GEOHYDROLOGIC ASSESSMENT OF THE FENNER GAP AREA

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BROWNSTEIN HYATT FARBER SCHRECK, LLP

TECHNICAL MEMORANDUM

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CONTENTS

FIGURES

TABLES

APPENDICES

BROWNSTEIN HYATT FARBER SCHRECK, LLP
TECHNICAL MEMORANDUM

GEOHYDROLOGIC ASSESSMENT OF THE FENNER GAP AREA

1 EXECUTIVE SUMMARY

An analysis of the geohydrologic conditions in the Fenner Gap area was conducted using data from previous GEOSCIENCE investigations along with information developed by CH2MHill during recent drilling and well installation activities. The following is a brief summary of the analysis:

- Cross-Section A-A' and B-B' indicate that the alluvium may reach a thickness of 470 ft and 1,500 ft in the center of Fenner Gap.
- The alluvium consists primarily of gravel and sand with some silt and clay lenses.
- The area of Cross-Section A-A' appears to represent a buried notch in the bedrock with alluvium thicknesses increasing to the northeast and southwest of Cross-Section A-A'.
- In Fenner Gap, the alluvium is underlain by a sequence of Paleozoic rock which is represented on the Flanks of the southern Marble Mountains and western Ship Mountains.
- The Paleozoic sequence is missing in the center of Fenner Gap north of Cross-Section B-B'.
- The dolomite penetrated in TW-1 contained abundant solution cavities which yielded large quantities of water. This carbonate aquifer represents a second significant aquifer in Fenner Gap.
- The full extent of this unit (Bonanza King Formation) in the subsurface across Fenner Gap is uncertain. However, a significant amount of subsurface underflow is anticipated based solely on the currently-known extent of the formation in the subsurface as well as the results of recent aquifer testing.
- Carbonate units of the Cadiz Formation interpreted to be penetrated by CI-2, in the lower portion of TW-1 and TW-3 may potentially yield a significant volume of water through localized solution cavities and/or joints and fractures.

- Two primary aquifer systems exist in the Fenner Gap area: 1) an alluvial aquifer system; and 2) a carbonate aquifer system. The alluvial aquifer system consists mainly of Quaternary alluvial sediments consisting of stream-deposited sand and gravel with lesser amounts of silt (Moyle, 1967). The thickness of this aquifer in Fenner Gap is interpreted to vary from approximately 200 ft towards the flanks of Fenner Gap to as much as 1,500 ft as depicted in the cross-sections. The alluvial material penetrated by recent borings consisted of very permeable gravel and sand with some silt and clay in lenses.

- Based on previous findings and confirmed by recent drilling and testing in the Fenner Gap area, carbonate bedrock of Paleozoic age, located beneath the lower alluvial aquifer, contains ground water and is considered a second main aquifer unit.

- Ground water movement and storage in the carbonate bedrock aquifer primarily occurs in secondary porosity (i.e., cracks, faults and solution cavities that have developed in the rocks over time. Recent tests show that portions of the carbonate aquifer, specifically in the Bonanza King Formation are highly transmissive. It is also likely that other carbonate units such as the Cadiz Formation may also exhibit localized areas of highly transmissive secondary porosity features

- Aquifer parameters derived from the recent pumping tests in the Fenner Gap area for the alluvial and carbonate units show very transmissive properties in the vicinity of the new test Wells TW-1 and TW-2. Hydraulic Conductivities for the alluvial aquifer system in the vicinity of pumping Well TW-2 average approximately 4,970 gpd/ft^2 or 664 ft/day. Storativities average approximately 0.002 reflecting semi-confined conditions. Hydraulic Conductivities for the carbonate aquifer in the vicinity of Well TW-1 average approximately 6,394 gpd/ft^2 or 855 ft/day. Storativities are representative of semi-confined (i.e. leaky) aquifer systems. The alluvial aquifer in the vicinity of TW-1 exhibits leakage effects suggesting hydraulic continuity with the underlying carbonate aquifer. The alluvial aquifer in the vicinity of TW-2 also shows leakage effects. Hydrologic boundaries were exhibited on the pumping test data reflecting the heterogeneous nature of the alluvial and carbonate aquifer system in the area.

- Underflow through the Fenner Gap occurs both in the alluvial and carbonate aquifer systems. Based on previous and current exploratory testing, saturated portions of the Bonanza King Formation may also occur in other sections of the Fenner Gap in addition to the area near Well TW-1. The ranges of hydraulic conductivity based on aquifer test data range between 200 – 600 ft/day for the alluvial aquifer system, and approximately 800 ft/day for the Bonanza King member of the carbonate aquifer.

2 BACKGROUND

2.1 Fenner Gap – Location, Drainage and Topography

The Fenner Gap is located in the eastern Mojave Desert of San Bernardino County, California approximately 200 miles east of Los Angeles, 60 miles southwest of Needles, and 40 miles northeast of Twentynine Palms (see Figure 1). Specifically, the Fenner Gap is located between the Marble and Ship mountains east of Cadiz within a topographically closed drainage system that includes three main drainage basins: Bristol, Cadiz, and Fenner. These basins are considered one drainage system because all surface and ground water within these basins drains to a central lowland area (i.e. Bristol and Cadiz dry lakes). The Bristol, Cadiz, and Fenner basin system is separated from the surrounding drainage basins by topographic divides (generally mountain ranges). Surface and ground water on the other sides of these divides (i.e. outside of

Fenner Gap Area

the three basin area) flows toward other areas. Because ground water flow directions in the eastern Mojave Desert are generally similar to surface water flow directions, for purposes of this report, the terms drainage basin and ground water basin are used interchangeably.

The total area of the Bristol, Cadiz and Fenner ground water basin system is approximately 2,710 square miles. The Bristol Basin is 1,170 square miles, the Cadiz Basin is 540 square miles, and the Fenner Basin is 1,000 square miles. Ground water flow within the Bristol Basin flows toward, and terminates in, Bristol Dry Lake. Ground water flow within the Cadiz Basin flows toward, and terminates in, Cadiz Dry Lake.

Ground water flow within the Fenner Basin flows through Fenner Gap. Some of the ground water flowing through Fenner Gap migrates toward Bristol Dry Lake and some flows toward Cadiz Dry Lake.

2.2 Prior Field Investigations

In 1998 and 1999 the Metropolitan Water District of Southern California (MWD), evaluated the feasibility of operating a ground water storage and transfer project near Cadiz, California in the eastern Mojave Desert. The project entailed transferring surplus water from the Colorado River Aqueduct (CRA) and artificially recharging it through a series of surface spreading basins located in the vicinity of Fenner Gap. A pipeline would have transported water from the CRA during storage operations (i.e. "put" operations) as well as transport pumped ground water from the Cadiz area back to the CRA during extraction operations (i.e. "take" operations). The project was given the title *Cadiz Ground Water Storage and Dry-Year Supply Program.* As part of the investigation phase of the proposed project, field testing was performed in and around the Fenner Gap to characterize geologic and hydrologic properties.

Leading up to the pilot recharge test, a comprehensive field testing program was conducted from December 1998 through January 1999 to collect geologic, hydrologic, and water quality data from the Fenner Gap vicinity. The field testing program included the installation of a deep 16-inch-diameter production well, and a total of ten ground water monitoring wells drilled and installed in the Fenner Gap area prior to construction of the pilot spreading basin followed by an 8-month large-scale artificial recharge test. The primary objective of the pilot test program was to collect data necessary to determine the feasibility of storing (and retrieving) CRA water. Results from the pilot test program showed good potential for a ground water banking project in the Fenner Gap area.

2.3 Purpose and Scope

The purpose of this Technical Memorandum is to provide an updated evaluation of the geohydrology in the Fenner Gap area considering the recent exploratory drilling and testing performed in late 2009 and early 2010. In conjunction with this task, independent analyses of pumping test data were made and aquifer parameters evaluated. In addition, the scope involved review of new geologic information gained from the exploratory drilling and testing and revisiting of some existing geophysical data performed in the Fenner Gap area.

2.4 Field Reconnaissance

On November 11, 2009, Dr Dennis Williams (GEOSCIENCE) visited the well site of Wells TW-1 and TW-2.

Well TW-2 was pumping at an approximate rate of 1,100 gallons per minute (gpm). The inset photograph shown to the right shows the discharge from Pumping Well TW-2 on November 11, 2009.

Discharge from Pumping Well TW-2
(See Figure 2a for Location)

3 REGIONAL GEOHYDROLOGIC CONDITIONS

3.1 Regional Geology

The geohydrologic conditions in the Project area were evaluated based on previous geohydrologic reports and information provided from two exploratory/test wells (TW-1 and TW-2), one shallow test boring (TW-2B) and one deep test boring (TW-3). The geology in the area as mapped by the California Division of Mines and Geology (CDMG, 1964) forms the basis for understanding local geologic conditions in the Fenner Gap.

3.1.1 Regional Geology Units

The project area is located within portions of the Bristol, Cadiz, and Fenner Valley watersheds in the Eastern Mojave Desert of California. Together the Bristol and Cadiz watersheds form a broad valley-like depression that has been referred to in literature as the Bristol Trough (Thompson, 1929; Bassett et al., 1964; Jachens et al., 1992). Because all surface and ground water flow terminate in the Bristol and Cadiz dry lakes, which are the low points of the regional watershed, (Bassett et al., 1959; Handford, 1982; Rosen, 1989), it is considered to be a closed system.

The depression that forms Bristol Dry Lake is thought to be 6-10 million years old (Rosen, 1989)--having formed as a result of movement on a system of regional faults.

This movement resulted in the relative raising of the mountain ranges and lowering of the basin floor.

3.1.1.1 Alluvium

Sediments eroding from the bedrock are deposited on the flanks of the hills and mountains as alluvium. Over time, this alluvium has largely filled the valleys between the mountain ranges. Geophysical evidence indicates that its depth locally exceeds 3,500 ft below ground surface in the area between Bristol Dry Lake and Fenner Gap in the vicinity of the irrigation wellfield (Maas, 1994). Based on recent drilling, alluvial sediment depths in Fenner Gap are known to reach 1,500 ft. It is believed that most of the ground water in the Bristol, Cadiz, and Fenner watershed area is stored in these alluvial sediments. However, permeable bedrock lying beneath the alluvium may contain an appreciable amount of ground water within secondary porosity features.

Alluvial sediments are primarily composed of layers of gravel, sand, silt, and clay in varying proportions (Koehler, 1983; Freiwald, 1984). The grain size of the alluvium is generally coarse on the upper parts of the alluvial slopes with more fine-grained deposits down slope (Dibblee, 1980b; Koehler, 1983; Freiwald 1984). However, significant layers of coarse-grained material (including cobbles and boulders) have been noted in Fenner Gap and as far down slope as Bristol Dry Lake (Rosen, 1989). Most of the exposed alluvial sediments were deposited from 10,000 years ago to the present. However, deposits older than 10,000 years have been noted in some areas (Dibblee, 1980).

3.1.1.2 Carbonate Units

Geologic formations found in the Bristol, Cadiz, and Fenner watersheds can be grouped into three broad categories:

1) the bedrock of the mountain ranges and watershed margins;
2) the loose alluvial sediments weathering off of the flanks of the hills and mountains; and
3) the fine-grained (silt and clay) sediments and evaporite (salt and gypsum) deposits underlying Bristol and Cadiz dry lakes (see Figure 3).

The bedrock exposed in the mountain ranges surrounding these regional watersheds consists of Precambrian (up to 1.5 billion years old; Silver et al., 1963) and in some areas Mesozoic (250 to 65 million years old) granitic and metamorphic rocks; Paleozoic (590 to 250 million years old) sedimentary rocks (sandstone, shale, limestone, and dolomite); and Tertiary (younger than 65 million years old) volcanic rocks. The most common rocks in the area are granitic and metamorphic rocks of Precambrian age, which are found in

Southern Marble Mountains and Ship Mountains

almost all of the hills and mountains. Paleozoic sedimentary rocks are limited primarily to the southern Marble Mountains and northwest Ship Mountains.

Volcanic rocks are found primarily on the northeast side of the Marble Mountains, the north side of the Ship Mountains, and in the Clipper Mountains.

4 GEOHYDROLOGY OF THE FENNER GAP AREA

4.1 Geology

Geologic formations found in the Fenner gap can be grouped into four broad categories:

1) the bedrock of the Marble and Ship mountains, which consist of Pre-Cambrian (up to 1.5 billion years old; Silver et al., 1963) granitic rock, Paleozoic (590 to 250 million years old) formations consisting of Cambrian metasediments (carbonate, shale, and quartzite), Permian and Pennsylvanian marine sedimentary and metasedimentary rocks, and Mesozoic (250 to 65 million years old) granitic and metamorphic rocks;

2) Tertiary sediments and volcanics,

3) Quaternary alluvial deposits consisting of alluvial fan and wash deposits which were eroded from the surrounding mountains filling a basin between the Ship and Marble Mountains, and

4) the more recent alluvial wash deposits located in Schulyler Wash and the ephemeral drainages in the gap and the flanks of the mountains.

Figures 2a and 2b (Local Geology) shows the surface distribution of geologic units in the vicinity of Fenner Gap.

4.1.1 Subsurface Geologic Conditions

The analysis of subsurface geologic condition was conducted using two geologic cross-sections constructed at two locations across Fenner Gap (see Figure 2a). The geologic cross-sections were constructed using information collected from

1) Recent borings conducted by CH2MHill (TW-1, TW-2, TW-2B, and TW-3, 2009/2010),

2) GEOSCIENCE data collected during previous investigations (CI-1, CI-2, CI-3, and Monitoring Wells MW-1, MW-2, MW-3, MW-5, MW-6, and MW-7; GEOSCIENCE, 1995,1999),

3) the interpretation of a seismic reflection line prepared by NORCAL (NORCAL, 1997), (see Figure 3a),

4) surface geologic mapping prepared by the California Division of Mines and Geology (CDMG, 1964),

5) field reconnaissance geologic mapping in the Marble and Ship Mountains conducted by GEOSCIENCE staff (2010), and

6) inspection of recent aerial photographs available online from Google Earth (2010).

4.1.2 Geologic Cross-Section A-A'

Cross-Section A-A' is the southerly of the two cross-sections. It depicts the structural relationship between geologic units in the subsurface in the Fenner Gap area at the extreme southern tip of the Marble Mountains on the northwest, and the Ship Mountains on the southeast. The cross-section was constructed using the interpretation of a seismic reflection line prepared by NORCAL (NORCAL, 1997) reproduced as Figure 3a, and surface geologic mapping. Geologic Cross-Section A-A' is provided as Figure 3b. The NORCAL report documented three Horizons (Horizon 1, 2, and 3) which were interpreted to be:

1) the base of the alluvium (Horizon 1)
2) the base of Tertiary Sediments and Volcanics (Horizon 2), and
3) a contact with an unknown lithologic unit (Horizon 3) thought to be possibly foliations or jointing in Precambrian granitic or metamorphic rock (NORCAL, 1997).

Boring CI-2 was drilled subsequently to the NORCAL report and allows for some correlation of subsurface lithologic units with the seismic reflection profile.

4.1.2.1 Quaternary Alluvium

Monitoring wells MW-1, MW-3, and MW-5 were drilled in 1999 and are located within 1,200 ft of the cross-section line. The wells did not encounter bedrock to depths of 500, 550, and 400 ft below ground surface respectively. The interpretation of NORCAL is that the base of the alluvium is approximately 470 ft at the deepest point along the line of section (see Figure 3c) The alluvium penetrated consisted of permeable to highly permeable silty sand, poorly graded sand, gravel, and cobbles.

4.1.2.2 Carbonates

Boring CI-2 drilled in 1999, penetrated a section of carbonates beneath alluvium and a sequence of Cambrian (Lower Paleozoic) Dolomite, Shale and Quartzite which may represent from youngest to oldest, the Cambrian Bonanza King Formation and underlying Cambrian Cadiz Formation. Based on the correlation of lithologic units penetrated in CI-2 which is nearly on the line of the cross-section, it appears that Paleozoic carbonate, shale, and quartzite units extend across the Fenner Gap and may rest upon granitic basement at depths coincident with Horizon 2. The seismic reflection profile suggests several faults in the form of off-set reflectors (see Figure 3a). However, the same reflectors which correlate with the Paleozoic lithologic units appear to have been faulted downward in the center of Fenner Gap beneath the alluvial units. It is likely that the Bonanza King and Cadiz Formations interpreted to be present in the boring TW-1, extend to the south as depicted in the cross-section.

Cross-Section A-A' depicts a buried bedrock notch with Paleozoic units resting over Pre-Cambrian granitic rock (southern Marble Mountains) and in fault contact with Mesozoic granitic rock (western Ship Mountains). The alluvial thickness increases to the northeast into Fenner Valley and to the southwest towards areas of Cadiz Valley. The area along the cross-section appears to the location across Fenner Gap where bedrock is closest to the land surface.

4.1.3 Geologic Cross-Section B-B'

Cross-Section B-B' extends from Hilltop 362T and 337T in the southern Marble Mountains on the Northwest to Hilltop 546T in the Ship Mountains on the Southeast. Cross-Section B-B' is shown on Figure 3c. The cross-section was prepared using data from the recent borings (TW-1, TW-2, TW-2B, and TW-3), geologic mapping published by the California Division of Mines and Geology (CDMG, 1964), and field reconnaissance mapping in the southern Marble Mountains and Western Ship Mountains.

The subsurface geologic conditions illustrated on Cross-Section B-B' suggests that the Paleozoic formations exposed in the southern Marble Mountains extend across Fenner Gap in the subsurface at this location, with exception of the where granitic rock has

been juxtaposed by faulting against Paleozoic carbonates in the area between TW-1 and TW-2B.

In the central Fenner Gap portion of the area between TW-2 and TW-3, the alluvium is directly underlain by granitic rock or in part, possibly by Tertiary sandstone and conglomerate. Insufficient data is available to determine the relationship of carbonates penetrated in TW-3 (Cambrian Bonanza King Formation and Cambrian Cadiz Formation?) and the Upper Paleozoic carbonates exposed on the western flanks of the Ship Mountains (see Figures 2a and 2b). It is possible that carbonate units are present under alluvium and sandstone and conglomerate to ground surface on the western Ship Mountains.

4.1.3.1 Quaternary Alluvium

Quaternary alluvium was penetrated in borings TW-1, TW-2, TW-2B, and TW-3 to depths of 457, 860, 810, and 960 ft below ground surface respectively. The alluvium consists of sand and gravel with silt and clay.

4.1.3.2 Carbonates

The Cambrian Bonanza King Formation (lower Paleozoic) overlying the Cambrian Cadiz Formation was interpreted to be present in boring TW-1. The boring drilled to a depth of 1,002 ft was in carbonate rock from the base of alluvium encountered at 457 ft bgs to the total depth. Undifferentiated Paleozoic carbonate, shale, and quartzite underlying sandstone and conglomerate were penetrated by boring TW-3 at a depth of 1,630 ft bgs. The units were approximately 250 ft in thickness at this location and were highly fractured. Correlation of these Paleozoic units to Paleozoic units on the west side of Fenner Gap is uncertain. The Paleozoic rocks rest on top of granitic rock.

4.1.4 Lithologic Findings in New Test Wells

4.1.4.1 Test Well TW-1

TW-1 penetrated carbonate rocks consisting of dolomite and limestone from a depth of 457 ft to the bottom of the boring at approximately 1,000 ft. The upper portion of the carbonate rocks contained numerous solutions cavities developed along what appear to be joint systems which yield large quantities of water. This section of the carbonate rocks extended to a depth of approximately 735 ft below ground surface. Below this depth, sandy limestone with a much less proportion of solution cavities was penetrated to the bottom of the boring. The dolomite and sandy limestone penetrated in TW-1 were identified by CH2MHill (2009) as units of the Cambrian Bonanza King formation. The boring penetrated a sequence of dolomite, shale, and sandy limestone which is

likely representative of the Cadiz Formation which lies stratigraphically below the Cambrian Bonanza King Formation.

4.1.4.2 Test Wells TW-2 and TW-2B

Test Wells TW-2 and TW-2B are located south of TW-1, but to the east in relation to the trend of the drainages in Fenner Gap. These borings penetrated granitic bedrock at depths of 860 ft and 810 ft respectively. Core collected from TW-2B was highly fractured and contained at least one rock face bearing slickensides. It is assumed that the granitic rocks represent intrusive Mesozoic granitic rock which has been subjected to faulting.

4.1.4.3 Test Well TW-3

Test Well TW-3 penetrated alluvium to 960 ft underlain by approximately 670 ft of conglomerate and sandstone (960 ft to 1,630 ft bgs) followed by a sequence of carbonate rock with shale interbeds (1,630 to 1,768) consisting of a 38-ft of limestone with shale interbeds followed by 50-foot thick shale unit, underlain by 32 ft of quartzite, and in turn underlain by 20-ft of carbonates resting upon granitic rock. This sequence of rock may be correlative with the portions of the Chambless Formation, Cadiz Formation, and Zabriesky/Wood Canyon Quartzite faulted into contact with Mesozoic granitic basement rock, however this designation is uncertain.

4.1.5 Summary of Geology in the Fenner Gap Area

The geologic cross-sections depict an alluvial-filled basin formed by faulting. Cross-Section B-B' indicates that the alluvium may reach a thickness of as much 1,500 ft and in turn is underlain locally by Tertiary sandstone and conglomerate (western Ship Mountains) and Paleozoic and Mesozoic granitic rock. Cross-Section A-A' indicates that the alluvium is shallower in the area overlying a buried bedrock notch. The alluvium may reach a thickness of approximately 470 ft. The alluvium increases in thickness to the northeast and southwest of Cross-Section A-A'. The alluvium is underlain by a sequence of Paleozoic rock in the subsurface, on the Flanks of the southern Marble Mountains and western Ship Mountains. The Paleozoic sequence is missing in the center of Fenner Gap north of Cross-Section B-B' (likely due to faulting and erosion). The dolomite penetrated in TW-1 contained abundant solution cavities which yielded large quantities of water. The extent of this unit (Bonanza King Formation) in the subsurface below Fenner Gap is uncertain. However, it may be present in subsurface underlying the western flank of Ship Mountains. Carbonate units of the Cadiz Formation interpreted to be penetrated by CI-2, in the lower portion of TW-1 and TW-3 may also yield water through localized solution cavities or joints and fractures.

4.2 Hydrology

The Eastern Mojave Desert is characterized as an arid desert climate with low annual precipitation, low humidity, and relatively high temperatures. Winters are mild and summers are hot with a relatively large range in daily temperature. Temperature and precipitation vary greatly with altitude. Lower temperatures and higher precipitation amounts occur in the higher elevations.

4.2.1 Precipitation

Most of the precipitation in the Eastern Mojave Desert accumulates during the winter months from November through March. Early summer and late fall are typically periods of little rainfall. The amount of precipitation in the Bristol, Cadiz, and Fenner basins vary with differences in altitude. Average annual precipitation ranges from approximately 3 inches on the Cadiz and Bristol dry lakes (elevations of 545 to 595 ft amsl) to over 12 inches in the Providence and New York mountains (elevations over 7,000 ft amsl). However, most of the study area receives, on the average, 4 to 6 inches of rain annually.

4.2.2 Ground Water Occurrence and Movement

In the Fenner Gap area, the principal geologic deposits that store and transmit ground water (i.e. aquifers) can be divided into two main aquifer units (alluvial and carbonate). Within these two main units four subunits exist:

1) an upper alluvial aquifer,
2) a lower alluvial aquifer,
3) Tertiary sediments (encountered in TW-3), and
4) a bedrock aquifer consisting primarily of Paleozoic Limestone and to a much lesser extent, fractured and faulted granite.

In general, the alluvial units and the Paleozoic Limestone are in hydraulic continuity with each other and the separation is primarily due to stratigraphic differences or the extent of interconnecting secondary porosity with the limestone. Movement of ground water in the Fenner Gap is from northeast to the southwest at a gradient of approximately 10 ft/mi.

4.2.3 Alluvial Aquifer System

The alluvial aquifer system consists mainly of Quaternary alluvial sediments consisting of stream-deposited sand and gravel with lesser amounts of silt (Moyle, 1967). The thickness of this aquifer in Fenner Gap is interpreted to vary from approximately 200 ft towards the flanks of Fenner Gap to as much as to 1,500 ft as depicted in the cross-sections. The alluvial material penetrated by recent borings consisted of very

permeable gravel and sand with some silt and clay in lenses. Three clay layers between 10 and 20 ft thick were penetrated below a depth of 710 ft to the depth of bedrock at 860 ft in boring TW-2. While only one 10-foot clay lens was encountered in TW-2B. No clay material was reported in the log of TW-3.

4.2.4 Carbonate Aquifer System

Based on findings during previous and recent drilling work in the Fenner Gap area, carbonate bedrock of Paleozoic age, located beneath the lower alluvial aquifer, contains ground water and is considered a second main aquifer unit. Ground water movement and storage in the carbonate bedrock aquifer primarily occurs in secondary porosity (i.e., cracks, faults and solution cavities that have developed in the rocks over time) (GEOSCIENCE, 1999). Recent tests performed by CH2MHill (to be discussed in a subsequent section in this report), show that portions of the carbonate aquifer, specifically in the Bonanza King Formation are highly transmissive. It is also likely that other carbonate units such as the Cadiz Formation may also exhibit localized areas of highly-transmissive secondary porosity features

Granitic and metamorphic basement rock forms the subsurface margins of the aquifer system within the project area (Freiwald, 1984). This basement rock is generally impermeable and typically yields only minor quantities of water to wells (Freiwald, 1984). However, due to local and regional faulting, it is likely that localized transmissive areas of increased fracture frequency may exist.

4.3 New Exploratory Drilling and Well Construction

Four exploratory borings were drilled at the project site between October 2009 and February 2010. The borings are as follows:

1) TW-1, drilled to a total depth of 1,002 ft.
2) TW-2, drilled to a total depth of 1,380 ft.
3) TW-2B, drilled to a total depth of 1,007 ft, and
4) TW-3 drilled to a total depth of 1,942 ft.

The borings provided information on depth to the base of the alluvial sequence and information on the subsurface distribution of Paleozoic meta-sedimentary rock and Mesozoic granitic rock.

4.3.1 TW-1

TW-1 was initially drilled using the mud rotary method to a depth of 467 ft below ground surface (bgs). Geophysical logging was conducted which consisted of dual-

induction, natural gamma, and caliper logs. A well was constructed by installing 10-inch well casing in the boring to a depth of 455 ft within the alluvium. The well was constructed with 10-inch-ID, mild steel and screen supplied by Roscoe Moss. FullFlo louvered well screen with a 0.060-inch slot size was used; the as-built screen interval is 355 to 440 ft bgs. Tacna 8x20 gradation filter pack was emplaced to a depth of 335 ft bgs, and a cement-grout seal was installed to ground surface. Blank casing was installed below the well screen to a depth of 455 ft bgs without a base plate.

After installation of the well casing, the borehole was advanced past the base of the well casing to a total depth of 1,002 ft bgs. The dual-tube reverse air rotary drilling method, using a 9.5-inch-diameter bit was used to advance the boring to total depth. Geophysical logs were prepared for the completed borehole; the logging suite included long and short normal resistivity, spontaneous potential, lateral resistivity, natural gamma, sonic, and caliper logs. The boring penetrated carbonate rock, underlying alluvium from a depth of approximately 457 ft to the total depth of the boring. A video log was made to confirm well construction details and to observe the condition of the carbonate rock at depth. The as-built diagram for the TW-1 is provided as Figures 4a and 4b. Figures 4c and 4d provide information on the packer testing assembly used to isolate the deeper carbonate aquifer from the shallow alluvial system. [See Appendix A for details of the soil boring log.]

4.3.2 TW-2

Well TW-2 was drilled and completed as a cased well within the alluvium. Afterward, the borehole was advanced below the cased well further into alluvium and crystalline bedrock. The pilot borehole in alluvium at TW-2 was initially advanced to a total depth of 352 ft bgs using reverse rotary drilling techniques. Geophysical borehole logs consisting of dual induction, natural gamma, and caliper logs were run. Installation of a 24-inch-ID mild steel surface casing was installed to a depth of 340 ft bgs to control water loss while drilling through the vadose zone. After installing the 24-inch casing, the pilot borehole was continued to a total depth of 798 ft bgs, where loss of fluid circulation occurred. The pilot borehole was reamed and conditioned for geophysical logging. The suite of geophysical logs included long and short normal resistivity, spontaneous potential, lateral resistivity, natural gamma, sonic, and caliper logs.

The well was constructed with 10-inch-ID mild steel and screen supplied by Roscoe Moss. FullFlo louvered well screen with a 0.060-inch slot size was used; the as-built screen interval was 340 to 779 ft bgs. Blank casing was installed below the well screen to a depth of 799 ft bgs without a base plate. The borehole annulus and bottom of the well were backfilled with cement grout to a depth of 785 ft bgs to form a seal between the alluvium and underlying rocks. Afterward, Tacna 8x20 gradation filter pack was emplaced to ground surface (inside the intermediate surface casing).

Subsequent to testing of the alluvial well, the cement plug at the base of TW-2 was drilled out and an exploratory borehole was advanced into the underlying rocks. The

borehole was advanced to a total depth of 1,380 ft bgs by dual-tube reverse air rotary drilling. However, before geophysical logging, the completed borehole collapsed to a depth of approximately 870 ft bgs. TW-2 was video logged to confirm the as-built well condition and to assess the condition of the upper portion of the borehole below the well screen. The as-built diagram for TW-2 is provided as Figures 5a and 5b. Reportedly the borehole penetrated alluvium to a depth of 860 ft underlain by Mesozoic granitic rock. [See Appendix B for details of the soil boring log.]

4.3.3 TW-2B

Well TW-2B is an exploratory boring located approximately 380 ft northwest of TW-2. It was drilled to confirm the deep lithologic conditions in this area after caving conditions in TW-2 precluded evaluation of the underlying bedrock. Exploration was conducted using a 6-inch-diameter STRATEX® casing advanced to a depth of 85 ft bgs to stabilize the upper portion of the borehole. Drilling continued through the casing using a small diameter drill bit (5.25-inch) a total depth of 798 ft bgs using dual-tube reverse air rotary drilling. Small diameter casing (4.25-inch) was subsequently set in the small diameter drill hole to the total depth. Drilling continued through the casing with HQ core equipment. Coring continued to a total depth of 1,007 ft bgs. Reportedly, conglomerate was encountered from the top of the core hole (798 ft bgs) to 809 ft bgs--a thickness of approximately 11 ft; granitic basement was encountered below this depth. After drilling was complete, the borehole was abandoned by backfilling with bentonite grout to ground surface. Details for the exploratory boring are shown on Figure 6. [Also see Appendix C for details of the soil boring log].

4.3.4 TW-3

Well TW-3 is located approximately 6,200 ft east of TW-2, and was drilled to explore the deep lithologic conditions in the eastern side of Fenner Gap. Drilling for TW-3 was similar to TW-2B with a conductor casing set to 85 ft using 6-inch-diameter STRATEX® casing to stabilize the upper portion of the borehole. The borehole was advanced to a depth of 960 ft bgs by dual-tube reverse air rotary drilling. A 4.5-inch-diameter casing was then installed in the exploratory boring to the total depth of 960 ft. HQ core was advanced through the casing to a depth of 1,230 ft bgs, at which point the borehole was telescoped and NQ core was advanced to a total depth of 1,942 ft bgs.

Reportedly, conglomerate was encountered from a depth of 960 ft to a depth of 1,630 ft bgs. Shale, limestone, and quartzite which were highly fractured were encountered between 1,630 and 1,880 ft bgs and presumably represent Cambrian sequences. Granitic basement was encountered from 1,880 ft bgs to total depth. Geophysical and video logs were run separately in the core hole after retracting the 4.25-inch casing to a depth of 538 ft bgs.

When drilling was completed, packer testing was conducted at two depths in the HQ hole to estimate the hydraulic conductivity of the conglomerates encountered at this location. TW-3 was subsequently completed as a 2-inch-diameter Schedule 80 polyvinyl chloride (PVC) monitoring well with a well screen positioned from 502 to 522 ft bgs. The borehole annulus and open borehole below 472 ft bgs was backfilled with Tacna 8x20 gradation filter pack. A bentonite grout seal was installed from the top of the filter pack to ground surface. Figure 7a provides the as-built diagram of Well TW-3. Figure 7b shows the packer assembly used for the slug testing. [See Appendix D for details of the soil boring log].

4.4 Analysis of Pumping Test Data

Recent well and aquifer tests were performed on the new exploratory/test wells constructed between October, 2009 and February, 2010. Pumping tests performed on these wells included step-drawdown tests, constant rate interference tests, isolated packer tests and slug tests. Time drawdown and recovery analyses were performed; and aquifer parameters obtained from the two principal aquifer systems (i.e. alluvium and carbonates) based on the TW-1 and TW-2 pumping test results. A summary of these tests are reported in the following sections and are tabulated in Table 1. Graphical analysis of the pumping tests can be seen in Figures 10 through 28. Transmissivities, storativities, and leakance (where applicable) were calculated from the pumping test data. Estimates of hydraulic conductivity were calculated from transmissivities assuming a saturated thickness based on the completed interval of the well in the particular aquifer being tested (see Table 1).

4.4.1 Pumping Tests of TW-1

4.4.1.1 TW-1 Step Drawdown Test – Alluvial Aquifer

The alluvial aquifer portion of Well TW-1 was isolated from the deeper carbonate system through an inflatable packer (see Figures 4c and 4d). A step drawdown test performed on the alluvial portion of this well is shown in Figures 10, 11 and 12. Discharge rates for the four step tests ranged from 181 gpm to 383 gpm. Formation and Well Loss Coefficients were 0.0062 ft/gpm and 0.00074 ft/gpm^2 respectively. The specific capacity diagram (Figure 12) shows that the alluvial portion of Well TW-1 is very inefficient. This may be in part to the fact that during construction of the deeper carbonate borehole, drilling debris may have impacted the shallow alluvial screened section resulting in lower permeability and inefficiency measured.

4.4.1.2 TW-1 Constant Rate Test – Alluvial Aquifer

Figures 13 and 14 show results from a 24-hr constant rate test performed on Well TW-1 alluvium. Transmissivity was low in the pumping well possibly reflecting a clogged

screen section (see above section). Figure 14 also shows effects of leakage between the underlying carbonate aquifer as measured in alluvial monitoring Well MW-7a (see Figure 9 for the technical cross section of the monitoring well). Transmissivity for the upper alluvial aquifer at this location was calculated as 23,500 gpd/ft with a storativity of 0.008-- reflecting semi-confined conditions.

4.4.1.3 TW-1 Step Drawdown Test – Carbonate Aquifer

Figure 15 shows the step-drawdown test for the carbonate aquifer. The discharge rates ranged from 291 gpm to 1,168 gpm. The rise in ground water levels during pumping were due to the very low drawdown in the well (negligible) and the result of thermal expansion of water in the sounding tubes (see explanation on Figures 16 and 17). As such, the step drawdown data from the carbonate aquifer testing on TW-1 could not be analyzed for well and formation loss coefficients.

4.4.1.4 TW-1 Constant Rate Test – Carbonate Aquifer

Figures 16 and 17 show analyses during the three-day constant rate pumping test on the Well TW-1 carbonate aquifer system. Figure 16 is a calculation of the thermal expansion observed during pumping of the carbonate section in Well TW-1. Ground water temperatures near the pump were measured as approximately 100 degrees F while ambient temperatures were measured at Needles during the November 9-12, 2009 pumping test period as averaging 69 degrees F. During pumping, the hot water flowing in the pump column "warms" the annular space, including the sounding tubes, resulting in the thermal expansion rise in water levels during pumping. Ground water elevations rose over 5 inches during pumping (due to thermal expansion of the water) and dropped during recovery due to thermal contraction of the water. As can be seen in Figure 17, this approximate 5 inch rise calculated from the thermal expansion equation (Figure 16) was actually observed during pumping. Kawecki, (1995) also reports this phenomenon.

Figures 18, 19 and 20 show results from the three day constant rate interference test on the carbonate aquifer system. TW-1 was pumping at a discharge rate of 1,168 gpm and interference was measured at monitoring well MW-7 which is 83 ft from the pumping well. MW-7 was completed in the carbonate aquifer as part of the 1999 MWD recharge evaluation program (see Figure 9). Results show a very high tranmissivity of 3,083,500 gpd/ft with a storativity of 0.012 which is reflective of the carbonate aquifer system (Sharp, 2010). Figure 19 is the calculated recovery analysis and Figure 20 shows the evaluation of boundaries. Based on the method of Strausberg (1967), boundaries occur at approximately 1,000 ft and 4,000 ft from the pumping well TW-1.

4.4.2 Pumping Test of TW-2

4.4.2.1 TW-2 Step Drawdown Test

Figures 21, 22 and 23 show the step drawdown test performed on the alluvial aquifer system in the vicinity of new Well TW-2. Discharge rates ranged from 420 gpm to 1,130 gpm. Formation and Well Loss Coefficients were measured as 0.0057 gpm/ft and 3.48 x 10^{-7} ft/gpm^2 respectively (Figure 22). The specific capacity diagram (Figure 23) shows that if the well were designed at a discharge rate of 1,100 gpm the drawdown in the pumping well would be 6.7 ft with a well efficiency of 94% and a specific capacity of 165 gpm/ft--reflecting very permeable materials.

4.4.2.2 TW-2 Constant Rate Test

Figures 24 through 29 show results of the three day constant rate pumping test performed on Well TW-2. The discharge rate was 1,116 gpm. Transmissivity from the interference analysis with monitoring Well TW-6 can be seen in Figures 26, 27 and 28. Well MW-6 was constructed during the original MWD testing and is 815 ft from Well TW-2.

The effects of leakage are shown in the interference analysis of data from monitoring well MW-6 located 815 ft from pumping well TW-2 (see Figure 26). Transmissivities were very high being approximately 2 million gpd/ft from the time drawdown and recovery analysis. Storativities of 0.002 reflect a leaky aquifer system as does the leakance coefficient (K'/b') of 0.022 / days. Boundary effects were noticed on the time drawdown and recovery measurements and were estimated to range between approximately 3,000 ft and 9,000 ft from the Pumping well. Two methods were used to analyze the boundaries. Strausberg (1997) was used for the analysis on Figure 28; and Roscoe Moss (1990) was used to analyze the distance to the boundary observed on Figure 26.

4.4.3 Summary of Aquifer Parameters

Table 1 is a summary of aquifer parameters derived from the recent pumping tests in the Fenner Gap area. Various methods were used in the analysis and are stated in the Table. Hydraulic Conductivity for the alluvial aquifer system in the vicinity of pumping Well TW-2 average approximately 4,970 gpd/ft^2 or 664 ft/day. Storativities average approximately 0.002 reflecting semi-confined conditions.

Hydraulic Conductivity for the carbonate aquifer in the vicinity of Well TW-1 average approximately 6,394 gpd/ft^2 or 855 ft/day. One of the methods used to analyze the carbonate transmissivity was an empirical method by Mace (1997) which was developed

specifically for karstic formations. Results from the Mace analysis complement the time drawdown and recovery analysis results.

5 UNDERFLOW THROUGH THE FENNER GAP

5.1 Historical Estimates

Ground water recharge to the aquifers in the Cadiz irrigation wellfield is primarily from infiltration of precipitation and runoff in the higher elevations of the Fenner Watershed. A smaller contribution of recharge comes from Orange Blossom Wash. Historical estimates of average annual recharge in the Fenner Watershed have included ranges from 2,070 to 10,343 acre-ft/yr (United States Geological Survey, 2000; unpublished report) and 15,000 to 37,000 acre-ft/yr (GEOSCIENCE, 1999). Lawrence Livermore National Laboratory has estimated average annual recharge to the Fenner Watershed (based on site-specific measurements of elevation versus precipitation and conservative parameters) within a range of 7,864 to 29,185 acre-ft/yr (Davisson & Rose, 2000).

5.2 Sensitivity of Recent Aquifer Parameters in Relation to Underflow through the Fenner Gap

In the Bristol and Cadiz watersheds, ground water flows toward the Bristol and Cadiz dry lakes from Fenner Gap and the surrounding hills and mountains (see Figures 2a and 2b). In Orange Blossom Wash, located between the Marble and Bristol mountains, ground water flows southeasterly from the Granite Mountains through the wash, before it veers southwestward into Bristol Dry Lake. In the Fenner watershed, ground water generally flows southward from the New York and Providence mountains into the main part of Fenner Valley, and then southwesterly through Fenner Gap. Some of the ground water flowing through Fenner Gap migrates toward Bristol Dry Lake and some of the ground water flows toward Cadiz Dry Lake. Based on recent ground water elevation measurements, the hydraulic gradient in the vicinity of the Fenner Gap is approximately 10 ft/mi.

The underflow through the Fenner Gap may be estimated using a Darcian calculation, namely:

$$Q = 365 \times A \times V / (43{,}560 \times 5{,}280)$$

Where:

Q = Underflow through the Fenner Gap (acre-ft/yr)
A = Cross Sectional Area of Ground Water Flow Through Aquifers in the Gap (ft^2)
V = Darcian Velocity = K x dh/dx, (ft/day)
K = Hydraulic Conductivity, (ft/day)
dh/dx = Hydraulic Gradient, (ft/mi)

Unit Values of Underflow

Both transmissivities and hydraulic gradients vary in aquifers across the Fenner Gap depending upon the various aquifer systems (alluvium and carbonate) through which flow occurs. As such, the underflow is dependent upon the saturated thickness, the hydraulic conductivity and the hydraulic gradient as discussed above. Figure 29 is a graphical representation of the range of underflow for the two principal aquifer types (alluvium and carbonates).

The ranges of hydraulic conductivity used to construct Figure 29 are based on aquifer test data and range between 200 – 600 ft/day for the alluvial aquifer system, and approximately 800 ft/day for the Bonanza King member of the carbonate aquifer. The range of hydraulic gradients is based on recent field measurements.

These estimates illustrate the Darcian calculation of underflow in the Fenner Gap area and can be refined using a ground water model to simulate multiple flow sections and variation in aquifer parameters.

6 FINDINGS

- Cross-Section A-A' and B-B' indicate that the alluvium may reach a thickness of 470 ft and 1,500 ft in the center of Fenner Gap.
- The alluvium consists primarily of gravel and sand with some silt and clay lenses.
- The area of Cross-Section A-A' appears to represent a buried notch in the bedrock with alluvium thicknesses increasing to the northeast and southwest of Cross-Section A-A'.
- In Fenner Gap, the alluvium is underlain by a sequence of Paleozoic rock which is represented on the Flanks of the southern Marble Mountains and western Ship Mountains.
- The Paleozoic sequence is missing in the center of Fenner Gap north of Cross-Section B-B'.
- The dolomite penetrated in TW-1 contained abundant solution cavities which yielded large quantities of water. However the full extent of this unit (Bonanza King Formation) in the subsurface below Fenner Gap is uncertain. This carbonate aquifer represents a second significant aquifer in Fenner Gap
- Carbonate units of the Cadiz Formation interpreted to be penetrated by CI-2, in the lower portion of TW-1 and TW-3 may potentially yield a significant volume of water through localized solution cavities and/or joints and fractures.

- Cross-Section A-A' and B-B' indicate that the alluvium may reach a thickness of 470 ft and 1,500 ft in the center of Fenner Gap.
- The alluvium consists primarily of gravel and sand with some silt and clay lenses.
- The area of Cross-Section A-A' appears to represent a buried notch in the bedrock with alluvium thicknesses increasing to the northeast and southwest of Cross-Section A-A'.
- In Fenner Gap, the alluvium is underlain by a sequence of Paleozoic rock which is represented on the Flanks of the southern Marble Mountains and western Ship Mountains.
- The Paleozoic sequence is missing in the center of Fenner Gap north of Cross-Section B-B'.

- The dolomite penetrated in TW-1 contained abundant solution cavities which yielded large quantities of water. This carbonate aquifer represents a second significant aquifer in Fenner Gap.

- The full extent of this unit (Bonanza King Formation) in the subsurface across Fenner Gap is uncertain. However, a significant amount of subsurface underflow is anticipated based solely on the currently know extent of the formation in the subsurface and the results of aquifer testing.

- Carbonate units of the Cadiz Formation interpreted to be penetrated by CI-2, in the lower portion of TW-1 and TW-3 may potentially yield a significant volume of water through localized solution cavities and/or joints and fractures.

- Two primary aquifer systems exist in the Fenner Gap area. They are:

    1) an alluvial aquifer system; and
    2) a carbonate aquifer system.

- The alluvial material penetrated by recent borings consisted of very permeable gravel and sand with some silt and clay in lenses.

- Ground water movement and storage in the carbonate bedrock aquifer primarily occurs in secondary porosity (i.e., cracks, faults and solution cavities that have developed in the rocks over time.

- Recent tests show that portions of the carbonate aquifer, specifically in the Bonanza King Formation are highly transmissive.

- It is also likely that other carbonate units such as the Cadiz Formation may also exhibit localized areas of highly transmissive secondary porosity features

- Aquifer parameters derived from the recent pumping tests in the Fenner Gap area for the alluvial and carbonate units show very transmissive properties in the vicinity of the new test Wells TW-1 and TW-2.

- Hydraulic Conductivities for the alluvial aquifer system in the vicinity of pumping Well TW-2 average approximately 4,970 gpd/ft^2 or 664 ft/day.

- Storativities for the alluvial aquifer in the vicinity of TW-2 average approximately 0.002 reflecting semi-confined conditions.

- Hydraulic Conductivities for the carbonate aquifer in the vicinity of Well TW-1 average approximately 6,394 gpd/ft^2 or 855 ft/day.

- Carbonate aquifer Storativities are representative of semi-confined (i.e. leaky) aquifer systems.

- The alluvial aquifer in the vicinity of TW-1 exhibits leakage effects suggesting hydraulic continuity with the underlying carbonate aquifer.

- The alluvial aquifer in the vicinity of TW-2 shows leakage effects.

- Hydrologic boundaries in the alluvial and carbonate aquifer pumping tests reflect the heterogeneous nature of the alluvial and carbonate aquifer system in the area.

- Based on previous and current exploratory testing, saturated portions of the Bonanza King Formation may also occur in other sections of the Fenner Gap in addition to the Well TW-1 area.

- Underflow through the Fenner Gap occurs both in the alluvial and carbonate aquifer systems.

- Both transmissivities and hydraulic gradients vary in aquifers across the Fenner Gap depending upon the various aquifer systems (alluvium and carbonate) through which flow occurs. As such, the underflow is dependent upon the saturated thickness, the hydraulic conductivity and the hydraulic gradient.

- The ranges of hydraulic conductivity based on aquifer test data range between 200 – 600 ft/day for the alluvial aquifer system, and approximately 800 ft/day for the Bonanza King member of the carbonate aquifer.

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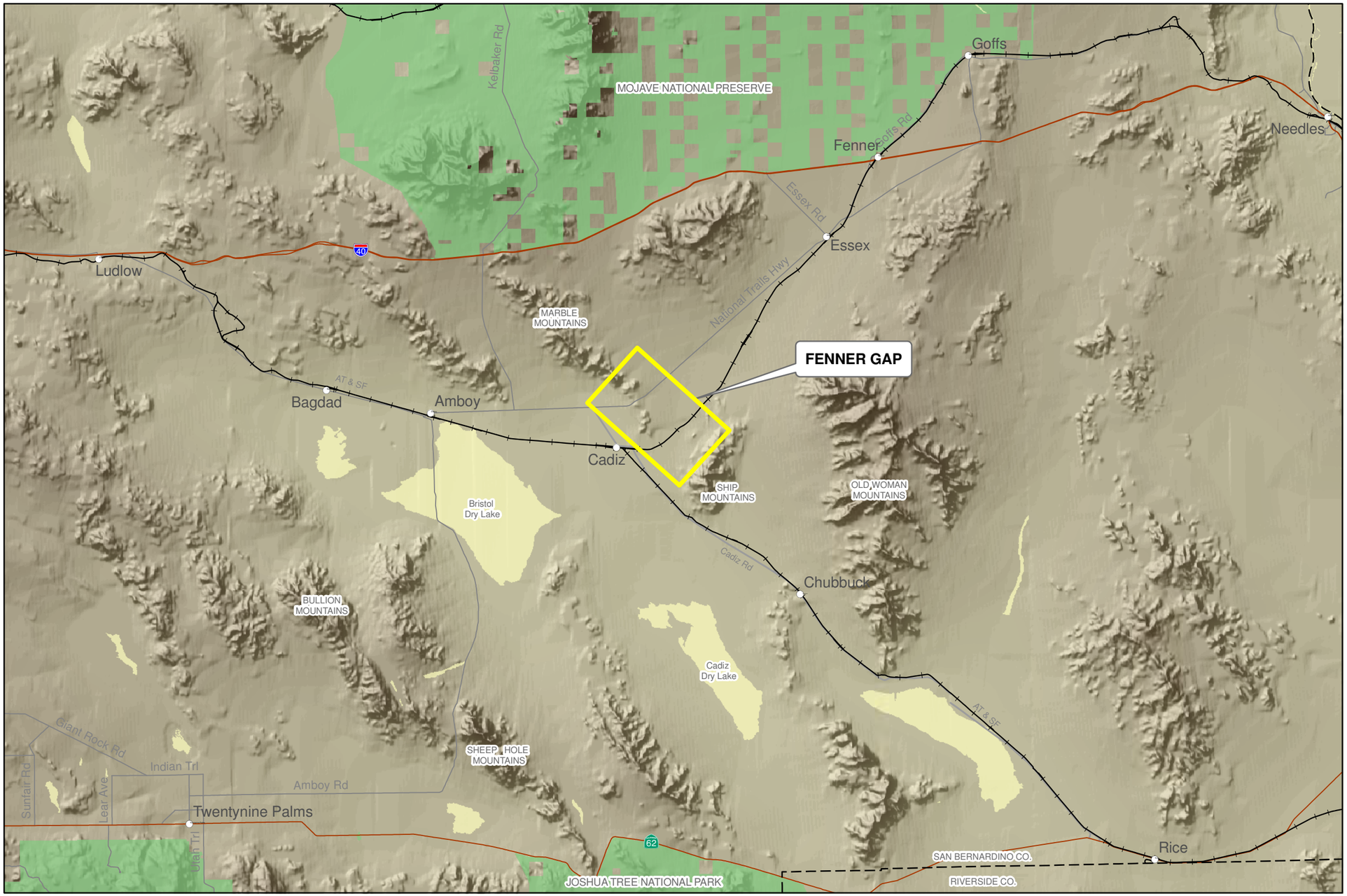
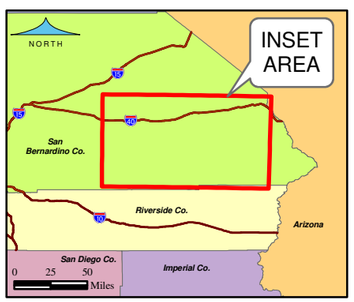
FIGURES

PROJECT LOCATION



EXPLANATION

- City
- Dry Lake Bed
- State Park / Preserve



16-Apr-10

Prepared by: LB

Map Projection:
State Plane, Zone 5 (1983)

NORTH

0 40,000 80,000 Feet

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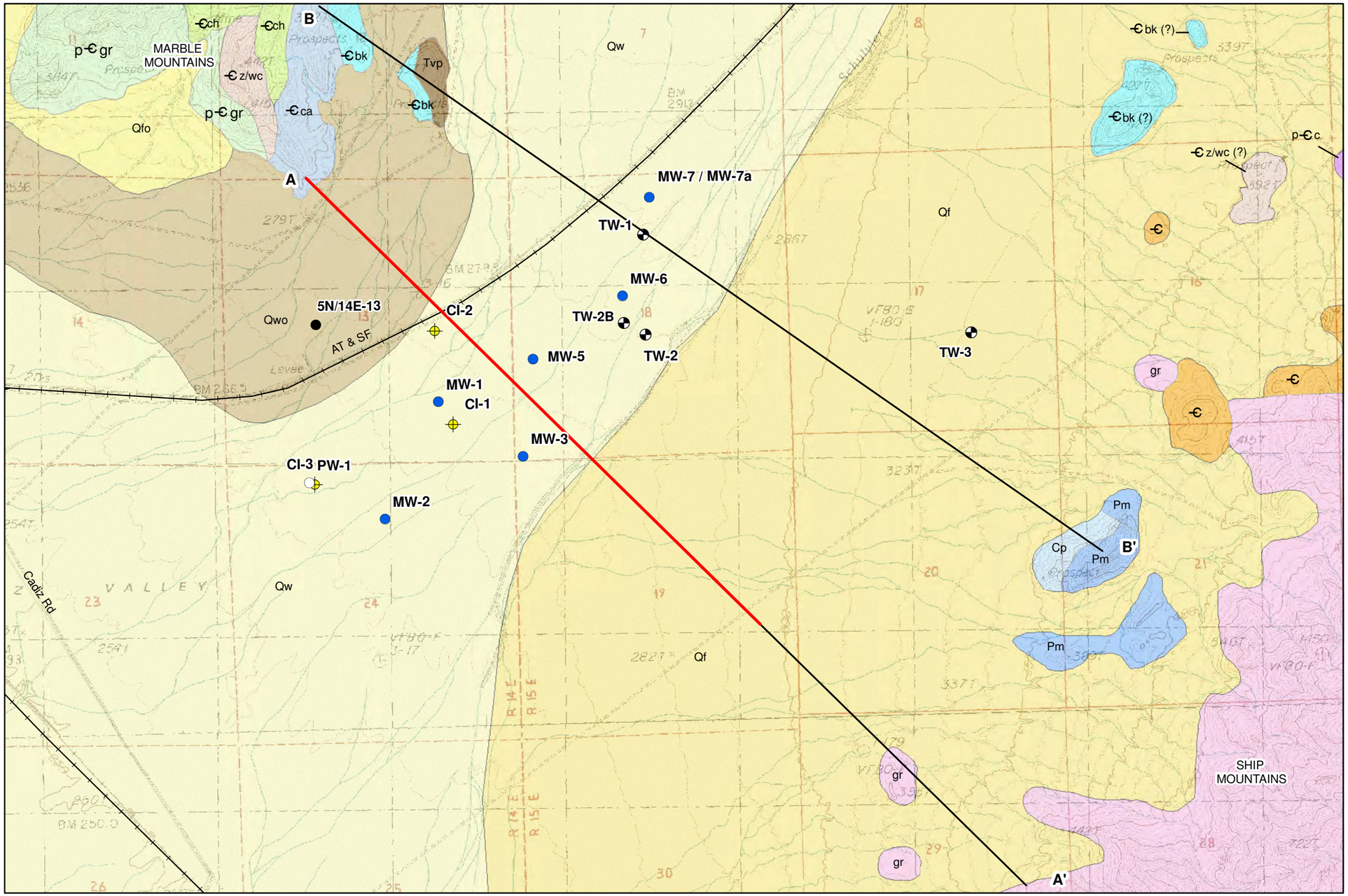
Figure 1

GIS_proj/brownstein_cadiz_Fenner_asses_4-10/0_Fig_1_regional_location_4-10.mxd



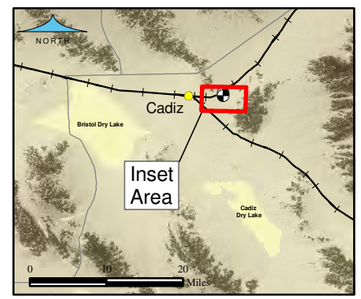
GEOLOGIC CROSS SECTION LOCATIONS

EXPLANATION

Wells

- Test Well
- Pumping Well
- CI Well
- Monitoring Well
- Other Well
- Geologic Cross-Section Location (see Figures 3b and 3c)
- NORCAL Seismic Profile Location (see Figure 3a)

See Figure 2b for geologic legend



16-Apr-10

Prepared by: LB

Map Projection:
State Plane, Zone 5 (1983)

NORTH
0 2,000 4,000 Feet

Source: Geologic Map of California Olaf P. Jenkins Edition. Needles Sheet. Compilation by Charles C. Bishop, 1963. Differentiation of alluvial fan and wash deposits based on aerial photographic review. Detail of Cambrian Marine Sediments based on field mapping.

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Figure 2a

GIS_proj/brownstein_cadiz_Fenner_asses_4-10/0_Fig_2a_geology_4-10.mxd

GEOLOGIC LEGEND

Qw	Recent Wash Deposits
Qf	Alluvial Fan Deposits
Qwo	Older Wash Deposits
Qfo	Older Alluvial Fan Deposits
Tvp	Pyroclastic Tertiary Volcanic Rocks
Tcgl	Tertiary Conglomerate (not shown on map)
gr	Undifferentiated Mesozoic Rocks
Pm	Permian Marine Sedimentary and Metasedimentary Rocks
Cp	Pennsylvanian Marine Sedimentary and Metasedimentary Rocks
-Є	Undifferentiated Cambrian Marine Sedimentary and Metasedimentary Rocks
-Єbk	Cambrian Bonanza King Formation (Limestone)
-Єca	Cambrian Cadiz Formation (Shale / Limestone)
-Єch	Cambrian Chambless Limestone
-ЄL	Cambrian Latham Shale (not shown on map)
-Єz/wc	Cambrian Zabriesky Quartzite / Wood Canyon Formation
pЄgr	Undivided Precambrian Granitic Rocks
pЄc	Precambrian Igneous and Metamorphic Rocks

Source: Geologic Map of California Olaf P. Jenkins Edition. Needles Sheet.
Complilation by Charles C. Bishop, 1963.
**Geologic classification modified based on aerial photographic review and field reconnaissance.*

16-Apr-10

Prepared by: LB

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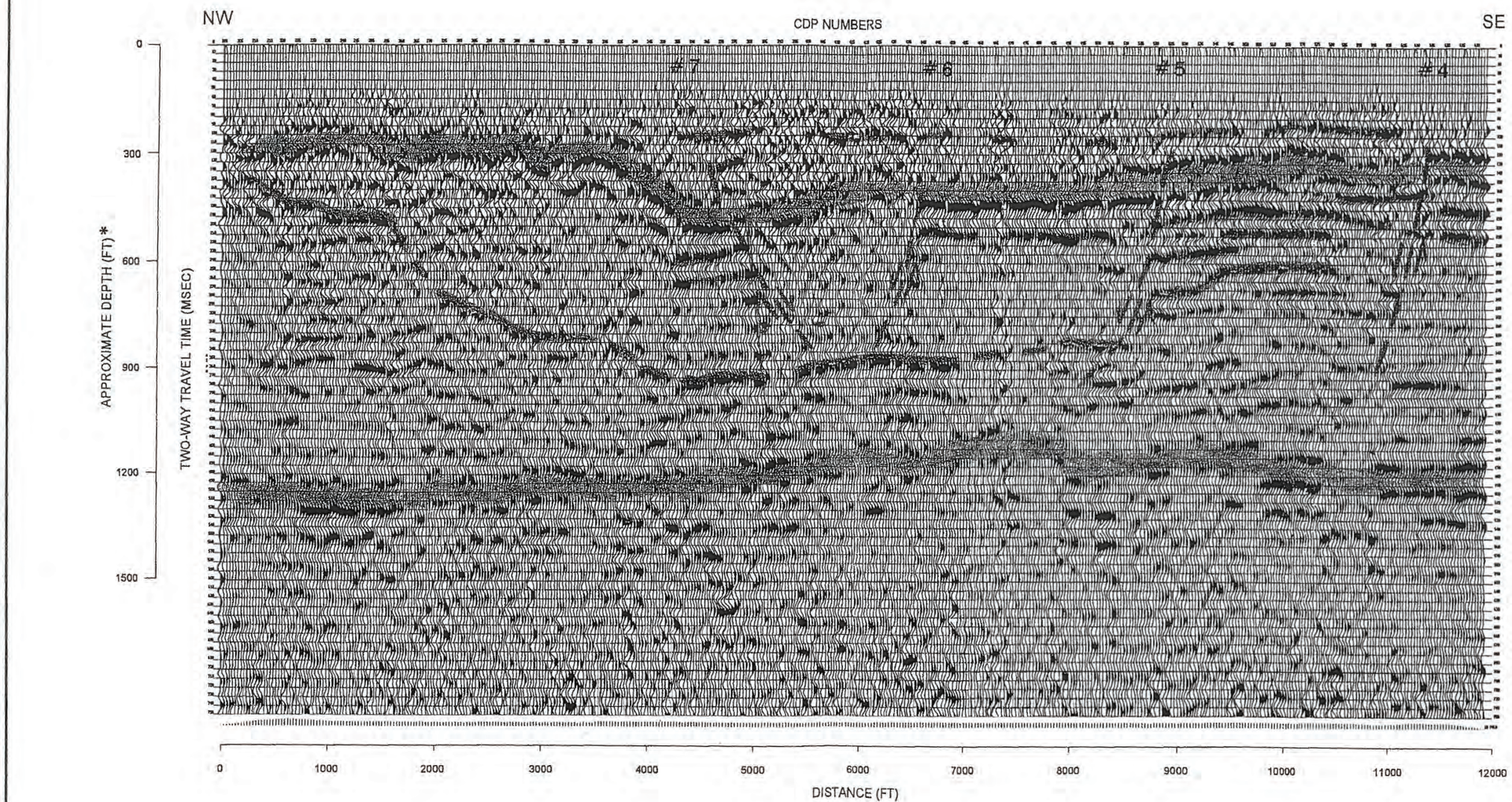
Figure 2b



LEGEND

HORIZON 1

HORIZON 2

HORIZON 3

DISCONTINUOUS REFLECTIONS

POSSIBLE FAULT (SHOWING RELATIVE MOTION)

NOTE: THE REFLECTING HORIZONS AND STRUCTURES SHOWN ON THIS SECTION ARE BASED ON OBSERVATIONS MADE THROUGOUT THE PROCESSING PROCEDURE.

* DEPTH SCALE IS NON-LINEAR

VERTICAL EXAGGERATION = 3:1

NORCAL GEOPHYSICAL CONSULTANTS INC.

JOB: 95-386.01 | APPR: WEB | DATE: 8/97

INTERPRETED CDP STACKED SEISMIC SECTION

CADIZ LAND COMPANY
CADIZ, CA

PLATE 2

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BROWNSTEIN HYATT FARBER SHRECK, LLP

NORCAL SEISMIC PROFILE
FENNER GAP, SAN BERNARDINO COUNTY

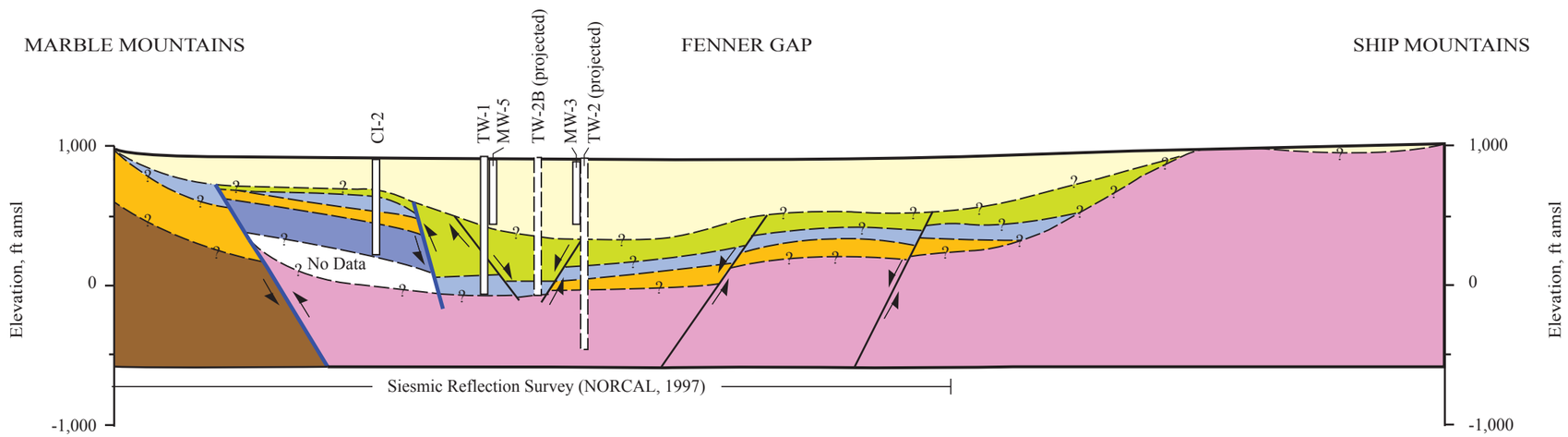
Drawn: LB
Checked:
Approved:
Date: 16-APR-10

Figure 3a

Projects\Brownstein Hyatt Farber Schreck, LLP\cadiz 2009-10\00) DEW 16-Apr-2010 REPORT\02) Figures\01) FINAL FIGURES\02) Original Working Figures\Fig_3a_norcal_cross_section_4-10.ai

Northwest
A

Southeast
A'



Fault, proposed by GEOSCIENCE

Fault, proposed by NORCAL

Geologic contact, dashed where inferred

Well

Well projected
(Lithology not reflected
in cross section

Alluvium

Paleozoic Carbonate (Bonanza King Formation)

Undifferentiated Paleozoic Bedded Shale and Siltstone

Undifferentiated Paleozoic Bedded Shale / Siltstone and Quartzite

Mesozoic Granitics

Pre-Cambrian Granitics

0 2,000 4,000
Approximate Horizontal Scale Feet

0 1,000 2,000
Approximate Vertical Scale Feet

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GEOLOGIC CROSS SECTION A-A'
FENNER GAP, SAN BERNARDINO COUNTY

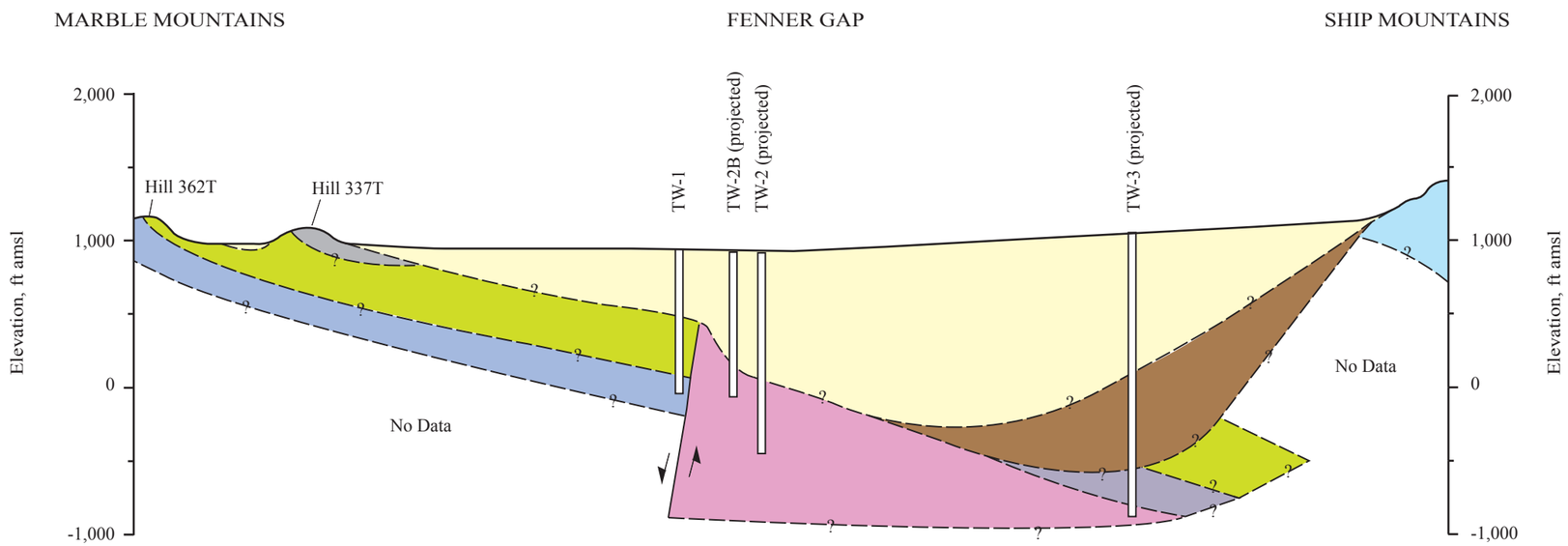
Drawn: LB
Checked:
Approved:
Date: 16-APR-10

Figure 3b

Projects\Brownstein Hyatt Farber Schreck, LLP\cadiz 2009-10\00) DEW 16-Apr-2010 REPORT\02) Figures\01) FINAL FIGURES\02) Original Working Figures\Fig_3b_siesmic_cross_section_4-10.ai

Northwest
B

Southeast
B'



Fault

Geologic Contact, dashed where inferred

Well

Alluvium

Volcanics

Tertiary Conglomerate

Pennsylvanian / Permian Carbonate

Bonanza King Formation

Cadiz Formation

Undifferentiated Fractured Paleozoic Shale, Limestone and Quartzite

Mesozoic Granitics

0 2,000 4,000
Approximate Horizontal Scale Feet

0 1,000 2,000
Approximate Vertical Scale Feet

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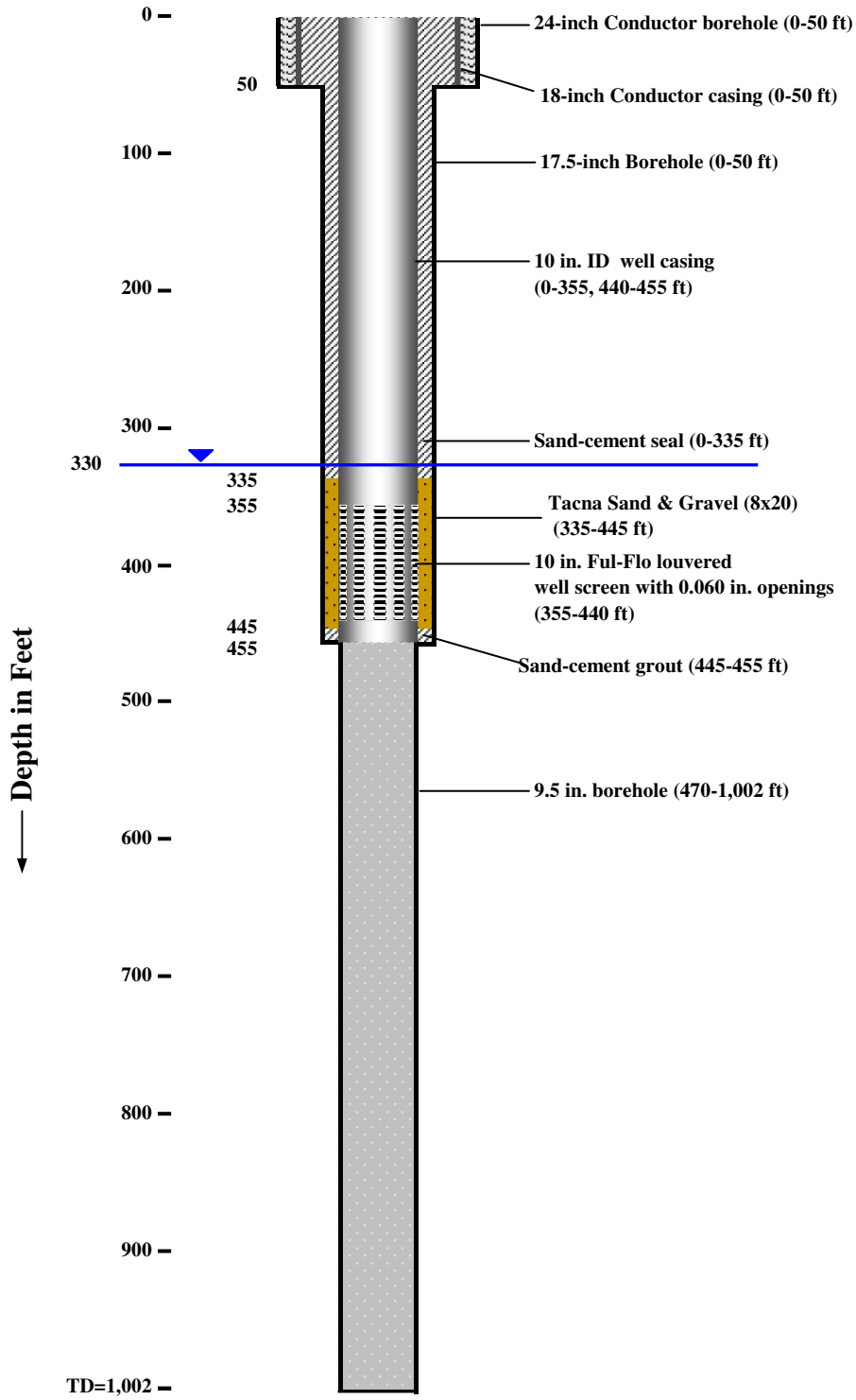
Figure 3c



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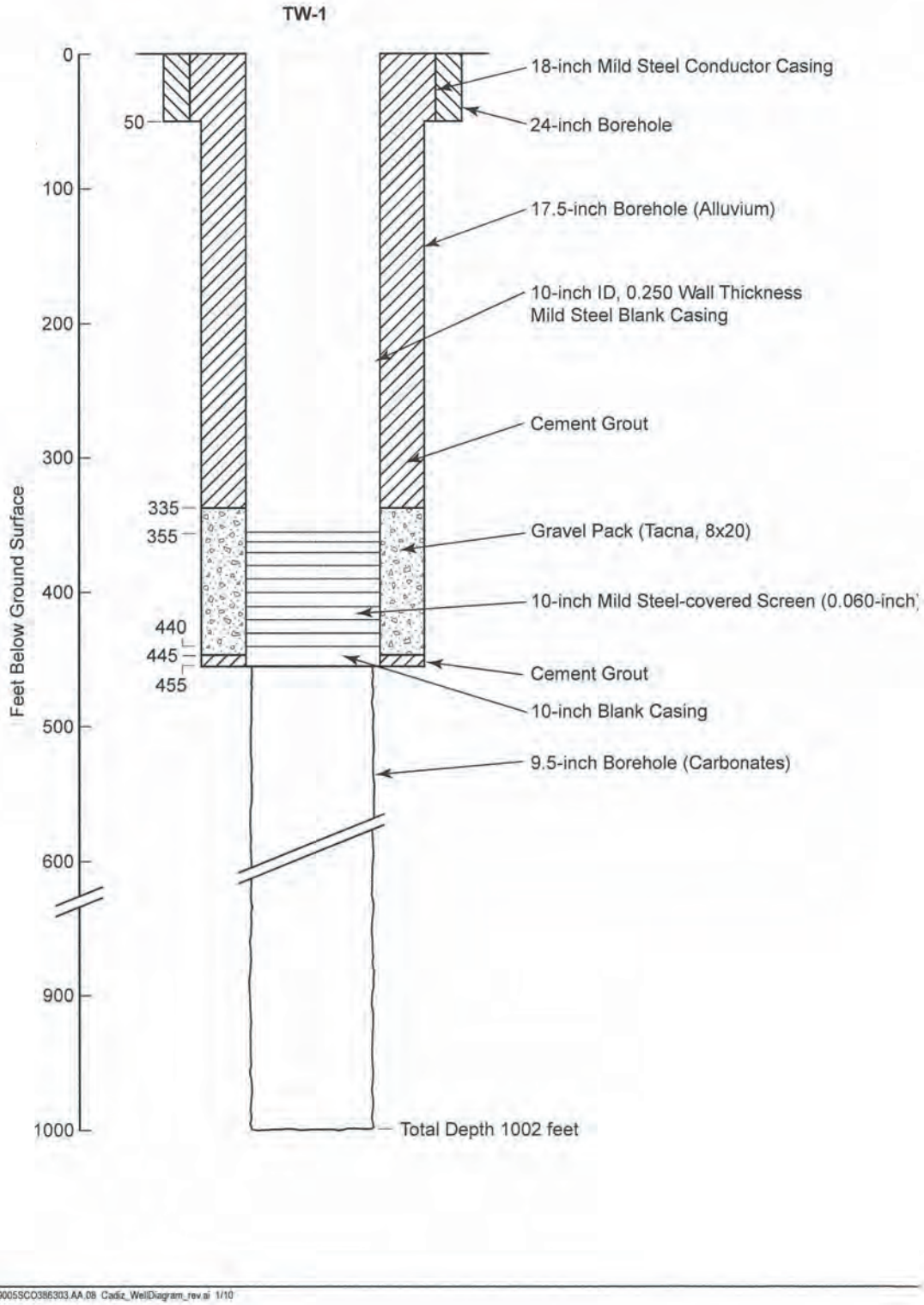
TW-1 AS BUILT DIAGRAM

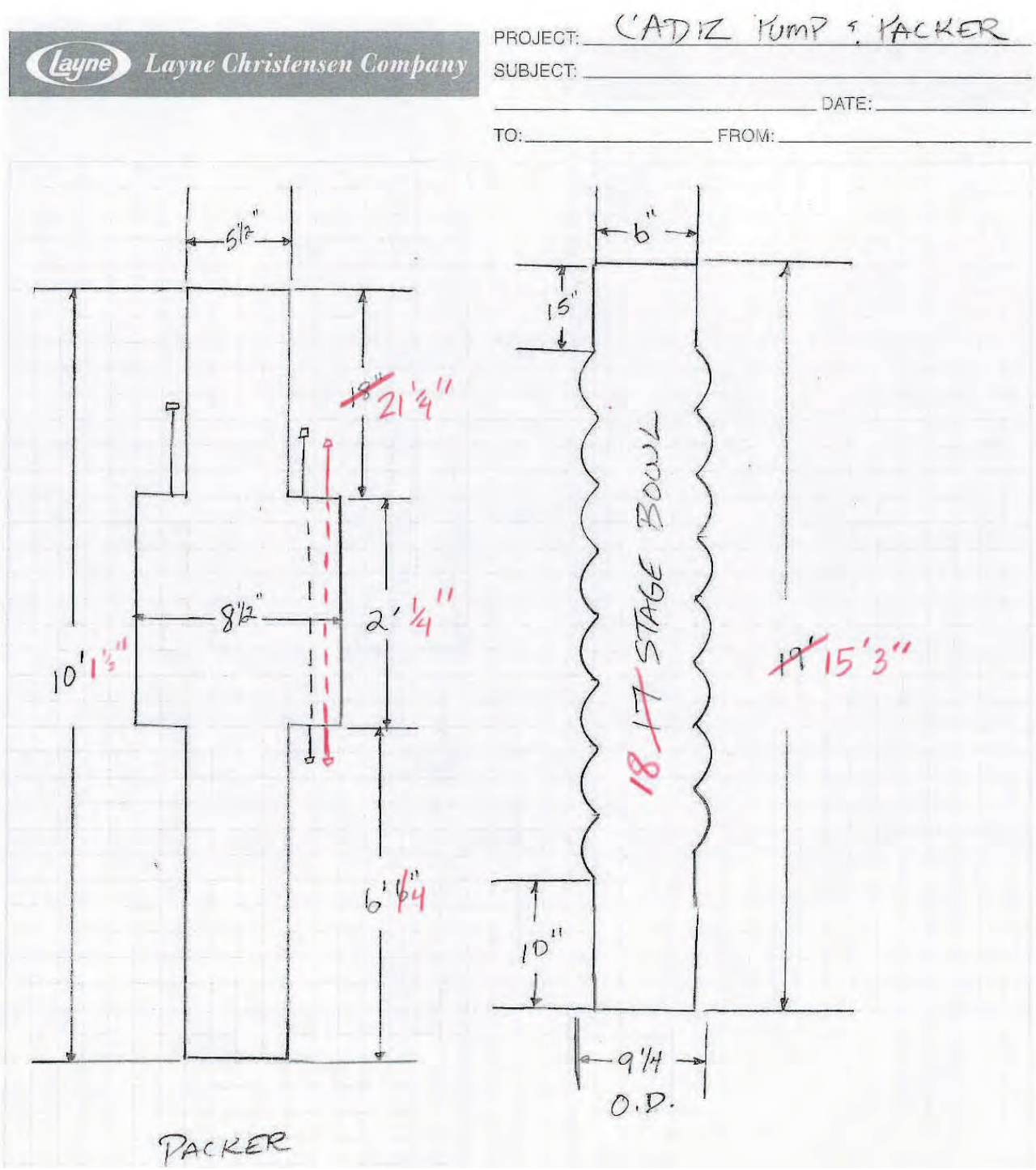
Figure
4a



Source: CH2MHill

GEOSCIENCE GEOSCIENCE Support Services, Incorporated P.O. Box 220, Claremont, CA 91711 Tel: (909) 451-6650 Fax: (909) 451-6638 www.gssiwater.com	Drawn: Checked: Approved: Date: 16-APR-10	BROWNSTEIN HYATT FARBER SCHRECK, LLP TW-1 AS BUILT DIAGRAM FROM CH2MHILL	Figure 4b

X:\Projects\Brownstein Hyatt Farber Schreck, LLP\cadiz 2009-10\00) DEW 16-Apr-2010 REPORT\02) Figures\01) FINAL FIGURES (working and PDFs)\02) Original Working Figures\Fig_4b_4-10.ai



Source: CH2MHill

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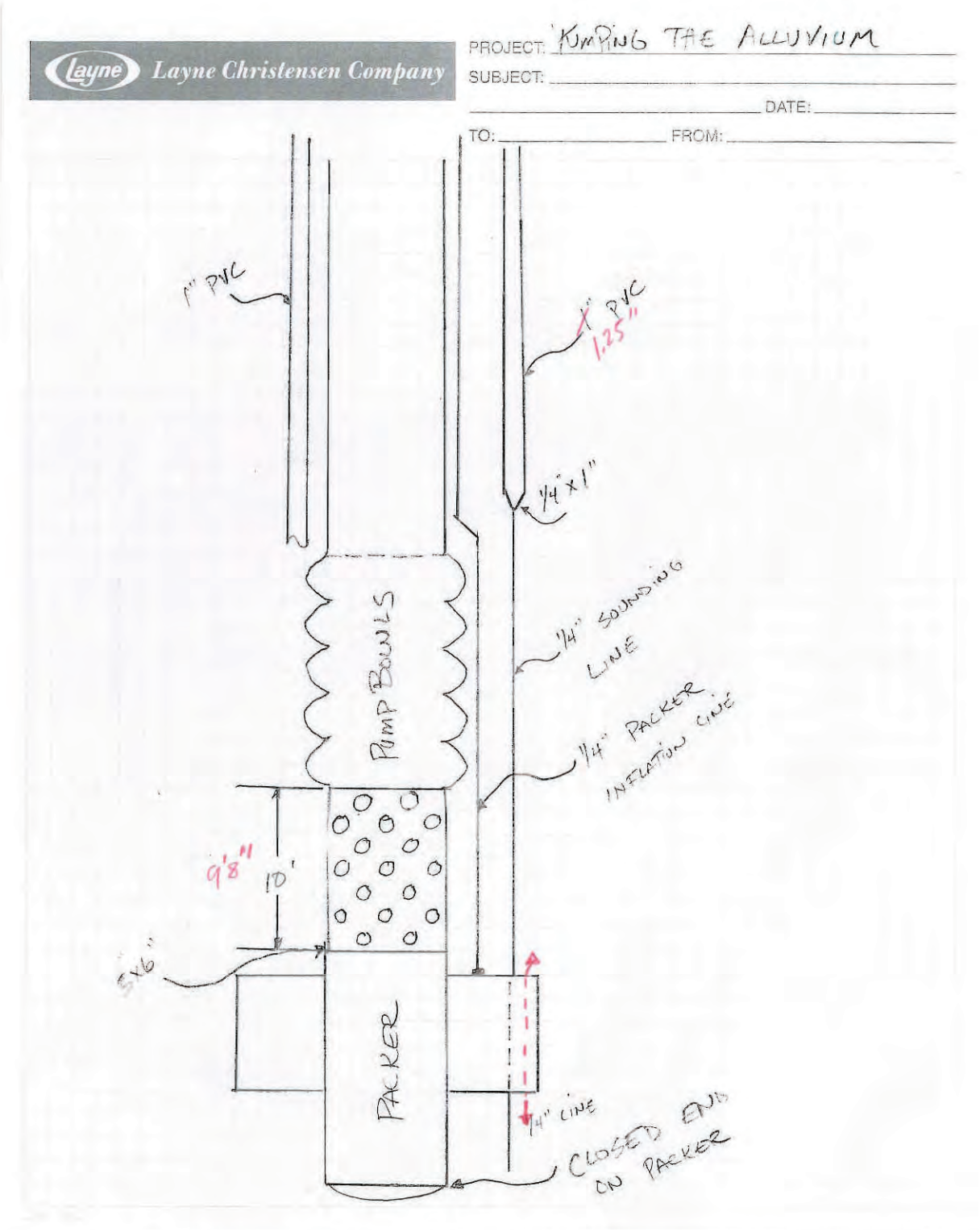
X:\Projects\Brownstein Hyatt Farber Schreck, LLP\cadiz 2009-10\00) DEW 16-Apr-2010 REPORT\02) Figures\01) FINAL FIGURES (working and PDFs)\02) Original Working Figures\Fig_4c_4-10.ai



Source: CH2MHill

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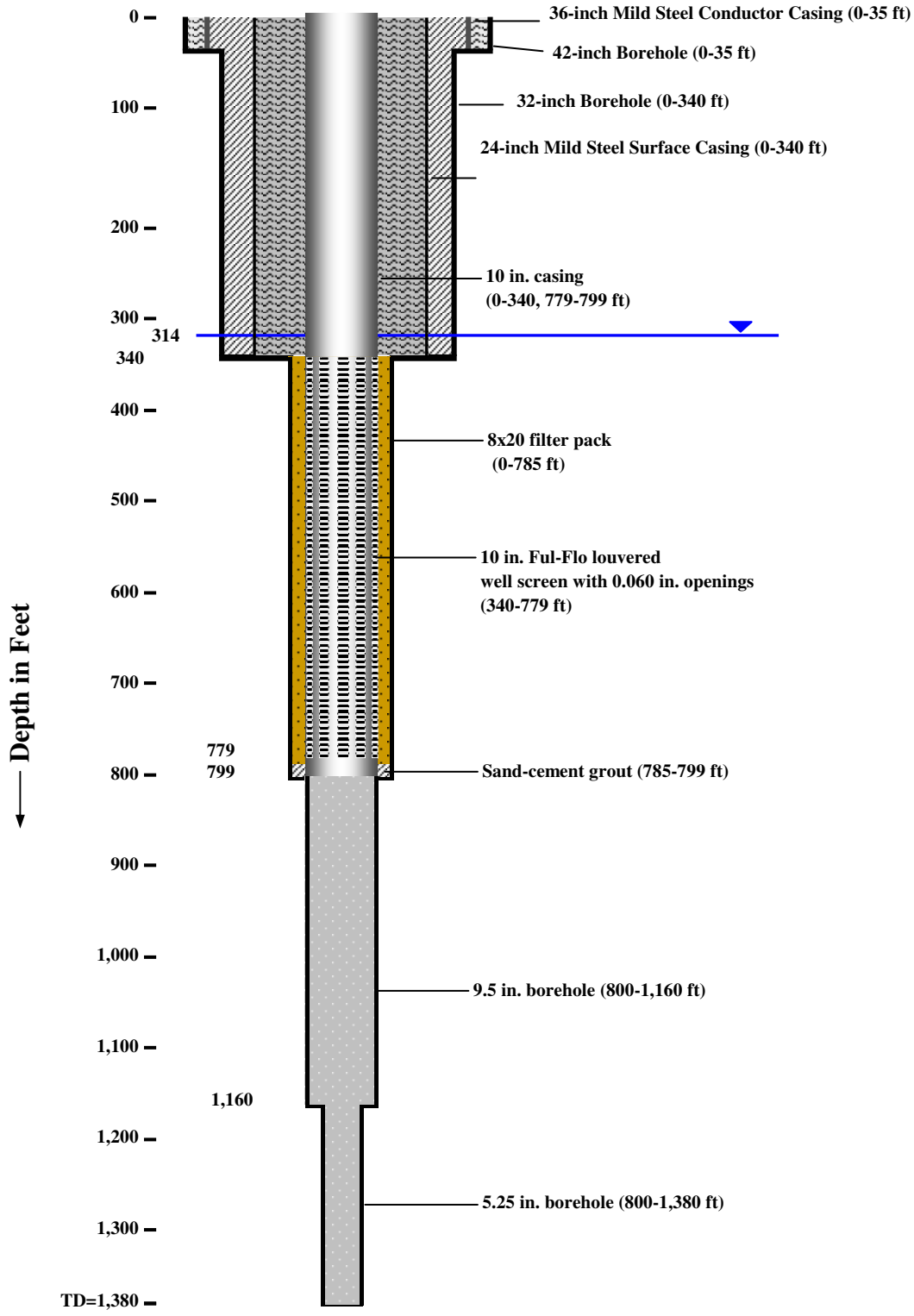
X:\Projects\Brownstein Hyatt Farber Schreck, LLP\cadiz 2009-10\00) DEW 16-Apr-2010 REPORT\02) Figures\01) FINAL FIGURES (working and PDFs)\02) Original Working Figures\Fig_4d_4-10.ai



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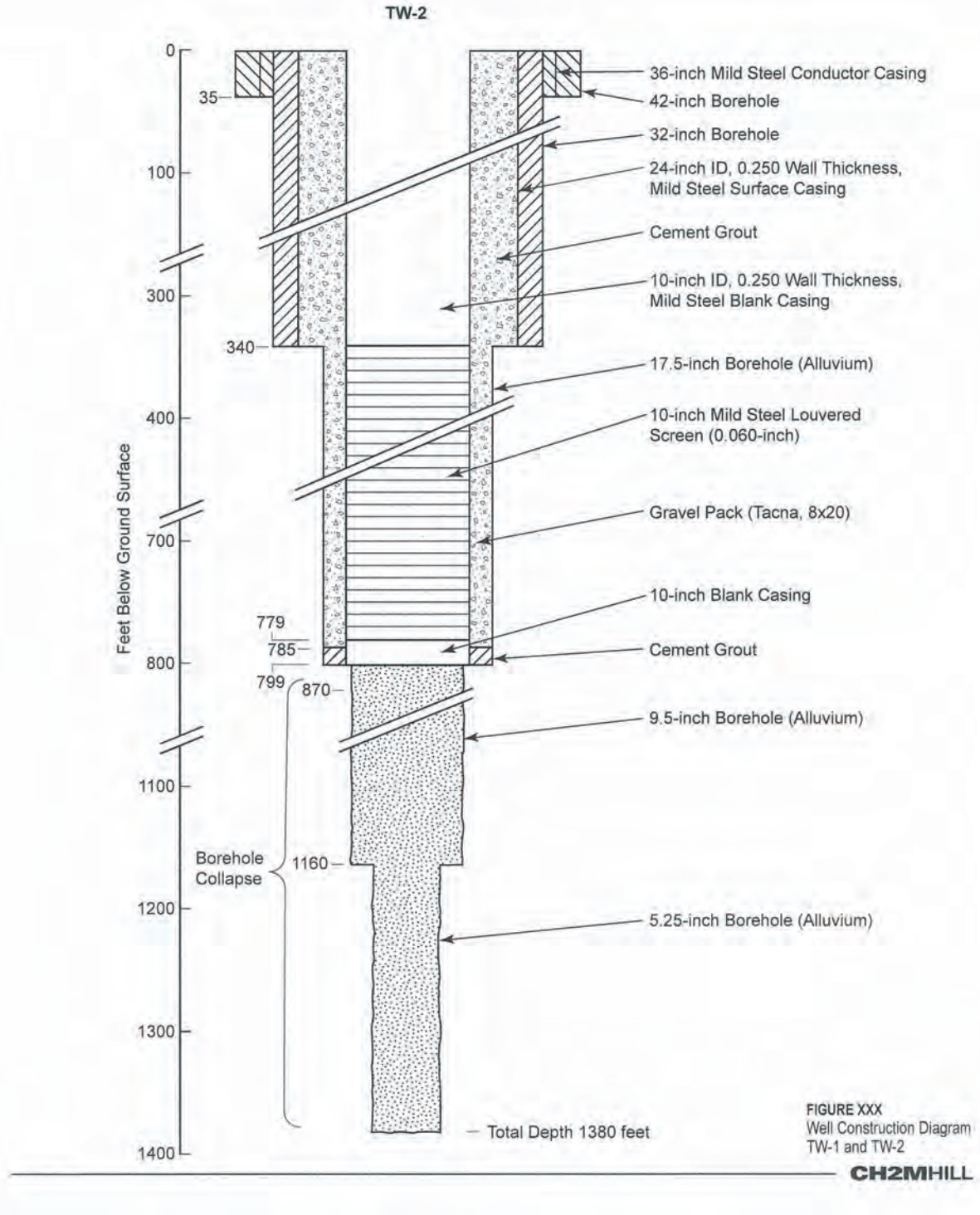
TW-2 AS BUILT DIAGRAM

Figure
5a



Source: CH2MHill

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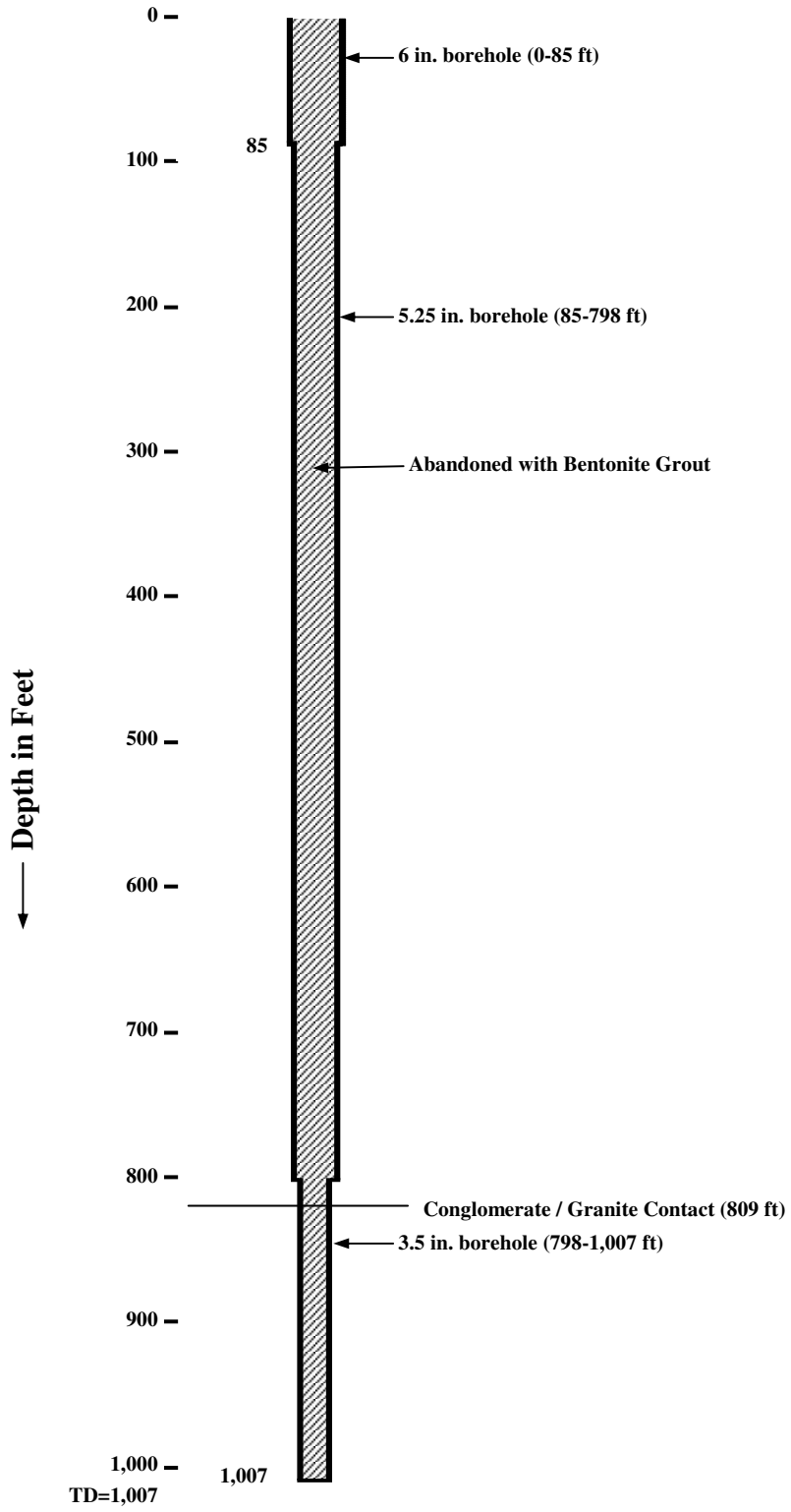

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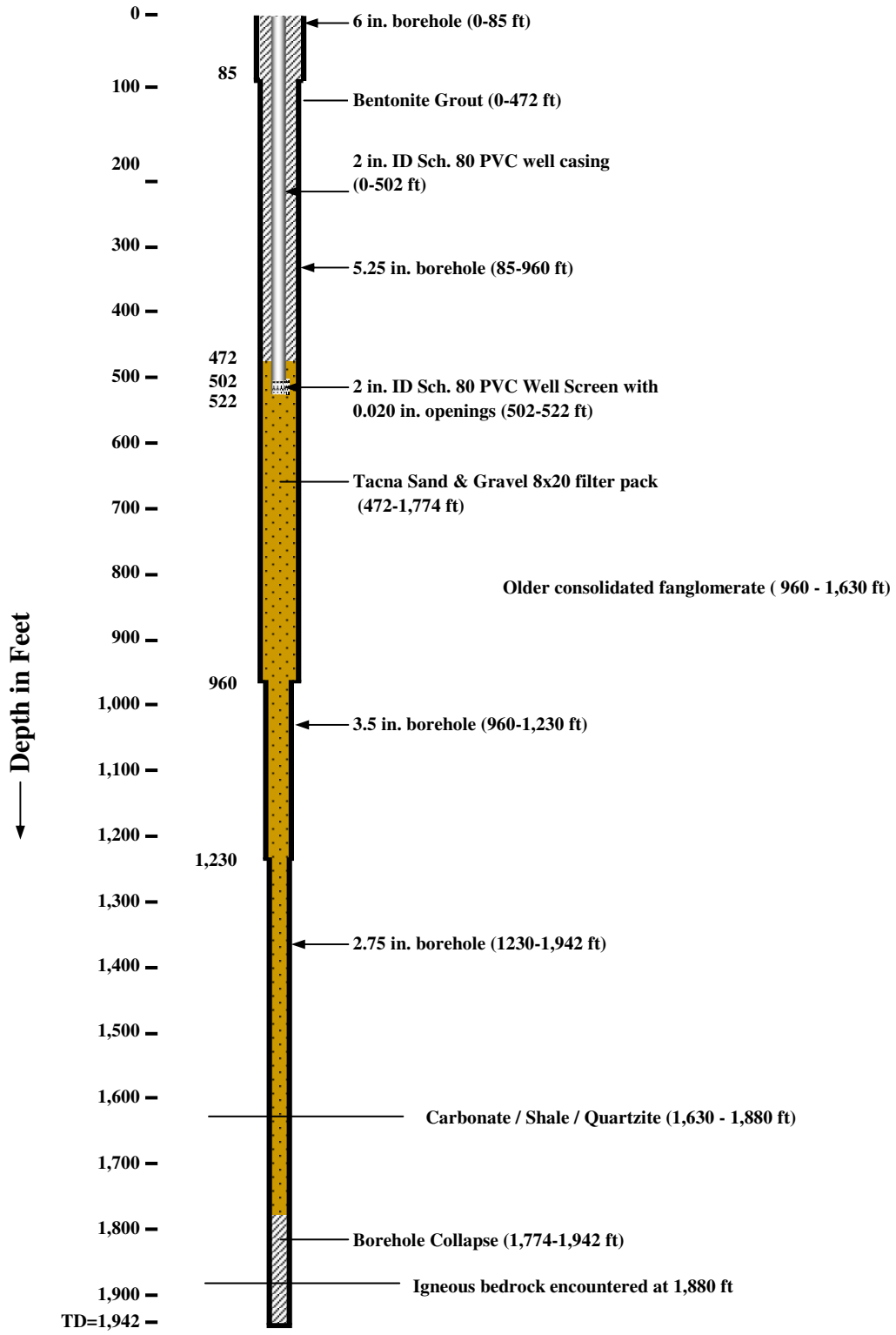
TW-2B AS BUILT DIAGRAM

Figure 6



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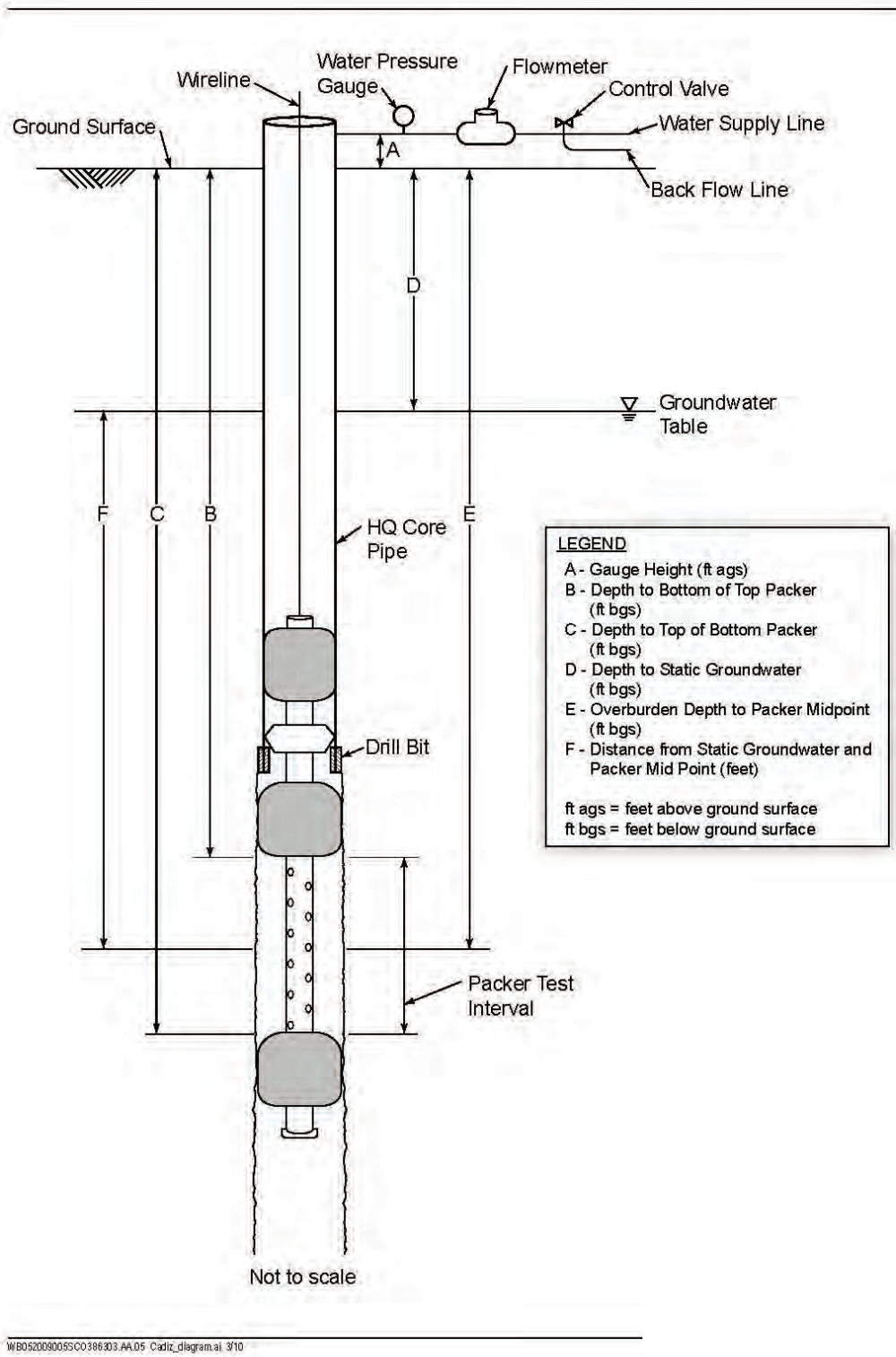
TW-3 AS BUILT DIAGRAM

Figure 7a



Source: CH2MHill

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Drawn:	BROWNSTEIN HYATT FARBER SCHRECK, LLP
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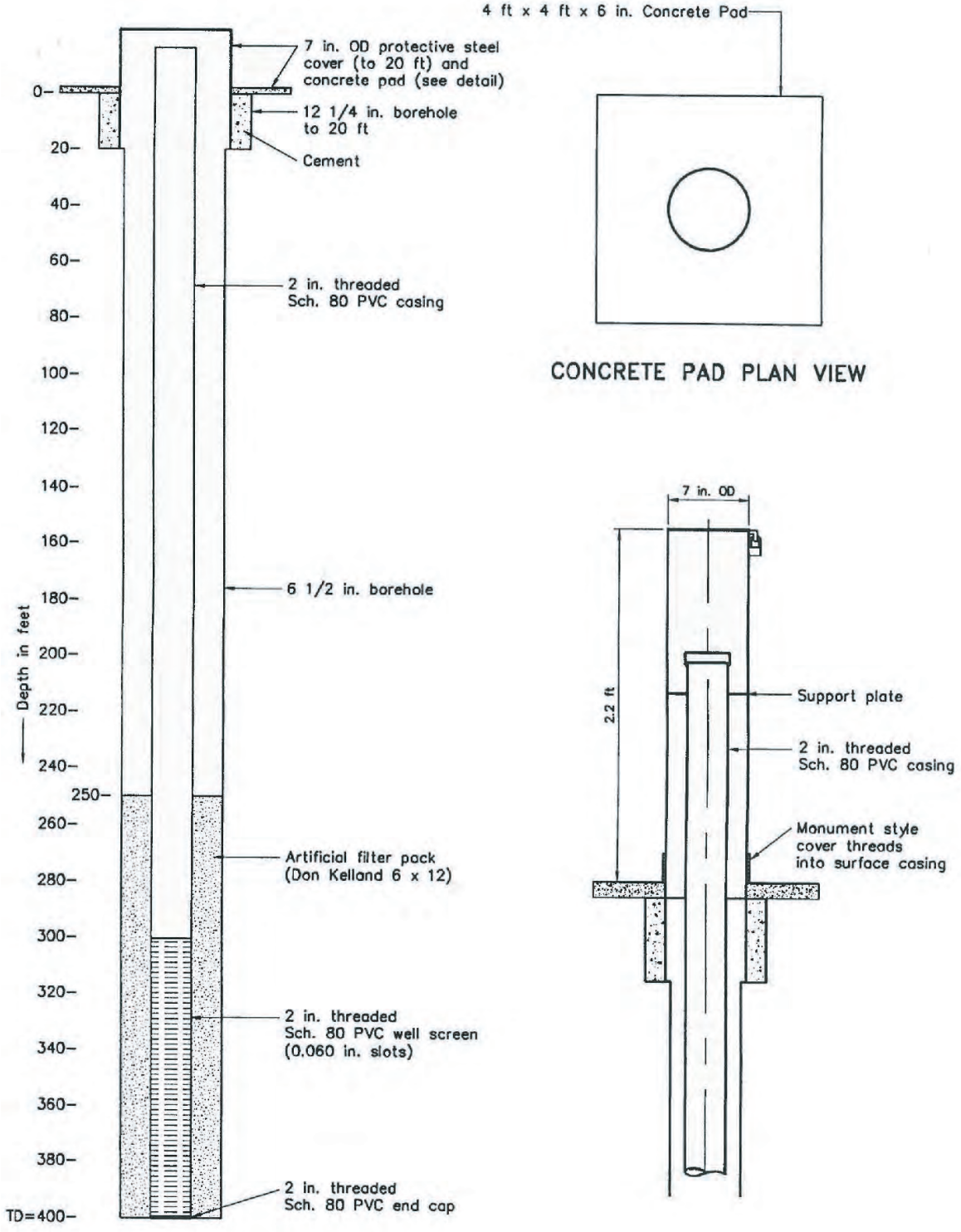
Approved:	TW-3 PACKER TEST CONFIGURATION
Date: 16-APR-10	

Figure 7b

X:\Projects\Brownstein Hyatt Farber Schreck, LLP\cadiz 2009-10\00) DEW 16-Apr-2010 REPORT\02) Figures\01) FINAL FIGURES (working and PDFs)\02) Original Working Figures\Fig_7b_TW-3_packer_4-10.ai



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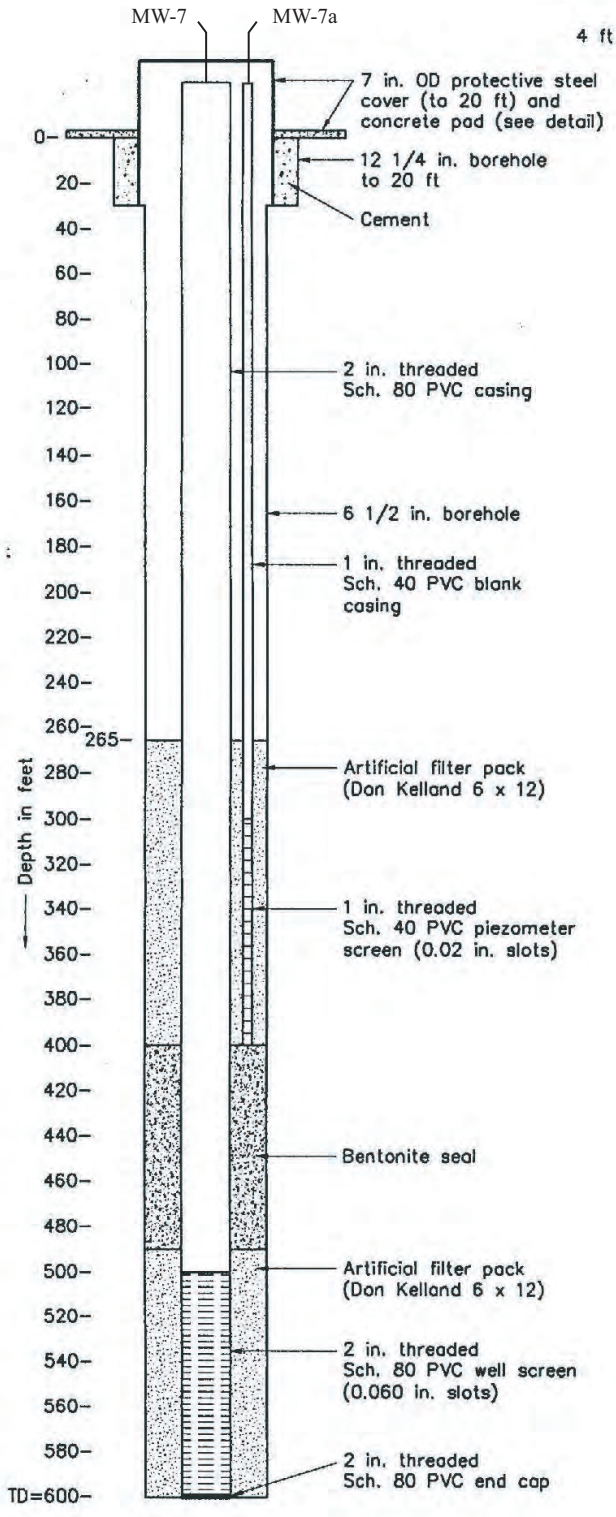
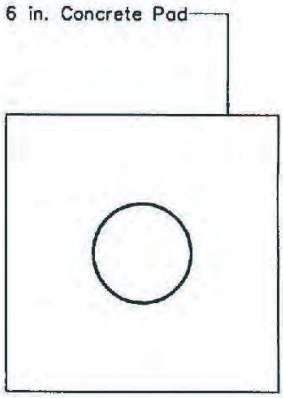
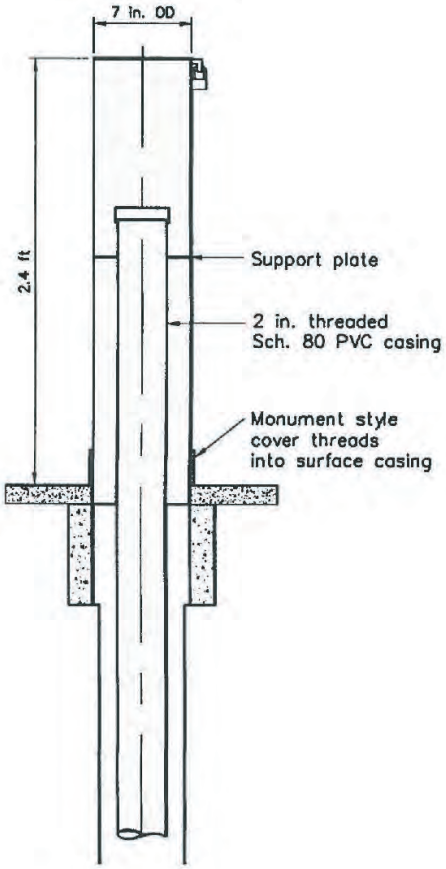


WELL CROSS SECTION



CONCRETE PAD PLAN VIEW



PROTECTIVE STEEL CASING AND CONCRETE PAD DETAIL

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Approved:	MW-7 AND 7A AS BUILT DIAGRAM
Date: 16-APR-10	

Figure 9

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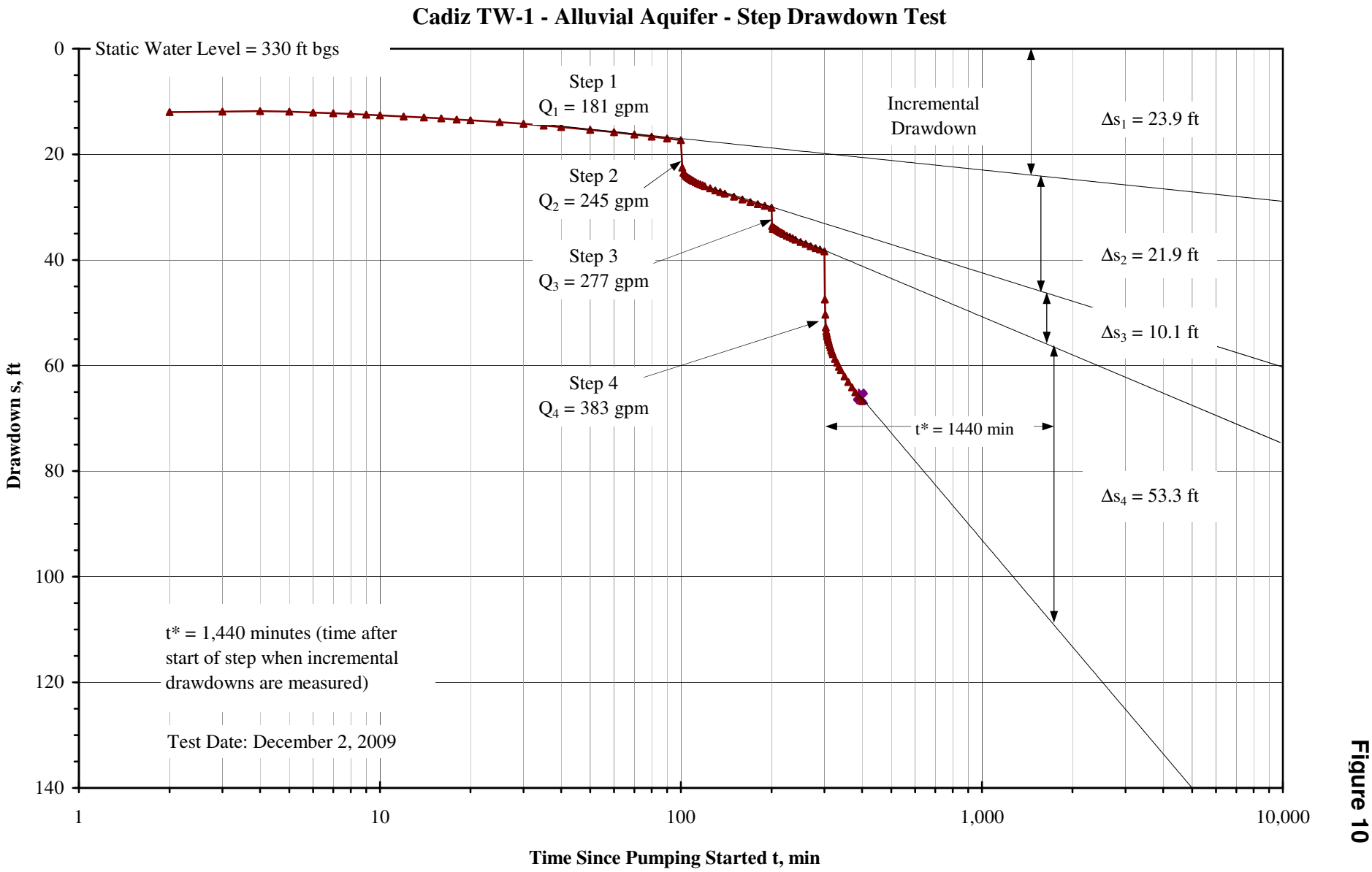

Cadiz TW-1 - Alluvial Aquifer - Step Drawdown Test
Static Water Level = 330 ft bgs
Step 1
Q1 = 181 gpm
Step 2
Q2 = 245 gpm
Step 3
Q3 = 277 gpm
Step 4
Q4 = 383 gpm
Incremental Drawdown
Δs1 = 23.9 ft
Δs2 = 21.9 ft
Δs3 = 10.1 ft
Δs4 = 53.3 ft
t* = 1440 min
t* = 1,440 minutes (time after start of step when incremental drawdowns are measured)
Test Date: December 2, 2009
Drawdown s, ft
0
20
40
60
80
100
120
140
1
10
100
1,000
10,000
Time Since Pumping Started t, min

Figure 10

Cadiz TW-1 - Alluvial Aquifer - Specific Drawdown vs. Discharge Rate

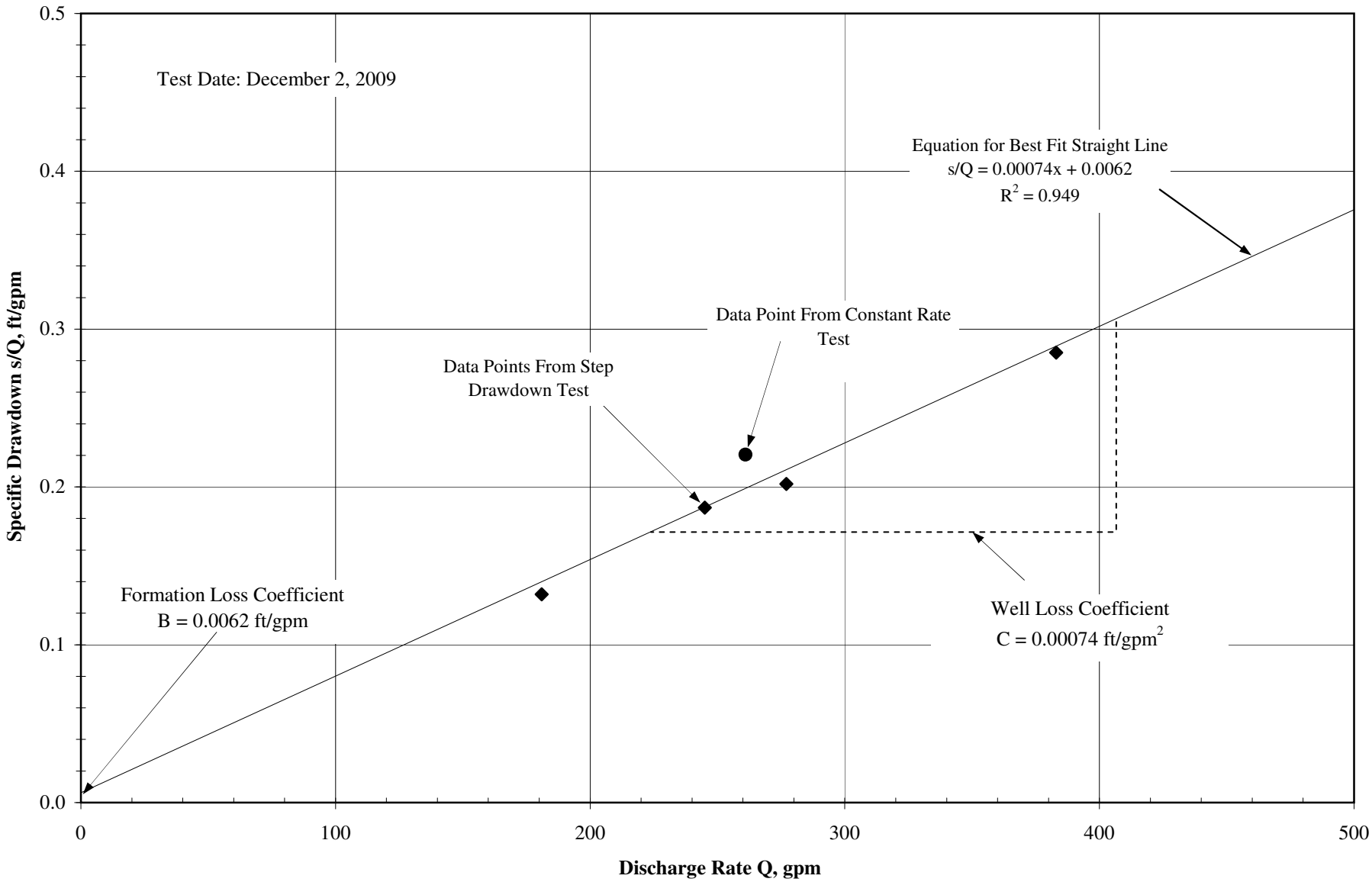


Figure 11

Cadiz TW-1 - Alluvial Aquifer - Specific Capacity and Well Efficiency Diagram

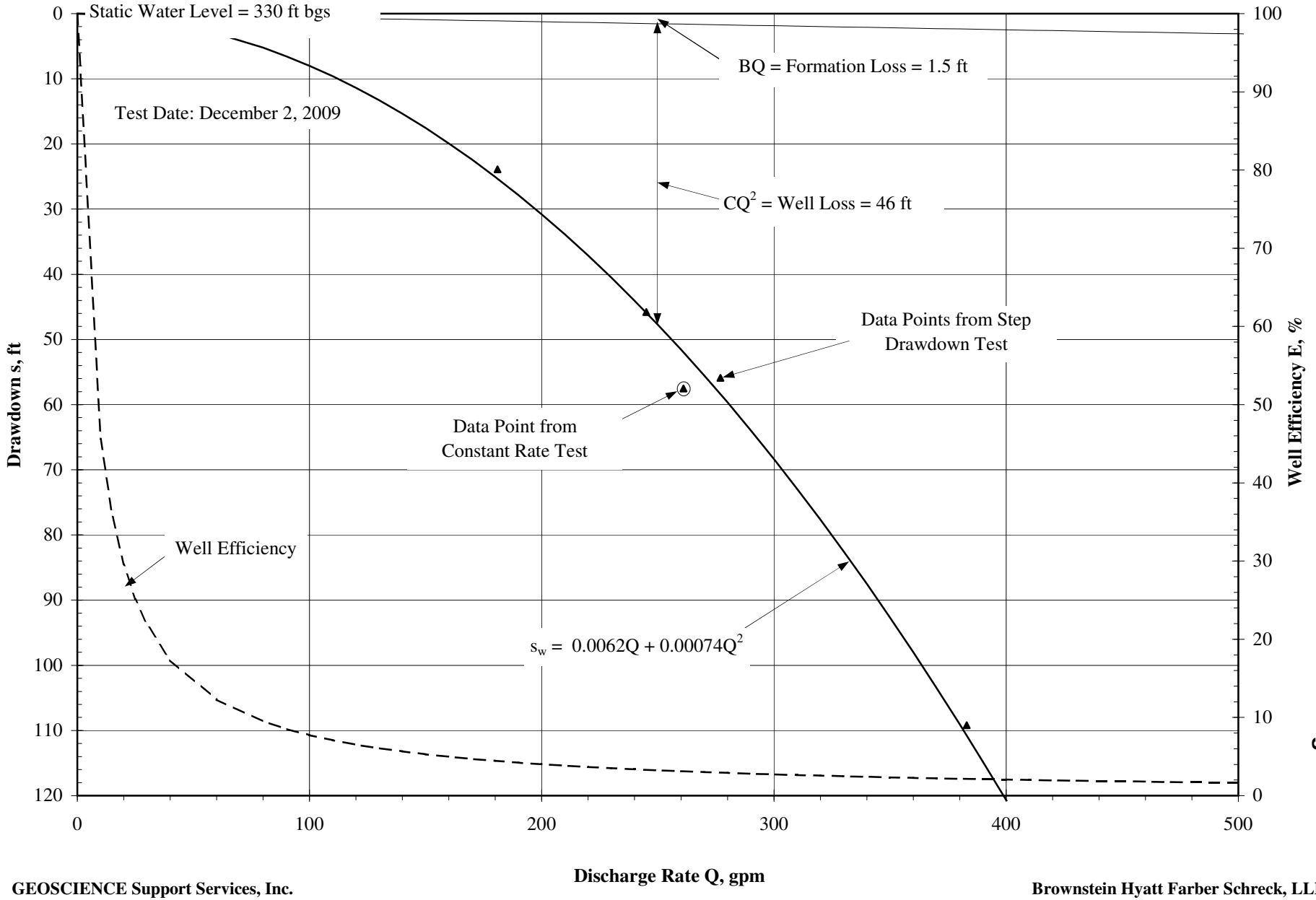


Figure 12

Cadiz TW-1 - Alluvial Aquifer - Constant Rate Test

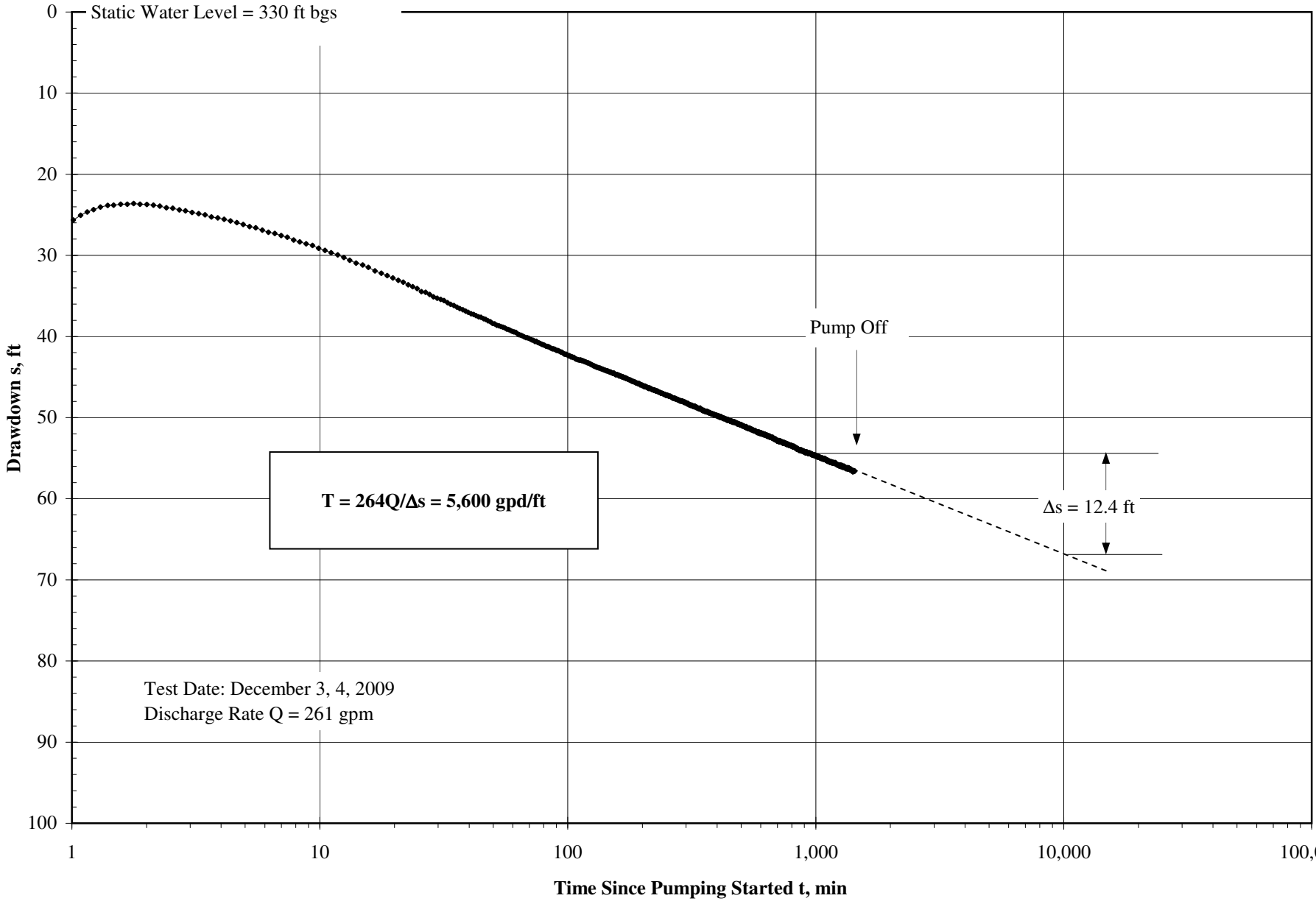


Figure 13

Cadiz MW-7a - Alluvial Aquifer - Constant Rate Test
Distance From Pumping Well TW-1 = 83 ft

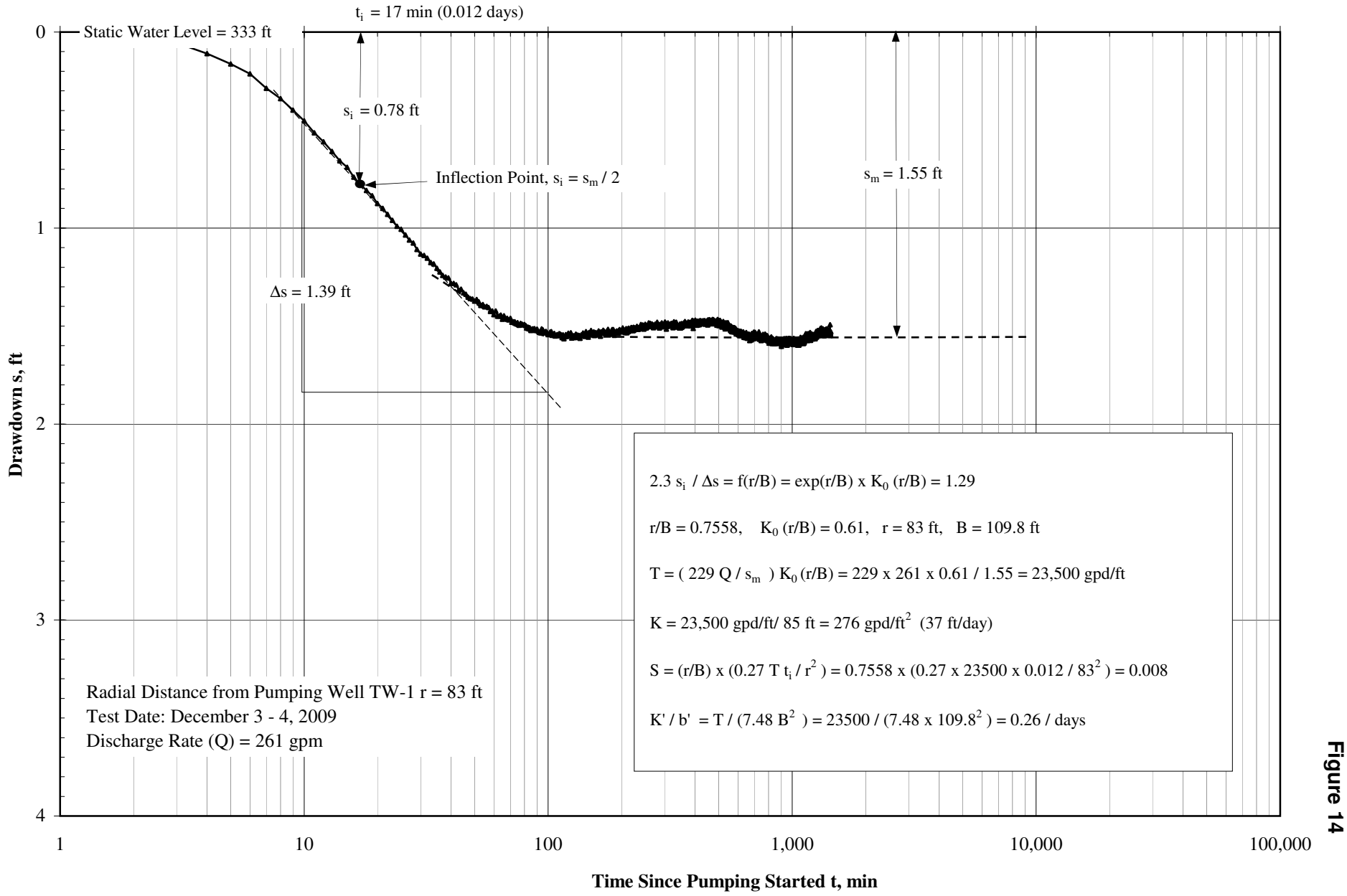


Figure 14

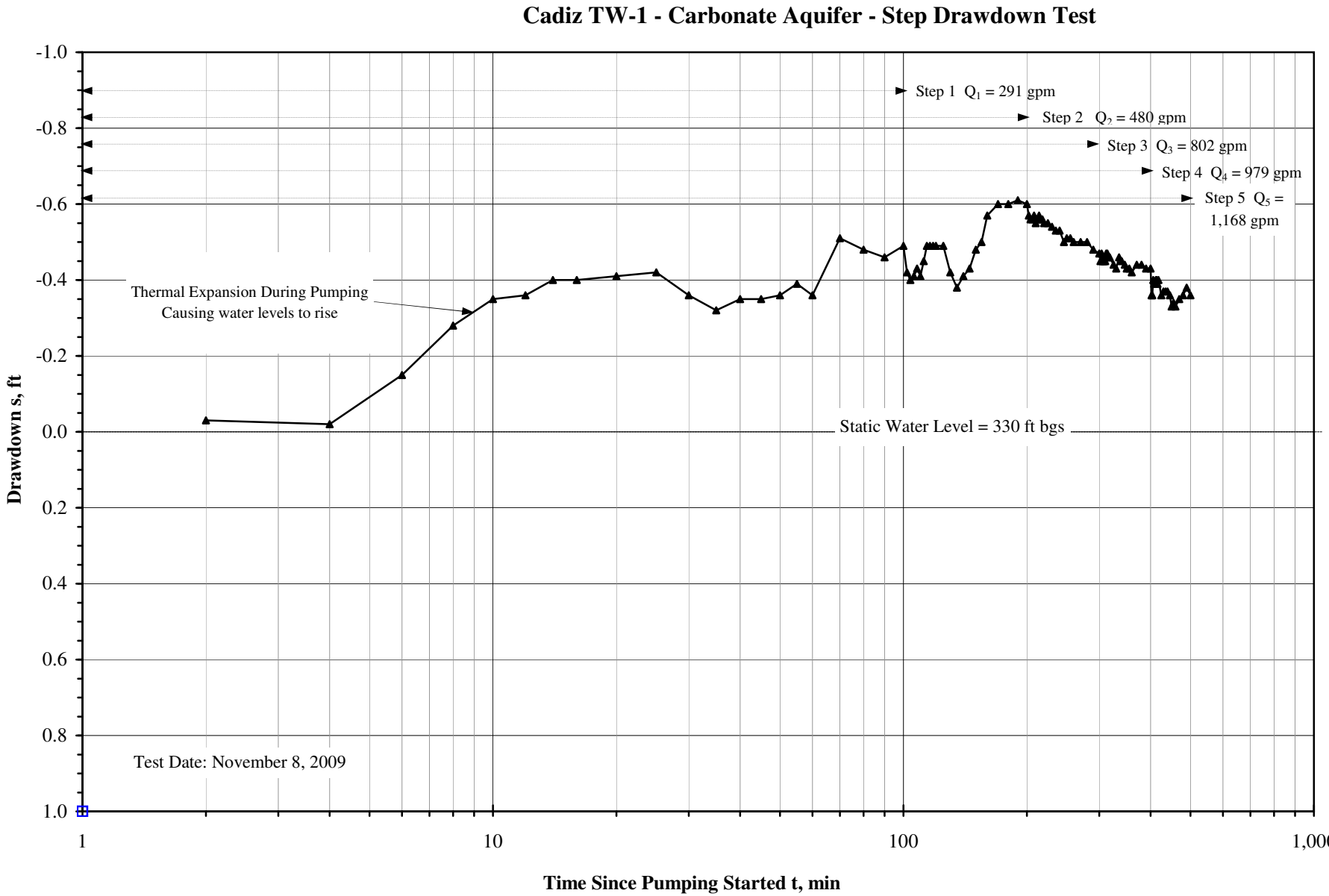
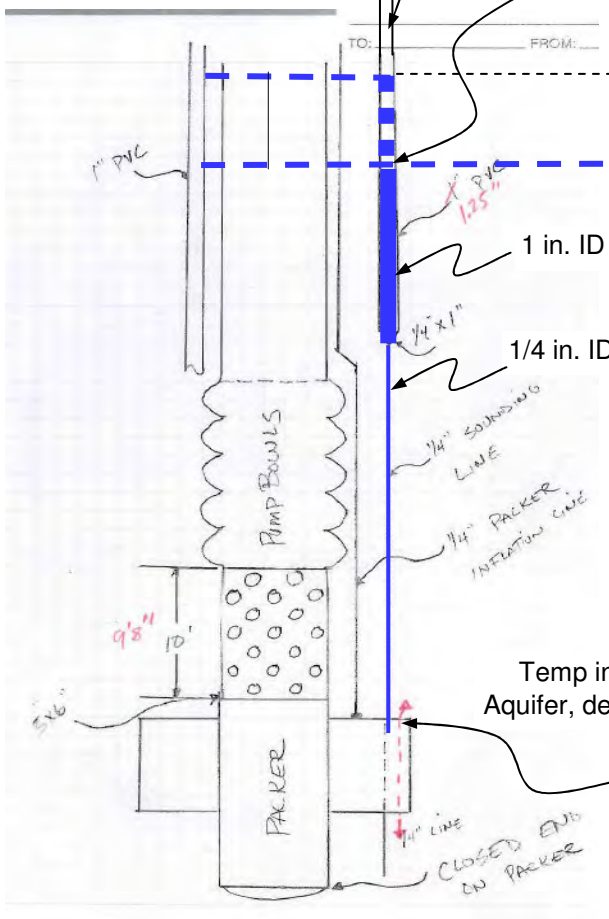

Cadiz TW-1 - Carbonate Aquifer - Step Drawdown Test
Drawdown s, ft
-1.0
-0.8
-0.6
-0.4
-0.2
0.0
0.2
0.4
0.6
0.8
1.0
1
10
100
1,000
Time Since Pumping Started t, min
Step 1 Q1 = 291 gpm
Step 2 Q2 = 480 gpm
Step 3 Q3 = 802 gpm
Step 4 Q4 = 979 gpm
Step 5 Q5 = 1,168 gpm
Thermal Expansion During Pumping
Causing water levels to rise
Static Water Level = 330 ft bgs
Test Date: November 8, 2009

Figure 15

Calculation of Thermal Expansion of Water During Pumping of Carbonate Well TW-1

$$dV = \beta \times V_0 \times dT$$

Coefficient of Volume Expansion of Water (β) = 0.00021 /deg C



Temp at SWL, deg F	deg, F	69
	deg, C	20.6
Rise in Water Level in Sounding Tube Due to Thermal Expansion, in.		5.4 in. / 0.45 ft
SWL		330.5 ft bgs
1 in. ID		
1/4 in. ID		455 ft bgs
1/4 in. ID		
Temp in Aquifer, deg F		470 ft bgs
	deg, F	100
	deg, C	37.8
	dT =	17.2 deg, C

Initial Volume (V_0), ft³

1 in. =	0.6790
1/4 in. =	0.0051
Total =	**0.6842** ft³

Change in Volume ($dV = \beta \times V_0 \times dT$), ft³ = **0.0025** ft³

Explanation: Initially, the ground water is approximately 100 deg F near the pump and bottom of the sounding tube. The temperature at the SWL depth is assumed to be ambient or close to ambient. During pumping, pumped water moves up the pump column and "warms" the annular space between the pump house casing and the pump column (including the sounding tubes), and due to thermal expansion, causes the water level to rise over 5 in. in the sounding tube.

Original Drawing from CH2MHill

Figure 16

Pumping Well TW-1 (Carbonates)
Constant Rate Test

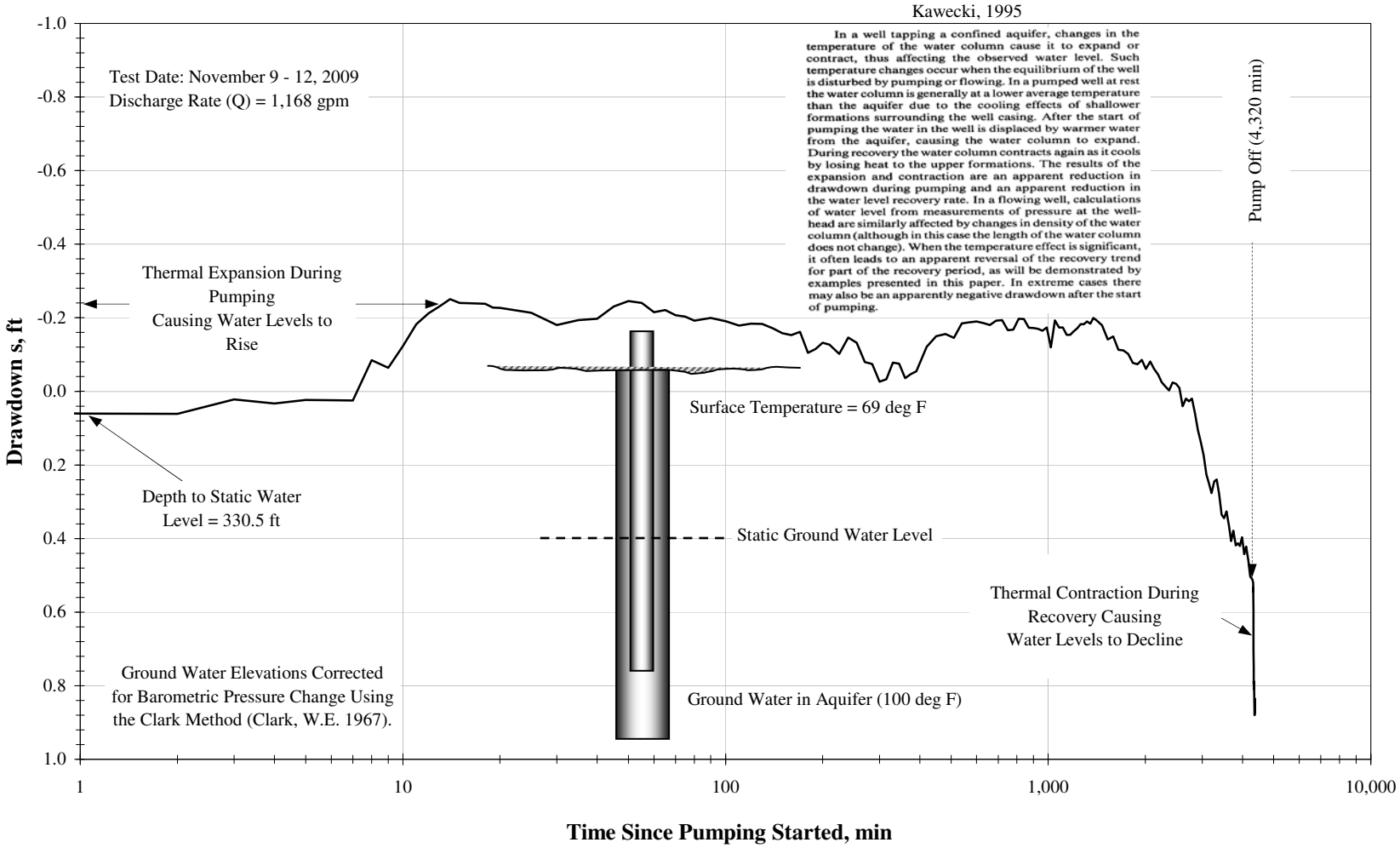


Figure 17

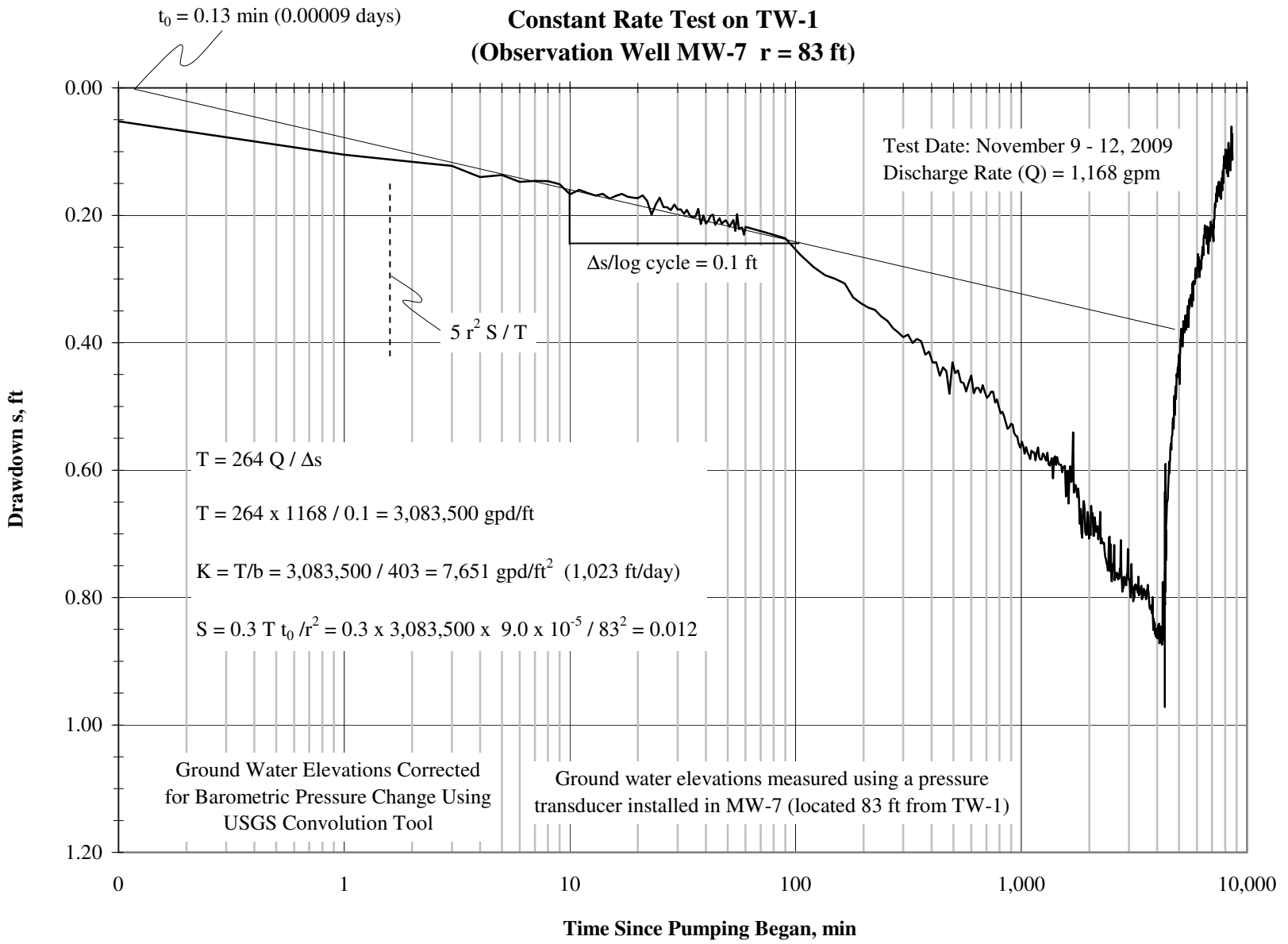

Constant Rate Test on TW-1
(Observation Well MW-7 r = 83 ft)
t_0 = 0.13 min (0.00009 days)
Test Date: November 9 - 12, 2009
Discharge Rate (Q) = 1,168 gpm
Δs/log cycle = 0.1 ft
5 r² S / T
T = 264 Q / Δs
T = 264 x 1168 / 0.1 = 3,083,500 gpd/ft
K = T/b = 3,083,500 / 403 = 7,651 gpd/ft² (1,023 ft/day)
S = 0.3 T t_0 /r² = 0.3 x 3,083,500 x 9.0 x 10⁻⁵ / 83² = 0.012
Ground Water Elevations Corrected for Barometric Pressure Change Using USGS Convolution Tool
Ground water elevations measured using a pressure transducer installed in MW-7 (located 83 ft from TW-1)
Drawdown s, ft
0.00
0.20
0.40
0.60
0.80
1.00
1.20
0
1
10
100
1,000
10,000
Time Since Pumping Began, min

Figure 18

Constant Rate Test on TW-1
Observation Well MW-7
r = 83 ft

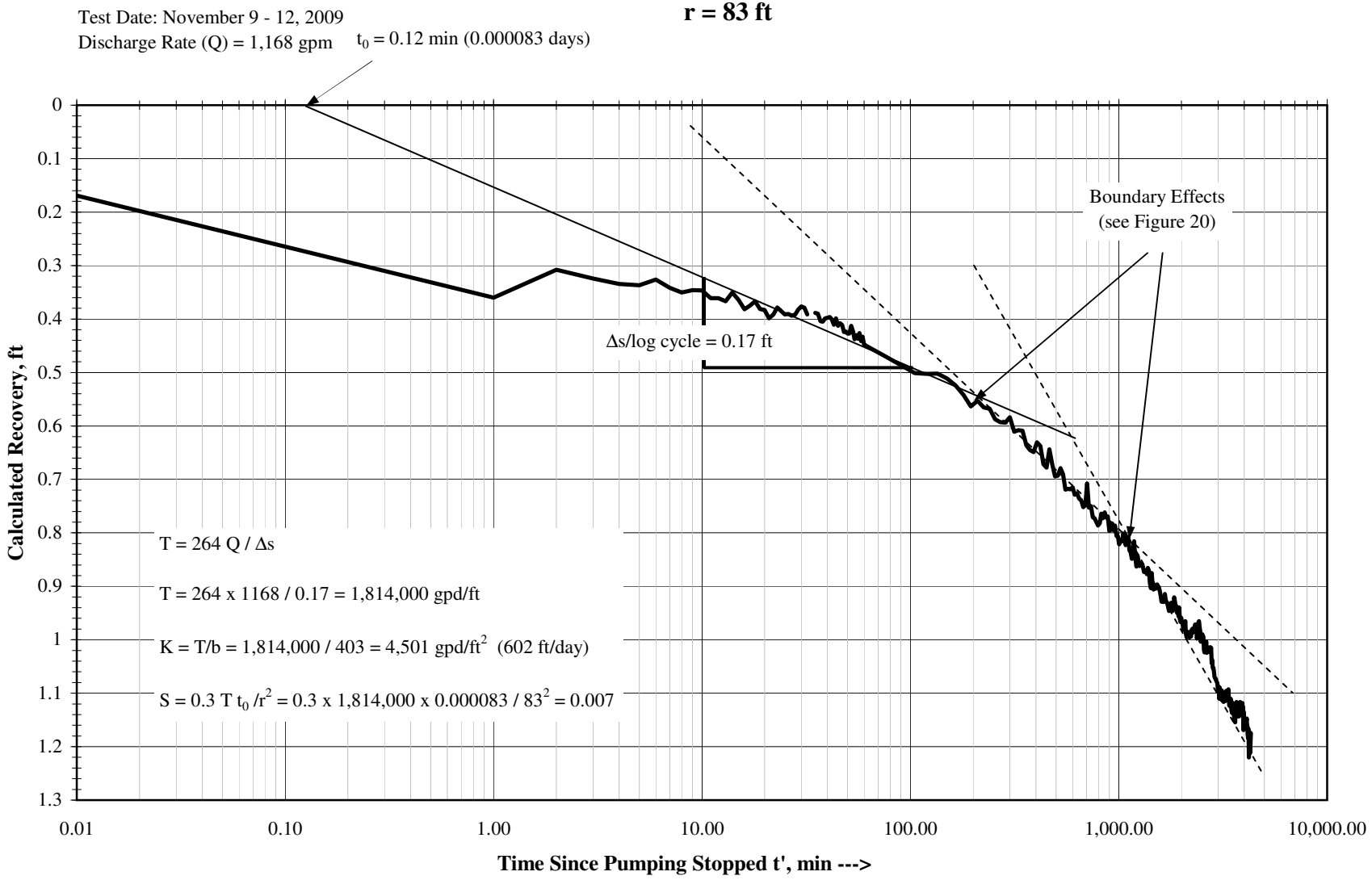
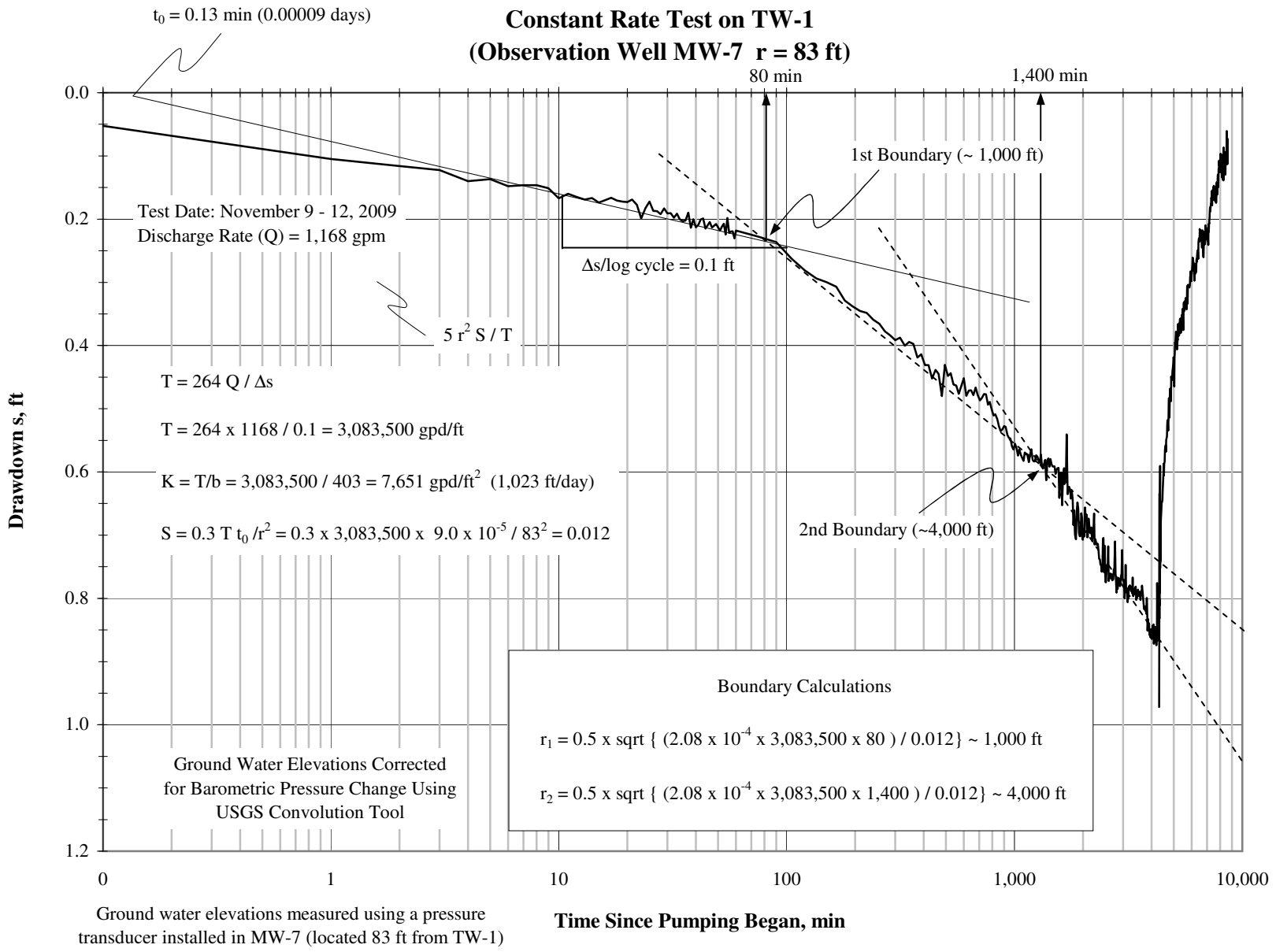


Figure 19



Ground water elevations measured using a pressure transducer installed in MW-7 (located 83 ft from TW-1)

Figure 20

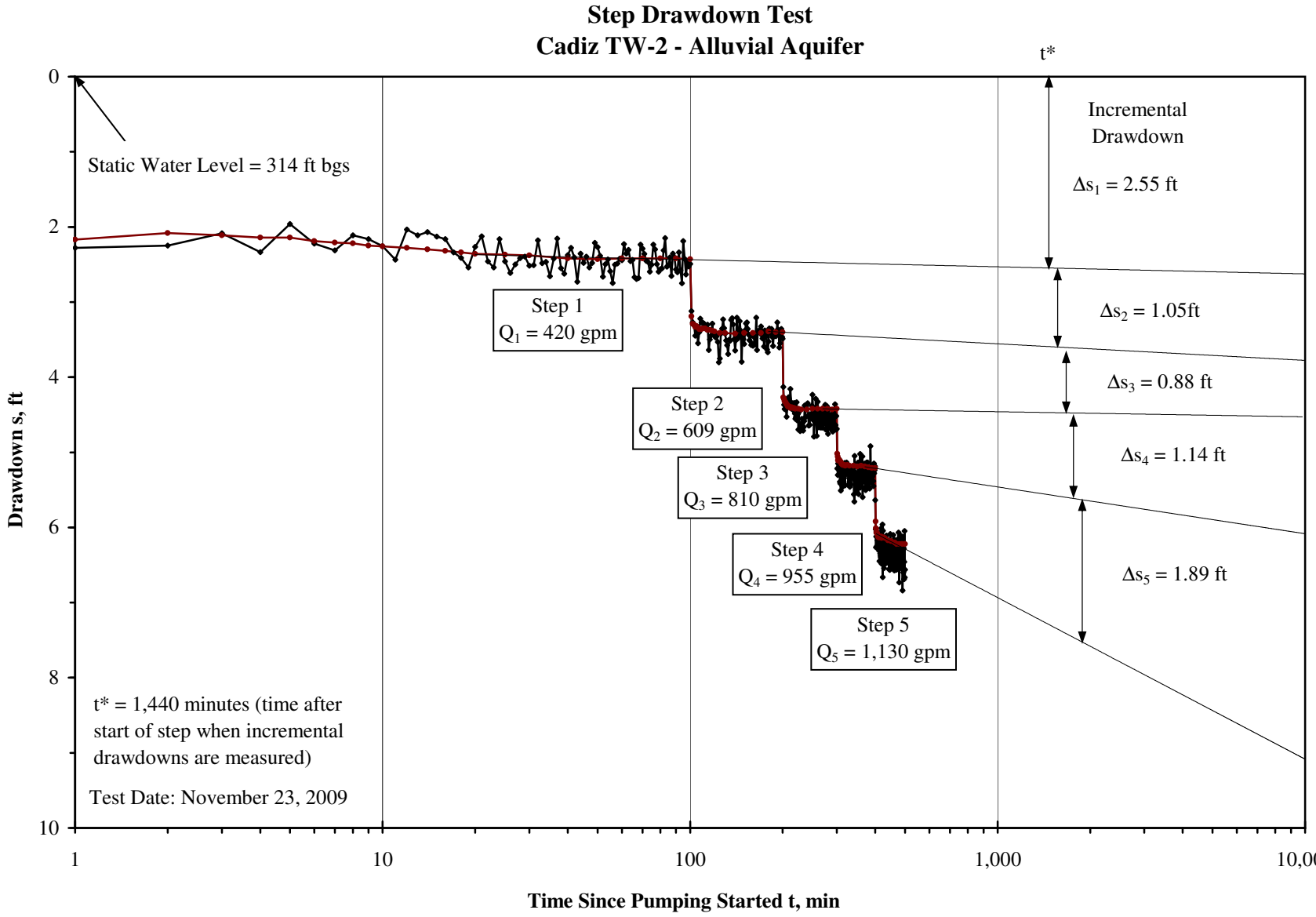

Step Drawdown Test
Cadiz TW-2 - Alluvial Aquifer
t*
Incremental Drawdown
Δs1 = 2.55 ft
Static Water Level = 314 ft bgs
Step 1
Q1 = 420 gpm
Δs2 = 1.05ft
Step 2
Q2 = 609 gpm
Δs3 = 0.88 ft
Step 3
Q3 = 810 gpm
Δs4 = 1.14 ft
Step 4
Q4 = 955 gpm
Δs5 = 1.89 ft
Step 5
Q5 = 1,130 gpm
t* = 1,440 minutes (time after start of step when incremental drawdowns are measured)
Test Date: November 23, 2009
Drawdown s, ft
0
2
4
6
8
10
1
10
100
1,000
10,000
Time Since Pumping Started t, min

Figure 21

Specific Drawdown Graph
Cadiz - TW-2 Alluvial Aquifer

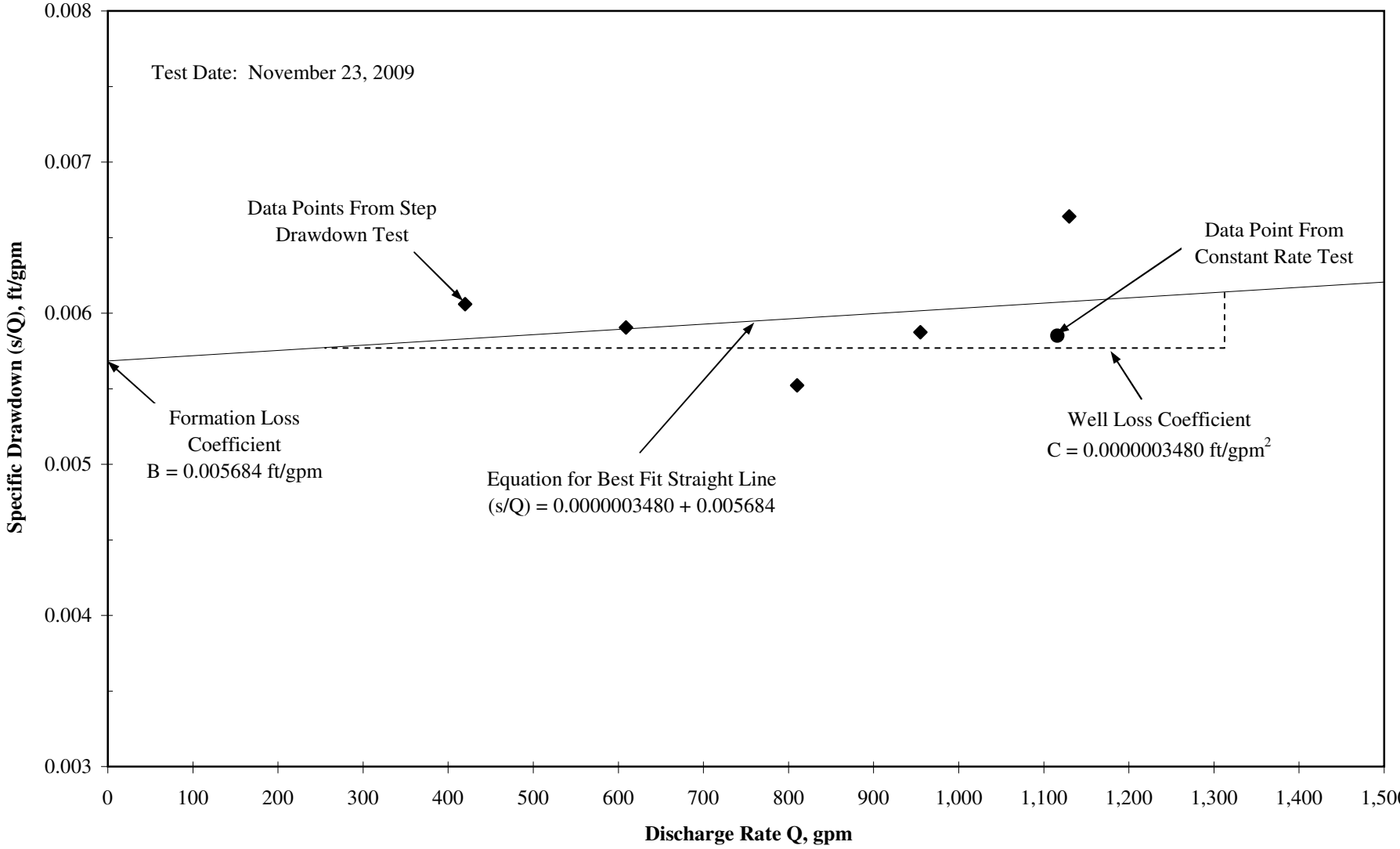


Figure 22

Specific Capacity and Well Efficiency Diagram
Cadiz TW-2 - Alluvium

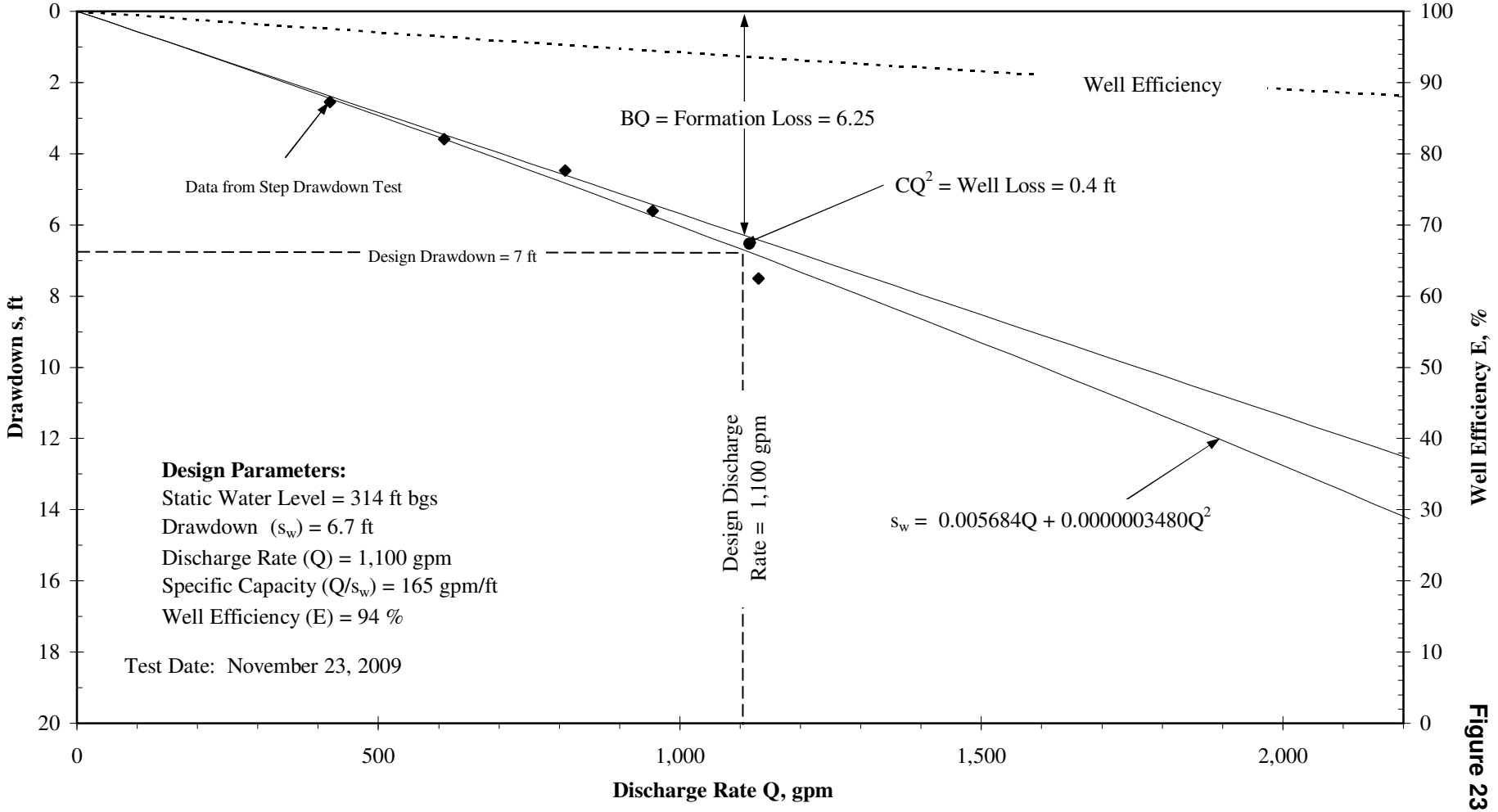


Figure 23

Constant Rate Pumping Test
Cadiz TW-2 - Alluvial Aquifer

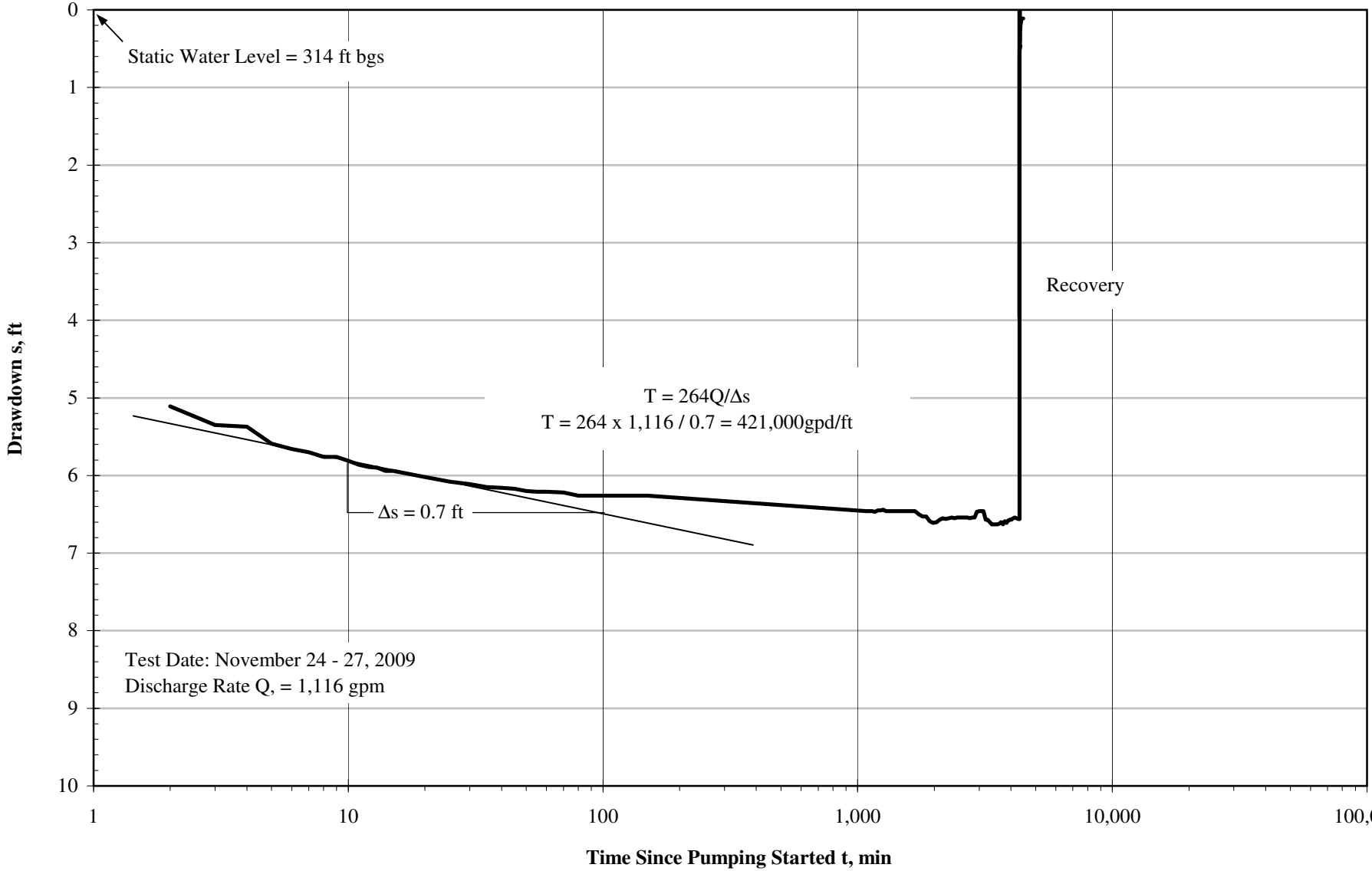


Figure 24

Calculated Recovery
Cadiz TW-2 - Alluvial Aquifer

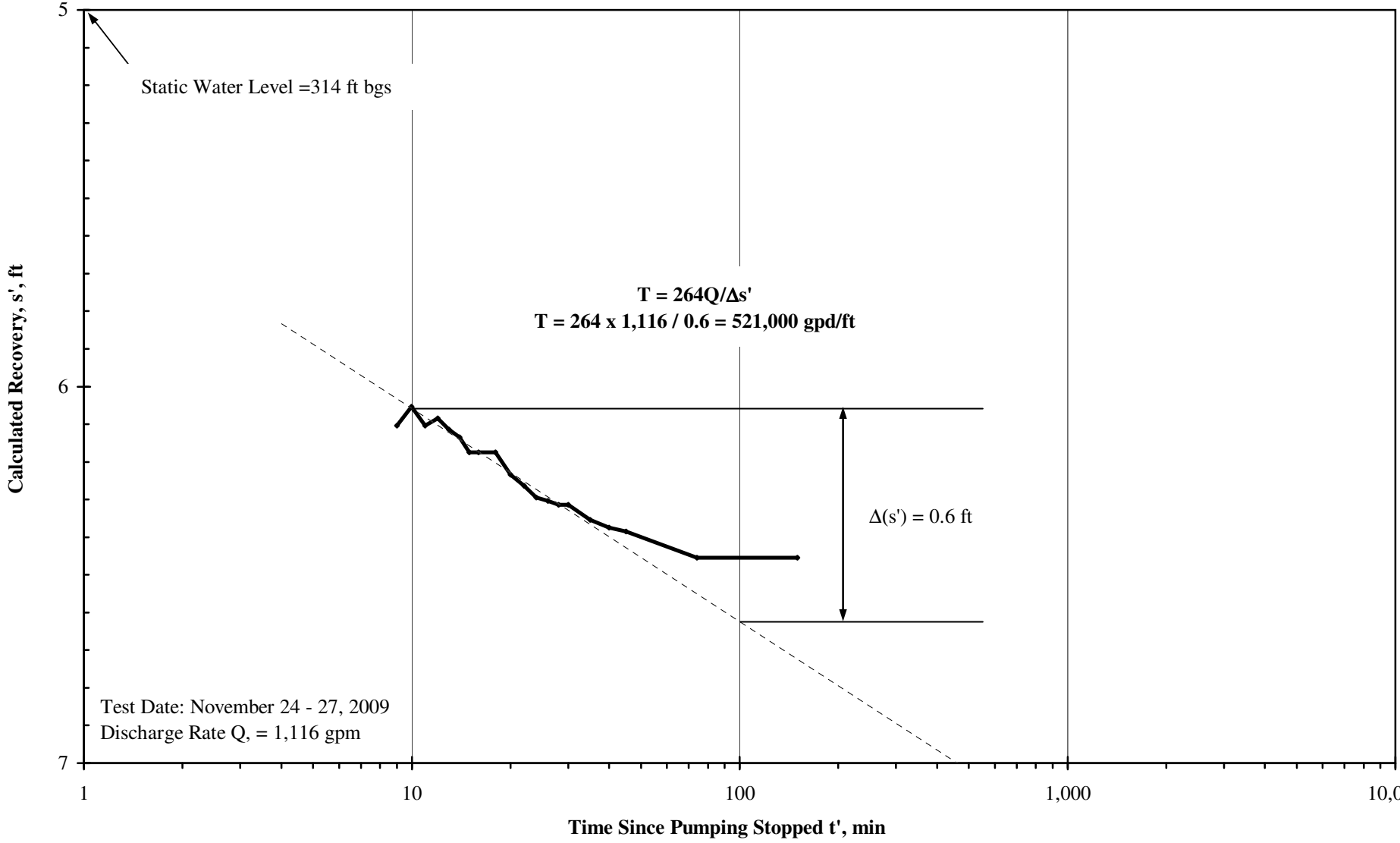


Figure 25

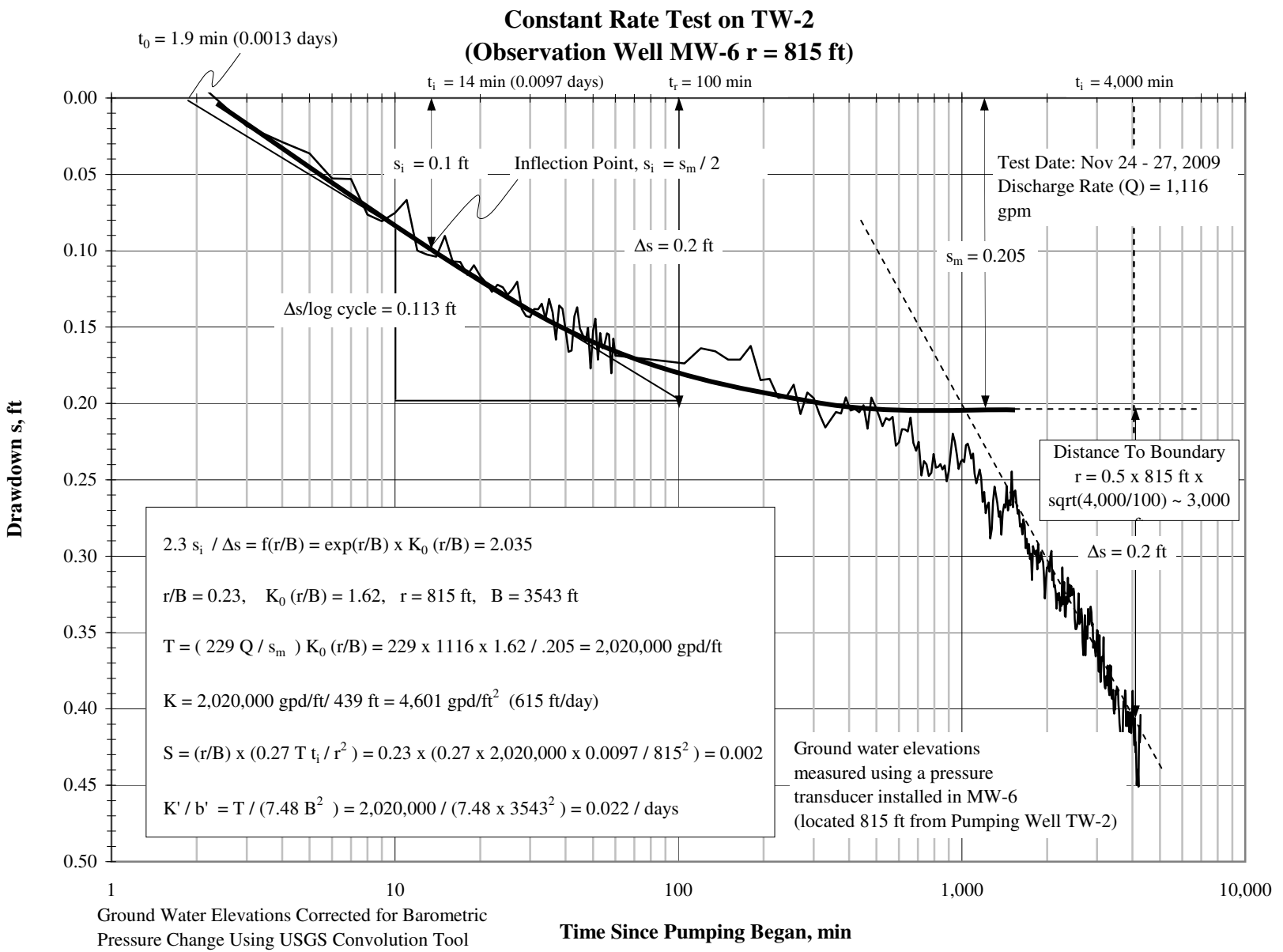

Constant Rate Test on TW-2
(Observation Well MW-6 r = 815 ft)
t_0 = 1.9 min (0.0013 days)
t_i = 14 min (0.0097 days)
t_r = 100 min
t_i = 4,000 min
s_i = 0.1 ft
Inflection Point, $s_i = s_m / 2$
Test Date: Nov 24 - 27, 2009
Discharge Rate (Q) = 1,116 gpm
Δs = 0.2 ft
s_m = 0.205
Δs/log cycle = 0.113 ft
Distance To Boundary
r = 0.5 x 815 ft x sqrt(4,000/100) ~ 3,000
Δs = 0.2 ft
2.3 s_i / Δs = f(r/B) = exp(r/B) x K_0 (r/B) = 2.035
r/B = 0.23, K_0 (r/B) = 1.62, r = 815 ft, B = 3543 ft
T = (229 Q / s_m) K_0 (r/B) = 229 x 1116 x 1.62 / .205 = 2,020,000 gpd/ft
K = 2,020,000 gpd/ft/ 439 ft = 4,601 gpd/ft^2 (615 ft/day)
S = (r/B) x (0.27 T t_i / r^2) = 0.23 x (0.27 x 2,020,000 x 0.0097 / 815^2) = 0.002
K' / b' = T / (7.48 B^2) = 2,020,000 / (7.48 x 3543^2) = 0.022 / days
Ground water elevations measured using a pressure transducer installed in MW-6 (located 815 ft from Pumping Well TW-2)
Drawdown s, ft
0.00
0.05
0.10
0.15
0.20
0.25
0.30
0.35
0.40
0.45
0.50
1
10
100
1,000
10,000
Ground Water Elevations Corrected for Barometric Pressure Change Using USGS Convolution Tool
Time Since Pumping Began, min

Figure 26

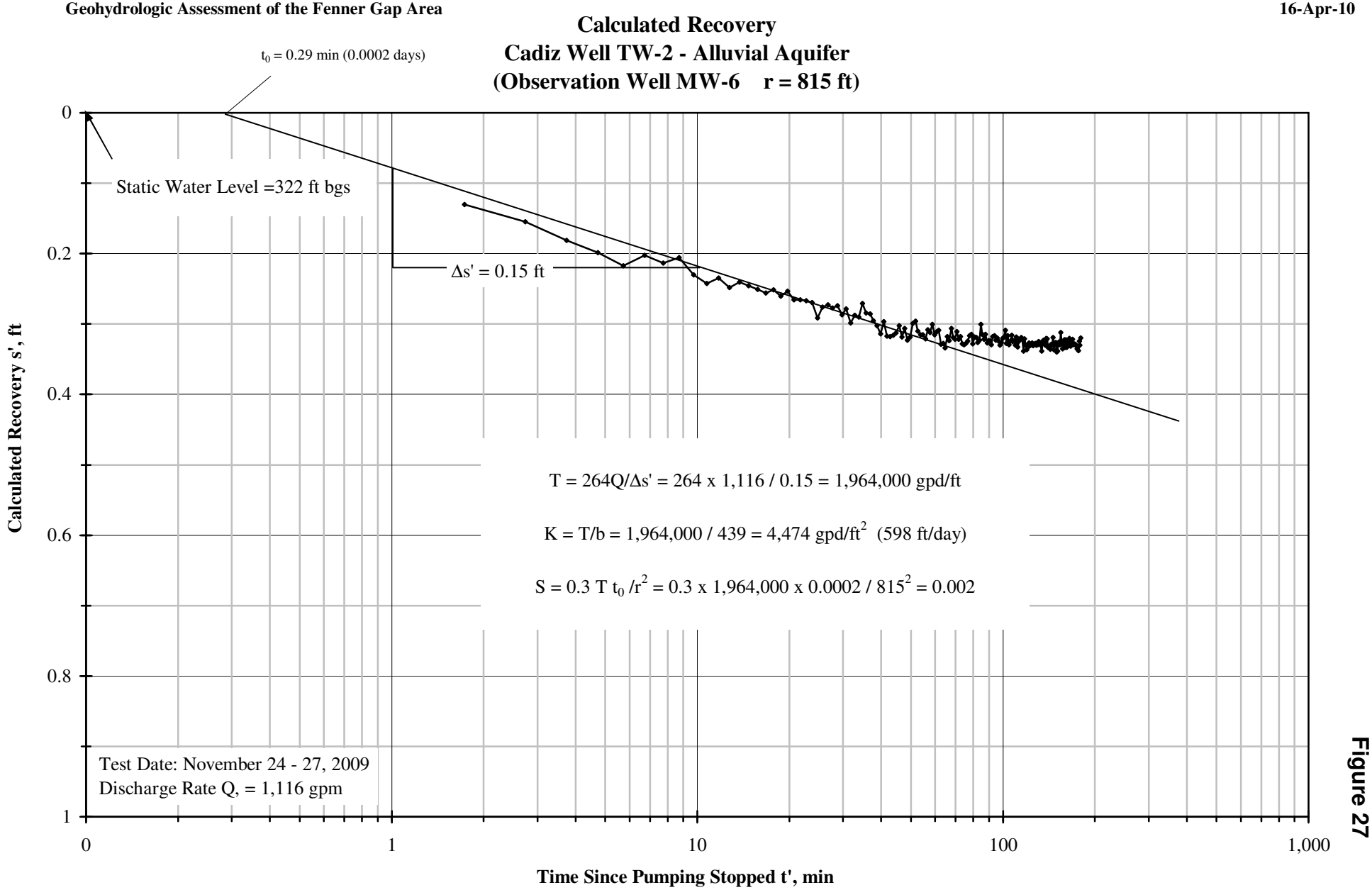
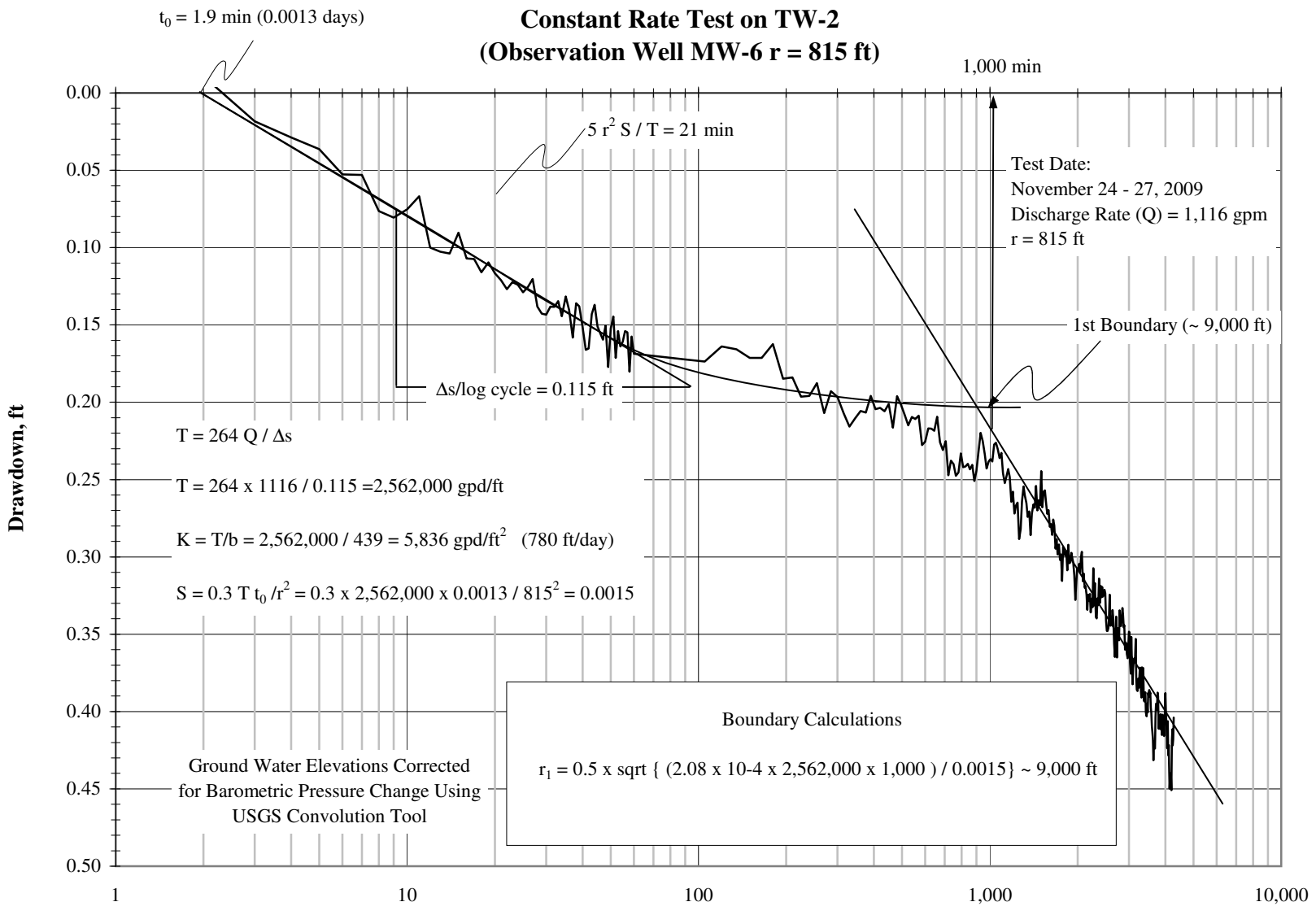

Calculated Recovery
Cadiz Well TW-2 - Alluvial Aquifer
(Observation Well MW-6 r = 815 ft)
t_0 = 0.29 min (0.0002 days)
Static Water Level =322 ft bgs
Δs' = 0.15 ft
T = 264Q/Δs' = 264 x 1,116 / 0.15 = 1,964,000 gpd/ft
K = T/b = 1,964,000 / 439 = 4,474 gpd/ft^2 (598 ft/day)
S = 0.3 T t_0 /r^2 = 0.3 x 1,964,000 x 0.0002 / 815^2 = 0.002
Test Date: November 24 - 27, 2009
Discharge Rate Q, = 1,116 gpm
Calculated Recovery s', ft
0
0.2
0.4
0.6
0.8
1
0
1
10
100
1,000
Time Since Pumping Stopped t', min

Figure 27



Ground water elevations measured using a pressure transducer installed in MW-6 (located 815 ft from Pumping Well TW-2)

Figure 28

Sensitivity of Aquifer Parameters in Relation to Underflow Through the Fenner Gap

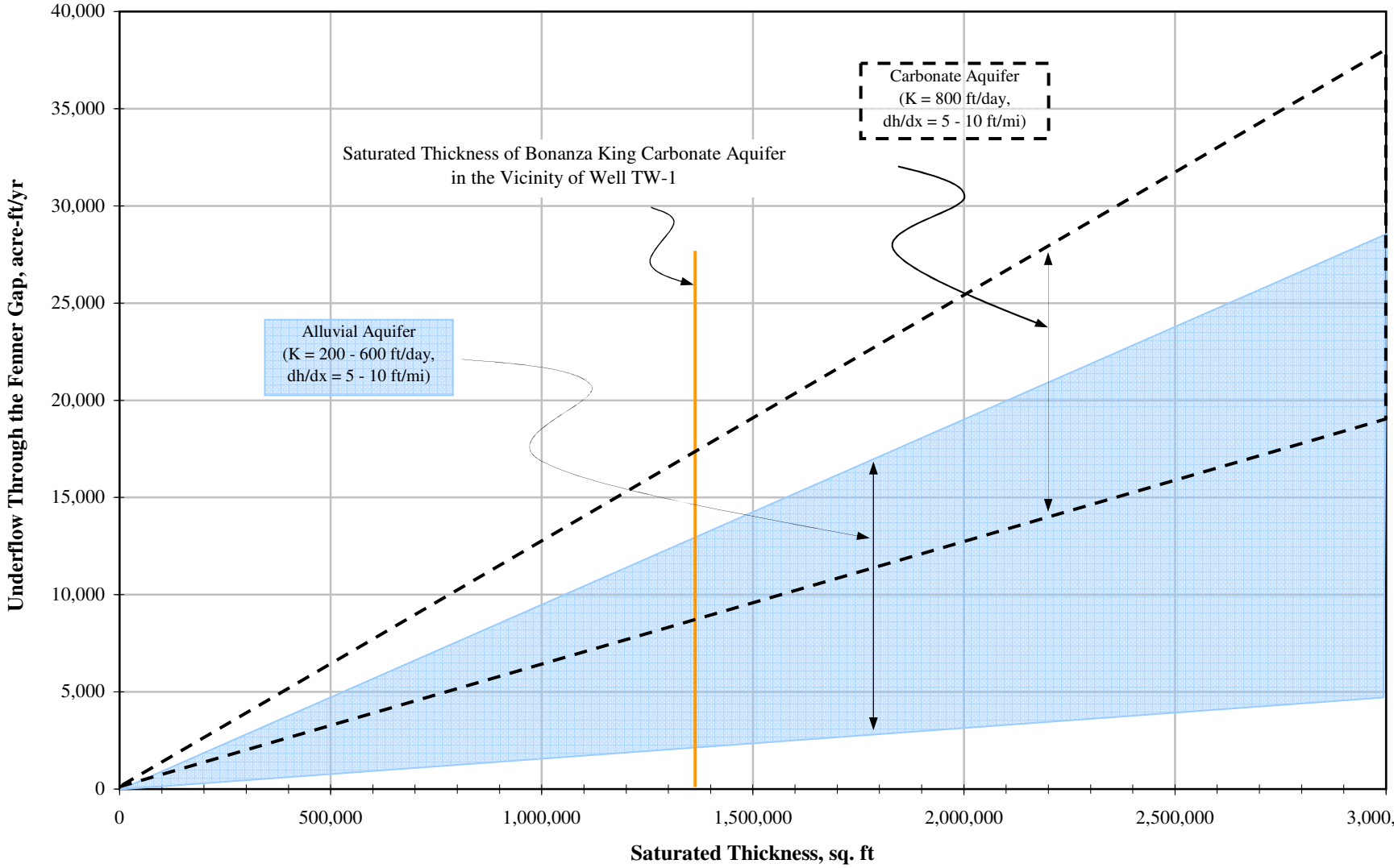


Figure 29

TABLES

TABLE 1 - Summary of Pumping Tests and Aquifer Parameters, Fenner Gap Area

Table 1

Well Being Analyzed	Report Figure	Aquifer	Pumping Well	Distance to Pumping Well	Type of Test	Date of Test	Discharge Rate	Type of Analysis	Formation Loss Coefficient B	Well Loss Coefficient C	Transmissivity T	Storativity S	Leakance K'/b'	Saturated Thickness b	Hydraulic Conductivity K	
				[ft]			[gpm]		[ft/gpm]	[ft/gpm^2]	[gpd/ft]		[1/day]	[ft]	[gpd/ft^2]	[ft/day]
TW-1	10	Alluvial	TW-1	0	Step Drawdown	2-Dec-09	181 - 383	Hantush								
TW-1	11	Alluvial	TW-1	0	Specifc Drawdown	2-Dec-09	181 - 383	Hantush	0.0062	7.40E-04						
TW-1	12	Alluvial	TW-1	0	Specific Capacity	2-Dec-09	181 - 383	Hantush								
TW-1	13	Alluvial	TW-1	0	Const. Rate	3-4, Dec-09	261	Jacob			5,600					
MW-7a	14	Alluvial	TW-1	83	Const. Rate	3-4, Dec-09	261	Hantush-Leaky			23,500	0.008	0.26	85	276	37
TW-1	15	Carbonate	TW-1	0	Step Drawdown	8-Nov-09	291 - 1,168	Hantush								
TW-1	16	Carbonate	TW-1	0	Const. Rate	9-12 Nov-09	1,168	Thermal Expansion								
TW-1	17	Carbonate	TW-1	0	Const. Rate	9-12 Nov-09	1,168	Mace			2,832,800			403	7,029	940
MW-7	18	Carbonate	TW-1	83	Const. Rate	9-12 Nov-09	1,168	Jacob			3,083,500	0.012		403	7,651	1,023
MW-7	19	Carbonate	TW-1	83	Calc Recovery	9-12 Nov-09	1,168	Jacob			1,814,000	0.007		403	4,501	602
MW-7	20	Carbonate	TW-1	83	Dist to Bound	9-12 Nov-09	1,168	Strausberg	Boundaries at ~ 1,000 ft and 4,000 ft from TW-1							
TW-2	21	Alluvial	TW-2	0	Step Drawdown	23-Nov-09	420 -1,130	Hantush								
TW-2	22	Alluvial	TW-2	0	Specifc Drawdown	23-Nov-09	420 -1,130	Hantush	0.0005684	3.48E-07						
TW-2	23	Alluvial	TW-2	0	Specific Capacity	23-Nov-09	420 -1,130	Hantush								
TW-2	24	Alluvial	TW-2	0	Const. Rate	24-27 Nov-09	1,116	Jacob			421,000					
TW-2	25	Alluvial	TW-2	0	Calc Recovery	24-27 Nov-09	1,116	Jacob			521,000					
MW-6	26	Alluvial	TW-2	815	Const. Rate	24-27 Nov-09	1,116	Hantush-Leaky	Boundary at ~ 3,000 ft from TW-2		2,020,000	0.002	0.02	439	4,601	615
MW-6	27	Alluvial	TW-2	815	Calc Recovery	24-27 Nov-09	1,116	Jacob			1,964,000	0.002		439	4,474	598
MW-6	28	Alluvial	TW-2	815	Const. Rate	24-27 Nov-09	1,116	Strausberg	Boundary at ~ 9,000 ft from TW-2		2,562,000	0.0015		439	5,836	780

Appendix A
Soil Boring Log – TW-1

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PROJECT NUMBER: 386303 **Sheet:** 1 of 17

SOIL BORING LOG: TW-1

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Direct Mud Rotary and Dual Tube Reverse/RD-20
WATER LEVELS: 330.60 ft bgs **START:** 10/6/2009 **END:** 10/28/2009 **LOGGER:** T. Henderson

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	SOIL DESCRIPTION: GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
							Ground Surface	
0	Bucket Auger	Grab			None		**SILTY SAND (SM)** dark yellowish brown (10YR 4/4), sand is well graded silt to coarse sand, sand is subangular, includes <10% fines to 1/2 gravel, angular to subangular	Grab samples from Bucket Auger Rig crew
10					None		**SILTY SAND WITH GRAVEL (SM)** as above, except gravel fraction is up to 20%	
20					None		**SILTY SAND (SM)** as above	
30					None			
40					None		**SILTY SAND (SM)** dark yellowish brown (10YR 4/4), sand is well graded silt to coarse sand, subangular; includes ~5% fines to 3/4 inch gravel (angular)	
50					None		**POORLY GRADED SAND (SP)** yellowish brown (10YR 3/4), sand is fine to medium, subangular	Samples collected by direct mud rotary drilling. Note: That samples appear to be artificially sorted due to the drilling method and probably do not accurately represent the full range of grain sizes.
	Mud Rotary	Grab			None			
60								

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PROJECT NUMBER: 386303 **Sheet:** 2 of 17

SOIL BORING LOG: TW-1

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Direct Mud Rotary and Dual Tube Reverse/RD-20
WATER LEVELS: 330.60 ft bgs **START:** 10/6/2009 **END:** 10/28/2009 **LOGGER:** T. Henderson

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	SOIL DESCRIPTION: GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
70	Mud Rotary	Grab			None		**POORLY GRADED SAND (SP)** as above, yellowish brown (10YR 3/4), sand is fine to medium, subangular	
					None			
					None			
80					None			
					None			
90					None			
					None			
100					None			
					None			
110					None		**POORLY GRADED SAND (SP)** as above	
120								

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PROJECT NUMBER: 386303 **Sheet:** 3 of 17

SOIL BORING LOG: TW-1

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Direct Mud Rotary and Dual Tube Reverse/RD-20
WATER LEVELS: 330.60 ft bgs **START:** 10/6/2009 **END:** 10/28/2009 **LOGGER:** T. Henderson

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	SOIL DESCRIPTION: GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
130	Mud Rotary	Grab			None		**POORLY GRADED SAND (SP)** as above, yellowish brown (10YR 3/4), sand is fine to medium, subangular	
					None			
140					None			
150					None			
160								
170	Mud Rotary	Grab			None		**POORLY GRADED SAND (SP)** as above	
180								

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 4 of 17

SOIL BORING LOG: TW-1

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Direct Mud Rotary and Dual Tube Reverse/RD-20
WATER LEVELS: 330.60 ft bgs **START:** 10/6/2009 **END:** 10/28/2009 **LOGGER:** T. Henderson

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	SOIL DESCRIPTION: GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
	Mud Rotary	Grab			None			
190					None		**POORLY GRADED SAND (SP)** above, yellowish brown (10YR 3/4), sand is fine to medium, subangular	
200					None			
210					None			
220					None		**WELL GRADED SAND WITH GRAVEL (SW)** fine sand to fine gravel, subangular	
230					None			
240								

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 5 of 17

SOIL BORING LOG: TW-1

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Direct Mud Rotary and Dual Tube Reverse/RD-20
WATER LEVELS: 330.60 ft bgs **START:** 10/6/2009 **END:** 10/28/2009 **LOGGER:** T. Henderson

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	SOIL DESCRIPTION: GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
	Mud Rotary	Grab			None			
250					None		**WELL GRADED SAND WITH SILT (SW-SM)** yellowish brown (10YR 5/4), sand is very fine to coarse, subangular	
260					None			
270					None			
280					None			
290					None			
300								

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 6 of 17

SOIL BORING LOG: TW-1

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Direct Mud Rotary and Dual Tube Reverse/RD-20
WATER LEVELS: 330.60 ft bgs **START:** 10/6/2009 **END:** 10/28/2009 **LOGGER:** T. Henderson

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	SOIL DESCRIPTION: GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
	Mud Rotary	Grab			None			
310					None		**WELL GRADED SAND WITH SILT (SW-SM)** yellowish brown (10YR 5/4), sand is very fine to coarse, subangular	
320					None			
330					None			
340					None			
350					None			
360								

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 7 of 17

SOIL BORING LOG: TW-1

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Direct Mud Rotary and Dual Tube Reverse/RD-20
WATER LEVELS: 330.60 ft bgs **START:** 10/6/2009 **END:** 10/28/2009 **LOGGER:** T. Henderson

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	SOIL DESCRIPTION: GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
	Mud Rotary	Grab			None			
370					None		**WELL GRADED SAND WITH SILT (SW-SM)** yellowish brown (10YR 5/4), sand is very fine to coarse, subangular	
380					None			
390					None			
400					None			
410					None			
420								

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 8 of 17

SOIL BORING LOG: TW-1

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Direct Mud Rotary and Dual Tube Reverse/RD-20
WATER LEVELS: 330.60 ft bgs **START:** 10/6/2009 **END:** 10/28/2009 **LOGGER:** T. Henderson

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	SOIL DESCRIPTION: GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
430	Mud Rotary	Grab			None			
					None		**WELL GRADED SAND WITH SILT (SW-SM)** yellowish brown (10YR 5/4), sand is very fine to coarse, subangular	
440					None			
450					None			10" steel casing placed in the alluvial portion of the well. Casing is landed without a bottom in rock at ~454' bgs. Airlift swab development of the screened section of the 10-inch casing in alluvial portion of the well.
460	Dual Tube Reverse	Grab			Slight		**DOLOMITE** bluish gray (5B 6/1), as angular chips ranging from coarse sand sized to 1/2 inch	Begin drilling at 454' bgs via dual tube reverse air rotary without additives.
470					Strong			Munsell color chart used for descriptions below 458' bgs.
480								10/23/2009 (14:15)

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 9 of 17

SOIL BORING LOG: TW-1

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Direct Mud Rotary and Dual Tube Reverse/RD-20
WATER LEVELS: 330.60 ft bgs **START:** 10/6/2009 **END:** 10/28/2009 **LOGGER:** T. Henderson

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	SOIL DESCRIPTION: GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
490	Dual Tube Reverse	Grab			Strong		**DOLOMITE** as above, except significant fraction of apparently altered dolomite to include clasts that are light bluish gray (5PB 8/1), crystalline faces on some clasts, evidence of secondary mineralization (calcite) including crystals up to 1/8 inch, chips up to 1 inch, subangular to angular	
					Strong			
500					Moderate		**DOLOMITE** bluish gray (5B 6/1), as angular chips ranging from coarse sand sized to 1/2 inch	10/23/2009 (16:09)
510					Strong			
520					Strong		**DOLOMITE** as above, except significant fraction of apparently altered dolomite to include clasts that are light bluish gray (5PB 8/1), crystalline faces on some clasts, evidence of secondary mineralization (calcite) including	10/23/2009 (22:30)
530					Strong		**DOLOMITE** bluish gray (5B 6/1), as angular chips ranging from coarse sand sized to 1/2 inch	
540								10/24/2009 (06:12)

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 10 of 17

SOIL BORING LOG: TW-1

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Direct Mud Rotary and Dual Tube Reverse/RD-20
WATER LEVELS: 330.60 ft bgs **START:** 10/6/2009 **END:** 10/28/2009 **LOGGER:** T. Henderson

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	SOIL DESCRIPTION: GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
550	Dual Tube Reverse	Grab			Strong		**DOLOMITE** light greenish gray (10BG 7/1), as chips up to 1/2 inch, abundant of alteration/secondary mineralization	
					Strong			
560					Strong		**DOLOMITE** bluish gray (5B 5/1), as chips, angular, ranging from 1/16 to 1/2 inch, less evidence of alteration/secondary mineralization, however, still present	10/24/2009 (16:09)
570					Strong			
580					Strong			10/24/2009 (22:20)
590					Strong			
600								10/25/2009 (09:15)

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 11 of 17

SOIL BORING LOG: TW-1

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Direct Mud Rotary and Dual Tube Reverse/RD-20
WATER LEVELS: 330.60 ft bgs **START:** 10/6/2009 **END:** 10/28/2009 **LOGGER:** T. Henderson

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	SOIL DESCRIPTION: GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
610	Dual Tube Reverse	Grab			Strong		**DOLOMITE** bluish gray (5B 5/1), as chips, angular, ranging from 1/16 to 1/2 inch, less evidence of alteration/secondary mineralization, however, still present	
					Strong			
620					Strong			10/25/2009 (14:40)
630					Strong			
640					Strong			10/25/2009 (17:42)
650					Slight			
660								10/25/2009 (21:25)

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 12 of 17

SOIL BORING LOG: TW-1

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Direct Mud Rotary and Dual Tube Reverse/RD-20
WATER LEVELS: 330.60 ft bgs **START:** 10/6/2009 **END:** 10/28/2009 **LOGGER:** T. Henderson

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	SOIL DESCRIPTION: GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
670	Dual Tube Reverse	Grab			Moderate		**DOLOMITE** dark bluish gray (5B 4/1), cuttings are much smaller 1/64 to 1/16 inch, suggesting different hardness	
					Strong			
680					Strong			10/26/2009 (03:57)
690					Moderate		**DOLOMITE** multicolored 1/8 to 1/2 inch chips, colors range from dark bluish gray (5B 4/1), to light bluish gray (5PB 8/1)	
					Moderate			10/26/2009 (07:56)
700					Strong			
710								
720								10/26/2009 (12:06)

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 13 of 17

SOIL BORING LOG: TW-1

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Direct Mud Rotary and Dual Tube Reverse/RD-20
WATER LEVELS: 330.60 ft bgs **START:** 10/6/2009 **END:** 10/28/2009 **LOGGER:** T. Henderson

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	SOIL DESCRIPTION: GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
	Dual Tube Reverse	Grab			Strong			10/26/2009 (14:02)
730					Moderate		**DOLOMITE** as above, except overall sample color is darker (90%+), dark bluish gray (10B 4/1)	
740					Strong			10/26/2009 (16:25)
750					Slight			10/26/2009 (17:35)
760					Strong			10/26/2009 (20:30)
770					Strong		**DOLOMITE** as above, less evidence of alteration and secondary mineralization	
780								10/27/2009 (00:15)

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 14 of 17

SOIL BORING LOG: TW-1

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Direct Mud Rotary and Dual Tube Reverse/RD-20
WATER LEVELS: 330.60 ft bgs **START:** 10/6/2009 **END:** 10/28/2009 **LOGGER:** T. Henderson

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	SOIL DESCRIPTION: GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
	Dual Tube Reverse	Grab			Strong			
790					Moderate		**DOLOMITE** as above, less evidence of alteration and secondary mineralization	
800					Slight			10/27/2009 (05:14)
810					Slight			
820					Slight			10/27/2009 (08:51)
830					Slight			
840								10/27/2009 (13:24)

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PROJECT NUMBER: 386303 **Sheet:** 15 of 17

SOIL BORING LOG: TW-1

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Direct Mud Rotary and Dual Tube Reverse/RD-20
WATER LEVELS: 330.60 ft bgs **START:** 10/6/2009 **END:** 10/28/2009 **LOGGER:** T. Henderson

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	SOIL DESCRIPTION: GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
	Dual Tube Reverse	Grab			None			
850					None		**DOLOMITE** as above, except clasts are multicolored gray and orange primarily, orange and lighter colored clasts may be interbeds of shales and/or sandy limestone	10/27/2009 (15:53)
860					Slight		**DOLOMITE/SHALE/SANDY LIMESTONE** as above	10/27/2009 (17:54)
870					Moderate			
880					Slight			10/28/2009 (21:30)
890					Moderate			
900							**DOLOMITE/SHALE/SANDY LIMESTONE** as above	10/28/2009 (01:38)

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 16 of 17

SOIL BORING LOG: TW-1

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Direct Mud Rotary and Dual Tube Reverse/RD-20
WATER LEVELS: 330.60 ft bgs **START:** 10/6/2009 **END:** 10/28/2009 **LOGGER:** T. Henderson

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	SOIL DESCRIPTION: GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
	Dual Tube Reverse	Grab			Strong			
910					Strong		**SANDY LIMESTONE** dark bluish gray (10B 4/1), sand is very fine to fine in a matrix of limestone	
920					Moderate			10/28/2009 (04:53)
930					Moderate			
940					Moderate			10/28/2009 (08:24)
950					Slight			
960								10/28/2009 (12:40)

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 17 of 17

SOIL BORING LOG: TW-1

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Direct Mud Rotary and Dual Tube Reverse/RD-20
WATER LEVELS: 330.60 ft bgs **START:** 10/6/2009 **END:** 10/28/2009 **LOGGER:** T. Henderson

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	SOIL DESCRIPTION: GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
970	Dual Tube Reverse	Grab			Slight		**SANDY LIMESTONE** as above	
					Slight			
980					Slight			
990					Slight			
1000							End of Boring	Total depth of borehole = 1,002' bgs
1010								
1020								

Appendix B
Soil Boring Log – TW-2

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 1 of 23

SOIL BORING LOG: TW-2

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Flooded Reverse/Challenger, Dual Tube Reverse/T3
WATER LEVELS: 314.43 ft bgs **START:** 10/26/2009 **END:** 12/8/09 **LOGGER:** B. Lechler

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
							Ground Surface	
0	Bucket Auger	Grab			None		**POORLY GRADED SAND WITH SILT (SP-SM)** yellowish brown (10YR 5/4), mostly fine to medium sand (70%), some coarse sand with fine gravel	Grab samples from Bucket Auger Rig crew.
10					None		**POORLY GRADED GRAVEL WITH SAND (GP)** yellowish brown (10YR 5/4), fine gravel (subangular to subrounded), some coarse gravel (10%), coarse to fine sand (45%)	
20					None		as above, dark grayish brown (10YR 4/2), coarse sand to gravel, more well rounded (subrounded)	
30					None		**POORLY GRADED SAND WITH GRAVEL (SP)** dark grayish brown (2.5Y 4/2), fine to medium sand (60%), coarse sand to fine gravel, angular to subrounded	
40	Mud Rotary	Grab			None		**POORLY GRADED GRAVEL WITH SAND (GP)** dark grayish brown (2.5Y 4/2), fine gravel, some coarse gravel (15%) (up to 55mm), subangular to subrounded, coarse sand (15%)	Sample collected by flooded reverse rotary drilling. Note: that samples appear to be artificially sorted due to the drilling method and probably do not accurately represent the full range of grain sizes.
50					None		more sand (30%)	
60								

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 2 of 23

SOIL BORING LOG: TW-2

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Flooded Reverse/Challenger, Dual Tube Reverse/T3
WATER LEVELS: 314.43 ft bgs **START:** 10/26/2009 **END:** 12/8/09 **LOGGER:** B. Lechler

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
70	Mud Rotary	Grab			None		**POORLY GRADED GRAVEL WITH SAND (GP)** as above	
					None			
80					None			
90					None		**POORLY GRADED GRAVEL WITH SAND (GP)** dark grayish brown (5Y 4/2), fine gravel (subrounded) with coarse sand (40%)	
100					None			
110					None		**POORLY GRADED SAND WITH GRAVEL (SP)** brown (10YR 5/3), medium to coarse sand with fine gravel (40%), subangular to subrounded	
120								

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 3 of 23

SOIL BORING LOG: TW-2

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Flooded Reverse/Challenger, Dual Tube Reverse/T3
WATER LEVELS: 314.43 ft bgs **START:** 10/26/2009 **END:** 12/8/09 **LOGGER:** B. Lechler

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	SOIL DESCRIPTION: GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
130	Mud Rotary	Grab			None		**POORLY GRADED SAND WITH GRAVEL (SP)** as above, some coarse gravel (5%)	
					None			
140					None			
150					None		**POORLY GRADED GRAVEL WITH SAND (GP)** dark grayish brown (2.5Y 4/2), fine gravel (rounded to subangular), coarse gravel (30%), medium to coarse sand (30%)	
160					None		**POORLY GRADED SAND WITH GRAVEL (SP)** dark grayish brown (2.5Y 4/2), medium to coarse sand with fine gravel (30%)	
170					None		**POORLY GRADED GRAVEL WITH SAND (GP)** dark grayish brown (2.5Y 4/2), fine to coarse gravel (subangular to subrounded), with medium coarse sand	
180								

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 4 of 23

SOIL BORING LOG: TW-2

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Flooded Reverse/Challenger, Dual Tube Reverse/T3
WATER LEVELS: 314.43 ft bgs **START:** 10/26/2009 **END:** 12/8/09 **LOGGER:** B. Lechler

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	SOIL DESCRIPTION: GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
190	Mud Rotary	Grab			None		**POORLY GRADED GRAVEL WITH SAND (GP)** as above	
					None		as above, sand fraction ~40%-50%, mostly coarse sand	
200					None		**POORLY GRADED SAND WITH GRAVEL (SP)** brown (10YR 5/3), mostly medium to coarse sand, some fine gravel	
210					None			
220					None		as above, % fine gravel increasing (40%)	
230					None			
240								

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 5 of 23

SOIL BORING LOG: TW-2

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Flooded Reverse/Challenger, Dual Tube Reverse/T3
WATER LEVELS: 314.43 ft bgs **START:** 10/26/2009 **END:** 12/8/09 **LOGGER:** B. Lechler

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	SOIL DESCRIPTION: GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
250	Mud Rotary	Grab			None		**POORLY GRADED SAND WITH GRAVEL (SP)** as above, gravel is fine (5-10mm)	
					None		as above, gravel fraction decreasing (20%)	
260					None		**POORLY GRADED SAND (SP)** yellowish brown (10YR 5/4), fine to coarse sand, some gravel (10%) and fines (5%)	
270					None		**POORLY GRADED SAND WITH GRAVEL (SP)** yellowish brown (10YR 5/4), fine to coarse sand with fine gravel (30%)	
280					None		**POORLY GRADED SAND (SP)** yellowish brown (10YR 5/4), fine to coarse sand, some fine gravel (10%), and fines (5%)	
290					None		as above, sand is coarser	
300								

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 6 of 23

SOIL BORING LOG: TW-2

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Flooded Reverse/Challenger, Dual Tube Reverse/T3
WATER LEVELS: 314.43 ft bgs **START:** 10/26/2009 **END:** 12/8/09 **LOGGER:** B. Lechler

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	SOIL DESCRIPTION: GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
310	Mud Rotary	Grab			None		**POORLY GRADED SAND (SP)** as above	
					None			
320					None			
330					None		**POORLY GRADED SAND WITH GRAVEL (SP)** yellowish brown (10YR 5/4), mostly medium to coarse sand, some fine sand, fine gravel (20%)	
340					None		**CLAYEY SAND (SC)** yellowish brown (10YR 5/4), medium to coarse sand, some fine gravel with fines (20%)	
350					None		**POORLY GRADED SAND WITH GRAVEL (SP)** yellowish brown (10YR 5/4), medium to coarse sand, some fine sand, fine gravel (angular to subangular) (40%)	
360								

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 7 of 23

SOIL BORING LOG: TW-2

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Flooded Reverse/Challenger, Dual Tube Reverse/T3
WATER LEVELS: 314.43 ft bgs **START:** 10/26/2009 **END:** 12/8/09 **LOGGER:** B. Lechler

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	SOIL DESCRIPTION: GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
370	Mud Rotary	Grab			None		**POORLY GRADED SAND WITH GRAVEL (SP)** as above	
					None		as above, % gravel decreasing (20%)	
380					None			
390					None		as above, trace coarse gravel	
400					None		as above, % gravel increasing (40%)	
410					None		as above, 50/50 coarse to fine gravel (40%), gravel up to 60mm (angular to subrounded), some weathered lithics	
420								

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 8 of 23

SOIL BORING LOG: TW-2

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Flooded Reverse/Challenger, Dual Tube Reverse/T3
WATER LEVELS: 314.43 ft bgs **START:** 10/26/2009 **END:** 12/8/09 **LOGGER:** B. Lechler

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	SOIL DESCRIPTION: GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
430	Mud Rotary	Grab			None		**POORLY GRADED SAND WITH GRAVEL (SP)** as above, gravel all fine gravel (40%)	
					None		gravel is fining, maximum diameter 10 mm, more fine sand than above (20%)	
440					None		gravel is all fine gravel (25%), trace clayey sand balls	
450					None		**POORLY GRADED SAND (SP)** dark yellowish brown (10YR 4/4), medium to coarse sand (80%), with fine sand and fine gravel	
460					None		**SILTY SAND (SM)** yellowish brown (10YR 5/6), fine to coarse sand, trace fine gravel, fines (40%), soft, low plasticity	
470					None		**POORLY GRADED SAND WITH GRAVEL (SP)** brown (10YR 5/3), medium to coarse sand with some fine sand, fine gravel (40%), angular to subrounded	
480								

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 9 of 23

SOIL BORING LOG: TW-2

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Flooded Reverse/Challenger, Dual Tube Reverse/T3
WATER LEVELS: 314.43 ft bgs **START:** 10/26/2009 **END:** 12/8/09 **LOGGER:** B. Lechler

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	SOIL DESCRIPTION: GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
490	Mud Rotary	Grab			None		**POORLY GRADED SAND WITH SILT AND GRAVEL (SP-SM)** yellowish brown (10YR 5/4), fine to coarse sand with silt (10%) and fine gravel (25%), trace coarse gravel	
					None		**SILTY SAND (SM)** yellowish brown (10YR 5/4), fine to coarse sand with silt (15%)	
500					None		**POORLY GRADED SAND WITH SILT AND GRAVEL (SP-SM)** yellowish brown (10YR 5/4), fine to coarse sand with silt (10%) and fine gravel (40%)	
510					None		as above, % gravel decreasing (20%)	
520					None		**WELL GRADED SAND (SW)** brown (10YR 5/3), fine to coarse sand, fine gravel (10%) (angular to subangular)	
530					None		**POORLY GRADED SAND WITH SILT AND GRAVEL (SP-SM)** brown (10YR 5/3), fine to coarse sand, fine gravel (20%), silt (10%)	
540								

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 10 of 23

SOIL BORING LOG: TW-2

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Flooded Reverse/Challenger, Dual Tube Reverse/T3
WATER LEVELS: 314.43 ft bgs **START:** 10/26/2009 **END:** 12/8/09 **LOGGER:** B. Lechler

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	SOIL DESCRIPTION: GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
	Mud Rotary	Grab			None		**SILTY SAND (SM)** brown (10YR 5/3), fine to coarse sand, silt (15%), fine gravel (10%)	
550					None		**POORLY GRADED SAND WITH SILT AND GRAVEL (SP-SM)** brown (10YR 5/3), fine to coarse sand, silt (10%), fine gravel (15%) (angular to subrounded), trace coarse gravel	
560					None		as above, % fine gravel increasing (30%)	
570					None			
580					None			
590					None			
600								

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 11 of 23

SOIL BORING LOG: TW-2

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Flooded Reverse/Challenger, Dual Tube Reverse/T3
WATER LEVELS: 314.43 ft bgs **START:** 10/26/2009 **END:** 12/8/09 **LOGGER:** B. Lechler

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	SOIL DESCRIPTION: GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
610	Mud Rotary	Grab			None		**POORLY GRADED SAND WITH GRAVEL (SP)** medium to coarse sand with fine sand (10%), and fine gravel (30%) (angular to subangular)	
					None		**POORLY GRADED GRAVEL WITH SAND (GP)** brown (10YR 5/3), fine to coarse gravel (70/30) angular to subrounded, with medium to coarse sand	
620					None			
630					None		as above, no coarse gravel, fines (5%)	
640					None		**POORLY GRADED SAND WITH SILT AND GRAVEL (SP-SM)** medium to coarse sand with silt (10%), and fine sand, fine gravel (35%) (angular to subrounded)	
650					None			
660								

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 12 of 23

SOIL BORING LOG: TW-2

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Flooded Reverse/Challenger, Dual Tube Reverse/T3
WATER LEVELS: 314.43 ft bgs **START:** 10/26/2009 **END:** 12/8/09 **LOGGER:** B. Lechler

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
670	Mud Rotary	Grab			None		**SILTY SAND WITH GRAVEL (SM)** brown (10YR 5/3), fine to coarse sand with silt (20%), and fine gravel (25%) (subangular to rounded)	
					None		**POORLY GRADED SAND WITH SILT AND GRAVEL (SP-SM)** brown (10YR 5/3), medium to coarse sand (some fine sand), with silt (10%), and fine gravel (30%) (angular to subrounded)	
680					None			
					None			
690					None		**POORLY GRADED GRAVEL WITH SAND (GP)** grayish brown (10YR 5/2), fine gravel (angular to subrounded), with medium to coarse sand, trace fines and fine sand	
700					None		**POORLY GRADED SAND WITH GRAVEL (SP)** brown (10YR 5/3), medium to coarse sand with fine gravel (40%), some fine sand and fines	
710					None		**LEAN CLAY (CL)** brown (10YR 5/3), medium plasticity, soft, fine sand, fine gravel (20%), some weathered lithic fragments	
720								

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 13 of 23

SOIL BORING LOG: TW-2

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Flooded Reverse/Challenger, Dual Tube Reverse/T3
WATER LEVELS: 314.43 ft bgs **START:** 10/26/2009 **END:** 12/8/09 **LOGGER:** B. Lechler

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	SOIL DESCRIPTION: GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
730	Mud Rotary	Grab			None		**LEAN CLAY (CL)** as above	
					None		**POORLY GRADED SAND WITH SILT AND GRAVEL (SP-SM)** brown (10YR 5/3), fine to coarse sand (more coarse), with fine gravel (rounded to angular), and silt	
740					None		**POORLY GRADED GRAVEL WITH SAND (GP)** brown (10YR 5/3), fine gravel (angular to subrounded), with medium to coarse sand, trace fine sand and fines	
750					None		**POORLY GRADED SAND WITH SILT AND GRAVEL (SP-SM)** brown (10YR 5/3), medium to coarse sand (some fine sand), and fine gravel (subangular to subrounded)	
760					None		**SANDY LEAN CLAY (CL)** brown (10YR 5/3), clay with fine to coarse sand (30%)	
770					None		**LEAN CLAY (CL)** brown (10YR 5/3), medium plasticity, soft, fine sand (10%), some weathered lithics	
780								

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 14 of 23

SOIL BORING LOG: TW-2

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Flooded Reverse/Challenger, Dual Tube Reverse/T3
WATER LEVELS: 314.43 ft bgs **START:** 10/26/2009 **END:** 12/8/09 **LOGGER:** B. Lechler

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	SOIL DESCRIPTION: GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
790	Mud Rotary	Grab			None		**POORLY GRADED GRAVEL WITH SILT AND SAND (GP-GM)** brown (10YR 5/3), fine gravel (angular to subrounded), with medium to coarse sand, and fines (10%)	
					None		**SANDY LEAN CLAY (CL)** brown (10YR 5/3), clay as above with fine sand to fine gravel (40%)	
800	Dual Tube Reverse				None		**POORLY GRADED SAND (SP)** dark grayish brown (10YR 4/2), mostly fine sand, little medium sand, trace fine gravel (subrounded), trace coarse sand (subrounded)	10" steel casing landed at 799' bgs. Airlift swab/pump development and aquifer testing of the screened section of the 10-inch casing in alluvial portion of the well.
810					None		**POORLY GRADED SAND WITH GRAVEL (SP)** dark grayish brown (10YR 4/2), mostly medium to coarse sand (angular to subrounded), some fine gravel (subangular to subrounded), granitic and volcanic in composition	Resume drilling at 800' bgs via dual-tube reverse air rotary without additives.
820					None			
830					None		as above, mostly coarse sand, some medium sand (subrounded to subangular), little fine gravel (subangular)	
840								

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PROJECT NUMBER: 386303 **Sheet:** 15 of 23

SOIL BORING LOG: TW-2

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Flooded Reverse/Challenger, Dual Tube Reverse/T3
WATER LEVELS: 314.43 ft bgs **START:** 10/26/2009 **END:** 12/8/09 **LOGGER:** B. Lechler

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	SOIL DESCRIPTION: GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
850	Dual Tube Reverse	Grab			None		**POORLY GRADED SAND WITH GRAVEL (SP)** as above, mostly fine to medium sand, little fine gravel (subrounded), granitics and volcanic in composition	
					None		**POORLY GRADED GRAVEL WITH SAND (GP)** dark grayish brown (10YR 4/2), mostly fine to coarse gravel (subrounded to angular), igneous, metamorphics, volcanics, angular broken clasts with oxidized surfaces, some medium to coarse sand (subangular to angular), abundant K-feldspar	
860					None		**CRYSTALLINE BEDROCK** gray (5Y 6/1), granitic, mostly quartz	Approximate alluvium-bedrock contact at 860' bgs.
870					None		light gray (5Y 7/1), granitic, quartz, weathered white feldspar with chalky consistency	
880					None		pinkish gray (5YR 6/2), quartz, less white feldspar, some K-feldspar	
890					None		light gray (5YR 7/1), granitic, weathered white feldspar with chalky consistency	
900								

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 16 of 23

SOIL BORING LOG: TW-2

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Flooded Reverse/Challenger, Dual Tube Reverse/T3
WATER LEVELS: 314.43 ft bgs **START:** 10/26/2009 **END:** 12/8/09 **LOGGER:** B. Lechler

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	SOIL DESCRIPTION: GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
910	Dual Tube Reverse	Grab			None		**CRYSTALLINE BEDROCK** light gray (5YR 7/1), granitic, quartz, K-feldspar, few weathered white feldspar with chalky consistency	
					None		very pale brown (10YR 7/3), granitic, quartz, K-feldspar	
920					None		reddish brown (5YR 5/3), granitic, abundant K-feldspar and quartz, few mafics	
930					None			
940					None		white (5YR 8/1), granitic, quartz, white feldspar (some weathered), chalky consistency	
950					None		reddish brown (5YR 5/3), granitic, K-feldspar, quartz, trace mafics	
960					None			

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 17 of 23

SOIL BORING LOG: TW-2

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Flooded Reverse/Challenger, Dual Tube Reverse/T3
WATER LEVELS: 314.43 ft bgs **START:** 10/26/2009 **END:** 12/8/09 **LOGGER:** B. Lechler

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	SOIL DESCRIPTION: GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
970	Dual Tube Reverse	Grab			None			
					None			
980					None			
990					None		**CRYSTALLINE BEDROCK** white (5YR 8/1), granitic, quartz, white feldspar	
1000					None		reddish brown (5YR 5/3), granitic, increasing K-feldspar	
1010					None			
1020								

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 18 of 23

SOIL BORING LOG: TW-2

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Flooded Reverse/Challenger, Dual Tube Reverse/T3
WATER LEVELS: 314.43 ft bgs **START:** 10/26/2009 **END:** 12/8/09 **LOGGER:** B. Lechler

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	SOIL DESCRIPTION: GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
1030	Dual Tube Reverse	Grab			None		**CRYSTALLINE BEDROCK** pinkish gray (5YR 7/2), granitic, Fe-oxide staining, decreasing K-feldspar, weathered mafics	
					None			
1040					None			
1050					None		reddish gray (5YR 5/2), granitic, quartz, some K-feldspar, few mafics	
1060					None			
1070					None			
1080								

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 19 of 23

SOIL BORING LOG: TW-2

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Flooded Reverse/Challenger, Dual Tube Reverse/T3
WATER LEVELS: 314.43 ft bgs **START:** 10/26/2009 **END:** 12/8/09 **LOGGER:** B. Lechler

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	SOIL DESCRIPTION: GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
1090	Dual Tube Reverse	Grab			None		**CRYSTALLINE BEDROCK** reddish brown (5YR 5/3), granitic, quartz, decreasing K-feldspar	
					None			
1100					None		pinkish gray (5YR 7/2), granitic, quartz, K-feldspar	
					None			
1110					None			
1120					None		red gray (5YR 5/2), granitic, increase in K-feldspar	
1130					None			
1140								

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 20 of 23

SOIL BORING LOG: TW-2

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Flooded Reverse/Challenger, Dual Tube Reverse/T3
WATER LEVELS: 314.43 ft bgs **START:** 10/26/2009 **END:** 12/8/09 **LOGGER:** B. Lechler

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	SOIL DESCRIPTION: GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
1150	Dual Tube Reverse	Grab			None		**CRYSTALLINE BEDROCK** very dark gray (5YR 3/1), diabase?, mafic, aphanitic texture	
					None		pinkish gray (5YR 7/2), granitic, quartz, white feldspar, few mafics	
1160					None			
1170					None			
1180					None		reddish brown (5YR 5/3), granitic, increasing K-feldspar	
1190					None			
1200					None			

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 21 of 23

SOIL BORING LOG: TW-2

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Flooded Reverse/Challenger, Dual Tube Reverse/T3
WATER LEVELS: 314.43 ft bgs **START:** 10/26/2009 **END:** 12/8/09 **LOGGER:** B. Lechler

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	SOIL DESCRIPTION: GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
1210	Dual Tube Reverse	Grab			None			
					None			
1220					None		**CRYSTALLINE BEDROCK** reddish brown (5YR 5/3), granitic	
1230					None			
1240					None		pinkish gray (5YR 6/2), granitic, quartz weathered white feldspar with chalky consistency, decreasing K-feldspar	
1250					None		pinkish gray (5YR 6/2), granitic, some Fe-oxide staining	
1260								

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 22 of 23

SOIL BORING LOG: TW-2

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Flooded Reverse/Challenger, Dual Tube Reverse/T3
WATER LEVELS: 314.43 ft bgs **START:** 10/26/2009 **END:** 12/8/09 **LOGGER:** B. Lechler

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	SOIL DESCRIPTION: GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
1270	Dual Tube Reverse	Grab			None		**CRYSTALLINE BEDROCK** red brown (5YR 5/3), granitic, increasing K-feldspar	
					None			
1280					None		light gray (5YR 7/1), granitic, quartz, white feldspar, decreasing K-feldspar	
1290					None			
1300					None		reddish gray (5YR 5/2), granitic, increasing K-feldspar, trace mafics	
1310					None			
1320					None			

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 23 of 23

SOIL BORING LOG: TW-2

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Flooded Reverse/Challenger, Dual Tube Reverse/T3
WATER LEVELS: 314.43 ft bgs **START:** 10/26/2009 **END:** 12/8/09 **LOGGER:** B. Lechler

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	SOIL DESCRIPTION: GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
1330	Dual Tube Reverse	Grab			None			
					None			
1340					None		**CRYSTALLINE BEDROCK** dark red gray (5YR 4/2), granitic, quartz, K-feldspar	
1350					None		pinkish gray (5YR 7/2), granitic	
1360					None			
1370					None			
1380					None			Total depth of borehole: 1380' bgs

Appendix C
Soil Boring Log – TW-2B

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 1 of 17

SOIL BORING LOG: TW-2B

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Dual Tube Reverse/T3, Rock Core/LF90D Core Drill
WATER LEVELS: NA **START:** 1/4/2010 **END:** 1/14/2010 **LOGGER:** B. Lechler

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	SOIL DESCRIPTION: GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
							Ground Surface	Samples collected by dual tube reverse air rotary without additives. Note: Samples appear to be artificially sorted due to the drilling method, and probably do not accurately represent the full range of grain sizes.
0	Dual Tube Reverse	Grab			None		**POORLY GRADED SAND WITH SILT (SP-SM)** yellowish brown (10YR 5/4), mostly fine to medium sand (70%), some coarse sand with fine gravel	
10					None		**POORLY GRADED GRAVEL WITH SAND (GP)** pale brown (10YR 6/3), fine gravel (subangular to subrounded), some coarse gravel (10%), coarse to fine sand (45%)	
20					None		**POORLY GRADED SAND WITH SILT (SP-SM)** brownish yellow (10YR 6/6), mostly fine sand, little medium sand, trace fine gravel (subrounded)	
30					None		**POORLY GRADED GRAVEL WITH SAND (GP)** gray (10YR 5/1), fine to coarse gravel, angular to subangular	
40					None		as above, dark grayish brown (10YR 4/2), fine gravel, little coarse gravel, subangular to subrounded, some fine to coarse sand	
50					None		more sand (30%)	
60								

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 2 of 17

SOIL BORING LOG: TW-2B

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Dual Tube Reverse/T3, Rock Core/LF90D Core Drill
WATER LEVELS: NA **START:** 1/4/2010 **END:** 1/14/2010 **LOGGER:** B. Lechler

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	SOIL DESCRIPTION: GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
70	Dual Tube Reverse	Grab			None		**POORLY GRADED GRAVEL WITH SAND (GP)** as above	
					None			
80					None			
90					None		as above, grayish brown (2.5Y 5/2), fine gravel (subrounded) with coarse sand (40%)	
100					None		**POORLY GRADED SAND WITH GRAVEL (SP)** grayish brown (2.5Y 5/2), medium to coarse sand with fine gravel (40%), subangular to subrounded	
110					None			
120								

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 3 of 17

SOIL BORING LOG: TW-2B

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Dual Tube Reverse/T3, Rock Core/LF90D Core Drill
WATER LEVELS: NA **START:** 1/4/2010 **END:** 1/14/2010 **LOGGER:** B. Lechler

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	SOIL DESCRIPTION: GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
130	Dual Tube Reverse	Grab			None			
					None			
140					None		**POORLY GRADED GRAVEL WITH SAND (GP)** dark grayish brown (2.5Y 4/2), fine gravel (rounded to subangular), coarse gravel (30%), medium to coarse sand (30%)	
150					None			
160					None		**POORLY GRADED SAND WITH GRAVEL (SP)** light brownish gray (2.5Y 6/2), medium to coarse sand with fine gravel (30%)	
170					None		**POORLY GRADED GRAVEL WITH SAND (GP)** dark grayish brown (2.5Y 4/2), fine to coarse gravel (subangular to subrounded), with medium coarse sand	
180								

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 4 of 17

SOIL BORING LOG: TW-2B

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Dual Tube Reverse/T3, Rock Core/LF90D Core Drill
WATER LEVELS: NA **START:** 1/4/2010 **END:** 1/14/2010 **LOGGER:** B. Lechler

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	SOIL DESCRIPTION: GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
190	Dual Tube Reverse	Grab			None		**POORLY GRADED GRAVEL WITH SAND (GP)** as above	
					None		as above, brown (10YR 5/3), sand fraction ~ 40%-50%, mostly coarse sand	
200					None			
210					None			
220					None			
230					None		**POORLY GRADED SAND WITH GRAVEL (SP)** pale brown (10YR 6/3), mostly medium to coarse sand, some fine gravel	
240								

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 5 of 17

SOIL BORING LOG: TW-2B

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Dual Tube Reverse/T3, Rock Core/LF90D Core Drill
WATER LEVELS: NA **START:** 1/4/2010 **END:** 1/14/2010 **LOGGER:** B. Lechler

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	SOIL DESCRIPTION: GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
250	Dual Tube Reverse	Grab			None		**POORLY GRADED SAND WITH GRAVEL (SP)** as above, gravel is fine (5-10mm)	
					None			
260					None			
270					None			
280					None		**POORLY GRADED GRAVEL WITH SAND (GP)** grayish brown (10YR 5/2), fine gravel, angular, medium to coarse sand, angular	
290					None			
300					None			

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 6 of 17

SOIL BORING LOG: TW-2B

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Dual Tube Reverse/T3, Rock Core/LF90D Core Drill
WATER LEVELS: NA **START:** 1/4/2010 **END:** 1/14/2010 **LOGGER:** B. Lechler

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	SOIL DESCRIPTION: GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
310	Dual Tube Reverse	Grab			None			
					None			
320					None		**POORLY GRADED SAND WITH GRAVEL (SP)** light gray (10YR 7/2), mostly medium to coarse sand, some fine sand, fine gravel (15%)	
330					None			
340					None			
350					None		as above, yellowish brown (10YR 5/4), medium to coarse sand, some fine sand, fine gravel (angular to subangular) (40%)	
360					None			

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 7 of 17

SOIL BORING LOG: TW-2B

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Dual Tube Reverse/T3, Rock Core/LF90D Core Drill
WATER LEVELS: NA **START:** 1/4/2010 **END:** 1/14/2010 **LOGGER:** B. Lechler

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	SOIL DESCRIPTION: GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
370	Dual Tube Reverse	Grab			None		**POORLY GRADED SAND WITH GRAVEL (SP)** as above	
					None			
380					None			
390					None		as above, % gravel decreasing (20%)	
400					None			
410					None			
420								

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 8 of 17

SOIL BORING LOG: TW-2B

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Dual Tube Reverse/T3, Rock Core/LF90D Core Drill
WATER LEVELS: NA **START:** 1/4/2010 **END:** 1/14/2010 **LOGGER:** B. Lechler

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	SOIL DESCRIPTION: GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
430	Dual Tube Reverse	Grab			None		**POORLY GRADED SAND WITH GRAVEL (SP)** as above, % gravel increasing (40%)	
					None			
440					None			
450					None		**POORLY GRADED SAND WITH GRAVEL (SP)** dark grayish brown (10YR 4/2), medium to coarse sand (80%), with fine sand and fine gravel	
460					None		as above, brown (7.5YR 4/2), fine to coarse sand, increase in fine gravel, angular	
470					None		as above, dark grayish brown (10YR 4/2), medium to coarse sand with some fine sand, fine gravel, angular to subrounded	
480								

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 9 of 17

SOIL BORING LOG: TW-2B

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Dual Tube Reverse/T3, Rock Core/LF90D Core Drill
WATER LEVELS: NA **START:** 1/4/2010 **END:** 1/14/2010 **LOGGER:** B. Lechler

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	SOIL DESCRIPTION: GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
490	Dual Tube Reverse	Grab			None		**POORLY GRADED SAND (SP)** very dark grayish brown (10YR 3/2), fine to coarse sand, trace fine gravel	
					None			
500					None		**POORLY GRADED SAND WITH GRAVEL (SP)** very dark grayish brown (10YR 3/2), fine to coarse sand, trace fine gravel (40%)	
510					None			
					None			
520					None		as above, % gravel decreasing (20%)	
530					None		**WELL GRADED SAND (SW)** brown (10YR 5/3), fine to coarse sand, fine gravel (10%) (angular to subangular)	
540								

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 10 of 17

SOIL BORING LOG: TW-2B

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Dual Tube Reverse/T3, Rock Core/LF90D Core Drill
WATER LEVELS: NA **START:** 1/4/2010 **END:** 1/14/2010 **LOGGER:** B. Lechler

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	SOIL DESCRIPTION: GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
	Dual Tube Reverse	Grab			None			
550					None		**POORLY GRADED SAND WITH GRAVEL (SP)** dark grayish brown (10YR 4/2), fine to coarse sand, fine gravel (15%) (angular to subrounded), trace coarse gravel	
560					None			
570					None		as above, % fine gravel increasing (30%)	
580					None		as above, medium to coarse sand with fine sand (10%), and fine gravel (25%) (angular to subangular)	
590					None			
600								

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 11 of 17

SOIL BORING LOG: TW-2B

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Dual Tube Reverse/T3, Rock Core/LF90D Core Drill
WATER LEVELS: NA **START:** 1/4/2010 **END:** 1/14/2010 **LOGGER:** B. Lechler

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	SOIL DESCRIPTION: GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
	Dual Tube Reverse	Grab			None			
610					None		**POORLY GRADED GRAVEL WITH SAND (GP)** brown (10YR 4/3), fine gravel, angular to subrounded, with medium to coarse sand	
620					None			
630					None			
640					None			
650					None		**POORLY GRADED SAND (SP)** brown (10YR 4/3), medium to coarse sand, and fine sand, trace fine gravel (angular to subrounded)	
660								

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 12 of 17

SOIL BORING LOG: TW-2B

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Dual Tube Reverse/T3, Rock Core/LF90D Core Drill
WATER LEVELS: NA **START:** 1/4/2010 **END:** 1/14/2010 **LOGGER:** B. Lechler

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	SOIL DESCRIPTION: GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
670	Dual Tube Reverse	Grab			None		**POORLY GRADED SAND WITH GRAVEL (SP-SM)** brown (10YR 5/3), medium to coarse sand (some fine sand), and fine gravel (15%) (angular to subrounded)	
					None			
680					None			
690					None			
700					None		as above, very dark brown (10YR 2/2), medium to coarse sand, trace fine sand, fine gravel (angular to subrounded)	
710					None		**LEAN CLAY (CL)** brown (10YR 5/3), medium plasticity, soft, fine sand, fine gravel (20%), some weathered lithic fragments	
720								

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 13 of 17

SOIL BORING LOG: TW-2B

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Dual Tube Reverse/T3, Rock Core/LF90D Core Drill
WATER LEVELS: NA **START:** 1/4/2010 **END:** 1/14/2010 **LOGGER:** B. Lechler

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	SOIL DESCRIPTION: GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
730	Dual Tube Reverse	Grab			None		**POORLY GRADED SAND WITH GRAVEL (SP)** dark grayish brown (10YR 4/2), fine to coarse sand (more coarse), with fine gravel (rounded to angular)	
					None			
740					None			
750					None		as above, fine to coarse sand, little fine gravel, angular to subangular	
760					None			
770					None			
780								

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 14 of 17

SOIL BORING LOG: TW-2B

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Dual Tube Reverse/T3, Rock Core/LF90D Core Drill
WATER LEVELS: NA **START:** 1/4/2010 **END:** 1/14/2010 **LOGGER:** B. Lechler

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
790	Dual Tube Reverse	Grab			None		**POORLY GRADED SAND WITH GRAVEL (SP)** as above, fine to coarse sand, little fine gravel, angular to subangular	
					None			
				100			**CONGLOMERATE** very pale brown (10YR 7/3), gravel and cobbles of granitic and volcanic origin, coarse grained, moderately weathered	Stop drilling with T3 rig. Set pre-collar to 798' bgs for core rig. Begin HQ core.
800	Rock Core	Continuous		31	None			
				42				
				70				
810				33			**CRYSTALLINE BEDROCK** white (N8) to greenish gray (5GY 6/1), quartz, white feldspar, granitic, coarse grained, moderately weathered, weathered white feldspars with chalky consistency, slightly to highly weathered, fractures throughout	
				0				
820				0				
				19				
				21			some chlorite alteration	
				8			chlorite alteration	
830				0				
				0				
				0				
840								

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 15 of 17

SOIL BORING LOG: TW-2B

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Dual Tube Reverse/T3, Rock Core/LF90D Core Drill
WATER LEVELS: NA **START:** 1/4/2010 **END:** 1/14/2010 **LOGGER:** B. Lechler

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	SOIL DESCRIPTION: GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
850	Rock Core	Continuous		31	None		**CRYSTALLINE BEDROCK** white (N8) to greenish gray (10Y 6/1), granitic, presence of K-feldspar, coarse grained, slightly to highly weathered, fractures throughout, weathered white feldspar, highly weathered feldspar at 849.5'	
				22				
				0				
				0				
				0				
				11				
				7				
860				0			increase in K-feldspar, presence of Fe-oxide	
				20				
				0			light reddish brown (5YR 6/4), granitic, quartz, K-feldspar, coarse grained, moderately weathered, Fe-oxide stained	
870				33				
				0				
				0				
880				46				
				0				
				0				
890				0				
				25				
				19				
900				0				

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 16 of 17

SOIL BORING LOG: TW-2B

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Dual Tube Reverse/T3, Rock Core/LF90D Core Drill
WATER LEVELS: NA **START:** 1/4/2010 **END:** 1/14/2010 **LOGGER:** B. Lechler

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
910	Rock Core	Continuous		0	None		**CRYSTALLINE BEDROCK** white (N8) to greenish gray (10Y 6/1), granitic, quartz, white feldspar, some K-feldspar, coarse grained, slightly to highly weathered, fractures throughout	
				0				
				10				
				13				
				24				
920				25				
				0				
				0				
				0				
930				0				
				0				
				0				
				0				
940				38				
				0			weathered white feldspar (no reaction with HCL)	
				14				
950				50				
				100	Strong		mafic interval (952'-955'), brown (7.5YR 5/2), mafics, calcite veins (HCL strong reaction), fine grained, clays with void-filling calcite at top contact	
				37				
960				0				

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 17 of 17

SOIL BORING LOG: TW-2B

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Dual Tube Reverse/T3, Rock Core/LF90D Core Drill
WATER LEVELS: NA **START:** 1/4/2010 **END:** 1/14/2010 **LOGGER:** B. Lechler

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	SOIL DESCRIPTION: GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
970	Rock Core	Continuous		30	None		**CRYSTALLINE BEDROCK** white (N8) to greenish gray (10Y 6/1), granitic, quartz, white feldspar, slightly to highly weathered, fractured throughout	
				26				
				55				
				0				
980				23				
				38			highly weathered/altered, abundant chlorite	
				76				
990				60				
				63				
1000				55			2' altered chlorite zone	
				85				
1010							End of Boring	
1020								

Appendix D
Soil Boring Log – TW-3

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 1 of 33

SOIL BORING LOG: TW-3

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Dual Tube Reverse/T3, Rock Core/LF90D Core Drill
WATER LEVELS: 444.45 ft bgs **START:** 1/21/2010 **END:** 2/3/2010 **LOGGER:** B. Lechler

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	SOIL DESCRIPTION: GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
							Ground Surface	Samples collected by dual tube reverse air rotary without additives. Note: that samples appear to be artificially sorted due to the drilling method and probably do not accurately represent the full range of grain sizes. 0'-960' logged from cuttings according to USCS. Contact between young and old alluvium (conglomerate) is unknown.
0	Stratex	Grab					**POORLY GRADED GRAVEL WITH SAND (GP)** brown (10YR 5/3), coarse to fine gravel (angular to subrounded) with coarse to medium sand (45%) (angular to rounded), trace fine sand	
10							as above	
20							**SILTY SAND (SM)** yellowish brown (10YR 5/4),coarse to fine sand (angular to subrounded) with silt (15%), and fine gravel (10%)	
30							as above, increase in silt (25%)	
40							**POORLY GRADED SAND WITH SILT AND GRAVEL (SP-SM)** light grayish brown (10YR 6/2), fine to coarse sand with silt and fine gravel, coarser grains (angular to subrounded), mostly granitic, some lithics and volcanics	
50							**POORLY GRADED SAND WITH GRAVEL (SP)** light brownish gray (10YR 6/2), coarse to fine sand with fine gravel (40%), coarse grains (angular to subrounded)	
60								

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 2 of 33

SOIL BORING LOG: TW-3

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Dual Tube Reverse/T3, Rock Core/LF90D Core Drill
WATER LEVELS: 444.45 ft bgs **START:** 1/21/2010 **END:** 2/3/2010 **LOGGER:** B. Lechler

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	SOIL DESCRIPTION: GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
70	Stratex	Grab					as above, gravel is coarser, 30% fine, 15% coarse	
							SILTY SAND (SM) light brownish gray (10YR 6/2), fine to coarse sand with silt (15%), and fine gravel (10%), coarse, mostly granitic with some lithics	
80							**POORLY GRADED GRAVEL WITH SAND (GP)** brown (7.5YR 4/3), mostly fine gravel, some coarse gravel (10%), with medium to coarse sand (30%), angular to subangular, granitic and lithics	
90	Dual Tube Reverse						as above, coarse gravel is subrounded, more medium sand	
100							as above, increasing sand content	
110								
120								

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 3 of 33

SOIL BORING LOG: TW-3

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Dual Tube Reverse/T3, Rock Core/LF90D Core Drill
WATER LEVELS: 444.45 ft bgs **START:** 1/21/2010 **END:** 2/3/2010 **LOGGER:** B. Lechler

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	SOIL DESCRIPTION: GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
130	Dual Tube Reverse	Grab					**POORLY GRADED SAND WITH GRAVEL (SP)** dark gray (5YR 4/1), medium to coarse sand, trace fine sand with fine gravel, granitics, lithics, subangular to subrounded	
							POORLY GRADED GRAVEL WITH SAND (GP) dark gray (5YR 4/1), fine gravel (subangular to subrounded), with medium to coarse sand, mostly granitic with some lithics	
140							as above, gravel is larger, some coarse gravel	
150							as above, % gravel decreasing	
160							as above, gravel includes angular to subangular dolomite fragments (strong HCL reaction)	
170							**POORLY GRADED SAND WITH GRAVEL (SP)** dark gray (5YR 4/1), medium to coarse sand with fine gravel, trace coarse gravel, granitics, limestone, mudstone (subangular to rounded)	
180								

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 4 of 33

SOIL BORING LOG: TW-3

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Dual Tube Reverse/T3, Rock Core/LF90D Core Drill
WATER LEVELS: 444.45 ft bgs **START:** 1/21/2010 **END:** 2/3/2010 **LOGGER:** B. Lechler

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	SOIL DESCRIPTION: GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
190	Dual Tube Reverse	Grab					**POORLY GRADED SAND WITH GRAVEL (SP)** as above, more fine gravel (40%), granitics and lithics (subangular to subrounded	
200							as above, gravel includes dolomite	
210							**POORLY GRADED GRAVEL WITH SAND (GP)** dark gray (5YR 4/1), fine gravel (subangular to subrounded), with medium to coarse sand, gravel mostly granitic, lithics, some dolomite	
220							as above	
230							as above, gravel decreasing in abundance	
240								

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 5 of 33

SOIL BORING LOG: TW-3

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Dual Tube Reverse/T3, Rock Core/LF90D Core Drill
WATER LEVELS: 444.45 ft bgs **START:** 1/21/2010 **END:** 2/3/2010 **LOGGER:** B. Lechler

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	SOIL DESCRIPTION		COMMENTS
						GRAPHIC LOG	SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
250	Dual Tube Reverse	Grab					**POORLY GRADED SAND WITH GRAVEL (SP)** dark reddish gray (5YR 4/2), medium to coarse sand (subangular to subrounded), with fine gravel (40%), mostly granitic, lithics, and carbonates	
260							**POORLY GRADED GRAVEL WITH SAND (GP)** reddish gray (5YR 5/2), fine gravel (angular to subrounded) with medium to coarse sand, 50/50 granitic/carbonate fragments	
270							**POORLY GRADED SAND WITH GRAVEL (SP)** dark reddish gray (5YR 4/2), medium to coarse sand (subangular to subrounded), with fine gravel, mostly granitics with carbonates and lithics	
280							**POORLY GRADED GRAVEL WITH SAND (GP)** dark reddish gray (5YR 4/2), fine gravel (subangular to subrounded), with medium to coarse sand, granitics and carbonates with some lithics as above, gravel mostly granitic	
290								
300								

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 6 of 33

SOIL BORING LOG: TW-3

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Dual Tube Reverse/T3, Rock Core/LF90D Core Drill
WATER LEVELS: 444.45 ft bgs **START:** 1/21/2010 **END:** 2/3/2010 **LOGGER:** B. Lechler

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	SOIL DESCRIPTION: GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
310	Dual Tube Reverse	Grab					**POORLY GRADED GRAVEL WITH SAND (GP)** sand increasing to 45% as above, sand decreasing to 30%	
320								
330							as above, some fine gravel likely from larger clasts (some weathered surfaces with some fresh surfaces)	
340								
350								
360								

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 7 of 33

SOIL BORING LOG: TW-3

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Dual Tube Reverse/T3, Rock Core/LF90D Core Drill
WATER LEVELS: 444.45 ft bgs **START:** 1/21/2010 **END:** 2/3/2010 **LOGGER:** B. Lechler

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	SOIL DESCRIPTION: GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
370	Dual Tube Reverse	Grab					**POORLY GRADED GRAVEL WITH SAND (GP)** grayish brown (2.5Y 5/2), fine gravel (subangular to subrounded) with fine to coarse sand, mostly granitic, some carbonates and lithics	
380							as above, sand decreasing to 30%, increase in carbonates	
390							as above, dark red gray (5YR 4/2), mostly granitic	
400							as above, dark reddish brown (5YR 3/3)	
410							as above, very dark gray (5YR 3/1)	
420								

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 8 of 33

SOIL BORING LOG: TW-3

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Dual Tube Reverse/T3, Rock Core/LF90D Core Drill
WATER LEVELS: 444.45 ft bgs **START:** 1/21/2010 **END:** 2/3/2010 **LOGGER:** B. Lechler

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	SOIL DESCRIPTION: GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
430	Dual Tube Reverse	Grab					**POORLY GRADED GRAVEL WITH SAND (GP)** carbonates increasing in abundance	
							POORLY GRADED GRAVEL (GP) very dark gray (N3), 95% angular carbonate fragments (possible boulder)	
440							**POORLY GRADED GRAVEL WITH SAND (GP)** dark gray (5YR 4/1), fine gravel (angular to subrounded), with medium to coarse sand, mostly granitics and carbonates	
450							**POORLY GRADED GRAVEL (GP)** very dark gray (5YR 3/1), fine gravel (angular to subrounded), 70% lithics (possible boulder)	
460							**POORLY GRADED GRAVEL WITH SAND (GP)** dark reddish gray (5YR 4/2), fine gravel (angular to subrounded), with medium to coarse sand (40%), trace fine sand, gravel made up of granitics, lithics, and carbonates	
470								
480								

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 9 of 33

SOIL BORING LOG: TW-3

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Dual Tube Reverse/T3, Rock Core/LF90D Core Drill
WATER LEVELS: 444.45 ft bgs **START:** 1/21/2010 **END:** 2/3/2010 **LOGGER:** B. Lechler

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	SOIL DESCRIPTION: GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
490	Dual Tube Reverse	Grab					**POORLY GRADED GRAVEL WITH SAND (GP)** as above	
							as above, more than 50% carbonate fragments	
500							as above, carbonates decreasing to 30%	
510							as above, gravel mostly granitic (60%), with carbonates and lithic fragments (subangular to subrounded)	Rig chatter, cuttings are angular granitic fragments.
520								
530								
540								

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 10 of 33

SOIL BORING LOG: TW-3

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Dual Tube Reverse/T3, Rock Core/LF90D Core Drill
WATER LEVELS: 444.45 ft bgs **START:** 1/21/2010 **END:** 2/3/2010 **LOGGER:** B. Lechler

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	SOIL DESCRIPTION		COMMENTS
						GRAPHIC LOG	SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
550	Dual Tube Reverse	Grab					**POORLY GRADED GRAVEL WITH SAND (GP)** sand increasing to 45%, abundant lithics in gravel	
560							as above, 50/50 fine gravel and medium to coarse sand, mostly granitic with carbonates, lithics, and quartzite (white)	
570							as above, granitic, lithics, and carbonates, absence of quartzite	
580							as above, carbonates increasing to 30%	
590								
600								

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PROJECT NUMBER: 386303 **Sheet:** 11 of 33

SOIL BORING LOG: TW-3

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Dual Tube Reverse/T3, Rock Core/LF90D Core Drill
WATER LEVELS: 444.45 ft bgs **START:** 1/21/2010 **END:** 2/3/2010 **LOGGER:** B. Lechler

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	SOIL DESCRIPTION: GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
610	Dual Tube Reverse	Grab					**POORLY GRADED SAND WITH GRAVEL (SP)** dark reddish gray (5YR 4/2), medium to coarse sand (angular to subrounded), with fine gravel (subangular to subrounded), 30% granitics, carbonates, and lithics	
620							as above, some fine sand	
630							as above, gravel increasing to 45%	
640							**POORLY GRADED GRAVEL WITH SAND (GP)** dark reddish gray (5YR 4/2), fine gravel (subangular to subrounded), with medium to coarse sand (45%), granitics, carbonates, and lithics	
650							as above, gravel increasing to 60%, mostly granitics and carbonates	
660								

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 12 of 33

SOIL BORING LOG: TW-3

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Dual Tube Reverse/T3, Rock Core/LF90D Core Drill
WATER LEVELS: 444.45 ft bgs **START:** 1/21/2010 **END:** 2/3/2010 **LOGGER:** B. Lechler

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	SOIL DESCRIPTION: GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
670	Dual Tube Reverse	Grab					**POORLY GRADED SAND WITH GRAVEL (SP)** dark reddish gray (5YR 4/2), medium to coarse sand (subangular to subrounded), with fine gravel (40%), granitics, lithics increasing and carbonates	
680							as above, trace fine sand, 40% granitic, 30% carbonates, 30% lithic, trace coarse gravel	Measure water level in borehole after sitting overnight. Measured through drill pipe. DTW = 446.1' bgs
690							as above, granitics increasing to 75%, fine gravel decreasing to 30%	
700								
710							as above, fine sand increasing to 15%	
720								

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 13 of 33

SOIL BORING LOG: TW-3

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Dual Tube Reverse/T3, Rock Core/LF90D Core Drill
WATER LEVELS: 444.45 ft bgs **START:** 1/21/2010 **END:** 2/3/2010 **LOGGER:** B. Lechler

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	SOIL DESCRIPTION: GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
730	Dual Tube Reverse	Grab					**POORLY GRADED SAND WITH GRAVEL (SP)** reddish gray (5YR 5/2), medium to coarse sand with fine sand (15%), and fine gravel (40%) (subangular to subrounded), mostly granitic, some lithics and carbonates	
740							as above, fine sand increasing, gravel decreasing in percent and size, average size at ~ 10mm	
750							as above, sand contains quartz, feldspar, carbonates, and lithics	
760							as above, gravel increasing to 40%	Discharge water temperature at 84.5° F
770							as above, carbonates increasing in abundance, sand and gravel fraction	
780								

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 14 of 33

SOIL BORING LOG: TW-3

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Dual Tube Reverse/T3, Rock Core/LF90D Core Drill
WATER LEVELS: 444.45 ft bgs **START:** 1/21/2010 **END:** 2/3/2010 **LOGGER:** B. Lechler

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	SOIL DESCRIPTION: GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
790	Dual Tube Reverse	Grab					**POORLY GRADED SAND WITH GRAVEL (SP)** reddish gray (10YR 5/2), mostly medium to coarse sand, with some fine sand (angular to subrounded), fine gravel (40%), granitics, lithics, and carbonates	
800								
810							**POORLY GRADED GRAVEL WITH SAND (GP)** reddish gray (5YR 5/2), mostly fine gravel (angular to subrounded), with medium to coarse sand, granitics, lithics, and carbonates, trace coarse gravel	
820							**POORLY GRADED SAND WITH GRAVEL (SP)** reddish gray (5YR 5/2), mostly medium to coarse sand with fine gravel (30%), lithology as above	
830							as above, gravel decreasing in size and abundance (30%)	
840								

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 15 of 33

SOIL BORING LOG: TW-3

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Dual Tube Reverse/T3, Rock Core/LF90D Core Drill
WATER LEVELS: 444.45 ft bgs **START:** 1/21/2010 **END:** 2/3/2010 **LOGGER:** B. Lechler

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	SOIL DESCRIPTION: GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
850	Dual Tube Reverse	Grab					**POORLY GRADED SAND WITH GRAVEL (SP)** as above, carbonates increasing in abundance	
860							as above, gravel increasing to 40%, mostly granitics and carbonates	
870							as above, gravel decreasing to 30%	
880							as above, gravel size increasing to 10-20 mm	
890								
900								

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 16 of 33

SOIL BORING LOG: TW-3

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Dual Tube Reverse/T3, Rock Core/LF90D Core Drill
WATER LEVELS: 444.45 ft bgs **START:** 1/21/2010 **END:** 2/3/2010 **LOGGER:** B. Lechler

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	SOIL DESCRIPTION: GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
910	Dual Tube Reverse	Grab					**POORLY GRADED SAND WITH GRAVEL (SP)** dark reddish gray (5YR 4/2), fine to coarse sand (mostly medium size sand) (angular to subrounded), with fine gravel, trace coarse gravel, mostly granitics and carbonates	
920								
930							**POORLY GRADED GRAVEL WITH SAND (GP)** dark reddish gray (5YR 4/2), fine gravel (angular to subrounded), with medium to coarse sand, granitics, carbonates, and lithics	
940								
950							as above, more fine to medium sand than above	Stop drilling with T3 rig. Set pre-collar to 960' bgs for core rig.
960								Begin HQ coring.

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 17 of 33

SOIL BORING LOG: TW-3

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Dual Tube Reverse/T3, Rock Core/LF90D Core Drill
WATER LEVELS: 444.45 ft bgs **START:** 1/21/2010 **END:** 2/3/2010 **LOGGER:** B. Lechler

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	SOIL DESCRIPTION: GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
970	Rock Core	Continuous		43			**CONGLOMERATE** yellowish brown (10YR 5/6), fine to coarse gravel and cobbles (up to 150 mm). Formation is clast-supported, little sand (fine to coarse) and trace fines (silt and clay)	
				56				
				90				
				62	Weak		sand and gravel (angular to subrounded), mostly granitics and carbonates (strong HCL reaction), moderately cemented, some sandy/silty sand interbeds, 0.25' thick interbeds	
980				100				
				100	Weak		granite cobble (110 mm)	
990				54				
				94				
1000				40				
				100			1' of sandy silt/silty sand, layer moderately cemented	
				94			granite and carbonate cobbles	
1010				85			carbonate cobble (140 mm), matrix of silty fine sand	
1020				100				

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 18 of 33

SOIL BORING LOG: TW-3

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Dual Tube Reverse/T3, Rock Core/LF90D Core Drill
WATER LEVELS: 444.45 ft bgs **START:** 1/21/2010 **END:** 2/3/2010 **LOGGER:** B. Lechler

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
1030	Rock Core	Continuous					**CONGLOMERATE**	
				82			as above, fine to coarse gravel and cobbles (up to 150 mm), subangular to subrounded in matrix of sand to silty sand, moderately cemented, generally cLast supported, cobbles mostly carbonate and granitics, gravel, is same composition, but includes lithics	
				92				
				56				
1040				76				
				60			matrix fine to medium sand, some silty lenses	
				96				
1050				76				
				76				
1060				62			granite, quartzite, and carbonate cobbles	
				100			abundant cobbles	
1070				90	None		0.5' silt layer, moderately cemented, abundant coarse gravel and cobbles	
				100				
1080								

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 19 of 33

SOIL BORING LOG: TW-3

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Dual Tube Reverse/T3, Rock Core/LF90D Core Drill
WATER LEVELS: 444.45 ft bgs **START:** 1/21/2010 **END:** 2/3/2010 **LOGGER:** B. Lechler

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	SOIL DESCRIPTION: GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
	Rock Core	Continuous					**CONGLOMERATE**	
				100	Weak		as above, matrix yellowish brown (10YR 5/4), abundant cobbles, mostly granitic, some carbonates, fine to coarse sand with silt	
				80				
1090				90	Weak			
				100	None		matrix, sandy, moderately cemented	
1100				100			matrix, silty fine sand, not cemented	
							matrix, sandy, abundant cobbles	
				100	Weak			
1110				100				
				100	Weak			
1120								
				84			matrix fine sand, soft	
							matrix, sandy, moderately cemented	
				74	Weak			
1130				100			mostly fine to coarse gravel, clast supported, very little matrix material	
				100	Weak			
1140								

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 20 of 33

SOIL BORING LOG: TW-3

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Dual Tube Reverse/T3, Rock Core/LF90D Core Drill
WATER LEVELS: 444.45 ft bgs **START:** 1/21/2010 **END:** 2/3/2010 **LOGGER:** B. Lechler

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	SOIL DESCRIPTION: GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
	Rock Core	Continuous						
				100	Weak		**CONGLOMERATE** abundant cobbles (up to 200 mm), mostly carbonates and granitics, some volcanics and lithics	
1150				100				
				100	Weak		matrix fine silty sand	
1160				100	Weak		large granitic cobble (220 mm), ~1' of fine sand, few coarse sand, fine gravel fragments	
				100				
1170				100	Weak		large carbonate cobbles	
				82			sand interval, mostly fine to medium sand, some coarse sand to coarse gravel, yellowish brown (10YR 5/3)	
1180				82			coarse gravels and cobbles	
				40	Weak			
1190				70			~1' sand intervals	
				100				
1200				90	Weak			

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 21 of 33

SOIL BORING LOG: TW-3

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Dual Tube Reverse/T3, Rock Core/LF90D Core Drill
WATER LEVELS: 444.45 ft bgs **START:** 1/21/2010 **END:** 2/3/2010 **LOGGER:** B. Lechler

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	SOIL DESCRIPTION: GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
	Rock Core	Continuous						
				50	None			
				13	None		**INTERBEDDED CONGLOMERATE AND SANDSTONE** yellowish brown (10YR 5/5), core is less cohesive than above (poor recovery)	
1210				0				
				63				
1220				40				
				50	None		**CONGLOMERATE** yellowish brown (10YR 5/3), cobbles (quartzite and carbonate), with fine to coarse gravel	
				60				
1230				100	None		~0.5'-1' silty sand, interval, soft, gravel/cobbles (angular to subrounded), consist of carbonates, granitics, and lithics	Telescope from HQ to NQ core pipe.
1240				68	None		**INTERBEDDED CONGLOMERATE AND SANDSTONE** yellowish brown (10YR 5/4), intervals of gravel/sand are ~1-3' thick, gravel layers are generally thicker, sand is fine to medium with silt	
1250				100	Weak			
1260				100				

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 22 of 33

SOIL BORING LOG: TW-3

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Dual Tube Reverse/T3, Rock Core/LF90D Core Drill
WATER LEVELS: 444.45 ft bgs **START:** 1/21/2010 **END:** 2/3/2010 **LOGGER:** B. Lechler

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
	Rock Core	Continuous			None		**INTERBEDDED CONGLOMERATE AND SANDSTONE** as above, increase in abundance of lithics in gravel and cobbles	
				76	Weak		~1' fine sand interval coarse sand and fine gravel matrix with cobbles (clast supported), cobbles are quartzite and lithics	
1270								
				0			**CONGLOMERATE** yellowish brown (10YR 5/4), fine gravel to cobbles with matrix of mostly coarse sand with fines	
1280				79	None			
1290				35			cobble with parallel fractures ~1" apart, fracture surface show Fe-oxide staining and slickensides	
				73	Weak		as above, carbonate cobble (strong HCL reaction), 160mm	
1300				0	None		quartzite fragment (only recovery)	
1310								
				0	None		loose gravel/cobble, quartzite, granitics, carbonates (strong HCL reaction)	
1320								

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 23 of 33

SOIL BORING LOG: TW-3

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Dual Tube Reverse/T3, Rock Core/LF90D Core Drill
WATER LEVELS: 444.45 ft bgs **START:** 1/21/2010 **END:** 2/3/2010 **LOGGER:** B. Lechler

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	SOIL DESCRIPTION: GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
1330	Rock Core	Continuous		88	Weak		**CONGLOMERATE** yellowish brown (10YR 5/3), fine gravel to cobbles, with fine to coarse sand, gravel mostly carbonates and lithics, some granite ~1' sand/silty sand at 1326' bgs cobble fractured and filled with sediment	
				93				
				25			some gravel/cobbles have flat/planar surfaces (fracture?) and smooth	
1340				64				
				55	None			
				0			shoe recovered, loose gravel	
1350				0			loose gravel and sandy silt	
				0			loose gravel, mostly sedimentary quartzite	
1360				0			**CONGLOMERATE** angular to subrounded gravel in silty sand matrix	
				0				
				25			as above, smooth planar surface on cobble (fracture?)	
1370				90	Weak		cobbles of quartzite (sedimentary) and granite with gravel including, carbonates, shale, and lithics fractured quartzite cobble	
				80				
1380								

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 24 of 33

SOIL BORING LOG: TW-3

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Dual Tube Reverse/T3, Rock Core/LF90D Core Drill
WATER LEVELS: 444.45 ft bgs **START:** 1/21/2010 **END:** 2/3/2010 **LOGGER:** B. Lechler

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
	Rock Core	Continuous					**CONGLOMERATE** yellowish brown (10YR 5/4), color of matrix, cobbles mostly quartzite and carbonates (strong HCL reaction), gravel to coarse sand, includes shale, some quartz, with fines (some clay)	
				84	Weak		formation is clast supported	
1390								
				92				
1400								
				50	None		matrix is sandier than above quartzite cobble with parallel fractures	
1410				75			matrix becomes finer	
							SANDSTONE yellowish brown (10YR 5/4), fine sand with silt and coarse sand to cobbles, fractured larger grains, mostly carbonates, shale, quartzite, few granitics	
1420				93	Weak			
				90				
1430							**CONGLOMERATE** transition back to (GP), granite cobble	
				80				
1440								

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 25 of 33

SOIL BORING LOG: TW-3

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Dual Tube Reverse/T3, Rock Core/LF90D Core Drill
WATER LEVELS: 444.45 ft bgs **START:** 1/21/2010 **END:** 2/3/2010 **LOGGER:** B. Lechler

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	SOIL DESCRIPTION: GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
	Rock Core	Continuous					**CONGLOMERATE** as above, matrix is brown (10YR 5/3), clast supported fine gravel and coarse sand with coarse gravel and cobbles, matrix is silty sand, some clay	
1450				74	None		larger grains are angular to subrounded and mostly shale, carbonate, quartzite, with some lithics and granitics, cobbles mostly carbonates (strong HCL reaction)	
1460				95	None		mostly fine gravel to coarse sand	
1470				95	None		carbonate boulder (~1.5'/~450mm), largest clast cored fractured quartzite	
1480				69	Weak		quartzite cobble, fracture filled with reddish carbonate material (strong reaction with HCL)	
1490				95	Weak		matrix is sandier with medium to coarse sand **SANDSTONE** yellowish brown (10YR 5/4), mostly fine sand, some medium to coarse sand with silt and fine gravel, cobbles, fractured cobbles and fracture in sand interval (filled with clay)	
1500				78				

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 26 of 33

SOIL BORING LOG: TW-3

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Dual Tube Reverse/T3, Rock Core/LF90D Core Drill
WATER LEVELS: 444.45 ft bgs **START:** 1/21/2010 **END:** 2/3/2010 **LOGGER:** B. Lechler

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	SOIL DESCRIPTION: GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
	Rock Core	Continuous			None		**SANDSTONE** brown (10YR 5/3), fine to medium sand with some coarse sand, fines mostly silt, fine gravel to cobbles include granitics, lithics/volcanics, quartzite, carbonates	
1510				100	Weak		fractured granitic cobble matrix is becoming finer quartzite cobble	
1520				94	Strong		fractured quartzite cobble with calcite growth on fracture surface resting on top of a carbonate cobble ~1' gravel zone	
1530				100	Strong		calcite cementation matrix still fine sand with silt	
1540				97	Weak		fractured cobble granite cobble (260 mm)	
1550				80	Weak		core becomes sandier (fewer fines)	
1560				91	Weak			

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 27 of 33

SOIL BORING LOG: TW-3

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Dual Tube Reverse/T3, Rock Core/LF90D Core Drill
WATER LEVELS: 444.45 ft bgs **START:** 1/21/2010 **END:** 2/3/2010 **LOGGER:** B. Lechler

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	SOIL DESCRIPTION: GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
	Rock Core	Continuous			None		**SANDSTONE** yellowish brown (10YR 5/4), fine to coarse sand (angular to subrounded) with fines and fine gravel to cobbles	
1570				70	Strong		matrix becoming finer (silt and clay)	
1580				89	None		abundant volcanics in gravel very hard (fracture?), 2' silt layer with some 1" clay intervals	
1590				100	Weak		**SANDSTONE** abundant volcanics in gravel gravel abundance decreasing (sand with silt), fracture in sand	
1600				93	None		gravel zone, most gravel is subrounded, abundance of fines decreasing	
1610				87	Strong		~0.5' altered zone with calcite crystals in clayey matrix	
1620				100	None		coarse sand/gravel zone	

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PROJECT NUMBER: 386303 **Sheet:** 28 of 33

SOIL BORING LOG: TW-3

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Dual Tube Reverse/T3, Rock Core/LF90D Core Drill
WATER LEVELS: 444.45 ft bgs **START:** 1/21/2010 **END:** 2/3/2010 **LOGGER:** B. Lechler

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
	Rock Core	Continuous			None		**SANDSTONE** yellowish brown (10YR 5/4), fine sand, some medium to coarse sand with fine gravel to cobbles, trace fines, gravel size and abundance increases at 1625' bgs	
				80				
1630					None		**SHALE** olive brown (2.5Y 4/3), fractured, sandy at 1630', clayey at 1632', shear plane at fracture (1635') with slickensides	
				0	Weak			
1640				37	None		**LIMESTONE** olive gray (5Y 4/2), sandy, some intervals, hard to scratch, no reaction with HCL, fractured with calcite formation on fracture surfaces	
				46	None			
1650								
				40	Strong			
1660				94	Variable		laminated, some intervals have strong reaction with HCL, some intervals have no reaction with HCL, Fe-oxide staining in some layers	
				46	Strong		mottled, brownish yellow (10YR 6/6), to olive gray (5Y 5/2) with dark red bands	
1670								
				70			**SHALE** olive brown (2.5Y 4/3)	
1680								

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 29 of 33

SOIL BORING LOG: TW-3

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Dual Tube Reverse/T3, Rock Core/LF90D Core Drill
WATER LEVELS: 444.45 ft bgs **START:** 1/21/2010 **END:** 2/3/2010 **LOGGER:** B. Lechler

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
1690	Rock Core	Continuous		92	None		2' zone, highly deformed with calcite bands, and shale and limestone fragments included in fine matrix	
				80	Strong		mottled, brownish yellow (10YR 6/6), to olive gray (5Y 5/2) with dark red bands, deformed, parts easily along fine grained bedding surfaces 1689': rock becomes harder with abundant calcite veins	
				50	None		**SHALE** olive brown (2.5Y 4/4)	
1700				53	Strong		**LIMESTONE** gray (2.5Y 6/1), to dark yellowish brown (10YR 4/6), colors mottled, contains nodules (elliptical) (15-25 mm), with concentric rings (algal?) with smaller (10-15 mm), elongate objects with no rings (shell casts), calcite veins and vugs with calcite crysta	
1710				82	Strong		deformed zone containing shale fragments and limestone in a fine matrix, shear planes with slickensides 1711': transitions into shaley limestone, then limestone as above	
1720				94	Strong		1715', 1717', 1720.5', 1728' vugs with calcite crystals	
1730				95	Strong		1733-1734.5' and 1737'-1738.5' calcite matrix including rock fragments (breccia zone?)	
1740				90	Strong		vugs with calcite	

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 30 of 33

SOIL BORING LOG: TW-3

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Dual Tube Reverse/T3, Rock Core/LF90D Core Drill
WATER LEVELS: 444.45 ft bgs **START:** 1/21/2010 **END:** 2/3/2010 **LOGGER:** B. Lechler

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
	Rock Core	Continuous			Strong		**LIMESTONE** as above, less nodules, more calcite veins 1744'-1745': vugs with calcite (~15mm opening)	
1750				50			shale interval	
				0	Strong			
1760							increase in nodules/fossils	
				100	Strong		abundant reddish brown, mottling, circular to elongate/band forming	
1770				41	None		**SHALE** olive gray (5Y 4/2), abrupt contact, with above limestone finely laminated with some sandy carbonate rich interbeds (~10-20 mm) fracture at 1771' bgs	
1780				18	None		dark olive brown (2.5Y 3/3), some dark gray/black sandy interbeds (~10-30 mm)	
				0				
1790				18			fractured shale in fine (clay) matrix	
				33	None		very dark grayish brown (2.5Y 3/2), less fractured than above	
1800					None			

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 31 of 33

SOIL BORING LOG: TW-3

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Dual Tube Reverse/T3, Rock Core/LF90D Core Drill
WATER LEVELS: 444.45 ft bgs **START:** 1/21/2010 **END:** 2/3/2010 **LOGGER:** B. Lechler

DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
1810	Rock Core	Continuous		25			**SHALE** dark yellowish brown (10YR 4/4), fractured, matrix is sandy, some sandy layers (up to 50 mm thick)	
				43	Variable		gray (2.5Y 5/1) to black (2.5Y 2.5/1), some carbonate rich/sandy layers (weak HCL reaction) fractures with slickensides	
				26	Variable			
1820				35	None		**QUARTZITE** light gray (5Y 7/1), to olive brown (2.5Y 4/4), fractured with sand matrix, individual sand grains visible in hand sample	
				0	None		white soft mineralized zone (matrix) with quartzite fragments	
				0				
1830				0	None			
				0	None		finer grained, recovered rocks fragments (no matrix)	
1840				20			highly weathered/deformed zone, rock fragments (quartzite, granite), in brownish yellow (10YR 6/6), clayey sand matrix	
				0	Variable		weathered/altered rock, white/green/red, some calcite reaction and quartz greenish gray/white clayey zone with slickensides	
1850				0			**LIMESTONE/SHALE** poor recovery, all rock recovered were gravel sized fragments of olive gray shale (no HCL reaction) and gray limestone (strong HCL reaction)	
1860								

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 32 of 33

SOIL BORING LOG: TW-3

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
ELEVATION: NA **DRILLING CONTRACTOR:** Layne Christensen Inc.
DRILLING METHOD AND EQUIPMENT: Dual Tube Reverse/T3, Rock Core/LF90D Core Drill
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DEPTH BELOW	DRILLING METHOD	SAMPLE TYPE	RECOVERY (FT)	RQD (%)	HCL REACTION	GRAPHIC LOG	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
1870	Rock Core	Continuous			Variable		**LIMESTONE/SHALE** as above, poor recovery, limestone and shale fragments as loose gravel, (no matrix)	
				0				
				0				
1880				0			**GRANITE** alternating intervals of hard crystalline rock and weathered/altered zones, rock is granitic (feldspar, quartz, biotite) fracture surfaces have Fe-oxide staining and calcite crystallization	
				21				
1890				0				
				0				
1900				28			altered zones contain broken fragments of granitic rock in a clayey matrix (typically white and green), some chlorite alteration and pyrite crystallization	
				20				
1910				19				
				33				
1920				37				

CH2MHILL

PROJECT NUMBER: 386303 **Sheet:** 33 of 33

SOIL BORING LOG: TW-3

PROJECT: Cadiz Exploration **LOCATION:** Cadiz, CA
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1930	Rock Core	Continuous					**GRANITE** as above, contains altered zones with chlorite, very brittle	
				23				
				0				
1940				12				
							End of Boring	
1950								
1960								
1970								
1980								

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