# LABORATORY TESTING

Undisturbed and bulk samples of beach sand were obtained from the borings and transported to the laboratory for testing and analysis. The samples were obtained by driving a ring-lined, barrel sampler conforming to ASTM D 3550-01 with successive drops of the sampler. Experience has shown that sampling causes some disturbance of the sample. However, the test results remain within a reasonable range. The samples were retained in brass rings of 2.50 inches outside diameter and 1.00 inches in height. The samples were stored in close fitting, waterproof containers for transportation to the laboratory.

## Moisture-Density

The dry density of the samples was determined using the procedures outlined in ASTM D 2937-10. The moisture content of the samples was determined using the procedures outlined in ASTM D 2216-10. The results are shown on the enclosed Log of Borings.

## Maximum Density

The maximum dry density and optimum moisture content of the future compacted fill were determined using the procedures outlined in ASTM D 1557-12, a five-layer standard. Remolded samples were prepared at 90 percent of the maximum dry density. The remolded samples were tested for shear strength.

| Boring | Depth (Feet) | Earth Material | Soil Type and Color | Maximum Density (pcf) | Optimum Moisture % | Expansion Index |
|---|---|---|---|---|---|---|
| 2 | 0 - 5 | Beach Sand | Sand, Light Greenish-Brown | 115.0 | 11.0 | 14 - Very Low |

## Expansion Test

To find the expansiveness of the soil, a swell test was performed using the procedures outlined in ASTM D 4829-11. Based upon the testing, the near-surface earth materials are expected to exhibit a very low expansion potential.

LABORATORY TESTING (Continued)

## Shear Tests

Shear tests were performed on samples of beach sand using the procedures outlined in ASTM D 3080-11 and a strain controlled, direct-shear machine manufactured by Soil Test, Inc. The rate of deformation was 0.025 inches per minute. The samples were tested in an artificially saturated condition. Following the shear test, the moisture content of the samples was determined to verify saturation. The results are plotted on the enclosed Shear Test Diagrams.

## Consolidation

Consolidation tests were performed on *in situ* samples of the beach sand using the procedures outlined in ASTM D 2435-11. Results are graphed on the enclosed Consolidation Curves.

## Corrosion

A representative sample of the near-surface beach sand was transported to Environmental Geotechnology Laboratory for chemical testing. The testing was performed in accordance with Caltrans Standards 643 (pH), 422 (Chloride Content), 417 (Sulfate Content), and 532 (Resistivity). The results of the testing are reported in the following table:

CHEMICAL TEST RESULTS TABLE

| Sample | Depth (Feet) | pH | Chloride (PPM) | Sulfate (%) | Resistivity (Ohm-cm) |
|---|---|---|---|---|---|
| B2 | 0 - 5 | 7.14 | 95 | 0.004 | 2,000 |

The chloride and sulfate contents of the soil are negligible and not a factor in corrosion. The pH is near neutral and not a factor. The resistivity indicates that the soil is considered corrosive to ferrous metals.

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tel 818.549.9959 fax 818.543.3747

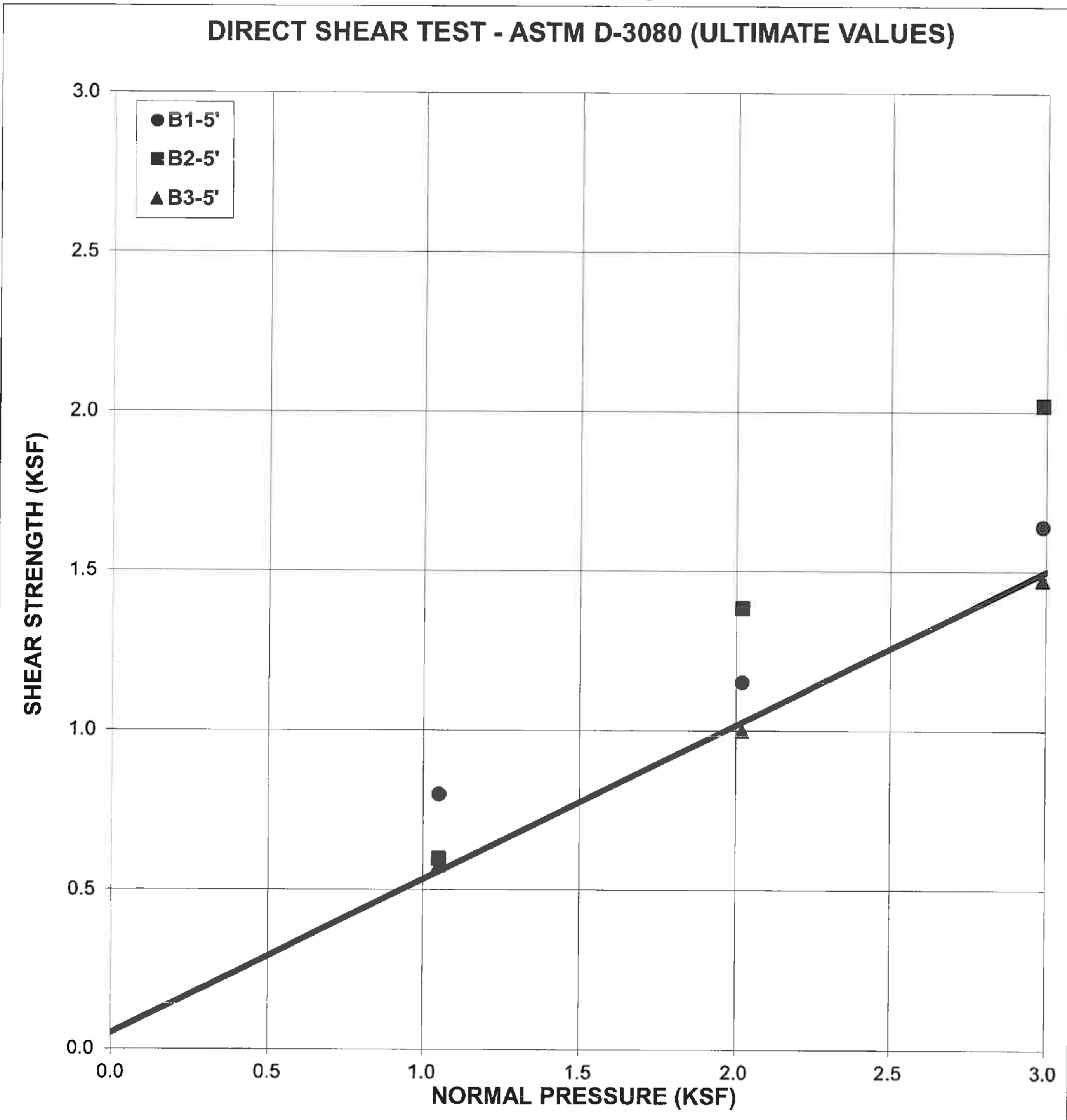
# SHEAR TEST DIAGRAM #1

BG: 21877 ENGINEER: RSB
CLIENT: Bolour Associates

EARTH MATERIAL: Beach Sand

Phi Angle = 25.8 degrees
Cohesion = 50 psf

Average Moisture Content 20.6%
Average Dry Density (pcf) 106.8
Average Saturation 99%



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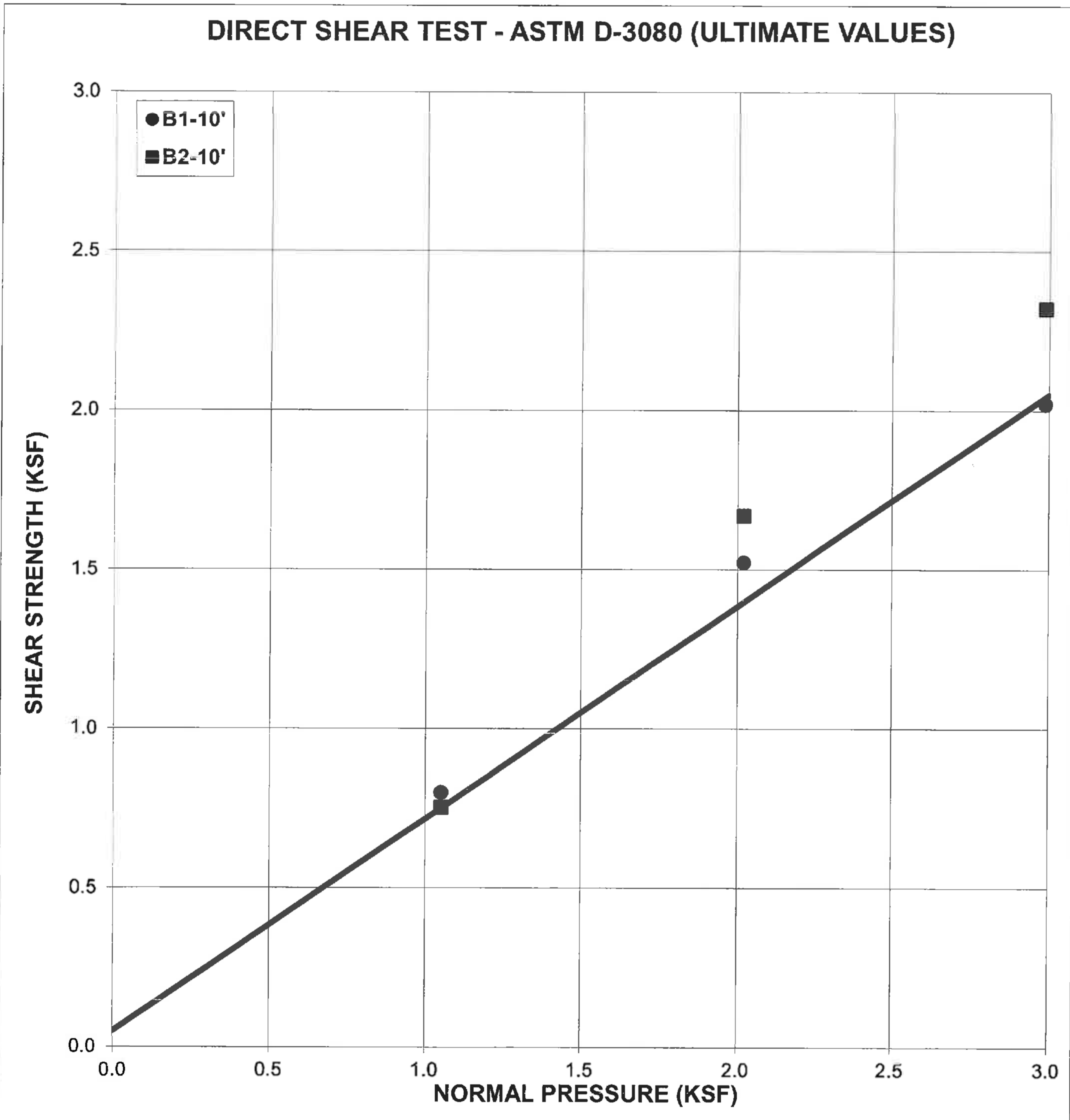
# SHEAR TEST DIAGRAM #2

BG: **21877** ENGINEER: **RSB**
CLIENT: **Bolour Associates**

EARTH MATERIAL: **Beach Sand**

**Phi Angle = 33.7 degrees**
**Cohesion = 50 psf**

**Average Moisture Content 19.1%**
**Average Dry Density (pcf) 109.8**
**Average Saturation 100%**



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# CONSOLIDATION CURVE #1

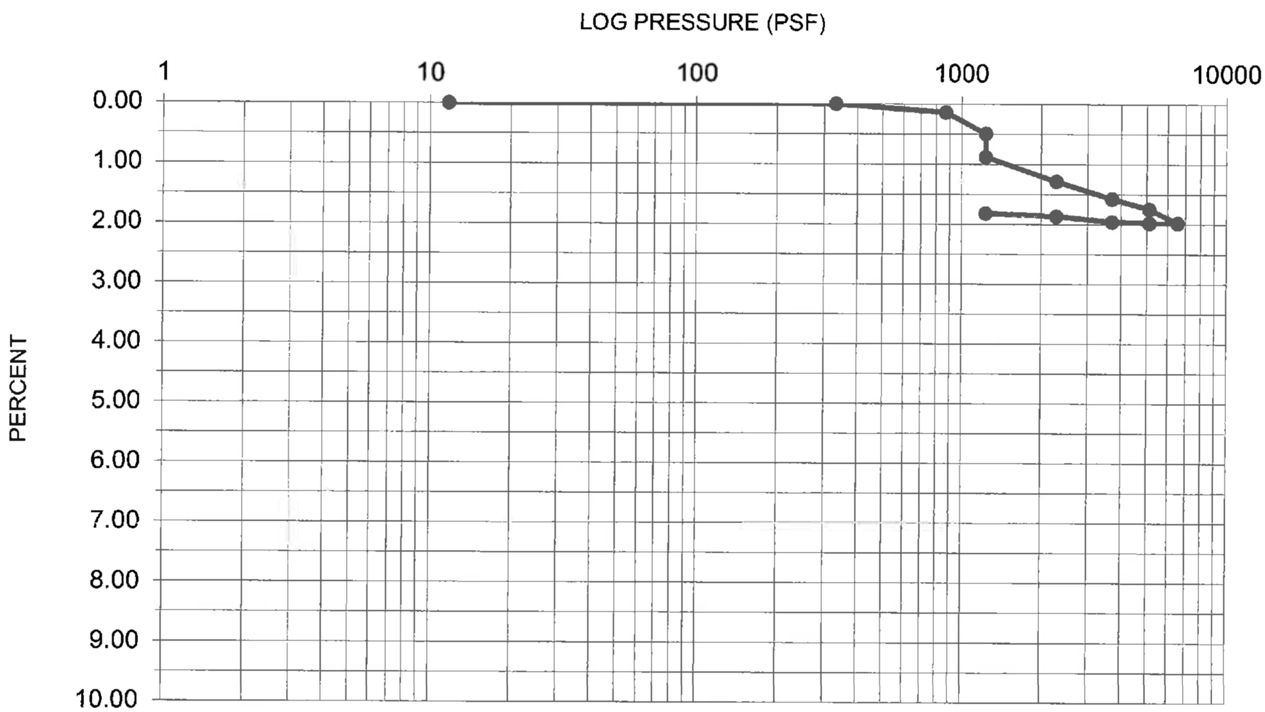
BG: 21877 ENGINEER: RSB

CLIENT: Bolour Associates

| | |
|---|---|
| Earth Material: | Beach Sand |
| Sample Location: | B1-5' |
| Dry Weight (pcf): | 103.0 |
| Initial Moisture: | 2.9% |
| Initial Saturation: | 12.7% |
| Water Added at (psf) | 1237 |

| | |
|---|---|
| Specific Gravity: | 2.65 |
| Initial Void Ratio: | 0.61 |
| Compression Index (Cc): | 0.035 |
| Recompression Index (Cr): | 0.007 |

## CONSOLIDATION DIAGRAM (ASTM D 2435-04)



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# CONSOLIDATION CURVE #2

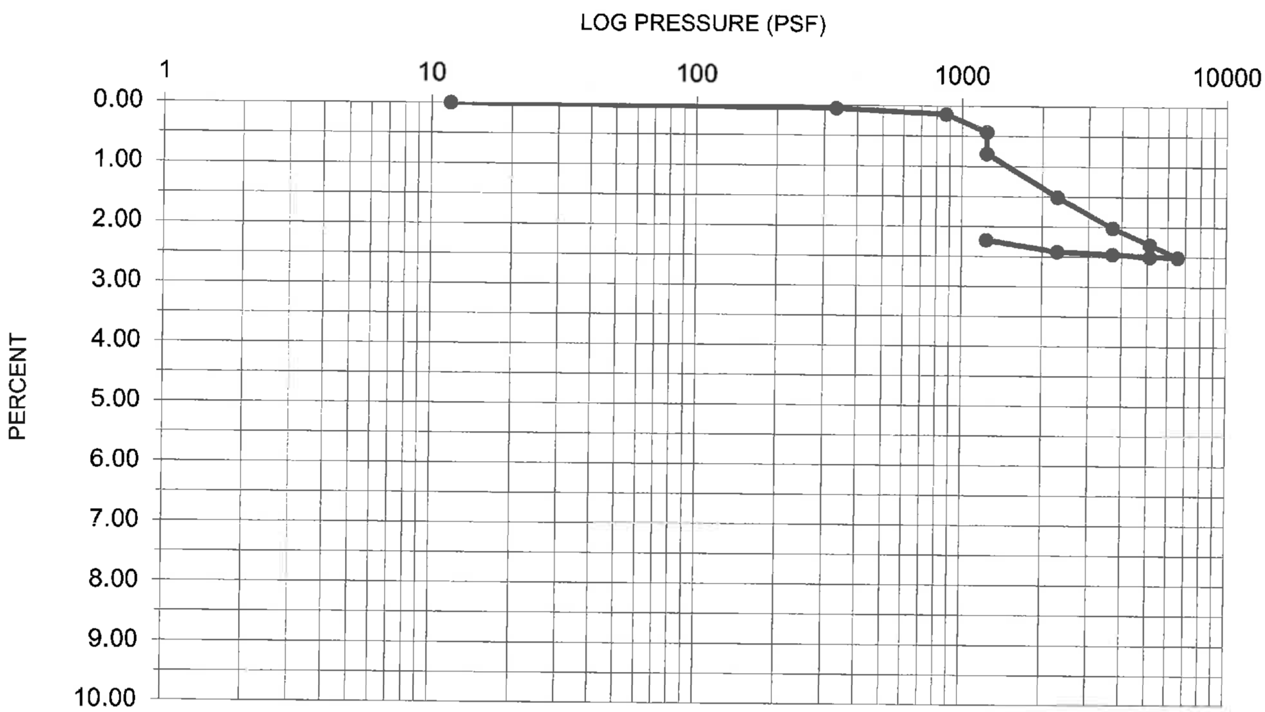
BG: 21877 ENGINEER: RSB

CLIENT: Bolour Associates

| | |
|---|---|
| Earth Material: | Beach Sand |
| Sample Location: | B3-5' |
| Dry Weight (pcf): | 111.2 |
| Initial Moisture: | 3.6% |
| Initial Saturation: | 19.6% |
| Water Added at (psf) | 1237 |

| | |
|---|---|
| Specific Gravity: | 2.65 |
| Initial Void Ratio: | 0.49 |
| Compression Index (Cc): | 0.040 |
| Recompression Index (Cr): | 0.011 |

## CONSOLIDATION DIAGRAM (ASTM D 2435-04)



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# CONSOLIDATION CURVE #3

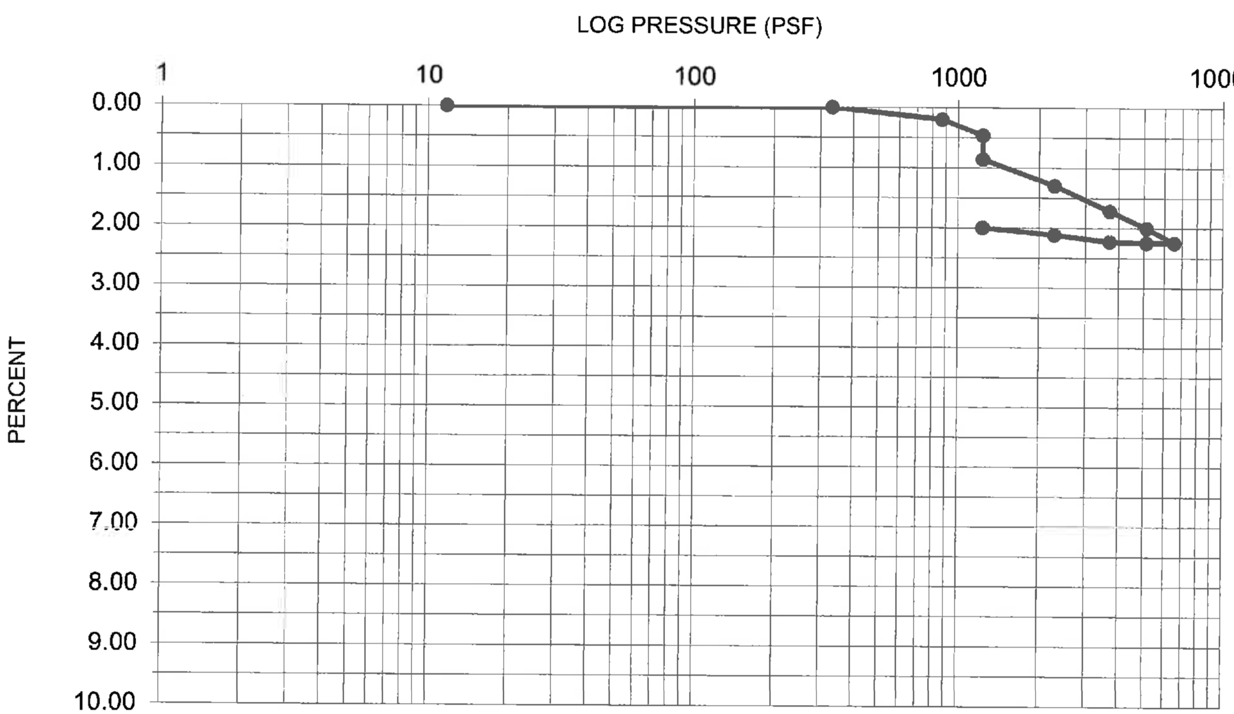
BG: **21877** ENGINEER: **RSB**

CLIENT: **Bolour Associates**

| | |
|---|---|
| Earth Material: | Beach Sand |
| Sample Location: | B2-10' |
| Dry Weight (pcf): | 108.5 |
| Initial Moisture: | 16.2% |
| Initial Saturation: | 82.0% |
| Water Added at (psf) | 1237 |

| | |
|---|---|
| Specific Gravity: | 2.65 |
| Initial Void Ratio: | 0.52 |
| Compression Index (Cc): | 0.036 |
| Recompression Index (Cr): | 0.008 |

## CONSOLIDATION DIAGRAM (ASTM D 2435-04)



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# CONSOLIDATION CURVE #4

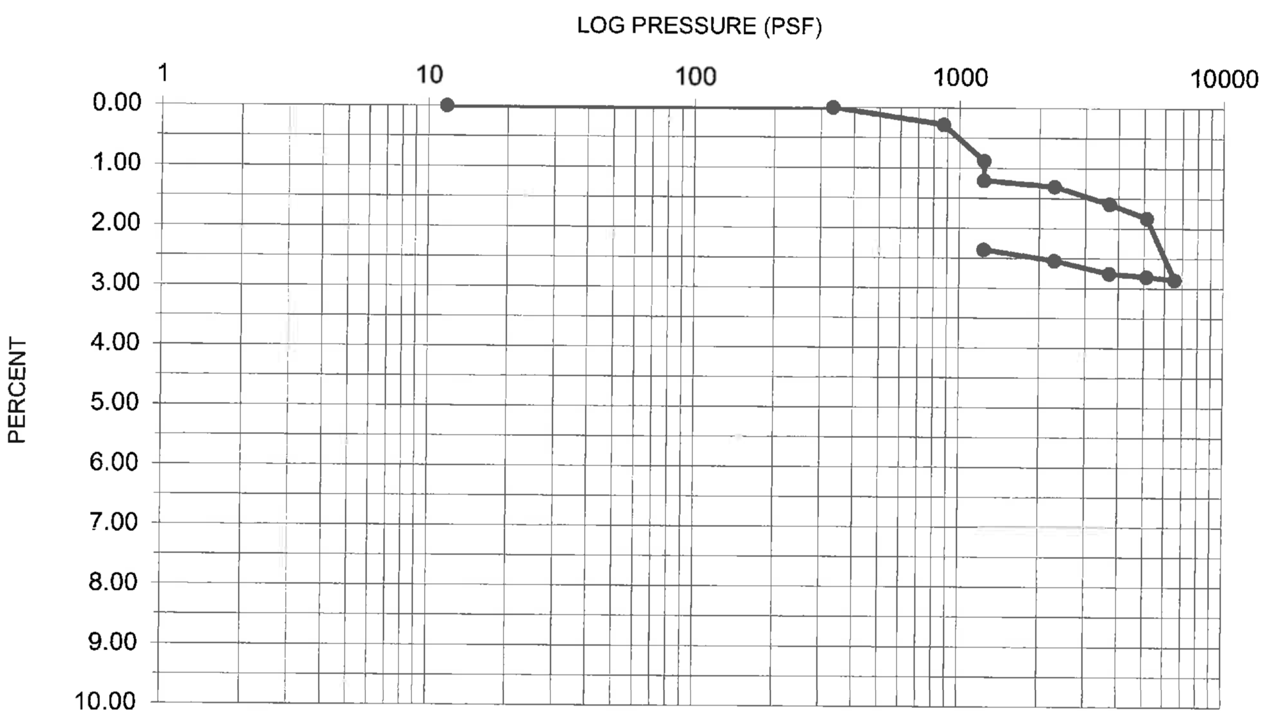
BG: 21877 ENGINEER: RSB

CLIENT: Bolour Associates

| | |
|---|---|
| Earth Material: | Beach Sand |
| Sample Location: | B1-15' |
| Dry Weight (pcf): | 102.4 |
| Initial Moisture: | 16.0% |
| Initial Saturation: | 69.0% |
| Water Added at (psf) | 1237 |

| | |
|---|---|
| Specific Gravity: | 2.65 |
| Initial Void Ratio: | 0.61 |
| Compression Index (Cc): | 0.156 |
| Recompression Index (Cr): | 0.017 |

## CONSOLIDATION DIAGRAM (ASTM D 2435-04)



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# CONSOLIDATION CURVE #5

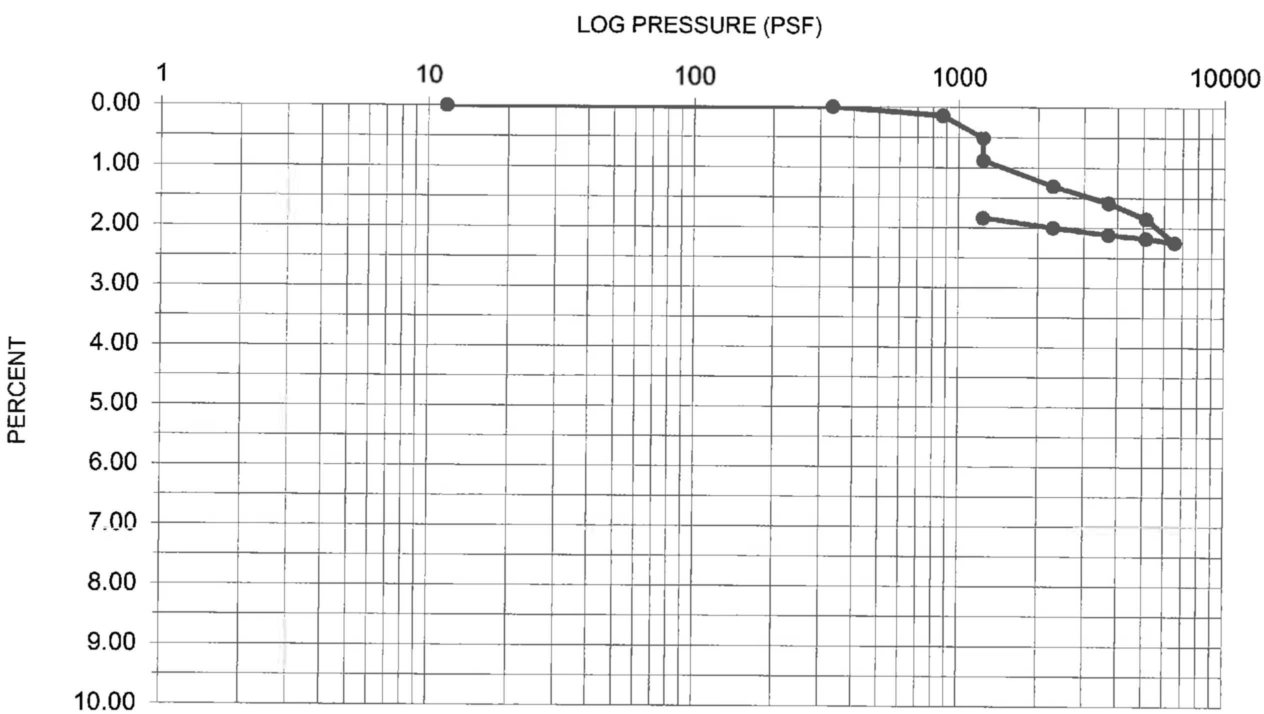
BG: **21877** ENGINEER: **RSB**

CLIENT: **Bolour Associates**

| | |
|---|---|
| Earth Material: | Alluvium |
| Sample Location: | B1-20' |
| Dry Weight (pcf): | 110.0 |
| Initial Moisture: | 17.8% |
| Initial Saturation: | 93.8% |
| Water Added at (psf) | 1237 |

| | |
|---|---|
| Specific Gravity: | 2.65 |
| Initial Void Ratio: | 0.50 |
| Compression Index (Cc): | 0.056 |
| Recompression Index (Cr): | 0.009 |

## CONSOLIDATION DIAGRAM (ASTM D 2435-04)



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# CONSOLIDATION CURVE #6

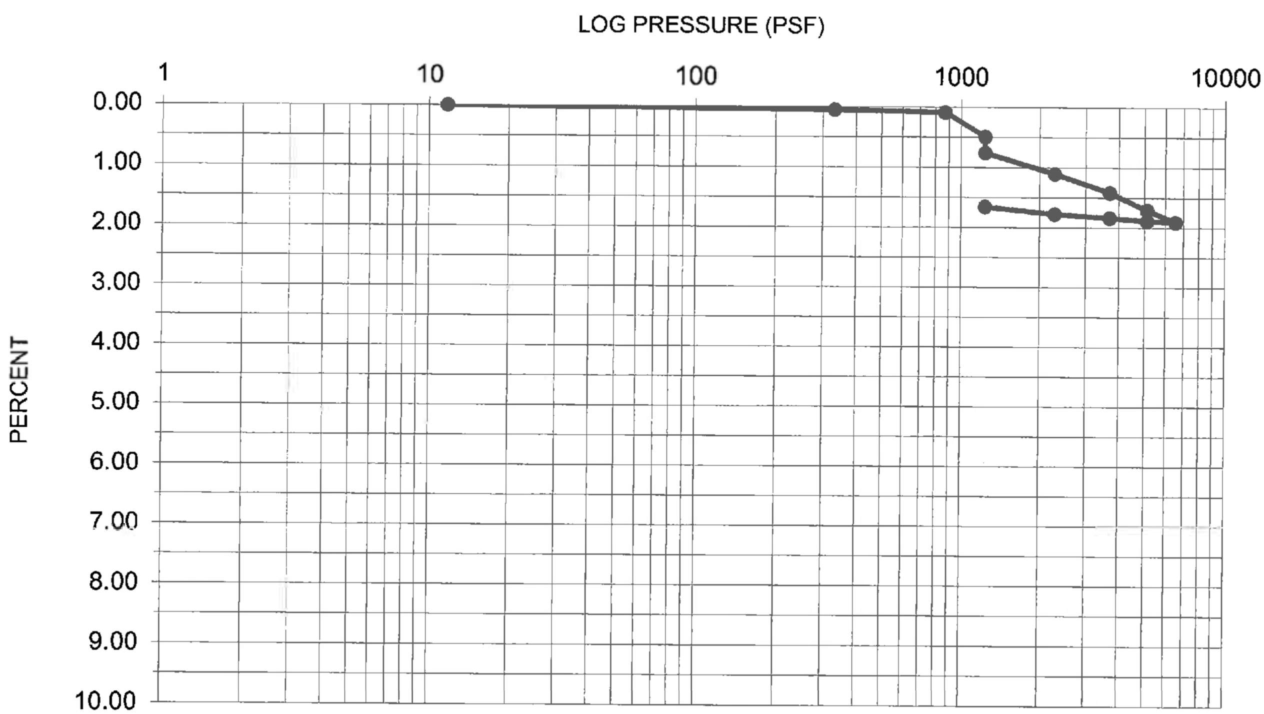
BG: **21877** ENGINEER: **RSB**

CLIENT: **Bolour Associates**

| | |
|---|---|
| Earth Material: | Alluvium |
| Sample Location: | B3-20' |
| Dry Weight (pcf): | 111.9 |
| Initial Moisture: | 18.0% |
| Initial Saturation: | 99.9% |
| Water Added at (psf) | 1237 |

| | |
|---|---|
| Specific Gravity: | 2.65 |
| Initial Void Ratio: | 0.48 |
| Compression Index (Cc): | 0.030 |
| Recompression Index (Cr): | 0.007 |

## CONSOLIDATION DIAGRAM (ASTM D 2435-04)



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# CONSOLIDATION CURVE #7

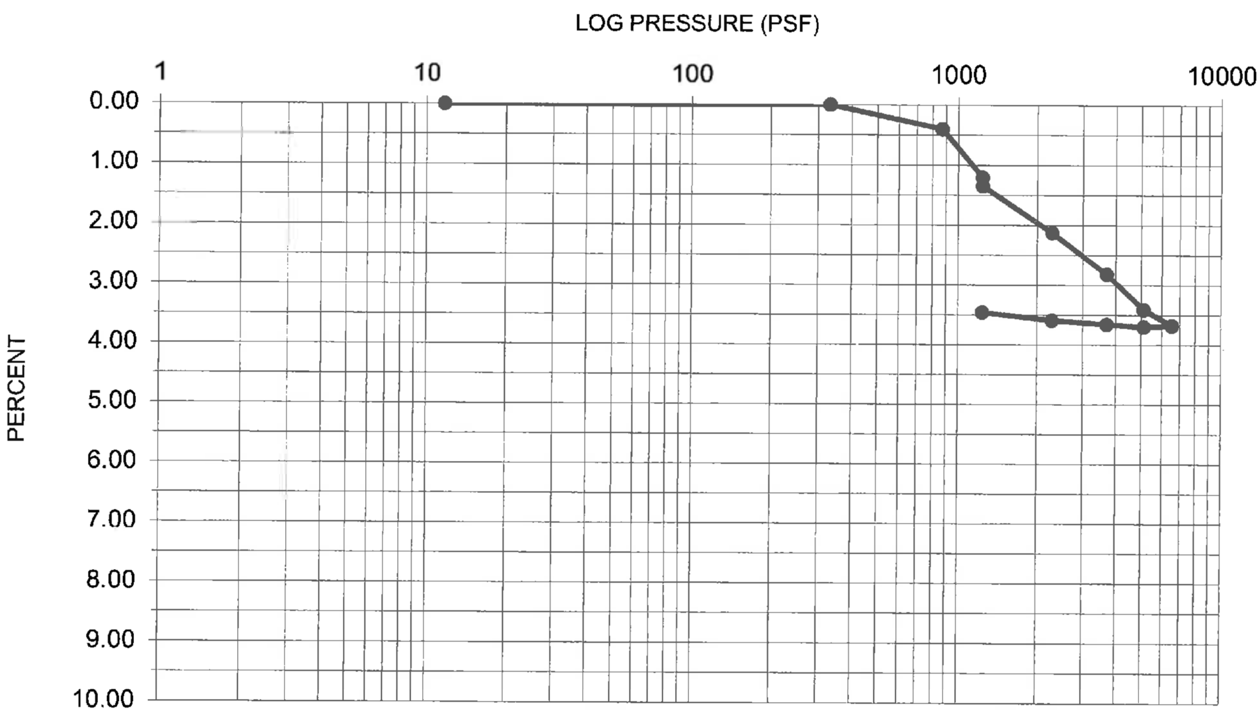
BG: **21877** ENGINEER: **RSB**

CLIENT: **Bolour Associates**

| | |
|---|---|
| Earth Material: | Alluvium |
| Sample Location: | B1-25' |
| Dry Weight (pcf): | 116.5 |
| Initial Moisture: | 15.9% |
| Initial Saturation: | 100% |
| Water Added at (psf) | 1237 |

| | |
|---|---|
| Specific Gravity: | 2.65 |
| Initial Void Ratio: | 0.42 |
| Compression Index (Cc): | 0.059 |
| Recompression Index (Cr): | 0.007 |

## CONSOLIDATION DIAGRAM (ASTM D 2435-04)



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tel 818.549.9959 fax 818.543.3747

# CONSOLIDATION CURVE #8

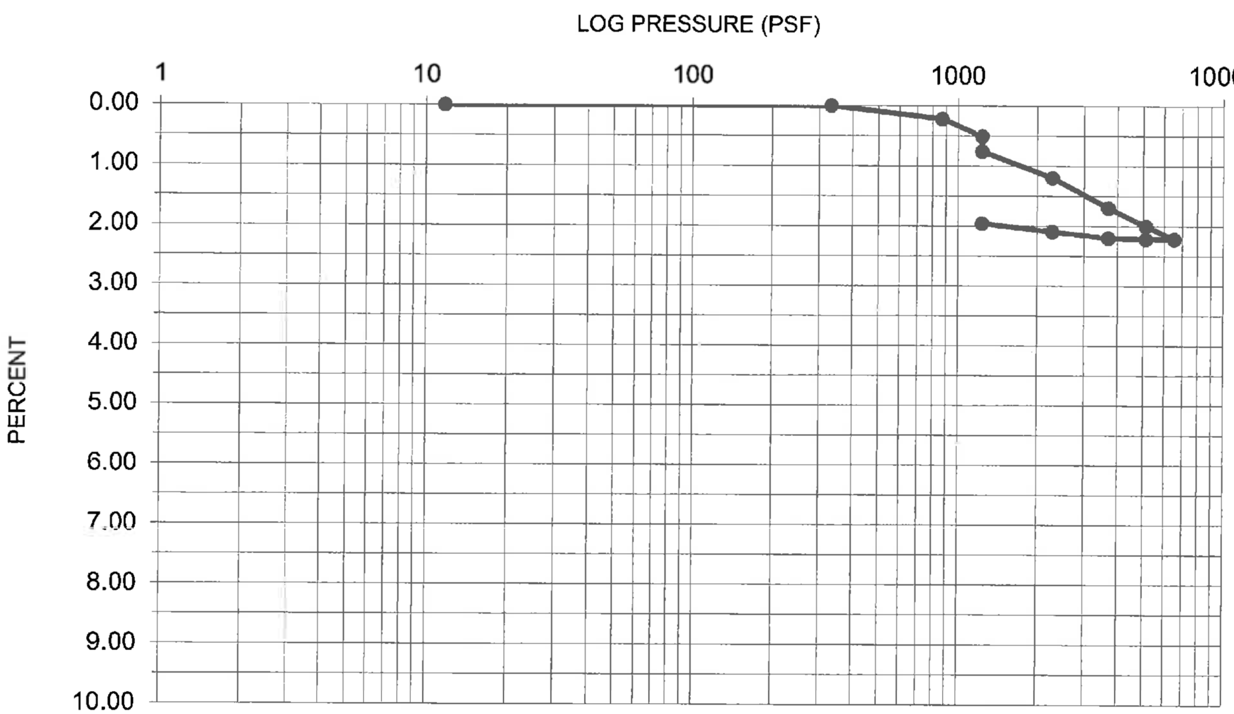
BG: 21877 ENGINEER: RSB

CLIENT: Bolour Associates

| | |
|---|---|
| Earth Material: | Alluvium |
| Sample Location: | B1-30' |
| Dry Weight (pcf): | 101.2 |
| Initial Moisture: | 17.8% |
| Initial Saturation: | 74.4% |
| Water Added at (psf) | 1237 |

| | |
|---|---|
| Specific Gravity: | 2.65 |
| Initial Void Ratio: | 0.63 |
| Compression Index (Cc): | 0.039 |
| Recompression Index (Cr): | 0.009 |

## CONSOLIDATION DIAGRAM (ASTM D 2435-04)



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tel 818.549.9959 fax 818.543.3747

# CONSOLIDATION CURVE #9

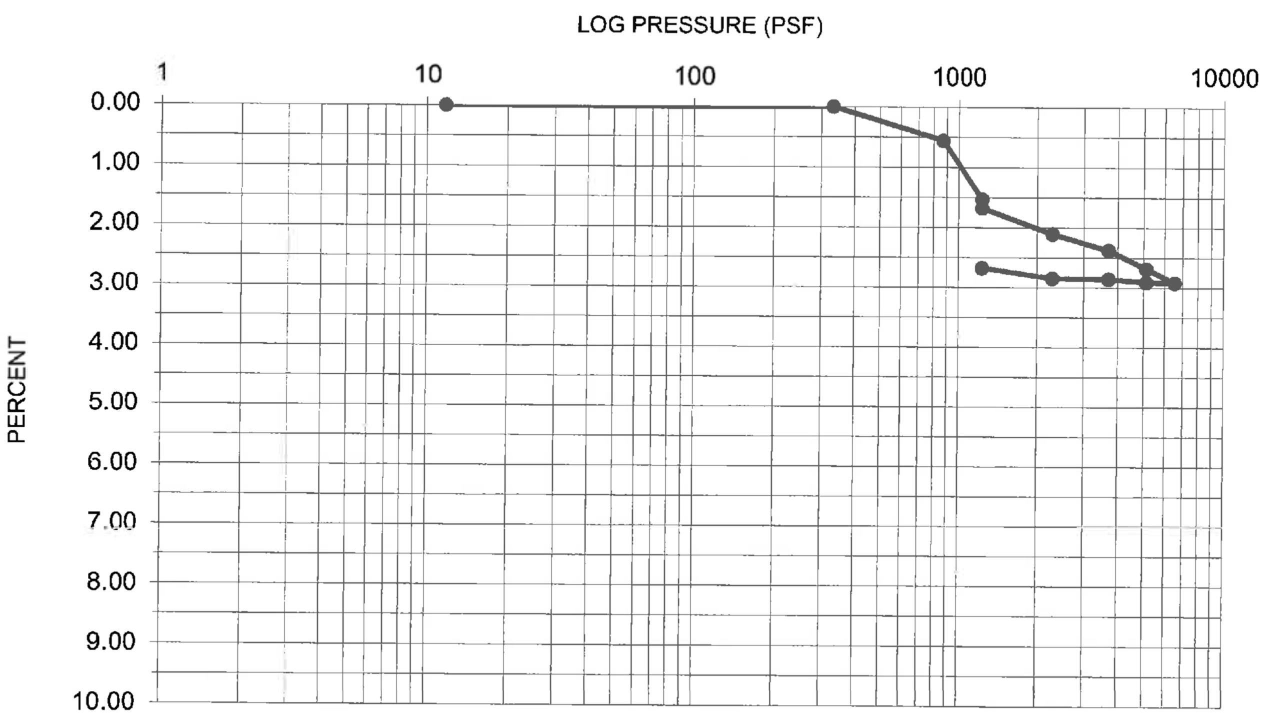
BG: **21877** ENGINEER: **RSB**

CLIENT: **Bolour Associates**

| | |
|---|---|
| Earth Material: | Alluvium |
| Sample Location: | B2-30' |
| Dry Weight (pcf): | 116.7 |
| Initial Moisture: | 15.9% |
| Initial Saturation: | 100% |
| Water Added at (psf) | 1237 |

| | |
|---|---|
| Specific Gravity: | 2.66 |
| Initial Void Ratio: | 0.42 |
| Compression Index (Cc): | 0.031 |
| Recompression Index (Cr): | 0.009 |

## CONSOLIDATION DIAGRAM (ASTM D 2435-04)



# Technical Memorandum

**To:** Mr. Michael Mathews
Bolour Associates, Inc.

**From:** Thomas Harder, P.G., C.HG.
Benjamin Lewis, P.G.
Thomas Harder & Co.

**Date:** 8-Jul-16

**Re:** Hydrogeologic Evaluation in Support of Environmental Documentation for the Strand and Pier Hotel, Hermosa Beach, California

## 1.0 Background

### 1.1 Background

This technical memorandum (TM) summarizes an evaluation of potential groundwater changes associated with planned groundwater pumping during the construction phase for the proposed Strand and Pier Hotel (the Site) in Hermosa Beach, California (see Figures 1, 2 and 3). The Site is located between 13th Street and Pier Avenue and is adjacent to the beach. The Site would include the construction of a mixed-use project with approximately 100-guest rooms, retail space, and other facilities. The design of the planned hotel includes a below-grade, two-level parking garage with a three story structure above it.

Groundwater levels at the Site are relatively shallow (within approximately 9 ft of the land surface) and the subsurface parking garage will extend below the water table. Although the subsurface garage will be designed to seal out the groundwater, it will be necessary to lower or alter groundwater levels below the planned excavation during construction.

This TM is prepared to support Bolour Associates, Inc. with applicable environmental documentation for the completion of the Project. This TM provides:

- A description of the hydrogeological setting of the Project.
- Estimates of required groundwater production rates to define construction dewatering requirements.
- An evaluation of potential temporary impacts to groundwater levels during construction dewatering.

- An evaluation of potential impacts to groundwater quality during construction dewatering.

## 1.2 Purpose and Scope of Work

The purpose of this work is to prepare a description of the hydrogeologic setting of the Site and conduct an analysis of potential groundwater level changes and groundwater quality changes associated with construction dewatering at the Site. It is anticipated that the findings will be incorporated into applicable environmental documentation for the project. The scope of work to address the objective included:

- Obtaining and reviewing existing geological, hydrological, and hydrogeological data.
- Completing a hydrogeological description of the Site area including well locations, groundwater occurrence and flow, groundwater level changes over time, and groundwater quality, as available.
- Identifying potential contaminating activities (PCA's) within a one-mile radius of the Site.
- Evaluating potential impacts of construction dewatering pumping on groundwater levels in the area.
- Evaluating potential impacts of construction dewatering pumping on groundwater quality in the area.

## 1.3 Data Sources

The various types of data used for this analysis included existing reports, groundwater level data, well completion data, groundwater quality data, well location maps, and tidal data. Groundwater levels were obtained from the Los Angeles County Department of Public Works (LADPW), the State Water Resources Control Board GeoTracker online database, and on-site boring logs from Byer Geotechnical Inc. (2015). Groundwater quality data was obtained from Water Replenishment District of Southern California. Tidal data for the Santa Monica Pier station was obtained from the National Oceanic and Atmospheric Administration (NOAA). Specific reports and data included:

- Byer Geotechnical Inc., 2015. Geotechnical Engineering Exploration, Proposed Three-Story Hotel Building Over Two Basement Levels, Hermosa Beach, California, Project Number BG 21877. Prepared for Bolour Associates, September 2015.
- California Geological Survey, 2009. *Geologic Map of the Long Beach 30' by 60' quadrangle, California: A Digital Database*.

- California Geological Survey, 2012. Geologic Compilation of Quaternary Surficial Deposits in Southern California. Special Report 217 (Revised).
- Environmental Data Resources, Inc., EDR Radius Map Report with GeoCheck. March 2, 2016.
- Environmental Management Strategies, Inc., 2012. Phase 1 Environmental Site Assessment, Redondo Beach Electrical Power Plant. February 2012.
- State of California, Department of Water Resources, 1961. *Planned Utilization of the Ground Water Basins of the Coastal Plain of Los Angeles County, Appendix A Ground Water Geology*. Bulletin No. 104.
- State of California, Department of Water Resources, 2013. Watermaster Service in the West Coast Basin, Los Angeles County, July 1, 2012 – June 30, 2013. September 2013.
- United States Geological Survey, 2003. *Geohydrology, Geochemistry, and Ground-Water Simulation-Optimization of the Central and West Coast Basins, Los Angeles County, California*. Water-Resources Investigations Report 03-4065.
- Unpublished Site designs and plans from Bolour Associates, Inc.
- Water Replenishment District of Southern California, 2015. *Regional Groundwater Monitoring Report, Water Year 2013-2014.* February 2015.

A full list of references is provided in Section 8.0.

# 2.0 Physical Setting

## 2.1 Hydrology

The Site is approximately 500 ft east of the Pacific Ocean. The current land surface elevation at the Site is approximately 14 to 15 ft above mean sea level (ft amsl) using the North American Vertical Datum 1988 (NAVD 1988). Tidal data from the Santa Monica Pier station, 11 miles north of the Site, from 1983 to 2001 relative to NAVD 1988 is as follows:

| Description | Elevation (NAVD 1988) |
|---|---|
| Mean Higher-High Water | 5.24 ft |
| Mean High Water | 4.50 ft |
| Mean Sea Level | 2.60 ft |
| Mean Low Water | 0.74 ft |
| Mean Lower-Low Water | -0.19 ft |

The Pacific Ocean in the vicinity of the Site experiences two high tides and two low tides a day, with one of each being stronger. For this study mean sea level was used.

## 2.2 Geology

The Site is situated within the Los Angeles Basin, a large, lowland plain (see Figure 1; Yerkes et al., 1965). The physiographic basin is underlain by an alluviated, structural depression (Yerkes et al., 1965). The Hermosa Beach area is within the El Segundo Sand Hills, a narrow strip of active or recent dunes along the coast (see Figure 4, DWR, 1961). The surface geology around the Site has been mapped as beach deposits, eolian (i.e. wind-blown) deposits, and older eolian deposits (CGS, 2012 and CGS, 2009; see Figure 4). The Site is situated above the beach deposits which were described as unconsolidated fine- to coarse-grained sand. Eolian deposits are unconsolidated and composed of mostly very well-sorted fine- to medium-grained sand. The contact between eolian and older eolian is described as gradational (CGS, 2009). Older eolian deposits are poorly consolidated, dense to very dense well-sorted, fine- to coarse-grained sand and silty sand.

Byer Geotechnical (2015) conducted a subsurface investigation at the Site that included three boreholes and three cone penetrometer tests (CPTs)(see Appendix A). The boreholes were 35 to 50 ft deep and sediments were logged as primarily medium dense fine-grained sand. The CPTs were advanced to 40 to 46 feet below ground surface (ft bgs) until reaching refusal from the equipment. The CPT logs indicate that sediments consist of sand and silty sand from the land surface to the total depth. An approximately 4-ft thick clay to silty clay layer was identified in all three CPTs at depths of approximately 21 to 25 ft bgs. While clay was not logged in the boreholes, a review of the logs suggests fine-grained sediments are present at a depth consistent with the CPTs. The B1 borehole log indicates that the moisture content of the sample from 23 ft bgs was relatively high at 36 percent, which is consistent with fine-grained sediments. The moisture content of the sand above and below the 23-ft sample were approximately 15 to 21 percent, which is consistent with coarse-grained sediments.

## 2.3 Hydrogeology

### 2.3.1 Regional Hydrogeologic Setting

The Site is located within the West Coast Groundwater Basin (see Figure 1). In the vicinity of the Site, the groundwater system consists of the Active Dune Sand, Older Dune Sand, the Lakewood formation, and the San Pedro formation (DWR, 1961). A cross section from DWR (1961) that included the Hermosa Beach area has been modified and is presented in Figure 5.

The Active and Older Dune Sands are roughly equivalent to the eolian and older eolian deposits, respectively, described above. Perched groundwater occurs in the dune sands with no groundwater production reported (DWR, 1961).

In the Hermosa Beach area, divisions of the Lakewood formation include the Bellflower aquiclude and the Gage aquifer (also known as the "200-foot sand"). The Bellflower aquiclude was mapped by DWR (1961) in the vicinity of the Site from approximately -20 to -60 ft msl but does not appear in cross section from the same report. In the Hermosa Beach area, the Bellflower aquiclude is composed largely of sandy and gravelly clay. The Gage aquifer extends over most of the West Coast Basin and is a secondary source of groundwater from production wells in the basin. It is composed of sand with minor amounts of gravel and thin beds of silt and clay and is approximately 60 ft thick in the area.

The Silverado aquifer underlies the Gage aquifer and is part of the San Pedro formation (see Figure 5). The aquifer is highly permeable and composed of sand and gravel with discontinuous layers of silt and clay. The aquifer is the major aquifer in the West Coast Basin and provides 80 to 90 percent of all groundwater extracted from the basin (CDWR 2013).

### 2.3.2 Groundwater Occurrence

Groundwater directly beneath the Site was measured at a depth of approximately 9 ft bgs (5.5 ft amsl) in the three open boreholes drilled on January 2, 2014 (see Appendix A). Saturated sediments beneath the Site may be perched but are likely in hydraulic continuity with the Gage aquifer. Groundwater elevations measured in shallow, 20-ft deep monitoring wells located approximately 400 ft northeast of the Site have ranged from approximately 4.9 to 6.2 ft amsl (NAVD 88) in 1986 and 2013 (GeoTracker Global ID T0603705023).

Monitoring well 7P'2, located approximately 3,100 ft east of the Site (see Figure 6) is a nested well with one completion in the Gage aquifer and one completion in the Silverado aquifer. Groundwater elevations in each completion are shown on Figure 7 and are consistently within one foot of each other. It is therefore assumed that the aquifers are in hydraulic connectivity.

Groundwater elevations in monitoring wells near the Site are shown on Figure 8. Groundwater elevations are typically 6 to 15 ft amsl. For the three monitoring wells closest to the Site, high groundwater levels occurred in February 2010 and low groundwater levels occurred in February 2014. High and low groundwater conditions in area monitoring wells are shown on Figures 9 and 10, respectively.

### 2.3.3 Groundwater Flow

Under pre-development conditions, groundwater would flow from inland areas toward the ocean and out of the basin (USGS, 2003). However, groundwater pumping in the basin in the first half of the twentieth century lowered inland groundwater levels below sea level causing a reverse in flow direction and therefore inducing seawater intrusion in coastal areas (USGS, 2003). To prevent seawater intrusion, the West Coast Basin Barrier Project was developed which currently includes 153 injection wells located in a line approximately parallel to the coastline (CDWR, 2013). Within one mile of the Site, there are eleven West Coast Basin Barrier Project injection wells (see Figure 6). These wells are perforated in either the Silverado aquifer or both the Silverado and Gage aquifers (see Figure 5). Between the ocean and the West Coast Basin Barrier wells, groundwater flows west to the ocean (see Figures 9 and 10).

# 3.0 Groundwater Quality

## 3.1 Potentially Contaminating Activities

An investigation of PCAs that could affect construction dewatering operation was conducted through a review of multiple State and Federal environmental databases. The search radius for the investigation of PCAs was one mile, centered on the Site (see Figure 11).

The majority of databases reviewed for this analysis were obtained from a report generated by Environmental Data Resources, Inc. (EDR) specific to the one-mile search radius (see Appendix B). A partial list of the databases reviewed include:

**Federally Regulated Site Databases**

- National Priority List Superfund Sites
- Comprehensive Environmental Response, Compensation and Liability Information System (CERCLIS) Sites
- Resource Conservation and Recovery Act (RCRA) Sites
- U.S. Department of Transportation Hazardous Materials Information Reporting System
- Land Use Control Information System (LUCIS) Sites
- Emergency Response Notification (ERN) Sites
- Brownfield Site Listings
- U.S. Department of Justice Clandestine Drug Labs

**State Regulated Site Databases**

- Department of Toxic Substances Control (DTSC) Sites
- Solid Waste Information System Database
- State Spills, Leaks, Investigations and Cleanup (SLIC) Program
- Local Brownfield Site Listings
- Waste Management Unit Database
- DTSC Calsites Database
- SWRCB Toxic Pits Cleanup Act Database
- DTSC Clandestine Drug Labs Database
- DTSC Military Cleanup Sites Listing
- SWRCB National Pollutant Discharge Elimination System (NPDES) Permit Listing
- California Oil and Gas Wells Database

A complete listing of databases included in the search is in the EDR report provided in Appendix B. The database search resulted in the identification of 451 environmental records for the designated search area. The most common record is for hazardous waste manifests (recorded in the "HAZNET" EDR database) associated with the Resource Conservation and Recovery Act (RCRA; approximately 50 percent of records)[1]. It is further noted than many of the records are found in multiple databases and therefore are duplicative. The remaining records include, but are not limited to, records for underground storage tanks, historical auto service stations, historical dry cleaners, and hazardous spills.

Given the large number of records, TH&Co grouped them into categories including:

- HAZNET Sites
- Underground Storage Tanks (USTs)
- Other RCRA
- Air Resources Board
- Dry Cleaner or Auto Store
- Sites with Reported Spills or Releases
- Other Sites

The database categories for the one-mile search radius are shown on Figure 11. A zoomed in view of the database records for sites in the immediate vicinity of the Site is shown on Figure 12.

The SWRCB maintains a database (the GeoTracker database) of leaky underground storage tank (LUST) and other cleanup program sites throughout California. Most of these sites are associated with gasoline stations but some are also industrial, military and municipal sites. A review of the GeoTracker database showed one active cleanup program site, one closed cleanup program site, and 17 closed LUST sites within the one-mile search radius (see Figure 11). The active cleanup program site is the Redondo Generating Station.

The Redondo Generating Station is an active groundwater contaminant cleanup site. A Phase 1 Environmental Assessment for the Redondo Generating Station (EMS, 2012) reported that "groundwater underlying the site is known to be impacted by metals, dioxins, sulfide, VOCs, hydrazine, and 1,4-dioxane." The extent of the contamination is not presented in Phase 1 documentation. Additionally, "groundwater level and flow direction are reportedly controlled by on-site dewatering wells installed to maintain groundwater levels below the retention basins. The operation of groundwater extraction wells will tend to draw groundwater on the site for off-site areas" (EMS, 2012).

[1] It is noted that these records indicate hazardous waste was stored and/or transported to a disposal facility but does not necessarily indicate the waste was spilled on the ground or released into the soil and groundwater.

For closed LUST sites the SWRCB has determined that the sites do not pose a threat to groundwater quality or they have been cleaned up to a point where they don't pose a threat to groundwater quality.

## 3.2 Ambient Groundwater

Groundwater produced from construction dewatering is expected to be a mixture of seawater from the west and groundwater from the West Coast Basin Barrier injection wells. Water quality for typical seawater is presented in Table 1. The source of water for the West Coast Basin Barrier injection wells is a combination of treated imported water (from the State Water Project and the Colorado River) and recycled water from the Edward C. Little Water Recycling Facility (ELWRF) (WRD, 2015). Water quality data for water year (i.e. October 1 through September 31) 2013-2014 of the two sources is also presented in Table 1 (WRD, 2015).

# 4.0 Evaluation of Potential Construction Dewatering Requirements

The planned hotel at the Site will be designed with a subsurface parking garage that will have to extend below the groundwater surface. Although the subsurface garage will ultimately be designed to seal out the groundwater, it will be necessary to temporarily lower groundwater levels below the planned excavation during construction.

Criteria for construction dewatering requirements are summarized as follows:

| | **Elevation<br>Feet Above/Below Sea Level** | **Depth<br>Feet Below Ground Surface** |
|---|---|---|
| Land Surface | 14.5 ft amsl | 0 ft bgs |
| Groundwater Surface | 5.5 ft amsl | 9 ft bgs |
| Bottom of Parking Structure | -9.5 ft bmsl | 24 ft bgs |
| Bottom of Excavation | -15.5 ft bmsl | 30 ft bgs |
| **Target Groundwater Level for Excavation** | **-20.5 ft bmsl** | **35 ft bgs** |

Notes: ft amsl = feet above mean sea level
ft bmsl = feet below mean sea level
ft bgs = feet below ground surface

Accordingly, groundwater levels will need to be lowered to a depth of approximately 35 ft bgs (-20 ft bmsl) or 26 ft below current levels during construction.

## 4.1 Analysis Methodology – Groundwater Flow Model

In order to evaluate required pumping rates for construction dewatering, TH&Co developed a two-dimensional analytical flow model. The analysis was conducted for steady state conditions using the model code WinFlow.[2] WinFlow simulates groundwater flow in a horizontal plane and uses the principle of superposition to evaluate the effects from multiple pumping and/or injection wells in a uniform regional flow field.

The model domain consists of a rectangle oriented with the long axis parallel to the ocean (see Figure 13). The long axis is approximately two miles long and centered on the Site. The short axis extends approximately one mile inland from the Pacific Ocean and encompasses the closest West Coast Basin Seawater Injection Barrier wells.

The analysis incorporated the following assumptions:

- The bottom of the aquifer is -100 ft bmsl.

[2] Winflow Version 3, Environmental Simulations Inc., 2003.

- During the low groundwater condition, the groundwater gradient is 0.004 ft/ft with a flow direction to the southwest (see Figure 9).
- During the high groundwater condition, the groundwater gradient is 0.0029 ft/ft with a flow direction to the southwest (Figure 10).
- The average hydraulic conductivity of the aquifer beneath the Site was assumed to be 80 ft/day, which is based on the thickness and transmissivity of the Gage aquifer as reported in DWR (1961).
- The shore is 540 ft from the Site and is a constant head boundary condition.
- The sediments in the aquifer are homogeneous (uniform thickness and permeability).

## 4.2 Model Calibration

For this analysis, the groundwater model was calibrated to both high and low steady state conditions based on measured groundwater levels in boreholes at the Site and from nearby monitoring wells (see Figures 9 and 10). Calibration was conducted by matching model-generated groundwater levels to measured groundwater levels. Groundwater levels at the shore were fixed to the mean sea level. A summary of the model calibration is summarized in the following table:

**Comparison of Measured and Model-Generated Groundwater Levels**

| Location | **High Condition** | | | |
|---|---|---|---|---|
| | Date Measured | Measured Groundwater Elevation (ft amsl) | Model-Generated Groundwater Elevation (ft amsl) | Residual Value (ft) |
| B1 | 2-Jan-14 | 5.5 | 5.1 | 0.4 |
| 7P'2 | 3-Feb-10 | 15.6 | 16.3 | -0.7 |
| 7EG | 9-Feb-10 | 12.9 | 11.8 | 1.2 |
| 7LN | 24-Feb-10 | 14.8 | 14.4 | 0.5 |
| Location | **Low Condition** | | | |
| | Date Measured | Measured Groundwater Elevation (ft amsl) | Model-Generated Groundwater Elevation (ft amsl) | Residual Value (ft) |
| B1 | 2-Jan-14 | 5.5 | 3.6 | 1.9 |
| 7P'2 | 5-Feb-14 | 7.1 | 7.9 | -0.8 |
| 7EG | 12-Feb-14 | 6.2 | 6.2 | 0.0 |
| 7LN | 10-Feb-14 | 6.4 | 7.2 | -0.7 |

The final calibrated model resulted in residual values (i.e. the difference between measured and model-generated groundwater levels) of -0.7 to 1.2 ft in the high condition and -0.8 to 1.9 ft in the low condition. These model-generated values very closely match the measured values and are considered adequate for the analysis.

### 4.3 Estimated Pumping Rate to Meet Construction Dewatering Requirements

The results of the model analysis estimates that groundwater levels can be lowered and maintained below the bottom of the planned excavation using four wells each pumping at constant rates of approximately 1,150 gallons per minute (gpm) or 4,600 gpm total (see Figure 13). If static groundwater levels at the time of excavation are higher than those observed for this analysis, then a higher pumping rate may be required to achieve the target groundwater levels. However, it is noted that the required pumping rate does not change under the range in groundwater levels that have been observed in the West Coast Basin barrier wells. It is also noted that the required number of wells may be less or more than estimated for the analysis, based on Site conditions. However, the total discharge rate would not change.

### 4.4 Sensitivity Analysis

The groundwater flow model developed for the analysis incorporates an assumed permeability (i.e. hydraulic conductivity) of sediments at the Site. The hydraulic conductivity of 80 ft/day was based on data from DWR (1961) and is generally consistent with permeabilities observed in beach sand deposits in other areas of southern California (TH&Co, 2015). However, no Site-specific permeability data have been collected to date and the actual hydraulic conductivity could be higher or lower than assumed for the analysis.

To address the uncertainty in permeability values, TH&Co conducted a sensitivity analysis to assess the impact of varying the hydraulic conductivity on required pumping rates for construction dewatering. The hydraulic conductivity range used for the analysis was 40 ft/day to 160 ft/day, which is a plausible range for the sediments observed beneath the Site (Freeze and Cherry, 1979). In general, if the permeability of the sediments beneath the Site is lower, the necessary pumping rate to adequately dewater the construction excavation will be lower. Thus, at a hydraulic conductivity of 40 ft/day, four extraction wells pumping a total of approximately 2,200 gpm (550 gpm each) are estimated to be adequate to dewater the construction excavation. In contrast, if the permeability is on the order of 160 ft/day, then four wells pumping a total of approximately 8,800 gpm (2,200 gpm each) would be required to adequately dewater the beach deposits for the planned excavation.

# 5.0 Evaluation of Potential Impacts to Groundwater Levels and Groundwater Flow

Groundwater dewatering, such as is conducted using pumping wells, will create a cone of depression on the groundwater surface at the Site to lower levels to the necessary depth for excavation. Although the greatest groundwater level lowering will occur at the Site where the wells are located, the cone of depression will extend beyond the Site, becoming less and less with distance from the location of pumping. The cone of depression will also cause a localized change in groundwater flow direction in the vicinity of the Site. The groundwater flow model described in Section 4.0 was also used to evaluate changes in groundwater levels and flow direction in the vicinity of the Site as a result of planned excavation dewatering.

## 5.1 Potential Impacts of Construction Dewatering Pumping on Groundwater Levels

Model-predicted groundwater elevations in the vicinity of the Site as a result of excavation dewatering are shown on Figure 13 (high groundwater levels at the barrier) and Figure 14 (low groundwater conditions at the barrier). Model-predicted differences in groundwater levels associated with Site pumping relative to a baseline groundwater condition without pumping are shown on Figures 15 and 16. As shown, groundwater level interference at the nearest West Coast Basin Barrier wells is estimated to be less than 4 ft in both high and low groundwater level conditions. The maximum estimated groundwater level interference at the closest barrier well is 3.7 ft.

Changing the hydraulic conductivity of aquifer sediments in the model did not significantly change the groundwater level interference at the nearest West Coast Basin Barrier wells (see Table 2). This is due to the fact that the change in required pumping rate at the new parameter values balanced the interference that would have otherwise occurred as a result of changing hydraulic conductivity.

## 5.2 Potential Impacts of Construction Dewatering Pumping on Groundwater Flow

With the exception of a localized pumping depression in the immediate vicinity of the Site, groundwater pumping for construction dewatering is not predicted to result in significant changes in the groundwater flow direction in other areas of the model (see Figures 13 and 14). Groundwater flow beneath the Redondo Generating Station, located approximately 0.75-mile to the south (see Figure 13) may shift slightly to the north based on model analysis and the assumptions presented in this technical memorandum.

## 6.0 Evaluation of Potential Impacts to Groundwater Quality

Groundwater pumped during construction dewatering is expected to be a blend of seawater and water from the West Coast Basin Barrier Project. Given the Site's proximity to the ocean and the increased hydraulic gradient expected from dewatering pumping, it is anticipated that the water quality of pumped groundwater will be closer to seawater (see Table 1). Pumped groundwater for construction dewatering will most likely be discharged back into the ocean. As such, there is no predicted impact to surface or groundwater quality associated with planned construction dewatering.

It is noted that there have historically been underground storage tank and other listed sites in the vicinity of the planned construction Site. None of these sites have active cases with applicable regulatory agencies. However, pumping discharge will be monitored in accordance with Regional Water Quality Control Board requirements to ensure that the water quality of the discharge water meets regulatory criteria.