | 100 | |
| 1½" / 37.5 | 100 | |
| 1" / 25 | 100 | |
| 3/4" / 19 | 97 | |
| ½" / 12.5 | 94 | |
| 3/8" / 9.5 | 92 | |
| 1/4" / 6.3 | 87 | |
| #4 / 4.75 | 83 | |
| #8 / 2.36 | 71 | |
| #10 / 2.00 | 68 | |
| #16 / 1.18 | 59 | |
| #30 / .600 | 50 | |
| #40 / .425 | 46 | |
| #50 / .300 | 44 | |
| #100 / .150 | 35 | |
| #200 / .075 | 28.4 | |

Comments: NT denotes material not tested for this property.

* denotes material out of specification.

| | |
|---|---|
| % Gravel | 17 |
| % Sand | 54 |
| % Silt/clay | 28 |

ADDITIONAL TESTING

| PHYSICAL PROPERTIES | TEST RESULTS | TARGET/ SPECIFICATION |
|---|---|---|
| MOISTURE CONTENT OF AGGREGATE, ASTM C 566 | | |
| Percent Moisture by Wt of Dry Aggr. | 4.1 | |
| LIQUID & PLASTIC PROPERTIES, ASTM D 4318 | | |
| Liquid Limit | 32 | |
| Plastic Limit | 17 | |
| Plasticity Index | 15 | |

Laboratory test results reported herein apply only to the specific sample on which the test was run. The above services and report were performed pursuant to the terms and conditions of the agreement or proposal, if any, between SA and client. SA warrants that this work was performed under the appropriate standard of care, including the skill and judgement that is reasonably expected from similarly situated professionals. No other warranty, guaranty, or representation, either express or implied is included or intended.

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**LABORATORY REPORT**

# Physical Properties of Soil and Aggregate

Client: Golder Associates, Inc.
ATTN: Chushi Mwewa
4730 N. Oracle Rd. Suite 210
Tucson, AZ 85705

Project No. 100652TT
Lab No. 337289
Field No. 7
Report Date: 6-17-2010

Project: Tres Lomas
Location: Arizona
Material: Soil — Sampled By: Client — Date: 6-10-2010
Source: Borings — Submitted By: DWH — Date: 6-11-2010
Supplier: n/a — Authorized By: Client — Date: 6-11-2010
Sample Location: B-2 bag 10'

SIEVE ANALYSIS - ASTM C 136 & D 1140 or D 6913

| SIEVE SIZE in/mm | CUMULATIVE % PASSING | PROJECT SPECIFICATION |
|---|---|---|
| 6" / 150 | 100 | |
| 3" / 75 | 100 | |
| 2½" / 62.5 | 100 | |
| 2" / 50 | 100 | |
| 1½" / 37.5 | 100 | |
| 1" / 25 | 100 | |
| 3/4" / 19 | 100 | |
| ½" / 12.5 | 100 | |
| 3/8" / 9.5 | 96 | |
| 1/4" / 6.3 | 89 | |
| #4 / 4.75 | 84 | |
| #8 / 2.36 | 73 | |
| #10 / 2.00 | 67 | |
| #16 / 1.18 | 54 | |
| #30 / .600 | 38 | |
| #40 / .425 | 33 | |
| #50 / .300 | 33 | |
| #100 / .150 | 22 | |
| #200 / .075 | 16.7 | |

Comments: NT denotes material not tested for this property.

* denotes material out of specification.

| | |
|---|---|
| % Gravel | 16 |
| % Sand | 67 |
| % Silt/clay | 17 |

ADDITIONAL TESTING

| PHYSICAL PROPERTIES | TEST RESULTS | TARGET/ SPECIFICATION |
|---|---|---|
| MOISTURE CONTENT OF AGGREGATE, ASTM C 566 | | |
| Percent Moisture by Wt of Dry Aggr. | 11.8 | |
| LIQUID & PLASTIC PROPERTIES, ASTM D 4318 | | |
| Liquid Limit | 34 | |
| Plastic Limit | 18 | |
| Plasticity Index | 16 | |

Laboratory test results reported herein apply only to the specific sample on which the test was run. The above services and report were performed pursuant to the terms and conditions of the agreement or proposal, if any, between SA and client. SA warrants that this work was performed under the appropriate standard of care, including the skill and judgement that is reasonably expected from similarly situated professionals. No other warranty, guaranty, or representation, either express or implied is included or intended.

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**LABORATORY REPORT**

## Physical Properties of Soil and Aggregate

Client: Golder Associates, Inc.
ATTN: Chushi Mwewa
4730 N. Oracle Rd. Suite 210
Tucson, AZ 85705

Project No. 100652TT
Lab No. 337285
Field No. 3
Report Date: 6-17-2010

Project: Tres Lomas
Location: Arizona
Material: Soil — Sampled By: Client — Date: 6-10-2010
Source: Borings — Submitted By: DWH — Date: 6-11-2010
Supplier: n/a — Authorized By: Client — Date: 6-11-2010
Sample Location: B-3 Ring 4.5'

SIEVE ANALYSIS - ASTM C 136 & D 1140 or D 6913

| SIEVE SIZE in/mm | CUMULATIVE % PASSING | PROJECT SPECIFICATION |
|---|---|---|
| 6" / 150 | NT | |
| 3" / 75 | NT | |
| 2½" / 62.5 | NT | |
| 2" / 50 | NT | |
| 1½" / 37.5 | NT | |
| 1" / 25 | NT | |
| 3/4" / 19 | NT | |
| ½" / 12.5 | NT | |
| 3/8" / 9.5 | NT | |
| 1/4" / 6.3 | NT | |
| #4 / 4.75 | NT | |
| #8 / 2.36 | NT | |
| #10 / 2.00 | NT | |
| #16 / 1.18 | NT | |
| #30 / .600 | NT | |
| #40 / .425 | NT | |
| #50 / .300 | NT | |
| #100 / .150 | NT | |
| #200 / .075 | NT | |

Comments: NT denotes material not tested for this property.

* denotes material out of specification.

| | |
|---|---|
| % Gravel | |
| % Sand | |
| % Silt/clay | |

ADDITIONAL TESTING

| PHYSICAL PROPERTIES | TEST RESULTS | TARGET/ SPECIFICATION |
|---|---|---|
| IN PLACE MOISTURE & DENSITY OF SOIL , ASTM D2937 | | |
| In Place Dry Density (pcf) | 97.1 | |
| In Place Moisture Content (%) | 13.7 | |

Laboratory test results reported herein apply only to the specific sample on which the test was run. The above services and report were performed pursuant to the terms and conditions of the agreement or proposal, if any, between SA and client. SA warrants that this work was performed under the appropriate standard of care, including the skill and judgement that is reasonably expected from similarly situated professionals. No other warranty, guaranty, or representation, either express or implied is included or intended.

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**LABORATORY REPORT**

## Physical Properties of Soil and Aggregate

Client: Golder Associates, Inc.
ATTN: Chushi Mwewa
4730 N. Oracle Rd. Suite 210
Tucson, AZ 85705

Project No. 100652TT
Lab No. 337286
Field No. 4
Report Date: 6-17-2010

Project: Tres Lomas
Location: Arizona
Material: Soil — Sampled By: Client — Date: 6-10-2010
Source: Borings — Submitted By: DWH — Date: 6-11-2010
Supplier: n/a — Authorized By: Client — Date: 6-11-2010
Sample Location: B-4 Ring 1.0'

SIEVE ANALYSIS - ASTM C 136 & D 1140 or D 6913

| SIEVE SIZE in/mm | CUMULATIVE % PASSING | PROJECT SPECIFICATION |
|---|---|---|
| 6" / 150 | NT | |
| 3" / 75 | NT | |
| 2½" / 62.5 | NT | |
| 2" / 50 | NT | |
| 1½" / 37.5 | NT | |
| 1" / 25 | NT | |
| 3/4" / 19 | NT | |
| ½" / 12.5 | NT | |
| 3/8" / 9.5 | NT | |
| 1/4" / 6.3 | NT | |
| #4 / 4.75 | NT | |
| #8 / 2.36 | NT | |
| #10 / 2.00 | NT | |
| #16 / 1.18 | NT | |
| #30 / .600 | NT | |
| #40 / .425 | NT | |
| #50 / .300 | NT | |
| #100 / .150 | NT | |
| #200 / .075 | NT | |

Comments: NT denotes material not tested for this property.

* denotes material out of specification.

| | |
|---|---|
| % Gravel | |
| % Sand | |
| % Silt/clay | |

ADDITIONAL TESTING

| PHYSICAL PROPERTIES | TEST RESULTS | TARGET/ SPECIFICATION |
|---|---|---|
| IN PLACE MOISTURE & DENSITY OF SOIL , ASTM D2937 | | |
| In Place Dry Density (pcf) | 105.9 | |
| In Place Moisture Content (%) | 16.0 | |

Laboratory test results reported herein apply only to the specific sample on which the test was run. The above services and report were performed pursuant to the terms and conditions of the agreement or proposal, if any, between SA and client. SA warrants that this work was performed under the appropriate standard of care, including the skill and judgement that is reasonably expected from similarly situated professionals. No other warranty, guaranty, or representation, either express or implied is included or intended.

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**LABORATORY REPORT**

# Physical Properties of Soil and Aggregate

Client: Golder Associates, Inc.
ATTN: Chushi Mwewa
4730 N. Oracle Rd. Suite 210
Tucson, AZ 85705

Project No. 100652TT
Lab No. 337290
Field No. 8
Report Date: 6-17-2010

Project: Tres Lomas
Location: Arizona
Material: Soil — Sampled By: Client — Date: 6-10-2010
Source: Borings — Submitted By: DWH — Date: 6-11-2010
Supplier: n/a — Authorized By: Client — Date: 6-11-2010
Sample Location: B-4 bag 7.5' to 10'

SIEVE ANALYSIS - ASTM C 136 & D 1140 or D 6913

| SIEVE SIZE in/mm | CUMULATIVE % PASSING | PROJECT SPECIFICATION |
|---|---|---|
| 6" / 150 | 100 | |
| 3" / 75 | 100 | |
| 2½" / 62.5 | 100 | |
| 2" / 50 | 100 | |
| 1½" / 37.5 | 100 | |
| 1" / 25 | 100 | |
| 3/4" / 19 | 100 | |
| ½" / 12.5 | 100 | |
| 3/8" / 9.5 | 98 | |
| 1/4" / 6.3 | 96 | |
| #4 / 4.75 | 95 | |
| #8 / 2.36 | 92 | |
| #10 / 2.00 | 90 | |
| #16 / 1.18 | 84 | |
| #30 / .600 | 68 | |
| #40 / .425 | 58 | |
| #50 / .300 | 51 | |
| #100 / .150 | 35 | |
| #200 / .075 | 29.2 | |

Comments: NT denotes material not tested for this property.

* denotes material out of specification.

| | |
|---|---|
| % Gravel | 5 |
| % Sand | 66 |
| % Silt/clay | 29 |

ADDITIONAL TESTING

| PHYSICAL PROPERTIES | TEST RESULTS | TARGET/ SPECIFICATION |
|---|---|---|
| MOISTURE CONTENT OF AGGREGATE, ASTM C 566 | | |
| Percent Moisture by Wt of Dry Aggr. | 18.3 | |
| LIQUID & PLASTIC PROPERTIES, ASTM D 4318 | | |
| Liquid Limit | 49 | |
| Plastic Limit | 18 | |
| Plasticity Index | 31 | |

Laboratory test results reported herein apply only to the specific sample on which the test was run. The above services and report were performed pursuant to the terms and conditions of the agreement or proposal, if any, between SA and client. SA warrants that this work was performed under the appropriate standard of care, including the skill and judgement that is reasonably expected from similarly situated professionals. No other warranty, guaranty, or representation, either express or implied is included or intended.

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**LABORATORY REPORT**

## Physical Properties of Soil and Aggregate

Client: Golder Associates, Inc.
ATTN: Chushi Mwewa
4730 N. Oracle Rd. Suite 210
Tucson, AZ 85705

Project No. 100652TT
Lab No. 337287
Field No. 5
Report Date: 6-17-2010

Project: Tres Lomas
Location: Arizona
Material: Soil — Sampled By: Client — Date: 6-10-2010
Source: Borings — Submitted By: DWH — Date: 6-11-2010
Supplier: n/a — Authorized By: Client — Date: 6-11-2010
Sample Location: PH-1 bag 1.5'

SIEVE ANALYSIS - ASTM C 136 & D 1140 or D 6913

| SIEVE SIZE in/mm | CUMULATIVE % PASSING | PROJECT SPECIFICATION |
|---|---|---|
| 6" / 150 | 100 | |
| 3" / 75 | 100 | |
| 2½" / 62.5 | 100 | |
| 2" / 50 | 100 | |
| 1½" / 37.5 | 100 | |
| 1" / 25 | 100 | |
| 3/4" / 19 | 100 | |
| ½" / 12.5 | 99 | |
| 3/8" / 9.5 | 99 | |
| 1/4" / 6.3 | 95 | |
| #4 / 4.75 | 93 | |
| #8 / 2.36 | 88 | |
| #10 / 2.00 | 86 | |
| #16 / 1.18 | 80 | |
| #30 / .600 | 70 | |
| #40 / .425 | 67 | |
| #50 / .300 | 66 | |
| #100 / .150 | 55 | |
| #200 / .075 | 48.0 | |

Comments: NT denotes material not tested for this property.

* denotes material out of specification.

| | |
|---|---|
| % Gravel | 7 |
| % Sand | 45 |
| % Silt/clay | 48 |

ADDITIONAL TESTING

| PHYSICAL PROPERTIES | TEST RESULTS | TARGET/ SPECIFICATION |
|---|---|---|
| MOISTURE CONTENT OF AGGREGATE, ASTM C 566 | | |
| Percent Moisture by Wt of Dry Aggr. | 23.3 | |
| LIQUID & PLASTIC PROPERTIES, ASTM D 4318 | | |
| Liquid Limit | 63 | |
| Plastic Limit | 23 | |
| Plasticity Index | 40 | |

Laboratory test results reported herein apply only to the specific sample on which the test was run. The above services and report were performed pursuant to the terms and conditions of the agreement or proposal, if any, between SA and client. SA warrants that this work was performed under the appropriate standard of care, including the skill and judgement that is reasonably expected from similarly situated professionals. No other warranty, guaranty, or representation, either express or implied is included or intended.

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Laboratory Manager

# Turner Laboratories, Inc.

**Date: 06/03/2010**

| | | | |
|---|---|---|---|
| **Client:** | Golder Associates, Inc. | **Client Sample ID:** | Sabino S1 |
| **Project:** | Sabino | **Collection Date/Time:** | 05/18/2010 0900 |
| **Work Order:** | 10E0560 | **Matrix:** | Solid |
| **Lab Sample ID:** | 10E0560-01 | **Order Name:** | 10392518 |

| Analyses | Result | PQL | Qual | Units | DF | Prep Date | Analysis Date | Analyst |
|---|---|---|---|---|---|---|---|---|
| **Anions by Ion Chromatography-E300** | | | | | | | | |
| Chloride | 11000 | 10000 | | mg/Kg | 1000 | 05/20/2010 1100 | 05/20/2010 1233 | JM |
| Sulfate | 300000 | 200000 | | mg/Kg | 4000 | 05/20/2010 1100 | 05/20/2010 1328 | JM |

# Turner Laboratories, Inc.

**Date: 06/08/2010**

**Client:** Golder Associates, Inc.
**Project:** Sabino
**Work Order:** 10E0558
**Lab Sample ID:** 10E0558-02

**Client Sample ID:** Sabino 2
**Collection Date/Time:** 05/18/2010 1000
**Matrix:** Storm Water
**Order Name:** 10392518

| Analyses | Result | PQL | Qual | Units | DF | Prep Date | Analysis Date | Analyst |
|---|---|---|---|---|---|---|---|---|
| **pH-E150.1** | | | | | | | | |
| pH (pH Units) | 7.5 | 0.0 | | - | 1 | 05/18/2010 1712 | 05/18/2010 1714 | BKW |
| Temperature (°C) | 13 | | | - | 1 | 05/18/2010 1712 | 05/18/2010 1714 | BKW |
| **ICP Total Metals-E200.7** | | | | | | | | |
| Boron | 2.1 | 0.10 | | mg/L | 1 | 05/20/2010 0900 | 05/22/2010 1540 | RAD |
| Calcium | 540 | 400 | | mg/L | 100 | 05/20/2010 0900 | 05/24/2010 0955 | RAD |
| Potassium | 9.6 | 5.0 | | mg/L | 1 | 05/20/2010 0900 | 05/22/2010 1539 | RAD |
| Sodium | 1600 | 500 | | mg/L | 100 | 05/20/2010 0900 | 05/24/2010 0955 | RAD |
| **Anions by Ion Chromatography-E300** | | | | | | | | |
| Bromide | 3.0 | 0.50 | | mg/L | 5 | 05/21/2010 1200 | 05/21/2010 1523 | JM |
| Chloride | 600 | 50 | | mg/L | 50 | 05/19/2010 0900 | 05/19/2010 1731 | JM |
| Fluoride | 12 | 5.0 | | mg/L | 10 | 05/19/2010 0900 | 05/19/2010 1712 | JM |
| Nitrogen, Nitrate (As N) | ND | 1.0 | | mg/L | 1 | 05/19/2010 0900 | 05/19/2010 1313 | JM |
| Nitrogen, Nitrite | ND | 0.10 | | mg/L | 1 | 05/19/2010 0900 | 05/19/2010 1313 | JM |
| Phosphorus, Dissolved Orthophosphate (As P) | ND | 0.50 | | mg/L | 1 | 05/19/2010 0900 | 05/19/2010 1313 | JM |
| Sulfate | 2000 | 1000 | | mg/L | 200 | 05/19/2010 0900 | 05/19/2010 1749 | JM |
| **Total Kjeldahl Nitrogen-E351.1** | | | | | | | | |
| Nitrogen, Kjeldahl, Total | 0.52 | 0.50 | | mg/L | 1 | 05/26/2010 0900 | 05/27/2010 1530 | JM |
| **Specific Conductance-SM2510 B** | | | | | | | | |
| Conductivity | 9200 | 1.0 | | µmhos/cm | 10 | 05/19/2010 1500 | 05/19/2010 1525 | EW |
| **Total Dissolved Solids (Residue, Filterable)-SM2540 C** | | | | | | | | |
| Total Dissolved Solids (Residue, Filterable) | 5300 | 20 | | mg/L | 1 | 05/19/2010 0820 | 05/21/2010 1545 | GW |
| **Ammonia as N-SM4500 B,C** | | | | | | | | |
| Nitrogen, Ammonia (As N) | ND | 0.50 | | mg/L | 1 | 05/28/2010 0830 | 05/28/2010 1330 | JM |

# Turner Laboratories, Inc.

**Date: 06/08/2010**

**Client:** Golder Associates, Inc.
**Project:** Sabino
**Work Order:** 10E0558
**Lab Sample ID:** 10E0558-01

**Client Sample ID:** Sabino 1
**Collection Date/Time:** 05/18/2010 1000
**Matrix:** Storm Water
**Order Name:** 10392518

| Analyses | Result | PQL | Qual | Units | DF | Prep Date | Analysis Date | Analyst |
|---|---|---|---|---|---|---|---|---|
| **pH-E150.1** | | | | | | | | |
| pH (pH Units) | 7.5 | 0.0 | | - | 1 | 05/18/2010 1712 | 05/18/2010 1713 | BKW |
| Temperature (°C) | 11 | | | - | 1 | 05/18/2010 1712 | 05/18/2010 1713 | BKW |
| **ICP Total Metals-E200.7** | | | | | | | | |
| Boron | 1.9 | 0.10 | | mg/L | 1 | 05/20/2010 0900 | 05/22/2010 1536 | RAD |
| Calcium | 130 | 4.0 | | mg/L | 1 | 05/20/2010 0900 | 05/22/2010 1536 | RAD |
| Potassium | 7.5 | 5.0 | | mg/L | 1 | 05/20/2010 0900 | 05/22/2010 1536 | RAD |
| Sodium | 1500 | 500 | | mg/L | 100 | 05/20/2010 0900 | 05/24/2010 0950 | RAD |
| **Anions by Ion Chromatography-E300** | | | | | | | | |
| Bromide | 2.3 | 0.50 | | mg/L | 5 | 05/21/2010 1200 | 05/21/2010 1446 | JM |
| Chloride | 460 | 50 | | mg/L | 50 | 05/19/2010 0900 | 05/19/2010 1636 | JM |
| Fluoride | 13 | 5.0 | | mg/L | 10 | 05/19/2010 0900 | 05/19/2010 1617 | JM |
| Nitrogen, Nitrate (As N) | ND | 1.0 | | mg/L | 1 | 05/19/2010 0900 | 05/19/2010 1254 | JM |
| Nitrogen, Nitrite | ND | 0.10 | | mg/L | 1 | 05/19/2010 0900 | 05/19/2010 1254 | JM |
| Phosphorus, Dissolved Orthophosphate (As P) | ND | 0.50 | | mg/L | 1 | 05/19/2010 0900 | 05/19/2010 1254 | JM |
| Sulfate | 2000 | 1000 | | mg/L | 200 | 05/19/2010 0900 | 05/19/2010 1654 | JM |
| **Total Kjeldahl Nitrogen-E351.1** | | | | | | | | |
| Nitrogen, Kjeldahl, Total | ND | 0.50 | | mg/L | 1 | 05/26/2010 0900 | 05/27/2010 1530 | JM |
| **Specific Conductance-SM2510 B** | | | | | | | | |
| Conductivity | 8200 | 1.0 | | µmhos/cm | 10 | 05/19/2010 1500 | 05/19/2010 1525 | EW |
| **Total Dissolved Solids (Residue, Filterable)-SM2540 C** | | | | | | | | |
| Total Dissolved Solids (Residue, Filterable) | 4800 | 20 | | mg/L | 1 | 05/19/2010 0820 | 05/21/2010 1210 | GW |
| **Ammonia as N-SM4500 B,C** | | | | | | | | |
| Nitrogen, Ammonia (As N) | ND | 0.50 | | mg/L | 1 | 05/28/2010 0830 | 05/28/2010 1330 | JM |

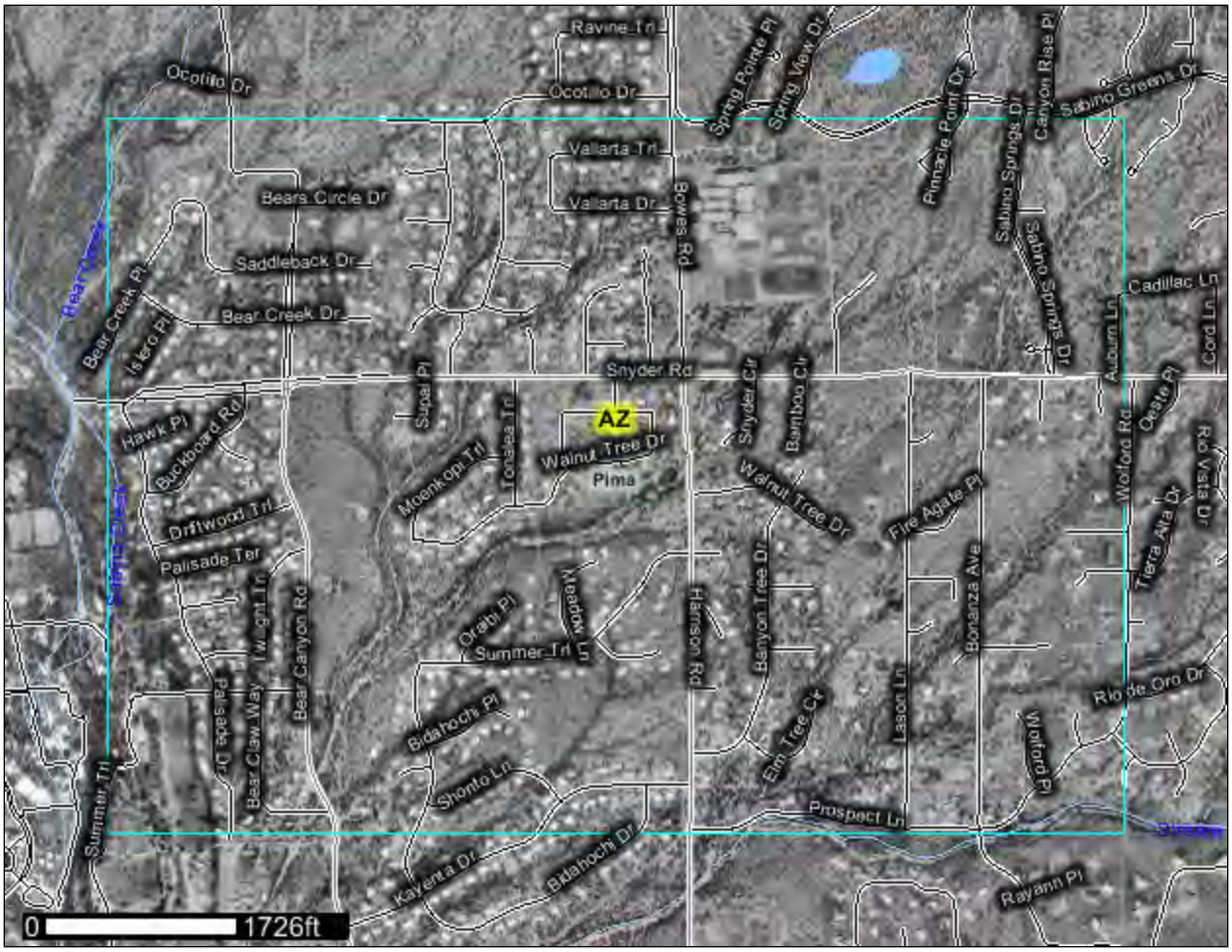
# APPENDIX C
# SOIL SURVEY REPORT

United States Department of Agriculture

Natural Resources Conservation Service

A product of the National Cooperative Soil Survey, a joint effort of the United States Department of Agriculture and other Federal agencies, State agencies including the Agricultural Experiment Stations, and local participants

# Custom Soil Resource Report for Pima County, Arizona, Eastern Part




June 29, 2010

# Preface

Soil surveys contain information that affects land use planning in survey areas. They highlight soil limitations that affect various land uses and provide information about the properties of the soils in the survey areas. Soil surveys are designed for many different users, including farmers, ranchers, foresters, agronomists, urban planners, community officials, engineers, developers, builders, and home buyers. Also, conservationists, teachers, students, and specialists in recreation, waste disposal, and pollution control can use the surveys to help them understand, protect, or enhance the environment.

Various land use regulations of Federal, State, and local governments may impose special restrictions on land use or land treatment. Soil surveys identify soil properties that are used in making various land use or land treatment decisions. The information is intended to help the land users identify and reduce the effects of soil limitations on various land uses. The landowner or user is responsible for identifying and complying with existing laws and regulations.

Although soil survey information can be used for general farm, local, and wider area planning, onsite investigation is needed to supplement this information in some cases. Examples include soil quality assessments (http://soils.usda.gov/sqi/) and certain conservation and engineering applications. For more detailed information, contact your local USDA Service Center (http://offices.sc.egov.usda.gov/locator/app?agency=nrcs) or your NRCS State Soil Scientist (http://soils.usda.gov/contact/state_offices/).

Great differences in soil properties can occur within short distances. Some soils are seasonally wet or subject to flooding. Some are too unstable to be used as a foundation for buildings or roads. Clayey or wet soils are poorly suited to use as septic tank absorption fields. A high water table makes a soil poorly suited to basements or underground installations.

The National Cooperative Soil Survey is a joint effort of the United States Department of Agriculture and other Federal agencies, State agencies including the Agricultural Experiment Stations, and local agencies. The Natural Resources Conservation Service (NRCS) has leadership for the Federal part of the National Cooperative Soil Survey.

Information about soils is updated periodically. Updated information is available through the NRCS Soil Data Mart Web site or the NRCS Web Soil Survey. The Soil Data Mart is the data storage site for the official soil survey information.

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# How Soil Surveys Are Made

Soil surveys are made to provide information about the soils and miscellaneous areas in a specific area. They include a description of the soils and miscellaneous areas and their location on the landscape and tables that show soil properties and limitations affecting various uses. Soil scientists observed the steepness, length, and shape of the slopes; the general pattern of drainage; the kinds of crops and native plants; and the kinds of bedrock. They observed and described many soil profiles. A soil profile is the sequence of natural layers, or horizons, in a soil. The profile extends from the surface down into the unconsolidated material in which the soil formed or from the surface down to bedrock. The unconsolidated material is devoid of roots and other living organisms and has not been changed by other biological activity.

Currently, soils are mapped according to the boundaries of major land resource areas (MLRAs). MLRAs are geographically associated land resource units that share common characteristics related to physiography, geology, climate, water resources, soils, biological resources, and land uses (USDA, 2006). Soil survey areas typically consist of parts of one or more MLRA.

The soils and miscellaneous areas in a survey area occur in an orderly pattern that is related to the geology, landforms, relief, climate, and natural vegetation of the area. Each kind of soil and miscellaneous area is associated with a particular kind of landform or with a segment of the landform. By observing the soils and miscellaneous areas in the survey area and relating their position to specific segments of the landform, a soil scientist develops a concept, or model, of how they were formed. Thus, during mapping, this model enables the soil scientist to predict with a considerable degree of accuracy the kind of soil or miscellaneous area at a specific location on the landscape.

Commonly, individual soils on the landscape merge into one another as their characteristics gradually change. To construct an accurate soil map, however, soil scientists must determine the boundaries between the soils. They can observe only a limited number of soil profiles. Nevertheless, these observations, supplemented by an understanding of the soil-vegetation-landscape relationship, are sufficient to verify predictions of the kinds of soil in an area and to determine the boundaries.

Soil scientists recorded the characteristics of the soil profiles that they studied. They noted soil color, texture, size and shape of soil aggregates, kind and amount of rock fragments, distribution of plant roots, reaction, and other features that enable them to identify soils. After describing the soils in the survey area and determining their properties, the soil scientists assigned the soils to taxonomic classes (units). Taxonomic classes are concepts. Each taxonomic class has a set of soil characteristics with precisely defined limits. The classes are used as a basis for comparison to classify soils systematically. Soil taxonomy, the system of taxonomic classification used in the United States, is based mainly on the kind and character of soil properties and the arrangement of horizons within the profile. After the soil scientists classified and named the soils in the survey area, they compared the

individual soils with similar soils in the same taxonomic class in other areas so that they could confirm data and assemble additional data based on experience and research.

The objective of soil mapping is not to delineate pure map unit components; the objective is to separate the landscape into landforms or landform segments that have similar use and management requirements. Each map unit is defined by a unique combination of soil components and/or miscellaneous areas in predictable proportions. Some components may be highly contrasting to the other components of the map unit. The presence of minor components in a map unit in no way diminishes the usefulness or accuracy of the data. The delineation of such landforms and landform segments on the map provides sufficient information for the development of resource plans. If intensive use of small areas is planned, onsite investigation is needed to define and locate the soils and miscellaneous areas.

Soil scientists make many field observations in the process of producing a soil map. The frequency of observation is dependent upon several factors, including scale of mapping, intensity of mapping, design of map units, complexity of the landscape, and experience of the soil scientist. Observations are made to test and refine the soil-landscape model and predictions and to verify the classification of the soils at specific locations. Once the soil-landscape model is refined, a significantly smaller number of measurements of individual soil properties are made and recorded. These measurements may include field measurements, such as those for color, depth to bedrock, and texture, and laboratory measurements, such as those for content of sand, silt, clay, salt, and other components. Properties of each soil typically vary from one point to another across the landscape.

Observations for map unit components are aggregated to develop ranges of characteristics for the components. The aggregated values are presented. Direct measurements do not exist for every property presented for every map unit component. Values for some properties are estimated from combinations of other properties.

While a soil survey is in progress, samples of some of the soils in the area generally are collected for laboratory analyses and for engineering tests. Soil scientists interpret the data from these analyses and tests as well as the field-observed characteristics and the soil properties to determine the expected behavior of the soils under different uses. Interpretations for all of the soils are field tested through observation of the soils in different uses and under different levels of management. Some interpretations are modified to fit local conditions, and some new interpretations are developed to meet local needs. Data are assembled from other sources, such as research information, production records, and field experience of specialists. For example, data on crop yields under defined levels of management are assembled from farm records and from field or plot experiments on the same kinds of soil.

Predictions about soil behavior are based not only on soil properties but also on such variables as climate and biological activity. Soil conditions are predictable over long periods of time, but they are not predictable from year to year. For example, soil scientists can predict with a fairly high degree of accuracy that a given soil will have a high water table within certain depths in most years, but they cannot predict that a high water table will always be at a specific level in the soil on a specific date.

After soil scientists located and identified the significant natural bodies of soil in the survey area, they drew the boundaries of these bodies on aerial photographs and identified each as a specific map unit. Aerial photographs show trees, buildings, fields, roads, and rivers, all of which help in locating boundaries accurately.

# Soil Map

The soil map section includes the soil map for the defined area of interest, a list of soil map units on the map and extent of each map unit, and cartographic symbols displayed on the map. Also presented are various metadata about data used to produce the map, and a description of each soil map unit.

# Custom Soil Resource Report
## Soil Map

Map Scale: 1:17,000 if printed on A size (8.5" x 11") sheet.

N

Meters: 0 200 400 800 1,200

Feet: 0 500 1,000 2,000 3,000

## MAP LEGEND

**Area of Interest (AOI)**

- Area of Interest (AOI)

**Soils**

- Soil Map Units

**Special Point Features**

- Blowout
- Borrow Pit
- Clay Spot
- Closed Depression
- Gravel Pit
- Gravelly Spot
- Landfill
- Lava Flow
- Marsh or swamp
- Mine or Quarry
- Miscellaneous Water
- Perennial Water
- Rock Outcrop
- Saline Spot
- Sandy Spot
- Severely Eroded Spot
- Sinkhole
- Slide or Slip
- Sodic Spot
- Spoil Area
- Stony Spot
- Very Stony Spot
- Wet Spot
- Other

**Special Line Features**

- Gully
- Short Steep Slope
- Other

**Political Features**

- Cities

**Water Features**

- Oceans
- Streams and Canals

**Transportation**

- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

## MAP INFORMATION

Map Scale: 1:17,000 if printed on A size (8.5" × 11") sheet.

The soil surveys that comprise your AOI were mapped at 1:24,000.

Please rely on the bar scale on each map sheet for accurate map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL: http://websoilsurvey.nrcs.usda.gov
Coordinate System: UTM Zone 12N NAD83

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Pima County, Arizona, Eastern Part
Survey Area Data: Version 8, Sep 8, 2008

Date(s) aerial images were photographed: 5/16/1992

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

# Map Unit Legend

| Pima County, Arizona, Eastern Part (AZ669) | | | |
|---|---|---|---|
| **Map Unit Symbol** | **Map Unit Name** | **Acres in AOI** | **Percent of AOI** |
| 5 | Arizo-Riverwash complex, 0 to 3 percent slopes | 164.6 | 12.4% |
| 35 | Hayhook sandy loam, 1 to 5 percent slopes | 7.1 | 0.5% |
| 36 | Hayhook-Sahuarita complex, 1 to 5 percent slopes | 407.8 | 30.8% |
| 54 | Palos Verdes-Jaynes complex, 2 to 8 percent slopes | 166.1 | 12.6% |
| 58 | Pantano-Granolite complex, 5 to 25 percent slopes | 227.1 | 17.2% |
| 62 | Pinaleno very cobbly sandy loam, 1 to 8 percent slopes | 331.7 | 25.1% |
| 86 | Yaqui fine sandy loam, 1 to 3 percent slopes | 18.2 | 1.4% |
| **Totals for Area of Interest** | | **1,322.5** | **100.0%** |

# Map Unit Descriptions

The map units delineated on the detailed soil maps in a soil survey represent the soils or miscellaneous areas in the survey area. The map unit descriptions, along with the maps, can be used to determine the composition and properties of a unit.

A map unit delineation on a soil map represents an area dominated by one or more major kinds of soil or miscellaneous areas. A map unit is identified and named according to the taxonomic classification of the dominant soils. Within a taxonomic class there are precisely defined limits for the properties of the soils. On the landscape, however, the soils are natural phenomena, and they have the characteristic variability of all natural phenomena. Thus, the range of some observed properties may extend beyond the limits defined for a taxonomic class. Areas of soils of a single taxonomic class rarely, if ever, can be mapped without including areas of other taxonomic classes. Consequently, every map unit is made up of the soils or miscellaneous areas for which it is named and some minor components that belong to taxonomic classes other than those of the major soils.

Most minor soils have properties similar to those of the dominant soil or soils in the map unit, and thus they do not affect use and management. These are called noncontrasting, or similar, components. They may or may not be mentioned in a particular map unit description. Other minor components, however, have properties and behavioral characteristics divergent enough to affect use or to require different management. These are called contrasting, or dissimilar, components. They generally are in small areas and could not be mapped separately because of the scale used. Some small areas of strongly contrasting soils or miscellaneous areas are identified by a special symbol on the maps. If included in the database for a given area, the contrasting minor components are identified in the map unit descriptions along with

some characteristics of each. A few areas of minor components may not have been observed, and consequently they are not mentioned in the descriptions, especially where the pattern was so complex that it was impractical to make enough observations to identify all the soils and miscellaneous areas on the landscape.

The presence of minor components in a map unit in no way diminishes the usefulness or accuracy of the data. The objective of mapping is not to delineate pure taxonomic classes but rather to separate the landscape into landforms or landform segments that have similar use and management requirements. The delineation of such segments on the map provides sufficient information for the development of resource plans. If intensive use of small areas is planned, however, onsite investigation is needed to define and locate the soils and miscellaneous areas.

An identifying symbol precedes the map unit name in the map unit descriptions. Each description includes general facts about the unit and gives important soil properties and qualities.

Soils that have profiles that are almost alike make up a *soil series*. Except for differences in texture of the surface layer, all the soils of a series have major horizons that are similar in composition, thickness, and arrangement.

Soils of one series can differ in texture of the surface layer, slope, stoniness, salinity, degree of erosion, and other characteristics that affect their use. On the basis of such differences, a soil series is divided into *soil phases*. Most of the areas shown on the detailed soil maps are phases of soil series. The name of a soil phase commonly indicates a feature that affects use or management. For example, Alpha silt loam, 0 to 2 percent slopes, is a phase of the Alpha series.

Some map units are made up of two or more major soils or miscellaneous areas. These map units are complexes, associations, or undifferentiated groups.

A *complex* consists of two or more soils or miscellaneous areas in such an intricate pattern or in such small areas that they cannot be shown separately on the maps. The pattern and proportion of the soils or miscellaneous areas are somewhat similar in all areas. Alpha-Beta complex, 0 to 6 percent slopes, is an example.

An *association* is made up of two or more geographically associated soils or miscellaneous areas that are shown as one unit on the maps. Because of present or anticipated uses of the map units in the survey area, it was not considered practical or necessary to map the soils or miscellaneous areas separately. The pattern and relative proportion of the soils or miscellaneous areas are somewhat similar. Alpha-Beta association, 0 to 2 percent slopes, is an example.

An *undifferentiated group* is made up of two or more soils or miscellaneous areas that could be mapped individually but are mapped as one unit because similar interpretations can be made for use and management. The pattern and proportion of the soils or miscellaneous areas in a mapped area are not uniform. An area can be made up of only one of the major soils or miscellaneous areas, or it can be made up of all of them. Alpha and Beta soils, 0 to 2 percent slopes, is an example.

Some surveys include *miscellaneous areas*. Such areas have little or no soil material and support little or no vegetation. Rock outcrop is an example.

# Pima County, Arizona, Eastern Part

## 5—Arizo-Riverwash complex, 0 to 3 percent slopes

### Map Unit Setting

*Elevation:* 2,000 to 3,000 feet
*Mean annual precipitation:* 10 to 12 inches
*Mean annual air temperature:* 64 to 70 degrees F
*Frost-free period:* 220 to 280 days

### Map Unit Composition

*Arizo and similar soils:* 50 percent
*Riverwash:* 20 percent

### Description of Arizo

#### Setting

*Landform:* Flood plains
*Landform position (two-dimensional):* Summit
*Landform position (three-dimensional):* Dip
*Down-slope shape:* Linear
*Across-slope shape:* Linear
*Parent material:* Mixed alluvium

#### Properties and qualities

*Slope:* 0 to 3 percent
*Depth to restrictive feature:* More than 80 inches
*Drainage class:* Excessively drained
*Capacity of the most limiting layer to transmit water (Ksat):* High to very high (6.00 to 20.00 in/hr)
*Depth to water table:* More than 80 inches
*Frequency of flooding:* Frequent
*Frequency of ponding:* None
*Calcium carbonate, maximum content:* 1 percent
*Maximum salinity:* Nonsaline (0.0 to 2.0 mmhos/cm)
*Available water capacity:* Very low (about 2.3 inches)

#### Interpretive groups

*Land capability (nonirrigated):* 6w
*Ecological site:* Sandy Wash 10-13" p.z. (R040XA115AZ)

#### Typical profile

*0 to 18 inches:* Gravelly loamy sand
*18 to 60 inches:* Very gravelly loamy sand

### Description of Riverwash

#### Properties and qualities

*Drainage class:* Excessively drained
*Frequency of flooding:* Frequent

#### Interpretive groups

*Land capability (nonirrigated):* 8

## 35—Hayhook sandy loam, 1 to 5 percent slopes

### Map Unit Setting

*Elevation:* 2,200 to 3,600 feet
*Mean annual precipitation:* 10 to 12 inches
*Mean annual air temperature:* 64 to 70 degrees F
*Frost-free period:* 220 to 280 days

### Map Unit Composition

*Hayhook and similar soils:* 85 percent

### Description of Hayhook

#### Setting

*Landform:* Fan terraces
*Landform position (two-dimensional):* Summit
*Landform position (three-dimensional):* Tread
*Down-slope shape:* Convex
*Across-slope shape:* Convex
*Parent material:* Alluvium derived from granite

#### Properties and qualities

*Slope:* 1 to 5 percent
*Depth to restrictive feature:* More than 80 inches
*Drainage class:* Well drained
*Capacity of the most limiting layer to transmit water (Ksat):* High (2.00 to 6.00 in/hr)
*Depth to water table:* More than 80 inches
*Frequency of flooding:* None
*Frequency of ponding:* None
*Calcium carbonate, maximum content:* 5 percent
*Maximum salinity:* Nonsaline (0.0 to 2.0 mmhos/cm)
*Available water capacity:* Low (about 5.8 inches)

#### Interpretive groups

*Land capability classification (irrigated):* 3e
*Land capability (nonirrigated):* 7e
*Ecological site:* Sandy Loam Upland 10-13" p.z. Deep (R040XA117AZ)

#### Typical profile

*0 to 5 inches:* Sandy loam
*5 to 24 inches:* Sandy loam
*24 to 38 inches:* Gravelly sandy loam
*38 to 60 inches:* Gravelly loamy sand

## 36—Hayhook-Sahuarita complex, 1 to 5 percent slopes

### Map Unit Setting

*Elevation:* 2,200 to 3,600 feet
*Mean annual precipitation:* 10 to 12 inches
*Mean annual air temperature:* 64 to 70 degrees F
*Frost-free period:* 220 to 280 days

### Map Unit Composition

*Hayhook and similar soils:* 45 percent
*Sahuarita and similar soils:* 30 percent

### Description of Hayhook

#### Setting

*Landform:* Fan terraces
*Landform position (two-dimensional):* Summit
*Landform position (three-dimensional):* Tread
*Down-slope shape:* Convex
*Across-slope shape:* Convex
*Parent material:* Alluvium derived from granite

#### Properties and qualities

*Slope:* 1 to 5 percent
*Depth to restrictive feature:* More than 80 inches
*Drainage class:* Well drained
*Capacity of the most limiting layer to transmit water (Ksat):* High (2.00 to 6.00 in/hr)
*Depth to water table:* More than 80 inches
*Frequency of flooding:* None
*Frequency of ponding:* None
*Calcium carbonate, maximum content:* 5 percent
*Maximum salinity:* Nonsaline (0.0 to 2.0 mmhos/cm)
*Available water capacity:* Low (about 5.8 inches)

#### Interpretive groups

*Land capability classification (irrigated):* 3e
*Land capability (nonirrigated):* 7e
*Ecological site:* Sandy Loam Upland 10-13" p.z. Deep (R040XA117AZ)

#### Typical profile

*0 to 5 inches:* Sandy loam
*5 to 24 inches:* Sandy loam
*24 to 38 inches:* Gravelly sandy loam
*38 to 60 inches:* Gravelly loamy sand

### Description of Sahuarita

#### Setting

*Landform:* Fan terraces
*Landform position (two-dimensional):* Summit
*Landform position (three-dimensional):* Tread
*Down-slope shape:* Convex

*Across-slope shape:* Convex
*Parent material:* Mixed alluvium

**Properties and qualities**

*Slope:* 1 to 5 percent
*Depth to restrictive feature:* More than 80 inches
*Drainage class:* Well drained
*Capacity of the most limiting layer to transmit water (Ksat):* Moderately high (0.20 to 0.60 in/hr)
*Depth to water table:* More than 80 inches
*Frequency of flooding:* None
*Frequency of ponding:* None
*Calcium carbonate, maximum content:* 35 percent
*Maximum salinity:* Nonsaline (0.0 to 2.0 mmhos/cm)
*Sodium adsorption ratio, maximum:* 3.0
*Available water capacity:* Moderate (about 8.3 inches)

**Interpretive groups**

*Land capability classification (irrigated):* 2s
*Land capability (nonirrigated):* 7s
*Ecological site:* Sandy Loam Upland 10-13" p.z. (R040XA118AZ)

**Typical profile**

*0 to 3 inches:* Very gravelly fine sandy loam
*3 to 28 inches:* Fine sandy loam
*28 to 45 inches:* Sandy clay loam
*45 to 60 inches:* Very gravelly sandy clay loam

## 54—Palos Verdes-Jaynes complex, 2 to 8 percent slopes

**Map Unit Setting**

*Elevation:* 2,200 to 3,200 feet
*Mean annual precipitation:* 10 to 12 inches
*Mean annual air temperature:* 64 to 70 degrees F
*Frost-free period:* 220 to 280 days

**Map Unit Composition**

*Palos verdes and similar soils:* 40 percent
*Jaynes and similar soils:* 35 percent

**Description of Palos Verdes**

**Setting**

*Landform:* Fan terraces
*Landform position (two-dimensional):* Summit
*Landform position (three-dimensional):* Tread
*Down-slope shape:* Convex
*Across-slope shape:* Convex
*Parent material:* Mixed alluvium

**Properties and qualities**

*Slope:* 2 to 8 percent
*Depth to restrictive feature:* 8 to 20 inches to dense material
*Drainage class:* Well drained
*Capacity of the most limiting layer to transmit water (Ksat):* Very low (0.00 in/hr)
*Depth to water table:* More than 80 inches
*Frequency of flooding:* None
*Frequency of ponding:* None
*Calcium carbonate, maximum content:* 40 percent
*Maximum salinity:* Nonsaline (0.0 to 2.0 mmhos/cm)
*Sodium adsorption ratio, maximum:* 3.0
*Available water capacity:* Very low (about 2.4 inches)

**Interpretive groups**

*Land capability (nonirrigated):* 7s
*Ecological site:* Loamy Upland 10-13" p.z. (R040XA114AZ)

**Typical profile**

*0 to 3 inches:* Gravelly sandy loam
*3 to 15 inches:* Gravelly sandy clay loam
*15 to 19 inches:* Gravelly sandy loam
*19 to 38 inches:* Sandy loam
*38 to 64 inches:* Gravelly loamy coarse sand

## Description of Jaynes

**Setting**

*Landform:* Fan terraces
*Landform position (two-dimensional):* Summit
*Landform position (three-dimensional):* Tread
*Down-slope shape:* Convex
*Across-slope shape:* Convex
*Parent material:* Alluvium derived from schist and/or alluvium derived from gneiss

**Properties and qualities**

*Slope:* 2 to 8 percent
*Depth to restrictive feature:* 4 to 16 inches to dense material
*Drainage class:* Well drained
*Capacity of the most limiting layer to transmit water (Ksat):* Very low (0.00 in/hr)
*Depth to water table:* More than 80 inches
*Frequency of flooding:* None
*Frequency of ponding:* None
*Calcium carbonate, maximum content:* 40 percent
*Maximum salinity:* Nonsaline (0.0 to 2.0 mmhos/cm)
*Sodium adsorption ratio, maximum:* 3.0
*Available water capacity:* Very low (about 0.9 inches)

**Interpretive groups**

*Land capability (nonirrigated):* 7s
*Ecological site:* Limy Upland 10-13" p.z. (R040XA111AZ)

**Typical profile**

*0 to 5 inches:* Gravelly sandy loam
*5 to 10 inches:* Gravelly sandy loam
*10 to 60 inches:* Loamy fine sand

## 58—Pantano-Granolite complex, 5 to 25 percent slopes

### Map Unit Setting

*Elevation:* 2,400 to 3,600 feet
*Mean annual precipitation:* 10 to 12 inches
*Mean annual air temperature:* 64 to 70 degrees F
*Frost-free period:* 220 to 280 days

### Map Unit Composition

*Pantano and similar soils:* 40 percent
*Granolite and similar soils:* 35 percent

### Description of Pantano

#### Setting

*Landform:* Pediments
*Landform position (two-dimensional):* Summit
*Landform position (three-dimensional):* Side slope
*Down-slope shape:* Convex
*Across-slope shape:* Convex
*Parent material:* Mixed alluvium and/or mixed colluvium

#### Properties and qualities

*Slope:* 5 to 25 percent
*Depth to restrictive feature:* 10 to 20 inches to paralithic bedrock
*Drainage class:* Well drained
*Capacity of the most limiting layer to transmit water (Ksat):* Very low to moderately low (0.00 to 0.06 in/hr)
*Depth to water table:* More than 80 inches
*Frequency of flooding:* None
*Frequency of ponding:* None
*Calcium carbonate, maximum content:* 35 percent
*Gypsum, maximum content:* 1 percent
*Maximum salinity:* Nonsaline (0.0 to 2.0 mmhos/cm)
*Sodium adsorption ratio, maximum:* 2.0
*Available water capacity:* Very low (about 1.1 inches)

#### Interpretive groups

*Land capability (nonirrigated):* 7s
*Ecological site:* Limy Upland 10-13" p.z. (R040XA111AZ)

#### Typical profile

*0 to 1 inches:* Extremely gravelly loam
*1 to 10 inches:* Very gravelly loam
*10 to 16 inches:* Extremely gravelly loam
*16 to 60 inches:* Bedrock

### Description of Granolite

#### Setting

*Landform:* Pediments
*Landform position (two-dimensional):* Summit
*Landform position (three-dimensional):* Side slope
*Down-slope shape:* Convex
*Across-slope shape:* Convex
*Parent material:* Mixed alluvium and/or residuum weathered from rhyolite

#### Properties and qualities

*Slope:* 5 to 25 percent
*Depth to restrictive feature:* 10 to 30 inches to paralithic bedrock; 20 to 30 inches to lithic bedrock
*Drainage class:* Well drained
*Capacity of the most limiting layer to transmit water (Ksat):* Very low (0.00 in/hr)
*Depth to water table:* More than 80 inches
*Frequency of flooding:* None
*Frequency of ponding:* None
*Calcium carbonate, maximum content:* 10 percent
*Maximum salinity:* Nonsaline (0.0 to 2.0 mmhos/cm)
*Available water capacity:* Very low (about 1.1 inches)

#### Interpretive groups

*Land capability (nonirrigated):* 7s
*Ecological site:* Granitic Upland 10-13" p.z. (R040XA121AZ)

#### Typical profile

*0 to 2 inches:* Extremely gravelly sandy loam
*2 to 16 inches:* Extremely gravelly sandy clay
*16 to 24 inches:* Bedrock
*24 to 60 inches:* Bedrock

## 62—Pinaleno very cobbly sandy loam, 1 to 8 percent slopes

### Map Unit Setting

*Elevation:* 2,200 to 3,450 feet
*Mean annual precipitation:* 10 to 12 inches
*Mean annual air temperature:* 64 to 70 degrees F
*Frost-free period:* 220 to 280 days

### Map Unit Composition

*Pinaleno and similar soils:* 80 percent

### Description of Pinaleno

#### Setting

*Landform:* Fan terraces
*Landform position (two-dimensional):* Summit
*Landform position (three-dimensional):* Tread

*Down-slope shape:* Convex
*Across-slope shape:* Convex
*Parent material:* Mixed alluvium

**Properties and qualities**

*Slope:* 1 to 8 percent
*Depth to restrictive feature:* More than 80 inches
*Drainage class:* Well drained
*Capacity of the most limiting layer to transmit water (Ksat):* Moderately high (0.20 to 0.60 in/hr)
*Depth to water table:* More than 80 inches
*Frequency of flooding:* None
*Frequency of ponding:* None
*Calcium carbonate, maximum content:* 35 percent
*Maximum salinity:* Nonsaline to very slightly saline (0.0 to 4.0 mmhos/cm)
*Available water capacity:* Low (about 3.7 inches)

**Interpretive groups**

*Land capability (nonirrigated):* 7s
*Ecological site:* Loamy Upland 10-13" p.z. (R040XA114AZ)

**Typical profile**

*0 to 2 inches:* Very cobbly sandy loam
*2 to 30 inches:* Extremely cobbly sandy clay loam
*30 to 60 inches:* Extremely gravelly sandy clay loam

## 86—Yaqui fine sandy loam, 1 to 3 percent slopes

**Map Unit Setting**

*Elevation:* 2,200 to 3,600 feet
*Mean annual precipitation:* 10 to 12 inches
*Mean annual air temperature:* 64 to 70 degrees F
*Frost-free period:* 220 to 280 days

**Map Unit Composition**

*Yaqui and similar soils:* 80 percent

**Description of Yaqui**

**Setting**

*Landform:* Alluvial fans
*Landform position (two-dimensional):* Summit
*Landform position (three-dimensional):* Tread
*Down-slope shape:* Convex
*Across-slope shape:* Convex
*Parent material:* Mixed alluvium

**Properties and qualities**

*Slope:* 1 to 3 percent
*Depth to restrictive feature:* More than 80 inches
*Drainage class:* Well drained
*Capacity of the most limiting layer to transmit water (Ksat):* Moderately high (0.20 to 0.60 in/hr)

*Depth to water table:* More than 80 inches
*Frequency of flooding:* None
*Frequency of ponding:* None
*Calcium carbonate, maximum content:* 20 percent
*Gypsum, maximum content:* 1 percent
*Maximum salinity:* Nonsaline to very slightly saline (0.0 to 4.0 mmhos/cm)
*Sodium adsorption ratio, maximum:* 13.0
*Available water capacity:* Moderate (about 8.9 inches)

**Interpretive groups**

*Land capability (nonirrigated):* 7c
*Ecological site:* Limy Fan 10-13" p.z. (R040XA108AZ)

**Typical profile**

*0 to 4 inches:* Fine sandy loam
*4 to 31 inches:* Sandy clay loam
*31 to 43 inches:* Clay loam
*43 to 60 inches:* Gravelly loam

# Soil Information for All Uses

## Soil Properties and Qualities

The Soil Properties and Qualities section includes various soil properties and qualities displayed as thematic maps with a summary table for the soil map units in the selected area of interest. A single value or rating for each map unit is generated by aggregating the interpretive ratings of individual map unit components. This aggregation process is defined for each property or quality.

## Soil Physical Properties

Soil Physical Properties are measured or inferred from direct observations in the field or laboratory. Examples of soil physical properties include percent clay, organic matter, saturated hydraulic conductivity, available water capacity, and bulk density.

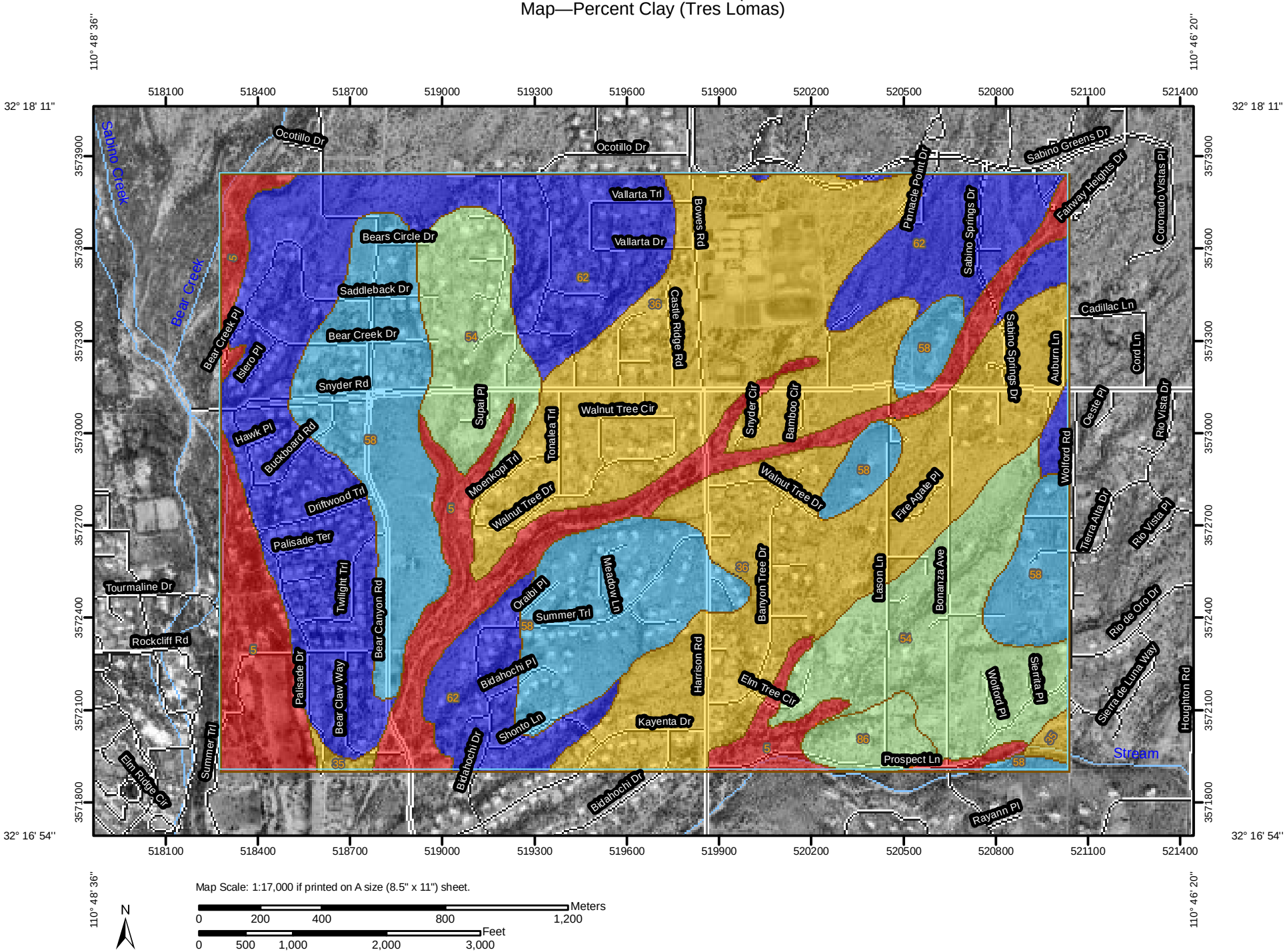
### Percent Clay (Tres Lomas)

Clay as a soil separate consists of mineral soil particles that are less than 0.002 millimeter in diameter. The estimated clay content of each soil layer is given as a percentage, by weight, of the soil material that is less than 2 millimeters in diameter. The amount and kind of clay affect the fertility and physical condition of the soil and the ability of the soil to adsorb cations and to retain moisture. They influence shrink-swell potential, saturated hydraulic conductivity (Ksat), plasticity, the ease of soil dispersion, and other soil properties. The amount and kind of clay in a soil also affect tillage and earth-moving operations.

Most of the material is in one of three groups of clay minerals or a mixture of these clay minerals. The groups are kaolinite, smectite, and hydrous mica, the best known member of which is illite.

For each soil layer, this attribute is actually recorded as three separate values in the database. A low value and a high value indicate the range of this attribute for the soil component. A "representative" value indicates the expected value of this attribute for the component. For this soil property, only the representative value is used.

# Custom Soil Resource Report
## Map—Percent Clay (Tres Lomas)




Map Scale: 1:17,000 if printed on A size (8.5" x 11") sheet.

N

Meters: 0 200 400 800 1,200

Feet: 0 500 1,000 2,000 3,000

## MAP LEGEND

**Area of Interest (AOI)**

Area of Interest (AOI)

**Soils**

Soil Map Units

**Soil Ratings**

<= 7

> 7 AND <= 13.7

> 13.7 AND <= 19.3

> 19.3 AND <= 20.2

> 20.2 AND <= 26.2

Not rated or not available

**Political Features**

Cities

**Water Features**

Oceans

Streams and Canals

**Transportation**

Rails

Interstate Highways

US Routes

Major Roads

Local Roads

## MAP INFORMATION

Map Scale: 1:17,000 if printed on A size (8.5" × 11") sheet.

The soil surveys that comprise your AOI were mapped at 1:24,000.

Please rely on the bar scale on each map sheet for accurate map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL: http://websoilsurvey.nrcs.usda.gov
Coordinate System: UTM Zone 12N NAD83

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Pima County, Arizona, Eastern Part
Survey Area Data: Version 8, Sep 8, 2008

Date(s) aerial images were photographed: 5/16/1992

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

## Table—Percent Clay (Tres Lomas)

| Percent Clay— Summary by Map Unit — Pima County, Arizona, Eastern Part | | | | |
|---|---|---|---|---|
| **Map unit symbol** | **Map unit name** | **Rating (percent)** | **Acres in AOI** | **Percent of AOI** |
| 5 | Arizo-Riverwash complex, 0 to 3 percent slopes | 7.0 | 164.6 | 12.4% |
| 35 | Hayhook sandy loam, 1 to 5 percent slopes | 13.7 | 7.1 | 0.5% |
| 36 | Hayhook-Sahuarita complex, 1 to 5 percent slopes | 13.7 | 407.8 | 30.8% |
| 54 | Palos Verdes-Jaynes complex, 2 to 8 percent slopes | 19.3 | 166.1 | 12.6% |
| 58 | Pantano-Granolite complex, 5 to 25 percent slopes | 20.2 | 227.1 | 17.2% |
| 62 | Pinaleno very cobbly sandy loam, 1 to 8 percent slopes | 26.2 | 331.7 | 25.1% |
| 86 | Yaqui fine sandy loam, 1 to 3 percent slopes | 18.8 | 18.2 | 1.4% |
| **Totals for Area of Interest** | | | **1,322.5** | **100.0%** |

## Rating Options—Percent Clay (Tres Lomas)

*Units of Measure:* percent

*Aggregation Method:* Dominant Component

*Component Percent Cutoff: None Specified*

*Tie-break Rule:* Higher

*Interpret Nulls as Zero:* No

*Layer Options:* Depth Range

*Top Depth:* 0

*Bottom Depth:* 60

*Units of Measure:* Centimeters

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# APPENDIX D

## IMPORTANT INFORMATION ABOUT YOUR GEOTECHNICAL ENGINEERING REPORT (TAKEN FROM ASFE)

# Important Information About Your

# Geotechnical Engineering Report

*Subsurface problems are a principal cause of construction delays, cost overruns, claims, and disputes. The following information is provided to help you manage your risks.*

## Geotechnical Services Are Performed for Specific Purposes, Persons, and Projects

Geotechnical engineers structure their services to meet the specific needs of their clients. A geotechnical engineering study conducted for a civil engineer may not fulfill the needs of a construction contractor or even another civil engineer. Because each geotechnical engineering study is unique, each geotechnical engineering report is unique, prepared solely for the client. *No one except you* should rely on your geotechnical engineering report without first conferring with the geotechnical engineer who prepared it. *And no one - not even you* - should apply the report for any purpose or project except the one originally contemplated.

## A Geotechnical Engineering Report Is Based on A Unique Set of Project-Specific Factors

Geotechnical engineers consider a number of unique, Project-specific factors when establishing the scope of a study. Typical factors include the client's goals, objectives, and risk management preferences; the general nature of the structure involved, its size, and configuration; the location of the structure on the site; and other planned or existing site improvements, such as access roads, parking lots, and underground utilities. Unless the geotechnical engineer who conducted the study specifically indicates otherwise, *do not rely on a geotechnical engineering report that was:*

- not prepared for you,
- not prepared for your project.
- not prepared for the specific site explored, or
- completed before important project changes were made.

Typical changes that can erode the reliability of an existing geotechnical engineering report include those that affect:

- the function of the proposed structure, as when it's changed from a parking garage to an office building, or from a light industrial plant to a refrigerated warehouse,
- elevation, configuration, location, orientation, or weight of the proposed structure,
- composition of the design team, or
- project ownership.

As a general rule, always inform your geotechnical engineer of project changes-even minor ones-and request an assessment of their impact. *Geotechnical engineers cannot accept responsibility or liability for problems that occur because their reports do not consider developments of which they were not informed.*

## Subsurface Conditions Can Change

A geotechnical engineering report is based on conditions that existed at the time the study was performed. *Do not rely on a geotechnical engineering report* whose adequacy may have been affected by: the passage of time; by man-made events, such as construction on or adjacent to the site; or by natural events, such as floods, earthquakes, or groundwater fluctuations*. Always* contact the geotechnical engineer before applying the report to determine if it is still reliable. A minor amount of additional testing or analysis could prevent major problems.

## Most Geotechnical Findings Are Professional Opinions

Site exploration identifies subsurface conditions only at those points where subsurface tests are conducted or samples are taken. Geotechnical engineers review field and laboratory data and then apply their professional judgment to render an *opinion* about subsurface conditions throughout the site. Actual sub-surface conditions may differ - sometimes significantly - from those indicated in your report. Retaining the geotechnical engineer who developed your report to provide construction observation is the most effective method of managing the risks associated with unanticipated conditions

## A Report's Recommendations Are *Not* Final

Do not over-rely on the construction recommendations included in your report. Those *recommendations are not final,* because geotechnical engineers develop them principally from judgment and opinion. Geotechnical engineers can finalize their recommendations only by observing actual subsurface conditions revealed during construction. *The geotechnical engineer who developed your report cannot assume responsibility or liability* for the report's recommendations if that engineer does not perform construction observation.

## A Geotechnical Engineering Report Is Subject To Misinterpretation

Other design team members' misinterpretation of geotechnical engineering reports has resulted in costly problems. Lower that risk by having your geotechnical engineer confer with appropriate members of the design team after submitting the report. Also retain your geotechnical engineer to review pertinent elements of the design team's plans and specifications. Contractors can also misinterpret a geotechnical engineering report. Reduce that risk by having your geotechnical engineer participate in prebid and preconstruction conferences, and by providing construction observation.

## Do Not Redraw the Engineer's Logs

Geotechnical engineers prepare final boring and testing logs based upon their interpretation of field logs and laboratory data. To prevent errors or omissions, the logs included in a geotechnical engineering report should never be redrawn for inclusion in architectural or other design drawings. Only photo graphic or electronic reproduction is acceptable, *but recognize that separating logs from the report can elevate risk.*

## Give Contractors a Complete Report and Guidance

Some owners and design professionals mistakenly believe they can make contractors liable for unanticipated subsurface conditions by limiting what they provide for bid preparation. To help prevent costly problems, give contractors the complete geotechnical engineering report, but preface it with a clearly written letter of transmittal. In that letter, advise contractors that the report was not prepared for purposes of bid development and that the report's accuracy is limited; encourage them to confer with the geotechnical engineer who prepared the report (a modest fee may be required) and/or to conduct additional study to obtain the specific types of information they need or prefer. A brand conference can also be valuable. *Be sure contractors have sufficient time* to perform additional study. Only then might you be in a position to give contractors the best information available to you, while requiring them to at least share some of the financial responsibilities stemming from unanticipated conditions.

## Read Responsibility Provisions Closely

Some clients, design professionals, and contractors do not recognize that geotechnical engineering is far less exact than other engineering disciplines. This lack of understanding has created unrealistic expectations that have led to disappointments, claims, and disputes. To help reduce such risks, geotechnical engineers commonly include a variety of explanatory provisions in their reports. Sometimes labeled "limitations", many of these provisions indicate where geotechnical engineers responsibilities begin and end, to help others recognize their own responsibilities and risks. Read these provisions closely. Ask questions. Your geotechnical engineer should respond fully and frankly.

## Geoenvironmental Concerns Are Not Covered

The equipment, techniques, and personnel used to perform a geoenvironmental study differ significantly from those used to perform a geotechnical study. For that reason, a geotechnical engineering report does not usually relate any geoenvironmental findings, conclusions, or recommendations: e.g., about the likelihood of encountering underground storage tanks or regulated contaminants. *Unanticipated environmental problems have led to numerous project failures*. If you have not yet obtained your own geoenviromental information, ask your geotechnical consultant for risk management guidance. *Do not rely on an environmental report prepared for someone else.*

## Rely on Your Geotechnical Engineer for Additional Assistance

Membership in ASFE exposes geotechnical engineers to a wide army of risk management techniques that can be of genuine benefit for everyone involved with a construction project. Confer with your ASFE-member geotechnical engineer for more information.

# ASFE

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