

APPENDIX C
DRILLING PROGRAM



TECHNICAL MEMORANDUM

2171 E. Francisco Blvd., Suite K • San Rafael, California • 94901
TEL: (415) 457-0701 FAX: (415) 457-1638 e-mail: stevenp@stetsonengineers.com

TO: Office of Water Resources

DATE: November 28, 2000

FROM: Steven Plunkett

JOB NO: 1828

RE: Observation Well Drilling Program

This technical memo describes well construction and drilling activities that occurred at Camp Pendleton between June 25 and July 5, 2000. The observation well locations were chosen to fill missing gaps in the available geologic data and to determine specific geologic and lithologic relationships in the Santa Margarita River Basin. Furthermore, these observation wells provide critical understanding of the complex hydrogeologic relationships in the Santa Margarita River basin.

Stetson Engineers planned an observation well drilling program as part of the permit 15000-compliance program. This memorandum presents the results of the drilling project, and the following information.

- ◆ Well drilling and construction activities.
- ◆ Geologic and hydrogeologic conditions.
- ◆ Observation well design drawings, graphic columnar sections, and lithologic well logs.
- ◆ Observation well development.

STUDY AREA

The study area is located approximately 45 miles north of downtown San Diego in the coastal region of northern San Diego County, California on the United States Marine Corps Base (MCB), Camp Pendleton. The five observation wells/piezometers are located in the upper Ysidora sub-basin in the Santa Margarita River watershed (see Figure 1). The flood plain deposits in this area consist of Recent and Pleistocene alluvial valley fill sediments. The valley fill is composed of three geologic units; the Terrace Deposits, the Lower Alluvium, and the Upper Alluvium.

GEOLOGY/HYDROGEOLOGY

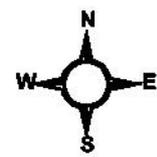
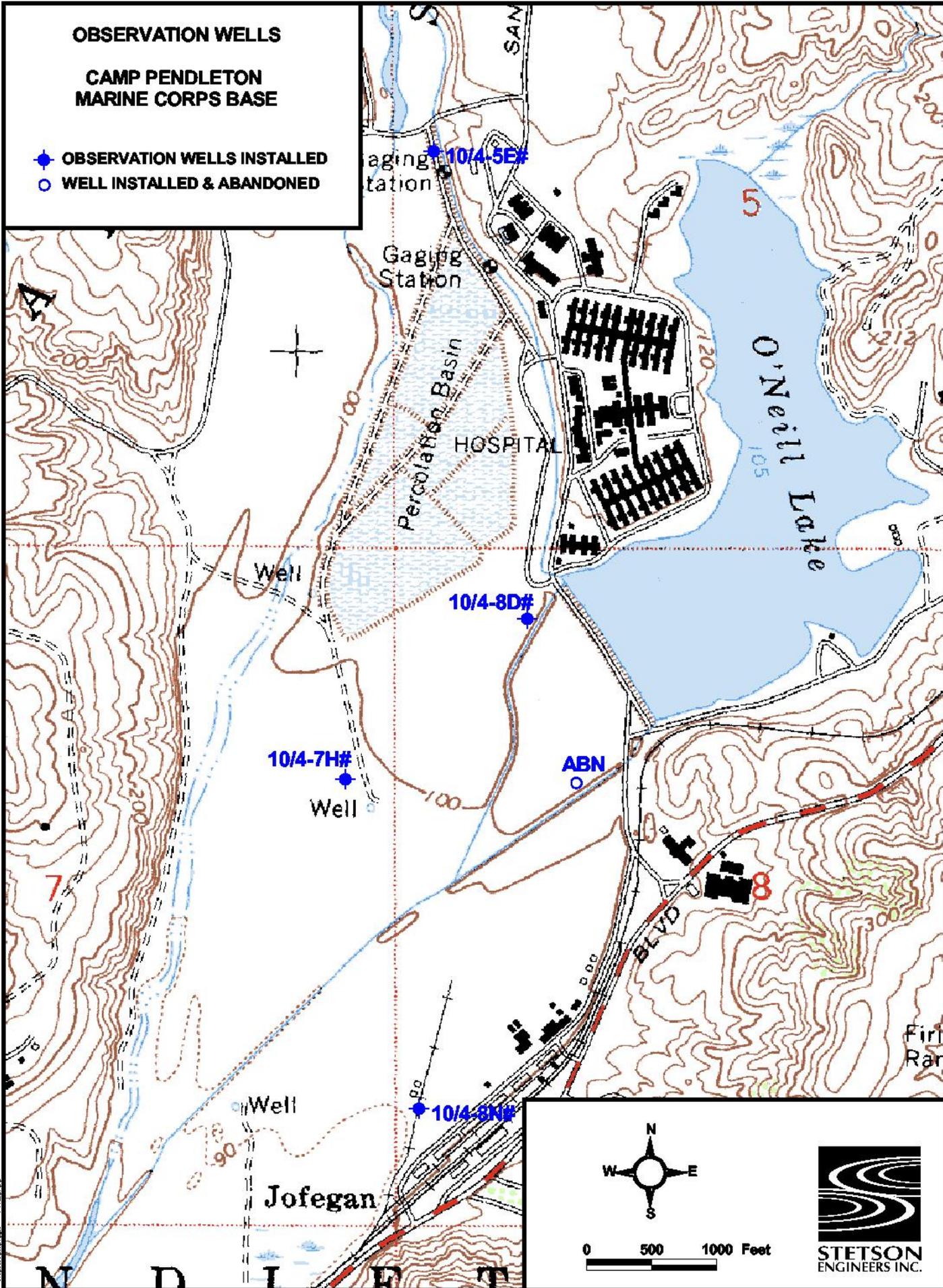
Sequentially the Santa Margarita River Basin originated during the Triassic period when the region was part of a pre-batholithic group of sandstone and shales. Due to tectonic forces during the Cretaceous period granites of the Peninsular Range Batholith were formed. From the uplift of the batholith the overlying rocks were eroded and deposited along the sea causing some sedimentation. In the Tertiary Period sedimentation was amplified, sea levels fluctuated, marine and continental sedimentation increased, and the area was subjected to regional uplift and tilting. During the Quaternary Period the sea receded and rose during glacial interludes and created marine terraces. More recently, movements along faults have caused breaking up of the region into blocks of varying altitudes. Additional rises in sea level filled the current river channels with alluvium. Currently, the Santa Margarita basin is a stream-eroded channel filled with unconsolidated alluvium; consolidated sedimentary and igneous rocks underlie it.

The geology of the Santa Margarita River Basin includes the Basement Complex, the San Onofre Formation, the La Jolla Group, and unconsolidated deposits. The Basement Complex is from the Jurassic and Cretaceous age, it is the oldest rock formation in the study area and consists of metamorphic and igneous rocks from the Peninsular Range Batholith (Leedshill-Herkenhoff, 1988).

OBSERVATION WELLS

CAMP PENDLETON
MARINE CORPS BASE

- OBSERVATION WELLS INSTALLED
- WELL INSTALLED & ABANDONED



0 500 1000 Feet



The Basement Complex is generally limited to the Upper Ysidora Sub-area and composes the slopes around the basin flood plain in the region of the De Luz Creek confluence. Of Eocene-age the La Jolla Group dominates the perimeter of the flood plain and beyond in the Chappo and Lower Ysidora Sub-areas. The La Jolla Group is a thinning-upward sequence of medium sandstone to siltstone and claystone with expansive clays in some sections. This Group is the dominating rock type around the Ysidora Hydrologic Sub-unit, it is found primarily to the east and south bordering the valley regions. The San Onofre Formation is of middle to upper Miocene age it consists mostly of breccia but it also has decreasing amounts of conglomerate and sandstone. In the Santa Margarita River Basin it is found only in the Lower Ysidora Sub-area in small amounts to the west of the basin. The unconsolidated deposits consist of terrace and old sand dune deposits of Pleistocene age and alluvium and channel deposits of Recent age. The marine terrace deposits, of Pleistocene age range in thickness between 20 and 100 feet. The deposits in the fluvial terraces range between 10 and 40 feet. The marine terraces are comprised of sand, silt and clay with lenses ranging in size from gravels to boulders. Streams that flowed across the region during the last ice age also deposited terraces. These deposits are most abundant in the northern portion of the Chappo Sub-area. Alluvial material of recent age occurs as flood plain deposits, alluvial fans, and stream channel deposits. The alluvial valley fill occurs throughout the length of the Santa Margarita River Basin. Thickness of these deposits ranges from 50 to 70 feet in the Upper Ysidora Sub-basin to 100 to 150 feet in the Lower Ysidora Sub-basin (Leedshill-Herenhoff, 1988).

OBSERVATION WELL DRILLING

Stetson Engineers applied for and obtained well construction permits from the County of San Diego, Department of Health Services, Land and Water Quality Division on June 23, 2000 (Appendix). Stetson Engineers also obtained clearance from Camp Pendleton personnel indicating that no Native American archeological sites would be disturbed. In addition, Camp Pendleton Assistant Chief of Staff, Assistant Chief of Staff, Environmental Securities Division provided a categorical exclusion to install 5 monitoring wells for Permit 15000 Feasibility Study, Upper Ysidora groundwater basin (attached), with the consideration that no endangered species

habitat be disturbed. Lastly, it was determined that the well site locations and drilling activities would not interfere with any utilities. Therefore, it was decided that utility clearances were not needed.

Stetson Engineers contracted with Gregg Drilling Inc., of Signal Hill, CA to drill five monitoring wells/piezometers using the hollow stem auger flight drilling method. A qualified geologist was on site monitoring all phases of the project. In addition, well site locations were surveyed using a Trimble GeoExplorer II Global Positioning System (GPS) unit to locate the latitude, longitude and elevation of each well site. The observation well locations were then plotted on the USGS 7.5 minute Morro Hill quadrangle.

Five monitoring wells were drilled with a 15-ton, Marl Technologies Drill rig. The soil borings were drilled with an eight-inch diameter auger bit, through unconsolidated alluvial deposits. The sediments encountered during drilling consist of silty fine to coarse sand and gravel, with some sandy clay lenses. In addition, the deposits are often composed of cobbles and boulders overlain by less coarse material. The observation wells were drilled until auger refusal occurred or at the bedrock contact. All cuttings generated by the drilling process were dispersed on site, as directed by MCB personnel. Dispersal of the drill cuttings precluded the use of the materials as habitat for the arroyo toad, and fencing was constructed around the drill site to further prevent the arroyo toad from accessing the site.

During the planning phase of the project, Stetson Engineers concluded that it would be possible to obtain a continuous, undisturbed lithologic sample. However, during drilling, “heaving sands” entered the augers and prevented recovering a continuous sample. A qualified geologist logged the soil borings in accordance with accepted geologic procedures (Appendix). Soil samples were collected continuously from auger return material generated during the drilling process. Upon completion of drilling, well casing and well screen was installed to the completed depth.

OBSERVATION WELL CONSTRUCTION

The observation well construction consists of two-inch diameter, flush thread schedule 40 PVC. While the screened portion of the observation well is composed of two-inch diameter, schedule 40 PVC with 0.02-inch perforations. A gravel pack using clean #3 Monterey sand was installed to approximately three feet above the screen interval. Detailed well construction diagrams have been included in the Appendix. After installation of the gravel pack, bentonite grout was placed into the annulus of the borehole to a depth of 20 feet below ground surface. The upper 20 feet of the annulus was filled with a sanitary cement seal. Following completion of the observation wells, each well site was equipped with a locking cap and cement pad with crash bumpers. Table 1 summarizes the borehole depth; well depth, screened interval, local well reference number, and static water level.

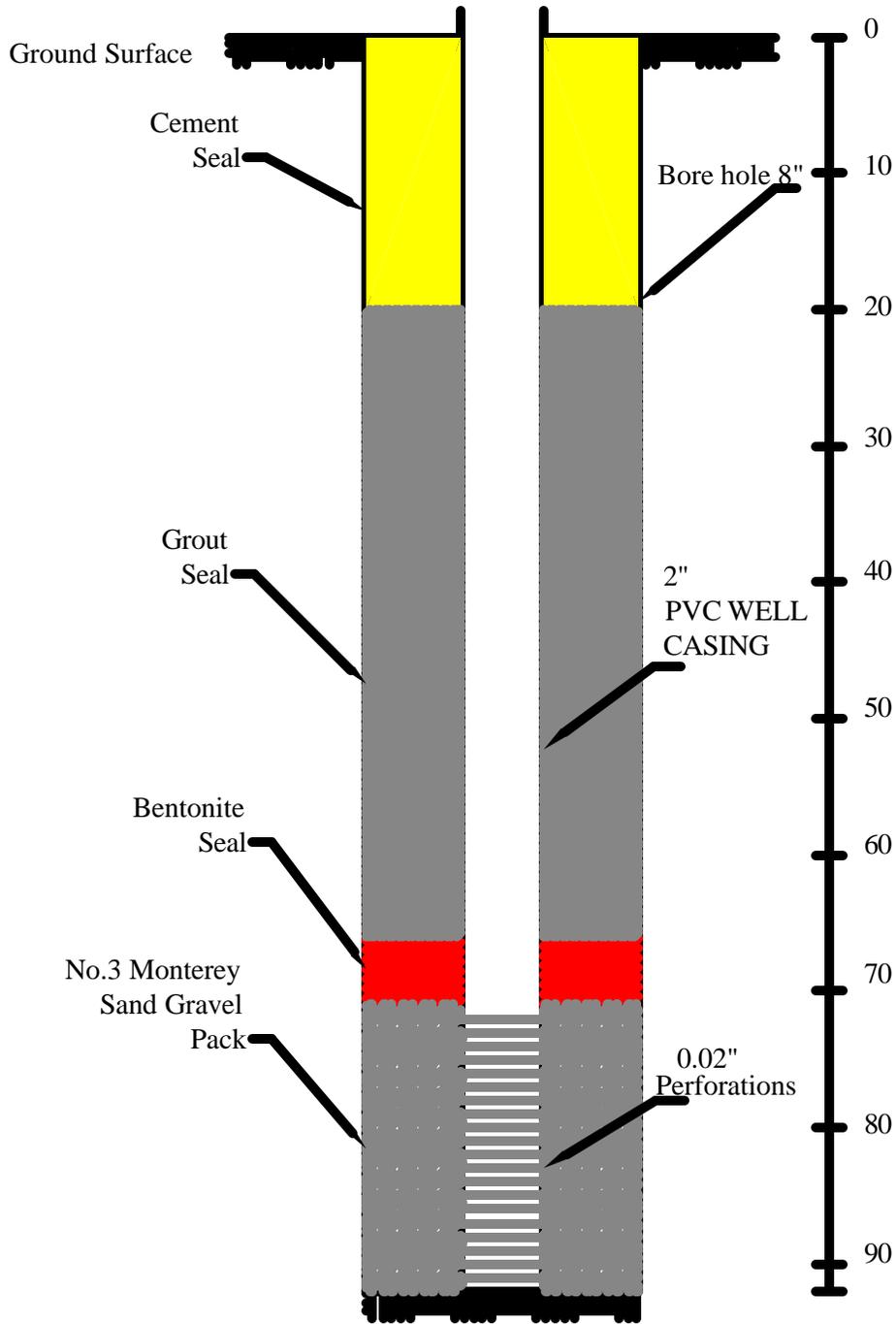
Table 1

Well No.	Local Well No.	Bore Hole Depth (ft)	Well Depth (ft)	Screen Interval (ft)	Static Water Level (ft)
OBS-1	10/4-7H#	92	92	72-92	11.9
OBS-2	10/4-5E#	91	91	71-91	14.5
OBS-3	Abandoned	Abandoned	Abandoned	Abandoned	Abandoned
OBS-4	10/4-8D#	96	96	76-96	14.3
OBS-10	10/4-8N#	97	97	77-97	12.9

*Note all measurements are from the top of PVC casing.

After completion and construction of the observation wells, a program of well development was initiated. Development consisted of installing a 1-horse power electric motor inside the well casing, at which point each well was pumped for 1.5 hours, until at least 3 well volumes were pumped from each well. Water produced during development of the observation wells was allowed to infiltrate back into the soil.

Observation
Well Construction Diagram
MCB Camp Pendelton
OBS - 1 10/4 - 7H
Date Completed 6/30/2000
Elevation 95.1 Feet



Scale 1" : 15'

TD 92'

Graphic Columnar Section

MCB Camp Pendelton

OBS - 1 10/4 - 7H

Date Completed 6/30/2000

Elevation 95.1 Feet



Scale 1" : 15'

TD 92'

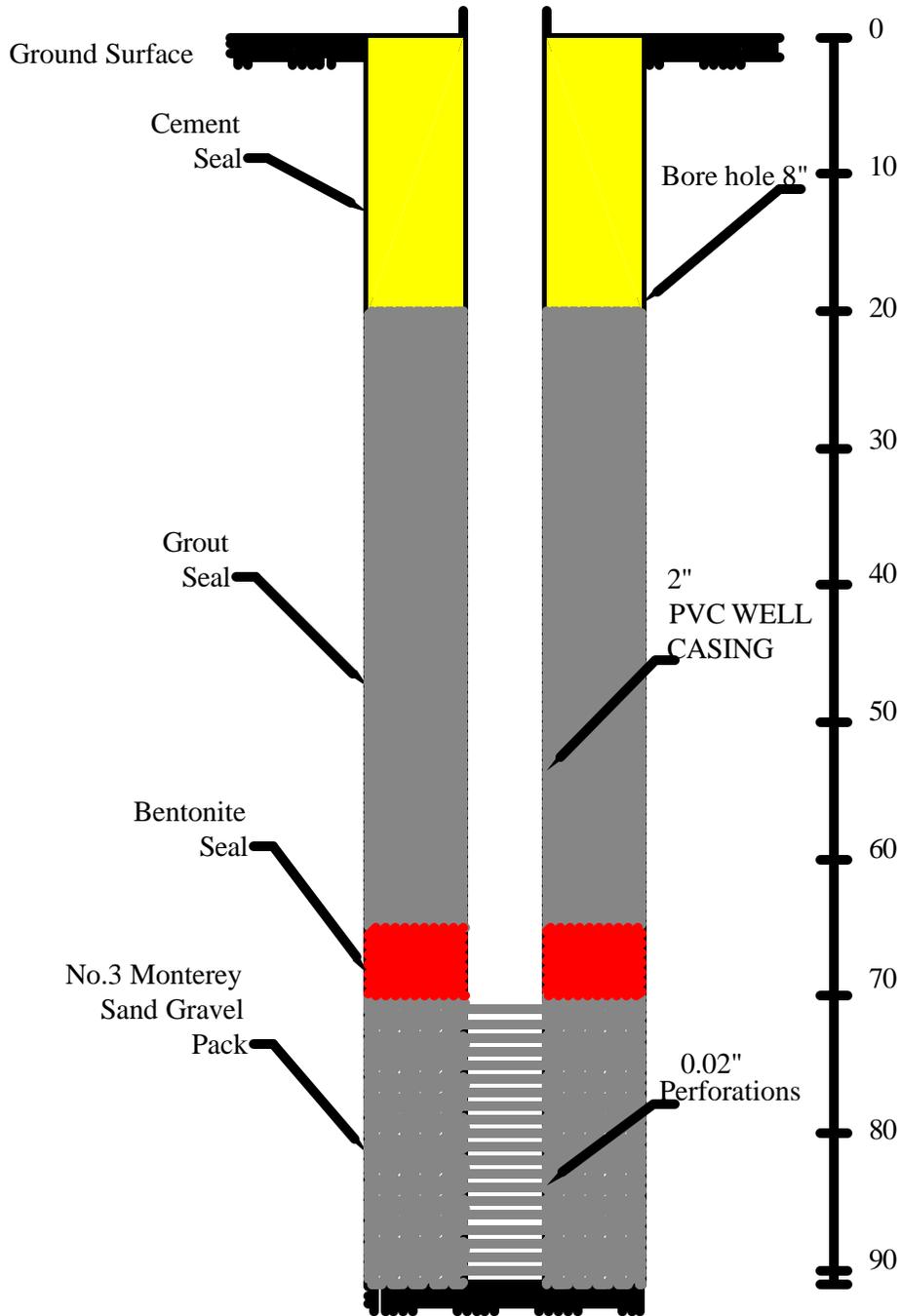
**Marine Corps Base, Camp Pendelton
Observation Well 10/4-7H
Lithologic Log**

Surface Elevation: 95.1 feet
Drilled and Cased Depth: 92 feet
Static Water Level: 11.9 feet
Casing Diameter: 2 inch

Borehole Diameter: 8 inch
Screened Interval: 72-92 feet
Drilled: 6/30/2000

Depth	Description
0-8	Soil horizon, brown, micaceous, very fine sandy silt, well sorted, some organic material present.
8-15	Medium to coarse quartz rich sand ~ 80%, sub angular to sub rounded, poorly sorted, abundant potassium feldspar, biotite and muscovite grains present, 20% fine to very fine sand.
15-20	Moderately sorted, clast supported coarse sand and gravel, sub angular to rounded ~ 90%, very little fine material present ~10%, clasts are made up of quartz, feldspar, mica and various sedimentary fragments.
20-30	Heaving sand occurred at ~22 feet, no longer able to obtain discrete sample by split spoon method, moderately well sorted coarse to medium sand ~ 90%, sub angular to rounded dominant mineralogy is quartz, feldspar, and mica.
30-55	Coarse to fine poorly sorted quartz rich sand, sub angular to rounded ~ 90%, fine material <10%.
55-56	Cobbles present, cuttings are mostly Coarse to fine poorly sorted quartz rich sand, sub angular to rounded ~ 90%, fine material <10%.
56-63	Coarse to fine poorly sorted quartz rich sand, sub angular to rounded ~ 90%, fine material <10%.
64-65	Cobbles present, cuttings are mostly Coarse to fine poorly sorted quartz rich sand, sub angular to rounded ~ 90%, fine material <10%.
65-74	Medium to fine micaceous, quartz rich sand ~95%, sub angular to rounded, poorly sorted.
74-75	Cobbles present, medium to fine micaceous, quartz rich sand ~95%, sub angular to rounded, poorly sorted.
75-83	Medium to fine micaceous, quartz rich sand ~95%, sub angular to rounded, poorly sorted.
84-92	Cobbles layer, production of cuttings decreasing mostly medium to fine quartz rich sand, refusal occurred at 92 feet.

Observation
Well Construction Diagram
MCB Camp Pendelton
OBS - 2 10/4 - 5E #
Date Completed 6/27/2000
Elevation 100.4 Feet



Scale 1" : 15'

TD 91'

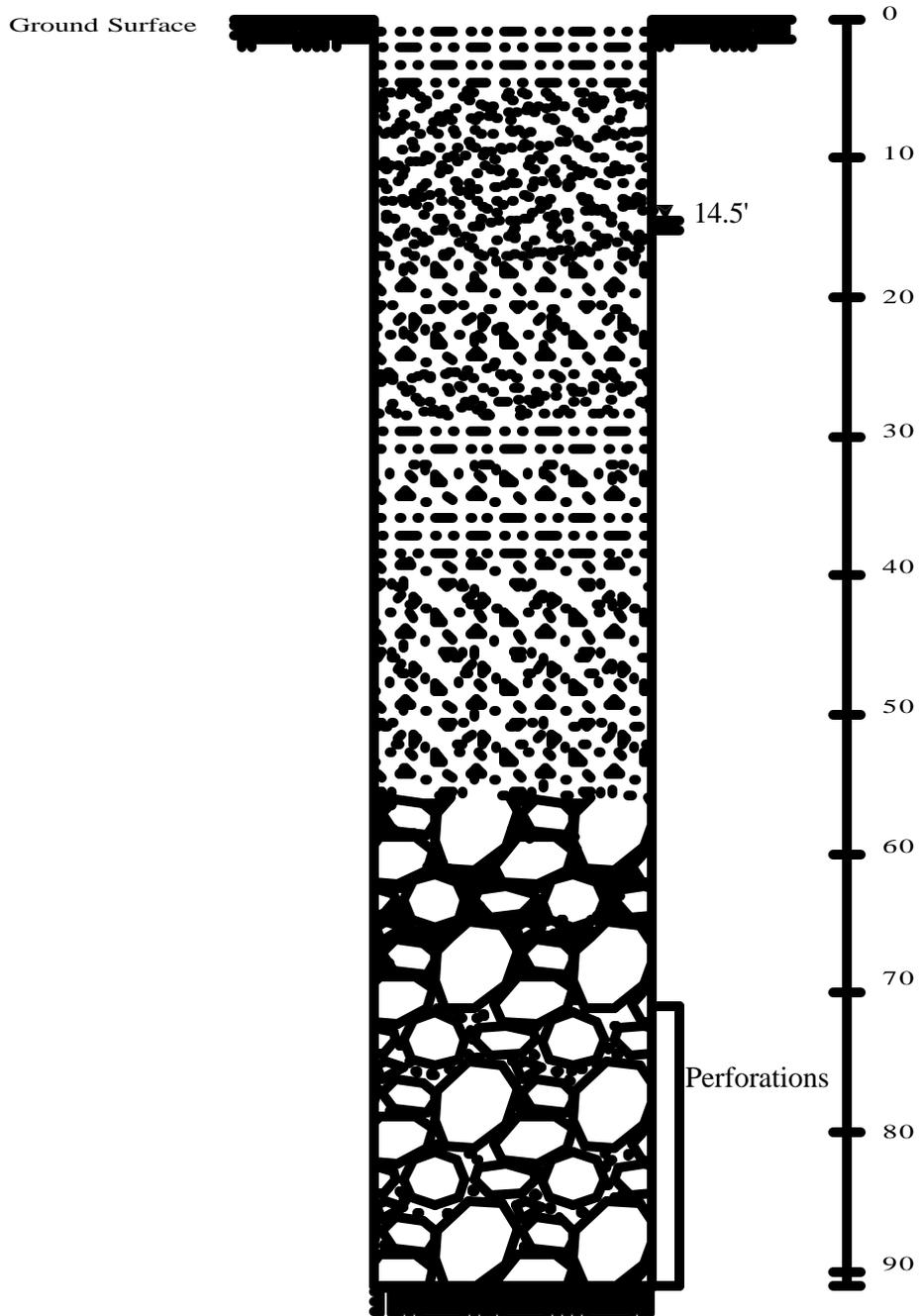
Graphic Columnar Section

MCB Camp Pendelton

OBS - 2 10/4 - 5E #

Date Completed 6/27/2000

Elevation 100.4 Feet



Scale 1" : 15'

TD 91'

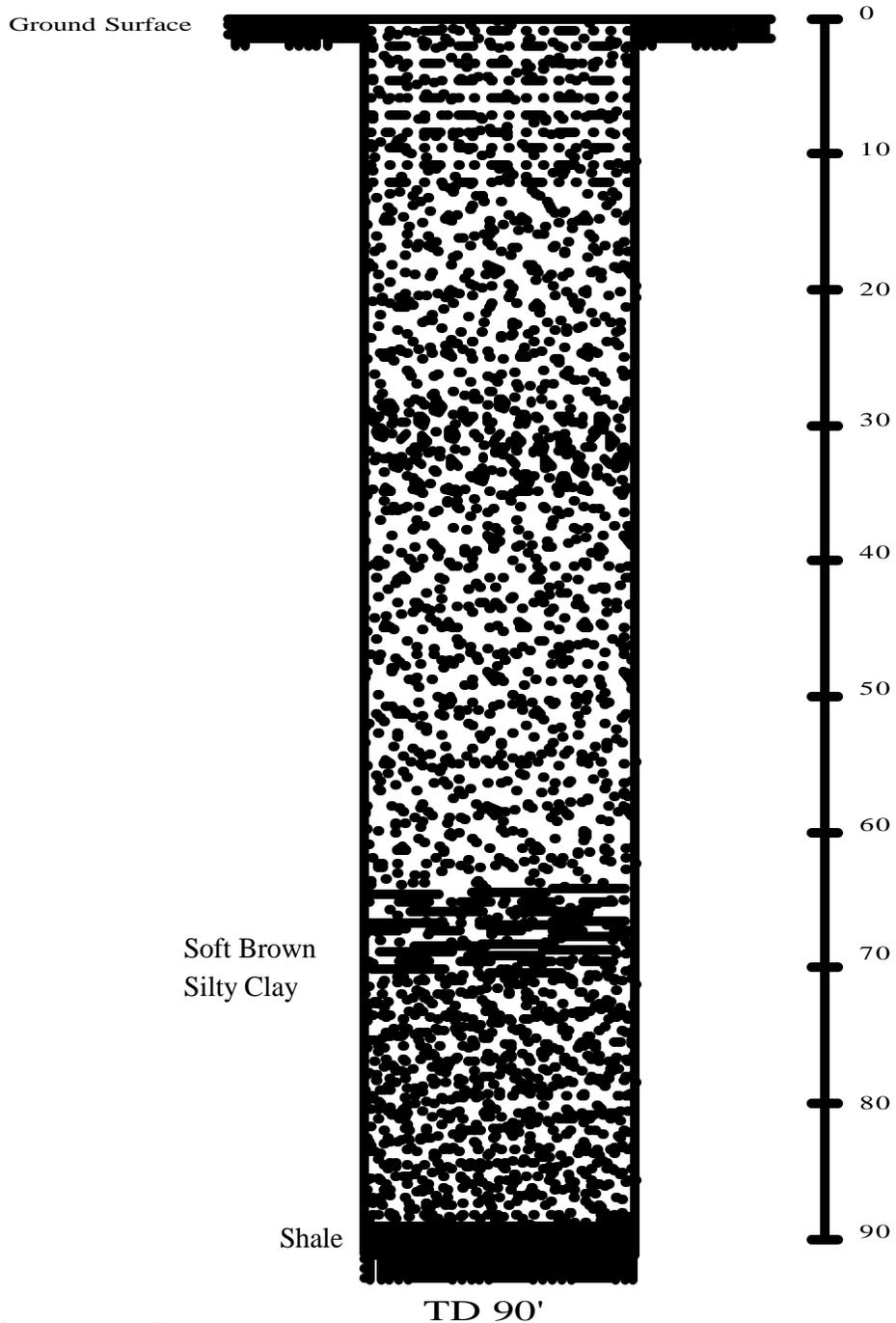
**Marine Corps Base, Camp Pendelton
Observation Well 10/4-5E
Lithologic Log**

Surface Elevation: 100.4 feet
Drilled and Cased Depth: 91 feet
Static Water Level: 14.5 feet
Casing Diameter: 2 inch

Borehole Diameter: 8 inch
Screened Interval: 71-91 feet
Drilled: 6/26-27/2000

Depth	Description
0-6	Soil horizon, brown, micaceous, very fine sandy silt, well sorted, some organic material present.
7-14	Quartz rich fine sand ~90%, silt ~10% moderately well sorted, sub angular to rounded, static water level 10.2 feet.
14-20	Medium sand to gravel ~85%, sub angular to rounded, mostly quartz, potassium feldspar, biotite and muscovite, silty sand ~15%.
20-25	Heaving sand occurred at 23 feet, no longer able to obtain discrete sample by split spoon method, clasts supported, coarse sand ~45%, gravel ~35% with a matrix of fine sand ~10%, silt ~5% and clay ~5%, deposits appear to be fining from upward.
25-38	Moderate to poorly sorted, sub angular to rounded clast supported, medium sand and gravel to 2 inches, mostly granitic and sedimentary clasts with significant quartz and mica.
38	Brown silty clay lense.
38-46	Moderate to poorly sorted, sub angular to rounded clast supported medium sand ~40%, gravel to 2 inches ~, mostly granitic and sedimentary clasts with significant quartz and mica.
46-54	Clast supported boulders and cobbles, cuttings indicate interstitial material is medium sand and gravel, sub angular to rounded, poorly sorted.
54-60	Medium sand ~30%, coarse sand ~35%, gravel ~20%, pebbles to 2 inch ~10%, silty sand with some clay ~5%, mineralogy is quartz, mica, and potassium feldspar, poorly sorted sub angular to rounded granitic and sedimentary clasts.
60-91	Clast supported boulders and cobbles, cuttings indicate interstitial material is medium sand and gravel, sub angular to rounded, poorly sorted, auger refusal at 91 feet.

Graphic Columnar Section
MCB Camp Pendelton
Abandoned Soil Boring
Date Completed 6/28/2000
Elevation 98.4 Feet



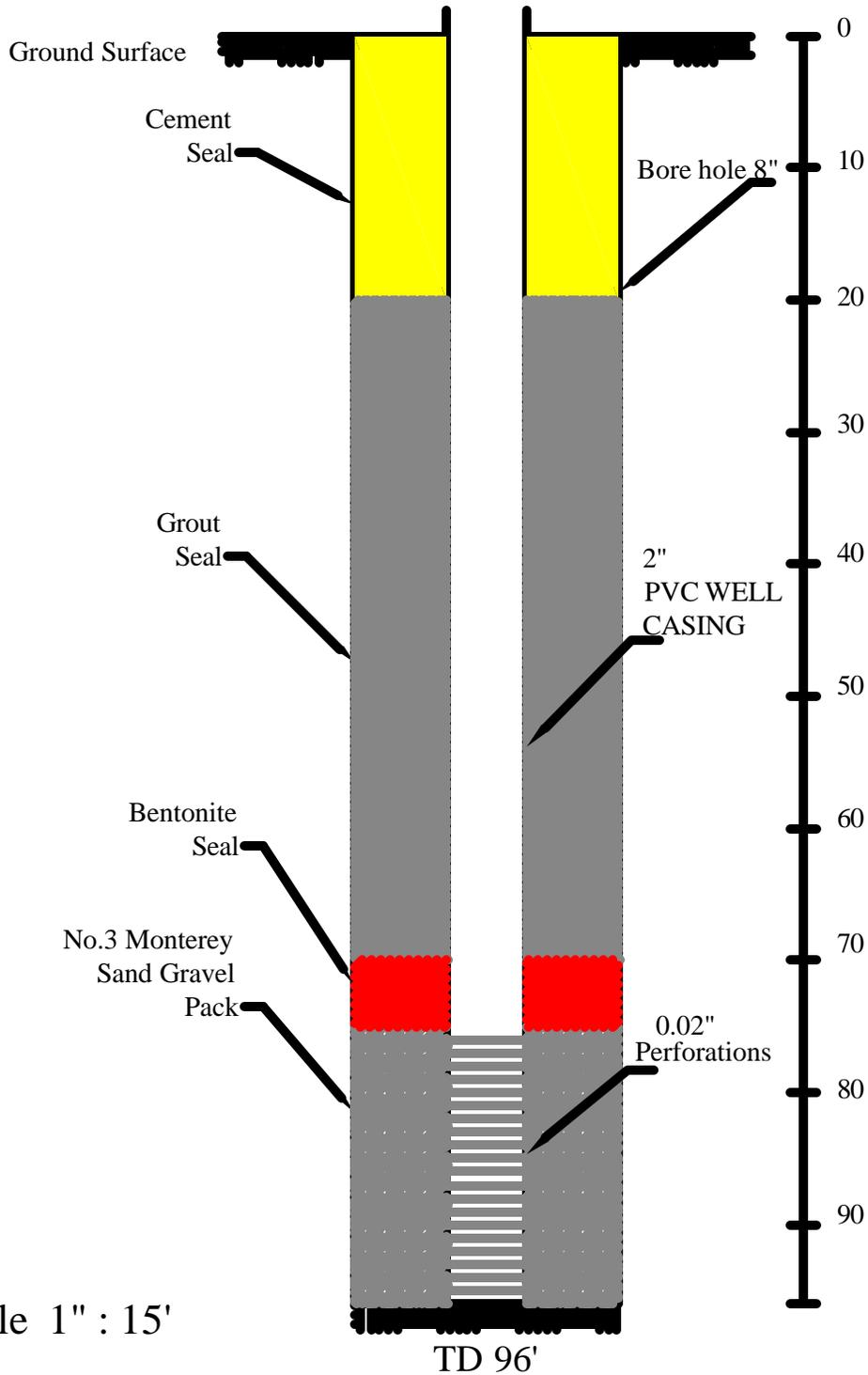
**Marine Corps Base, Camp Pendelton
Observation Well (Abandoned)
Lithologic Log**

Surface Elevation: 98.4 feet
Drilled Depth: 90 feet
Static Water Level: 12.2 feet
Casing Diameter:

Borehole Diameter: 8 inch
Screened Interval:
Drilled: 6/29/2000

Depth	Description
0-15	Soil horizon, mostly silt ~60%, fine sand ~40% tan/brown.
15-25	Saturated coarse to medium quartz rich sand ~40%, sub angular to rounded, fine sand ~30%, silt ~30%, static water level 12.2 feet, poorly sorted, sediments appear to fine upward.
25-30	Coarse to medium quartz rich sand, noticeable mica and potassium feldspar grains present, subangular to rounded, moderately to poorly sorted and poorly graded, deposits consists of sedimentary and granitic clasts.
30-45	Coarse quartz rich sand and gravel ~90%, amount of fine sand and silt present in cuttings decreasing ~10%, sub angular to rounded, moderately well sorted clast supported deposits.
45-53	Moderately well sorted, clean quartz rich fine to coarse grain sand, sub angular to rounded, amount of cuttings appears to be decreasing,
53-60	Moderately well sorted medium to fine grain, quartz rich micaceous sand, minor clay present.
60-65	Saturated brown Clay lense ~50%, medium to soft texture, medium to fine sand ~50%, sub angular to rounded, predominately quartz with lesser feldspar and mica.
65-87	Moderately well sorted medium to fine grain, quartz rich micaceous sand, minor clay present.
87-90	Distinct lithology change, competent unit, cuttings same as preceeding interval, auger refusal at 90 feet.

Observation
Well Construction Diagram
MCB Camp Pendelton
OBS - 4 10S / 4W - 8D #
Date Completed 6/30/2000
Elevation 103.8 Feet



Scale 1" : 15'

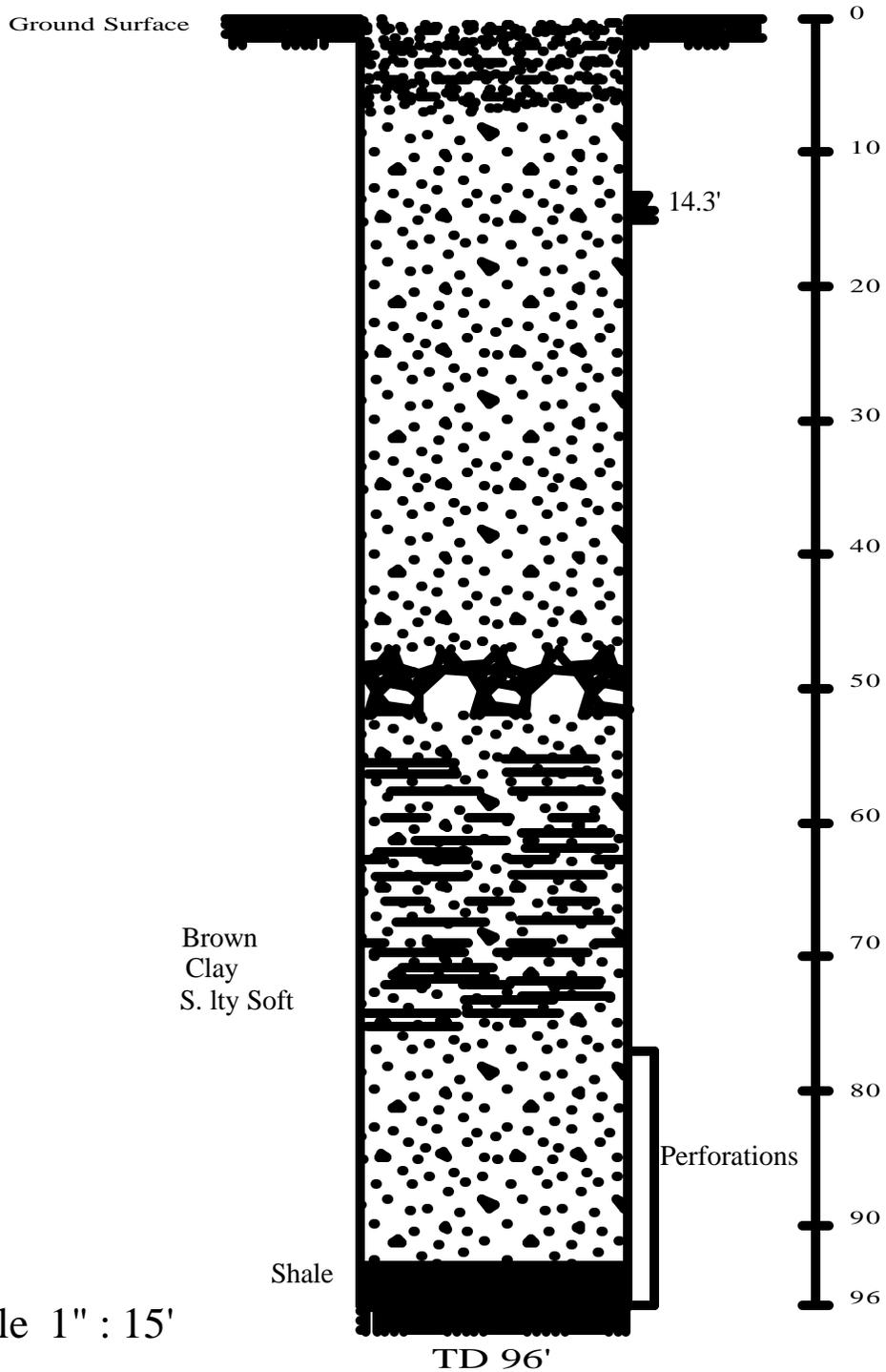
Graphic Columnar Section

MCB Camp Pendelton

OBS - 4 10/4 - 8D #

Date Completed 6/30/2000

Elevation 103.8 Feet



Scale 1" : 15'

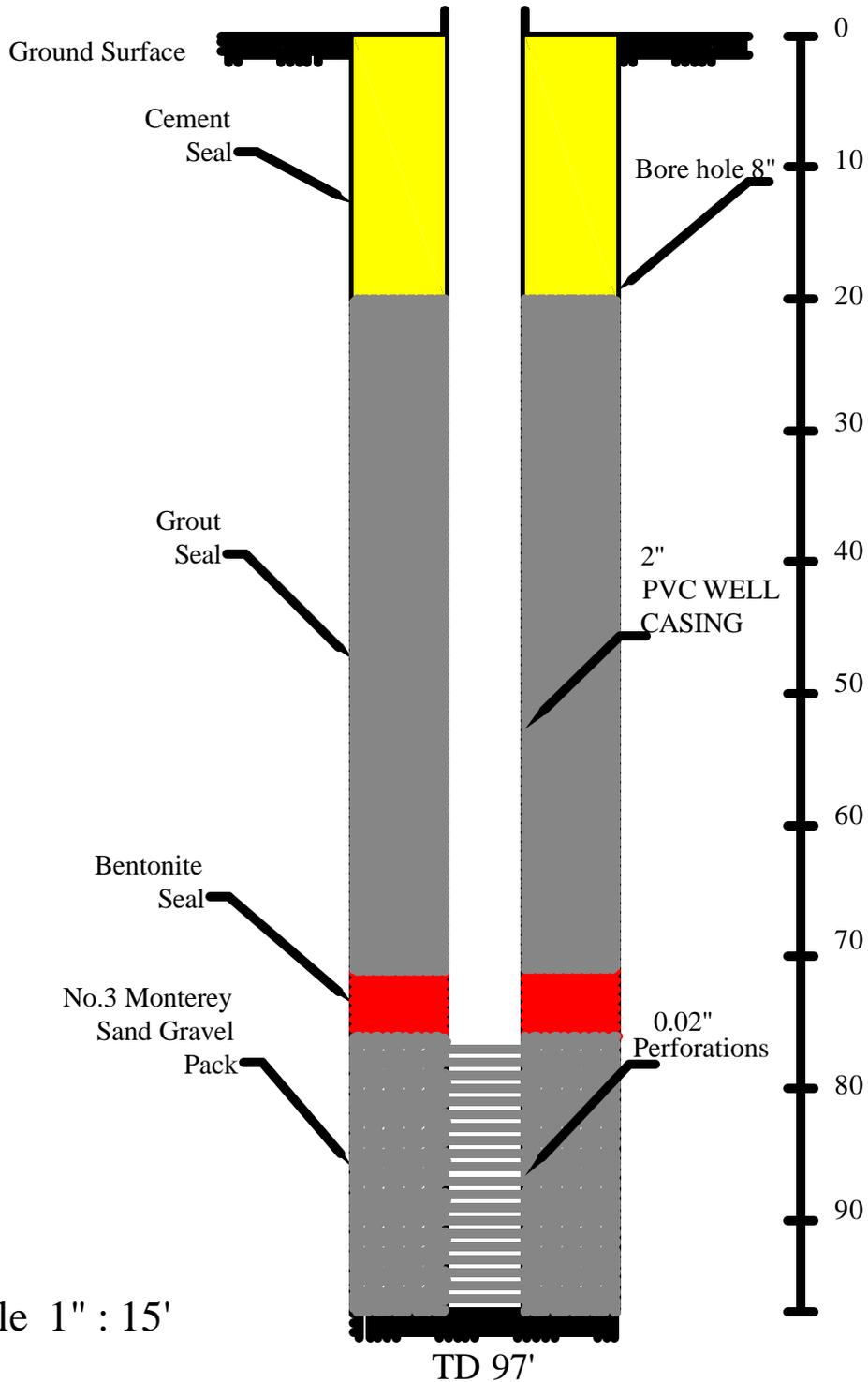
**Marine Corps Base, Camp Pendelton
Observation Well 10/4-8D
Lithologic Log**

Surface Elevation: 103.8 feet
Drilled and Cased Depth: 96 feet
Static Water Level: 14.3 feet
Casing Diameter: 2 inch

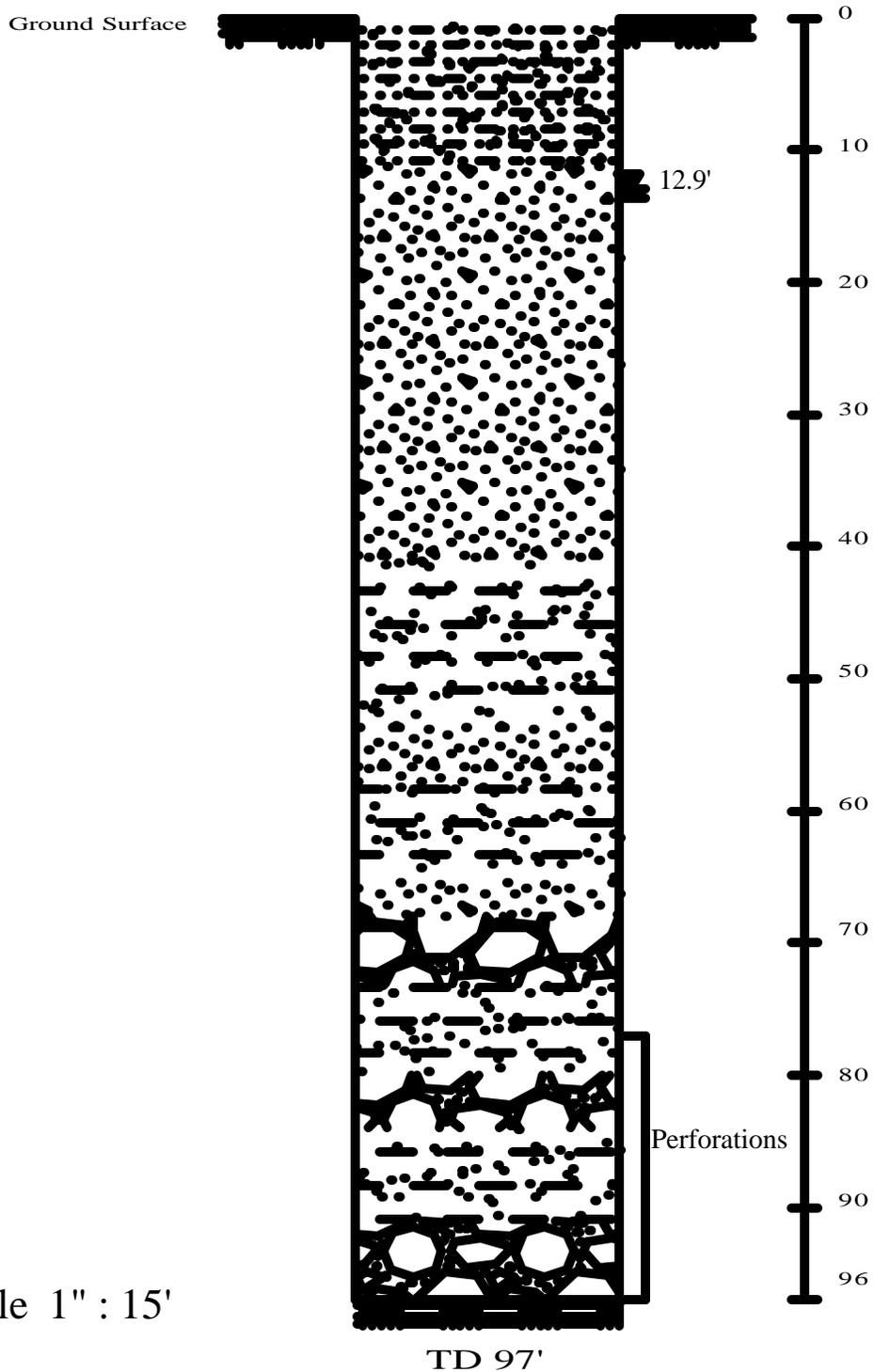
Borehole Diameter: 8 inch
Screened Interval: 76-96 feet
Drilled: 6/30/2000

Depth	Description
0-10	Medium to fine quartz rich brown sand and silt, moderately to poorly sorted, sub angular to rounded, abundant micaceous and feldspathic minerals present, moderate to poorly sorted.
10-15	Medium to fine quartz rich brown sand with noticable iron staining, moderately to poorly sorted, sub angular to rounded, abundant micaceous and feldspathic minerals present, moderate to poorly sorted.
15-20	Medium to coarse sand ~60%, gravel ~40%, quartz rich with abundant mica and feldspar, clast supported with a minor amount of fine matrix material.
20-35	Coarse sand ~45%, gravel ~45%, medium to fine sand ~10%, Heaving sands occurred at 19 feet, mostly quartz with minor mica a feldspar, sub angular to rounded, coarse material is composed of mostly granitic and sedimentary clasts.
35-43	Moderately stiff brown clay present ~50%, clay is viscous and loose, matrix supported, fine to medium quartz rich brown sand ~50%, sub angular to rounded, poorly sorted.
43-50	Clay content decreasing ~40 %, medium to fine sand ~60%, moderately well sorted, amount of cuttings is reduced due to augers being encased in brown clay.
50-95	Clay content decreasing ~20%, medium to fine sand and silt ~75%, coarse sand ~5%, sub angular to rounded, poorly sorted.
95-96	Distinct lithology change, cuttings are similar to previous interval, refusal at 96 feet.

Observation
Well Construction Diagram
MCB Camp Pendelton
OBS - 10 10 / 4 - 8N #
Date Completed 6/27/2000
Elevation 91.9 Feet



Graphic Columnar Section
MCB Camp Pendelton
OBS - 10 10 / 4 - 8N #
Date Completed 6/27/2000
Elevation 91.9 Feet



Scale 1" : 15'

**Marine Corps Base, Camp Pendelton
Observation Well 10/4-8N
Lithologic Log**

Surface Elevation: 91.9 feet
 Drilled and Cased Depth: 97 feet
 Static Water Level: 12.9 feet
 Casing Diameter: 2 inch

Borehole Diameter: 8 inch
 Screened Interval: 77-97 feet
 Drilled: 6/27/2000

Depth	Description
0-15	Soil Horizon, composed of brown/tan silty sand ~85%, coarse sand and gravel 10%, sub angular to rounded, moderately well sorted micaceous and quartz rich, dark grey/black clay ~5%.
15-25	Moderately well sorted medium to coarse sand ~85%, mineralogy consists of mostly quartz, mica, and feldspar, sub angular to rounded mostly granitic and sedimentary fragments, ~10% silty clay present in sample, heaving sands occurred at 19 feet no longer able to obtain discrete sample with the split spoon.
25-40	Moderately to poorly sorted coarse to medium quartz rich sand ~85%, sub angular to rounded, silty fine brown micaceous sand ~15%.
49-47	Distinct grain size change silty clay content increasing ~40% medium to fine quartz rich silty sand ~60%, sub angular to rounded.
47-67	Tight blue/grey impermeable dry clay ~70%, matrix supported, medium to fine quartz rich silty sand ~30%, sub angular to rounded felsic clasts, minor mafic component mostly mica.
67-72	Medium to fine silty brown quartz rich felsic sand ~45%, sub angular to rounded, clay content decreasing ~55%, clay is grey to brown tight and dry.
72-90	Cobbles and boulders, production of cuttings decreasing mostly medium to fine brown quartz rich sand.
90-93	Sandy brown silt ~80%, very little coarse material present >10%.
90-97	Coarse to Medium felsic sand ~50%, sub angular to rounded, sandy brown silt ~50%.