CHAPTER 5 – MONITORING NETWORK
Groundwater Sustainability Plan
for the Marina GSA Area
of the 180/400 Foot Aquifer Subbasin

City of Marina
Groundwater Sustainability Agency
Marina, California

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5 MONITORING NETWORK

Regulation Requirements:

§354.32 This Subarticle describes the monitoring network that shall be developed for each basin, including monitoring objectives, monitoring protocols, and data reporting requirements. The monitoring network shall promote the collection of data of sufficient quality, frequency, and distribution to characterize groundwater and related surface water conditions in the basin and evaluate changing conditions that occur through implementation of the Plan.

This chapter describes the monitoring networks used to collect data to support implementation of the Groundwater Sustainability Plan (GSP) for the Marina Groundwater Sustainability Agency (MGSA) Area. This chapter has been prepared in accordance with Title 23, California Code of Regulations (CCR) § 354.32 and describes monitoring objectives, monitoring protocols, and data reporting requirements.

5.1 INTRODUCTION

Regulation Requirements:

§354.34(a) Each Agency shall develop a monitoring network capable of collecting sufficient data to demonstrate short-term, seasonal, and long-term trends in groundwater and related surface conditions, and yield representative information about groundwater conditions as necessary to evaluate Plan Implementation.

The MGSA Area covers approximately 372 acres and is part of the broader 180/400 Foot Aquifer Subbasin (Subbasin). Salinas Valley Basin Groundwater Sustainability Agency (SVBGSA) manages the portions of the Subbasin that lie outside the MGSA Area under a regional GSP (Figure 5-1). Marina Coast Water District Groundwater Sustainability Agency (MCWD GSA) has jurisdiction over the Central Marina and Ord Community portions of its service area in this Subbasin, although MCWD has entered into an agreement with SVBGSA for SVBGSA to prepare the GSP in these areas.

This chapter describes the monitoring network that will be used to collect representative information about groundwater conditions as necessary to evaluate and guide implementation of the local GSP for the MGSA Area. Monitoring activities will focus on key resources and the following four principal aquifers within and proximal to the MGSA Area, which are further described in Section 3.1.6:

- **Dune Sand Aquifer (Dune Sand Aquifer).** The uppermost aquifer, which is of local importance due to its interaction with local groundwater-dependent ecosystems (GDEs), substantial storage of groundwater with designated potential beneficial use as a municipal or domestic supply, and importance in maintaining nearshore seawater intrusion dynamics;

- **180-Foot Aquifer.** The uppermost groundwater supply aquifer of regional importance in the Subbasin, which is seawater intruded in the vicinity of the MGSA Area, but includes significant zones of groundwater with a designated beneficial use as a domestic and municipal supply in the vicinity;

- **400-Foot Aquifer.** The second groundwater supply aquifer of regional importance in the Subbasin, which is seawater intruded in the vicinity of the MGSA Area, but includes significant

zones of groundwater with a designated beneficial use as a domestic and municipal supply in the vicinity; and

- **Deep Aquifer.** The deepest regional groundwater supply aquifer, which is not seawater intruded and currently provides the only source of municipal water supply for the City of Marina.

As described in Chapter 2, several existing monitoring programs that are being implemented by Monterey County Water Resources Agency (MCWRA), SVBGSA or others are relevant to the MGSA Area and data collected for these programs will be used for the monitoring program for this MGSA GSP as described further below.

In the event that the Monterey Peninsula Water Supply Project (MPWSP) is not implemented, MGSA will explore alternative arrangements with MCWRA to implement the monitoring program. MGSA is in the process of developing an agreement with MCWRA regarding utilization of monitoring data from its proposed coastal monitoring program. Once developed, this agreement would recognize that if the MPWSP does not move forward, MCWRA will consult with GSAs having jurisdiction in the area to develop an alternative coastal monitoring program using the existing monitoring and supply wells identified in the Mitigation Monitoring and Reporting Program (MMRP) for the MPWSP (CPUC 2018, Zidar and Feeney 2019).

5.1.1 MONITORING NETWORK OBJECTIVES

Regulation Requirements:

§354.34(b) Each Plan shall include a description of the monitoring network objectives for the basin, including an explanation of how the network will be developed and implemented to monitor groundwater and related surface conditions, and the interconnection of surface water and groundwater, with sufficient temporal frequency and spatial density to evaluate the affects and effectiveness of Plan implementation. The monitoring network objectives shall be implemented to accomplish the following:

1) Demonstrate progress toward achieving measurable objectives described in the Plan.
2) Monitor impacts to the beneficial uses or users of groundwater.
3) Monitor changes in groundwater conditions relative to measurable objectives and minimum thresholds.
4) Quantify annual changes in water budget components.

The Sustainable Groundwater Management Act (SGMA) requires that monitoring networks be developed to promote the collection of data of sufficient quality, frequency, and distribution to characterize groundwater and related surface water conditions in groundwater basins managed by GSAs, and to evaluate changing conditions that occur as GSPs are implemented. The monitoring networks must be established to collect representative information to demonstrate short-term, seasonal, and long-term trends as needed to support the following SGMA requirements:

- Monitor changes in groundwater conditions and demonstrate compliance with minimum thresholds and progress toward achieving measurable objectives and interim milestones, as appropriate;

- Monitor impacts to the beneficial uses or users of groundwater;

- Quantify annual changes in water budget components; and
- Assess the criteria that trigger the implementation and termination of management actions and assess their effectiveness under conditions that include minimum threshold exceedances, variable conditions, and adverse impacts to beneficial uses and users of groundwater.

5.1.2 NETWORK DEVELOPMENT PROCESS

Regulation Requirements:
§354.34(c) Each monitoring network shall be designed to accomplish the following for each sustainability indicator:
[§354.34(c)(1) through §354.34(c)(6) are individually listed below]

Monitoring networks are developed for each of the six sustainability indicators identified in SGMA, including:

- Chronic Lowering of Groundwater Levels;
- Reduction in Groundwater Storage;
- Seawater Intrusion;
- Degraded Groundwater Quality;
- Land Subsidence; and
- Depletion of Interconnected Surface Water.

Since DWR's regulations allow MGSA to use existing monitoring sites in its monitoring network, the monitoring networks described in this chapter include existing locations as well as currently planned expansions of existing programs. As described in Section 2.2, there are several existing and well-developed monitoring programs and networks that are used to monitor the principal aquifers in the 180/400 Foot Aquifer Subbasin. These include regional programs implemented by MCWRA to monitor groundwater elevations and seawater intrusion, including monitoring for the California Statewide Ambient Groundwater Elevation Monitoring (CASGEM) program. Other programs will be implemented by SVBGSA to monitor groundwater storage changes, subsidence, and surface-groundwater interaction for their 180/400 Foot Aquifer Subbasin GSP. These programs are pertinent to this MGSA GSP as they characterize regional conditions and trends in the Subbasin. However, because the MGSA Area comprises a relatively limited portion of the Subbasin's seaward edge, the MGSA GSP will rely primarily on data collected from a local monitoring network adopted in and around the MGSA Area under the Mitigation, Monitoring and Reporting Program (MMRP) for the proposed Monterey Peninsula Water Supply Project (MPWSP) (CPUC 2018, Zidar and Feeney 2019).

In the event that the MPWSP is not implemented, MGSA will explore alternative arrangements with MCWRA to implement the monitoring program. MGSA is in the process of developing an agreement with MCWRA regarding utilization of monitoring data from its proposed coastal monitoring program. Once developed, this agreement would recognize that if the MPWSP does not move forward, MCWRA will consult with GSAs having jurisdiction in the area to develop an alternative coastal monitoring program using the existing monitoring and supply wells identified in the MMRP for the MPWSP.

The locations of the existing and proposed wells in MCWRA's MMRP monitoring program are shown in Figure 5-2. There are currently eight monitoring well clusters with 24 wells within and near the MGSA Area that were installed to monitor test slant well pumping for the MPWSP design and environmental studies. Each of these clusters has a well completed in the Dune Sand Aquifer, the 180-Foot Aquifer, and the 400-Foot Aquifer The existing clusters are designated MW-1, MW-3, MW-4, MW-5, MW-6, MW-7, MW-8, and MW-9 (the MW-2 cluster was not constructed).[1] Under the MMRP for the proposed MPWSP, if the project moves forward, MCWRA will construct five additional well clusters with three wells each at locations MW-A, MW-B, MW-C, MW-D and MW-E, and construct another well at MW-5S screened in the Dune Sand Aquifer below the perched zone, to expand the network of nested monitoring wells to a total of 40 wells (Zidar and Feeney 2019). In addition, under the MMRP MCWRA will monitor a number of other existing wells in the vicinity of the MGSA Area that are in the MCWRA, MCWD or Fort Ord monitoring networks, including 10 wells completed in the Dune Sand Aquifer, eight wells completed in the 180-Foot Aquifer, five wells completed in the 400-Foot Aquifer and eight wells completed in the Deep Aquifer. MCWRA will also monitor six nested monitoring wells in the Deep Aquifer constructed by the United States Geological Survey (USGS) at two locations approximately ½ mile south of the MGSA Area. The locations and construction details of these 77 wells are summarized in Tables 5-1 through 5-4 for the Dune Sand, 180-Foot, 400-Foot, and Deep Aquifers, respectively. Boring logs and well completion diagrams are provided in Appendix 5.A.

This MGSA GSP monitoring network will include the MCWRA's MMRP monitoring program wells as described in the following sections. Data from all of the monitoring wells will be considered to characterize regional groundwater conditions surrounding the MGSA Area, but only a subset of wells will be included in the monitoring networks used to assess groundwater level and quality conditions for compliance with the measurable objectives and minimum thresholds established in Chapter 4. Tables 5-1 through 5-4 identify the wells which are included in the MGSA groundwater elevation, groundwater quality and/or induction logging monitoring networks. In addition to groundwater monitoring data, some sustainability indicators may rely on collection of other types of data (e.g., induction logging, groundwater extraction reporting and biological monitoring). Data gaps are identified for each monitoring network; filling these data gaps and developing more extensive and complete monitoring programs will improve MGSA's and others' ability to support sustainable groundwater management and refine the existing conceptual and numerical hydrogeologic models.

5.1.3 REPRESENTATIVE MONITORING SITES

Regulation Requirements:

§354.36 Each Agency may designate a subset of monitoring sites as representative of conditions in the basin or an area of the basin, as follows:

§354.36(a) Representative monitoring sites may be designated by the Agency as the point at which sustainability indicators are monitored, and for which quantitative values for minimum thresholds, measurable objectives, and interim milestones are defined.

[1] Monitoring data indicates MW-5S is screened in a perched aquifer above the DSA. Therefore, the monitoring well has been re-designated as MW-5S(P) to indicate it is representative of a local perched aquifer. Similarly, MW-6D is screened in the lower portion of the 180-Foot Aquifer and has been re-designated as MW-6M(L) to indicate it represents the 180-Foot Aquifer.

Representative monitoring sites (RMS) are defined in the regulations as a subset of monitoring sites that are considered representative of conditions in a subbasin. The subset of wells designated as the RMS for the Dune Sand Aquifer, 180-Foot, and the 400-Foot Aquifers in Chapter 4 was used to establish minimum thresholds and measurable objectives for each of the sustainability indicators (refer to Table 4-1). The network that will be used to collect data to evaluate the sustainability indicators will include all of the monitoring wells that are part of MCWRA's MMRP monitoring program and are identified in Tables 5-1 through 5-4, and discussed in the subsections for each sustainability indicator.

5.1.4 Review and Evaluation of Monitoring Network

Regulation Requirements:

§354.38(a) Each Agency shall review the monitoring network and include an evaluation in the Plan and each five-year assessment, including a determination of uncertainty and whether there are data gaps that could affect the ability of the Plan to achieve the sustainability goal for the basin.

MGSA will review the monitoring network described in this GSP at a frequency of not greater than every five years to assess whether data gaps exist that could affect MGSA's ability to achieve the sustainability goals for the MGSA Area. An initial evaluation will be conducted in collaboration with Marina Coast Water District (MCWD) GSA, SVBGSA, and MCWRA when the United States Geologic Survey (USGS) releases the Salinas Valley Integrated Hydrologic Model (SVIHM), as described below. Data gaps, if identified, could result in the need to install additional monitoring wells or add additional monitoring locations or procedures to complement the existing network and/or to increase the frequency of monitoring. Reviews and appropriate response actions will be performed in collaboration with SVBGSA, MCWRA and MCWD GSA. Several areas of review are identified at this time:

- As discussed in Section 7.1.4, USGS anticipates releasing its fully calibrated SVIHM in late 2020 (SVBGSA 2019). The SVIHM, when available, will represent the state of the science when it comes to groundwater management tools in the Salinas Valley Basin, and SVBGSA intends to update its GSP based on refined information regarding the groundwater flow system, water budgets and predictive capability of that model. MGSA intends to work in parallel with SVBGSA in its review of the calibrated SVIHM and update this GSP at the same time. If the new information is significant for local groundwater management, MGSA will prepare an addendum or update report refining the GSP.

- Monitoring of the Deep Aquifer in the 180/400 Foot Aquifer Subbasin has historically been limited considering the thickness and complexity of this aquifer system. The 14 Deep Aquifer wells included in the groundwater level and quality monitoring networks for this GSP help to address this data gap. Additional characterization and monitoring of the Deep Aquifer are currently being discussed by MCWRA, SVBGSA and MCWD GSA, and it is possible that additional monitoring wells will be completed in the Deep Aquifer near the MGSA Area in the future. Monitoring of the Deep Aquifer, for the purposes of this GSP, will be accomplished using

information from existing USGS and other monitoring wells that are being monitored by MCWRA, and expanded if new wells are installed in the area.

- MCWD GSA will review the adequacy of this monitoring well network during development of the GSP for the Monterey Subbasin, which is due to be completed in 2022. This review will be conducted in the context of developing a locally-refined groundwater flow, solute transport, and density-driven flow model. Any refinements or changes in the monitoring network adopted by MCWD GSA will be reviewed and considered for adoption in this GSP to ensure that the local monitoring system provides consistent data for both GSPs.

5.2 CHRONIC LOWERING OF GROUNDWATER LEVELS

Regulation Requirements:

§354.34(c) Each monitoring network shall be designed to accomplish the following for each sustainability indicator:

(1) Chronic Lowering of Groundwater Levels. Demonstrate groundwater occurrence, flow directions, and hydraulic gradients between principal aquifers and surface water features by the following methods:

A) A sufficient density of monitor wells to collect representative measurements through depth-discrete perforated intervals to characterize the groundwater table or potentiometric surface for each principal aquifer.

B) Static groundwater elevation measurements shall be collected at least two times per year, to represent seasonal low and seasonal high groundwater conditions.

The sustainability indicator for Chronic Lowering of Groundwater Levels is evaluated by monitoring groundwater elevations. The regulations require a network of monitoring wells sufficient to demonstrate groundwater occurrence, flow directions, and hydraulic gradients between principal aquifers and surface water features.

The California Statewide CASGEM program provides groundwater elevation data in a format that is readily and widely available to the public and can be readily adopted into SGMA compliance programs. SVBGSA has adopted the Subbasin CASGEM program into its monitoring network for the Subbasin. However, there is only one CASGEM well in the vicinity of the MGSA Area, which is not sufficient to fulfill the requirements of the GSP regulations for monitoring under this GSP. Therefore, groundwater elevation monitoring network of this GSP will include the existing and planned monitoring well clusters associated with the MPWSP to monitor the Dune Sand Aquifer, 180-Foot Aquifer and 400-Foot Aquifer, the existing USGS monitoring wells approximately ½ mile south of the MGSA Area to monitor the Deep Aquifer, and the remaining Deep Aquifer wells included in the MMRP monitoring program. Monitoring of these wells will be conducted by MCWRA under the *Integrated Coastal Groundwater Monitoring Program and Plan* (Zidar and Feeney 2019).

5.2.1 DESCRIPTION OF THE MONITORING APPROACH AND NETWORK

Regulation Requirements:

§354.34(g)(3) For each sustainability indicator, the quantitative values for the minimum threshold, measurable objective, and interim milestones that will be measured at each monitoring site or representative monitoring sites established pursuant to Section 354.36

§354.34(h) The location and type of each monitoring site within the basin displayed on a map, and reported in tabular format, including information regarding the monitoring site type, frequency of measurement, and the purposes for which the monitoring site is being used.

Chronic Lowering of Groundwater Levels is related in various ways to each of the other sustainability indicators. It has the potential to cause well interference, result in regionally greater pumping depths, reduce groundwater storage, result in additional seawater intrusion, degrade water quality, cause subsidence, and deplete interconnected surface waters. Beneficial users of shallow groundwater such as groundwater-dependent ecosystems (GDEs) could also be adversely affected by groundwater elevation declines.

In the vicinity of the MGSA Area, groundwater extraction from the seawater-intruded portions of the 180-Foot Aquifer and 400-Foot Aquifer is generally limited. As one of the management actions in SVBGSA's GSP for the Subbasin (SVBGSA 2019), SVBGSA proposes to adopt an ordinance that would prohibit the construction and operation of water supply wells within the Castroville Seawater Intrusion Project (CSIP) service area east and northeast of the MGSA Area. Nevertheless, small non-transient water systems reliant on groundwater are located near Neponset, near the Marina Airport and near the regional wastewater treatment plant located east of the MGSA Area (Section 3.1.8). In addition, interference drawdown with existing wells is a potential impact in the vicinity of the MGSA Area that is identified in the MMRP for the proposed MPWSP. Also, as discussed in Section 3.2.6.2, several GDEs that support protected habitat and species are located east of the MGSA Area, and similar features occur farther to the north and south. Based on this information, undesirable results for the Chronic Lowering of Groundwater Levels sustainability indicator in the MGSA Area are defined based on significant and unreasonable well interference drawdown, and significant and unreasonable hydrological or biological impacts to GDEs.

As described in Chapter 4, minimum thresholds and measurable objectives for the Chronic Lowering of Groundwater Levels sustainability indicator are defined for the principal aquifers as follows:

- **Dune Sand Aquifer** – MGSA has established the minimum threshold and measurable objective in the Dune Sand Aquifer as 1 foot above the 2015 low groundwater levels recorded in monitoring wells in the groundwater elevation monitoring network near GDEs in the vicinity of the MGSA Area, based on potential significant and unreasonable impacts to GDEs. The specific Minimum Thresholds and Measurable Objectives designated for each RMS are indicated on Table 4-1. These values are adopted on an interim basis based on the rationale in Section 4.4.2.1, and will be updated as discussed in Chapter 7 based on a baseline biological assessment of the GDEs to address a data gap in the understanding of GDE response and sensitivity to groundwater elevation declines.

- **180-Foot and 400-Foot Aquifers** – MGSA has established the minimum threshold at 1 foot above historical low groundwater elevations measured in 2015, adjusted for local hydrogeologic conditions and corresponding measurable objectives for SVBGSA RMS near the area as discussed in Section 4.4.2 and summarized in Table 4-1. Measurable objectives are also summarized in Table 4-1, and were established to provide sufficient operational flexibility under

variable conditions consistent with the nearest SVBGSA RMS, and in several cases were similarly adjusted.

- **Deep Aquifer** – Because groundwater is not currently extracted from the Deep Aquifer in the MGSA Area and future construction of new supply wells is currently prohibited, minimum thresholds and measurable objectives were not established for the Chronic Lowering of Groundwater Levels sustainability indicator in this aquifer. The need to establish sustainable management criteria for the Deep Aquifer for the decline in groundwater levels sustainability indicator will be reassessed during future reviews and GSP updates.

Tables 5-1 through 5-4 identify the monitoring wells included in the groundwater elevation monitoring network for each aquifer, provide summary information regarding these wells. These tables include wells utilized to assess groundwater occurrence, flow directions and hydraulic gradients, as well as RMS designated in Chapter 4. Boring logs and well completion diagrams are provided in Appendix 5-A.

The MPWSP monitoring wells were installed to monitor the effects of pumping the test slant well. The locations of the MPWSP monitoring wells are shown on Figure 5-2. Each monitoring location from MW-1 to MW-9 consists of a cluster of three wells (the MW-2 well cluster was not constructed). The individual wells in each cluster were drilled to monitor responses in the Dune Sand Aquifer (shallow well, *e.g.* MW-1S), 180-Foot Aquifer (moderate depth well, *e.g.* MW-1M), and 400-Foot Aquifer (deep well, *e.g.* MW-1D). Each of the MPWSP monitoring wells is equipped with a water level transducer that logs information at 5- to 15-minute intervals. Three of the existing MPWSP well clusters (MW-1, MW-3, and MW-4) are located within the MGSA Area. MCWRA is currently planning the installation of five new monitoring well clusters to provide additional coverage to monitor the hydrogeological effects of the MPWSP, if it is implemented (Zidar and Feeney 2019). These proposed well cluster locations have been preliminarily named MW-A through MW-E and are shown on Figure 5-2. Once installed, the new monitoring well clusters would be added to the existing monitoring network for the purposes of this MGSA GSP.

The USGS monitoring wells include two clusters of nested wells screened at differing intervals within the Deep Aquifer system. Information regarding the nested USGS wells is presented on Table 5-4, and the location of the nested wells is shown on Figure 5-2. The USGS wells are located approximately ½ mile south of the MGSA Area, and are equipped with pressure transducers and monitored quarterly by MCWRA. MCWRA will conduct monitoring of seven other Deep Aquifer wells as part of the MMRP. Locations of these wells are shown on Figure 5-2, and well construction and monitoring information is presented in Table 5-4. Although these other monitoring wells are not currently equipped with water level transducers, MCWRA plans to install transducers.

The current CASGEM monitoring network proposed in the SBVGSA GSP consists of 23 wells with publicly available data within the 180/400 Foot Aquifer Subbasin. As a voluntary program, MCWRA based the CASGEM network primarily on wells that were owned and monitored by MCWRA prior to initiation of the CASGEM program. The MGSA GSP will consider information from these CASGEM wells to interpret

the regional setting for its local groundwater monitoring program; however, these wells will not be part of the monitoring network for this GSP.

5.2.2 ADEQUACY OF THE MONITORING NETWORK

Regulation Requirements:
§354.34(d) The monitoring network shall be designed to ensure adequate coverage of sustainability indicators. If management areas are established, the quantity and density of monitoring sites in those areas shall be sufficient to evaluate conditions of the basin setting and sustainable management criteria specific to that area.
§354.34(e) A Plan may utilize site information and monitoring data from existing sources as part of the monitoring network.

Each MPWSP monitoring well cluster, both existing and planned for installation in the future, includes wells with generally similar depths and screen intervals completed in the Dune Sand Aquifer, the 180-Foot Aquifer and the 400-Foot Aquifer. Overall, with the planned additions, the MPWSP monitoring well network will include 40 monitoring wells within and adjacent to the MGSA Area (Tables 5-1 to 5-3 and Figure 5-2). The existing and proposed monitoring well clusters are designed and distributed to assess the potential groundwater level effects of groundwater extraction within the MGSA Area. The nearest existing Deep Aquifer monitoring wells are approximately ½ mile from the MGSA Area; however, no groundwater extraction from the Deep Aquifer using wells completed in the MGSA Area is anticipated.

Specific considerations related to the adequacy and sufficiency of the MGSA GSP groundwater elevation monitoring network include the following:

- **Dune Sand Aquifer** – The existing (and planned) MPWSP monitoring wells completed in the Dune Sand Aquifer and included in the MGSA GSP groundwater elevation monitoring network will provide relatively broad coverage to assess potential groundwater elevation declines associated with groundwater extraction in the MGSA Area, potential reduction of groundwater storage in the low total dissolved solids (TDS) zone in the DSA, changes in the low-TDS zone gradients and thickness that could portend advancing seawater intrusion, potential depletion of interconnected surface water, and potential adverse effects on beneficial groundwater users including GDEs.

- **180-Foot Aquifer** – The existing (and planned) MPWSP monitoring wells completed in the 180-Foot Aquifer and included in the MGSA GSP groundwater elevation monitoring network provide relatively broad coverage to assess potential groundwater level decline, interference drawdown effects to existing supply wells and net gradient changes. However, the length of the screened intervals of these wells (average 110 feet for existing wells) precludes assessment of gradient changes between the upper and lower 180-Foot Aquifer or thinning of the low TDS zone within this aquifer. MCWD will review the general adequacy of the monitoring well networks in the area to support the GSP being developed for the Monterey Subbasin. MGSA will review the outcome of this analysis and any additional studies, and the monitoring program of this GSP may be refined if needed to facilitate inter-basin coordination of groundwater monitoring programs.

- **400-Foot Aquifer** – The existing (and planned) MPWSP monitoring wells completed in the 400-Foot Aquifer and included in the MGSA GSP groundwater elevation monitoring network provide broad coverage to assess potential groundwater level decline, interference drawdown effects to existing supply wells, and gradient changes. Coverage is limited to the upper portion of the 400-Foot Aquifer.

- **Deep Aquifer** – The six existing nested USGS monitoring wells completed in the Deep Aquifer, and an additional eight supply wells included in the MGSA GSP groundwater elevation monitoring network cover a considerable area surrounding the MGSA Area; however, the Deep Aquifer is a complex system that is 1,300 feet thick. As such, these wells provide an indication of groundwater elevation trends, but may not be sufficient to assess gradients. MGSA will cooperate with planned efforts by MCWRA, SVBGSA and MCWD GSA to further investigate and monitor the Deep Aquifer during GSP implementation.

5.2.3 Density of Monitoring Sites and Frequency of Measurements

Regulation Requirements:

§354.34(f) The Agency shall determine the density of monitoring sites and frequency of measurements required to demonstrate short-term, seasonal, and long-term trends based upon the following factors:

1) Amount of current and projected groundwater use.
2) Aquifer characteristics, including confined or unconfined aquifer conditions, or other physical characteristics that affect groundwater flow.
3) Impacts to beneficial uses and users of groundwater and land uses and property interests affected by groundwater production, and adjacent basins that could affect the ability of that basin to meet the sustainability goal.
4) Whether the Agency has adequate long-term existing monitoring results or other technical information to demonstrate an understanding of aquifer response.

Based on DWR's SGMA regulations and the Best Management Practices (BMPs) published by DWR on monitoring networks (DWR 2016d), a visual analysis of the proposed MGSA GSP monitoring network was performed using professional judgment to evaluate whether there are data gaps in the groundwater elevation monitoring network in terms of density and frequency of measurements. While there is no definitive requirement on monitoring well density, DWR's BMPs cite several studies (Heath 1976, Sophocleous 1983, Hopkins 1994) that recommend 0.2 to 10 wells per 100 square miles for basin-wide groundwater management programs. The BMPs note that professional judgment should be used to design the monitoring network to account for high-pumping areas, proposed projects, and other subbasin specific factors.

The MGSA Area encompasses approximately 372 acres and is proposed as the location for the extraction of 17,400 acre-feet/year (AFY) of groundwater from slant wells screened in the Dune Sand Aquifer and 180-Foot Aquifer stratigraphic intervals for the MPWSP (HWG 2017). This proposed high rate of groundwater extraction at a single site is unique in the area, and assessing potential undesirable results associated with this extraction rate requires a relatively denser monitoring network and monitoring frequency than for the general regional groundwater management applications contemplated in DWR's BMPs. As described in previous subsections, the monitoring well network adopted for the MGSA GSP, if all wells are installed as proposed, will ultimately consist of up to 13 monitoring wells in each of the

Dune Sand Aquifer, the 180-Foot Aquifer and the 400-Foot Aquifer. These wells are (or will be) equipped with pressure transducers and will be monitored at least quarterly. The frequency and density of measurements is adequate for assessing potential effects that could lead to undesirable results in this setting; however, as discussed previously, the vertical distribution of monitoring points in the 180-Foot Aquifer is limited.

The six USGS monitoring wells and the other eight wells used to monitor the Deep Aquifer also are (or will be) equipped with pressure transducers and are monitored quarterly, which is an adequate monitoring frequency. These wells provide relatively good coverage around the MGSA Area; however, because of the thickness and complexity of the Deep Aquifer they may be insufficient to assess lateral gradients. Regionally, the monitoring well density in the Deep Aquifer has been identified by SVBGSA and MCWRA as being insufficient to assess conditions in this aquifer system (SVBGSA 2019, MCWRA 2017a). MCWRA, SVBGSA and MCWD GSA are discussing plans to investigate the Deep Aquifer system in the Salinas Valley. It is anticipated that the investigation results will provide information regarding the nature and hydraulic properties of the Deep Aquifer. Specifically, the groundwater flow patterns in the Deep Aquifer, the interconnection between the disparate aquifer units in this system, how they are recharged, and the extent of potential leakance from the overlying upper aquifer system is expected to be addressed. No specific scope or schedule has been proposed at this time. MGSA will provide comments on the scope and results of this study and incorporate the results into a future update of the MGSA GSP.

5.2.4 Additional Monitoring Network Information

5.2.4.1 Scientific Rationale for Site Selection

Regulation Requirements:
§354.34(g) Each Plan shall describe the following information about the monitoring network:
(1) Scientific rationale for the monitoring site selection process.

The MPWSP monitoring wells, both existing and planned for installation in the future, are adopted as the MGSA GSP groundwater elevation monitoring network because the wells are specifically designed and completed to monitor the effects of groundwater withdrawals associated with the MPWSP in the Dune Sand Aquifer, the 180-Foot Aquifer, and the 400-Foot Aquifer. The proposed additional well locations were designated by MCWRA under the MMRP for that project to address data gaps (CPUC 2018, MCWRA 2019e). Monitoring of the Deep Aquifer will be accomplished using wells constructed by USGS to investigate and characterize the Deep Aquifer at multiple depth intervals, and augmented with other available wells monitored by MCWRA.

The CASGEM network consists of much more widely distributed wells that are of limited use for managing groundwater in the MGSA Area but provide an informative regional context. For this reason, the CASGEM well information will be used only as necessary to augment data from the MPWSP and USGS wells. Information from other wells in the MCWRA network monitored as part of the MMRP will be used to interpret the regional setting for MGSA's local groundwater monitoring program.

5.2.4.2 CONSISTENCY WITH DATA AND REPORTING STANDARDS

Regulation Requirements:
§354.34(g) Each Plan shall describe the following information about the monitoring network:
(2) Consistency with data and reporting standards described in Section 352.4. If a site is not consistent with those standards, the Plan shall explain the necessity of the site to the monitoring network, and how any variation from the standards will not affect the usefulness of the results obtained.

SGMA requires certain data and reporting standards for groundwater monitoring wells that are used for GSP purposes. Relevant standards include the following:

- Field measurements of elevations of groundwater and land surface shall be measured and reported in feet to an accuracy of at least 0.1 feet relative to NAVD88;
- Geographic locations shall be reported in latitude and longitude coordinates in decimal degrees to five decimal places, to a minimum accuracy of 30 feet relative to NAD83;
- A description of well use, such as public supply, irrigation, monitoring, etc.;
- Casing perforations, borehole depth, and total well depth;
- Well completion reports, if available, from which the names of private owners have been redacted;
- Geophysical logs, well construction diagrams, or other relevant information if available;
- Identification of principal aquifers monitored; and
- Other relevant well construction information, such as well capacity, casing diameter, or casing modifications, as available.

The MPWSP and USGS wells that comprise the monitoring network for the MGSA GSP meet all of these relevant reporting standards as shown in Tables 5-1 through 5-4 and Appendix 5.A.

5.2.5 MONITORING PROTOCOLS

Regulation Requirements:
§352.2 Each Plan shall include monitoring protocols adopted by the Agency for data collection and management, as follows:
(a) Monitoring protocols shall be developed according to best management practices.
(b) The Agency may rely on monitoring protocols included as part of the best management practices developed by the Department, or may adopt similar monitoring protocols that will yield comparable data.
(c) Monitoring protocols shall be reviewed at least every five years as part of the periodic evaluation of the Plan, and modified as necessary.
§354.34(i) The monitoring protocols developed by each Agency shall include a description of technical standards, data collection methods, and other procedures or protocols pursuant to Water Code Section 10727.2(f) for monitoring sites or other data collection facilities to ensure that the monitoring network utilizes comparable data and methodologies.

Chapter 4 of the MCWRA CASGEM monitoring plan (MWCRA 2015) includes a description of the monitoring procedures employed by that agency. These CASGEM groundwater elevation monitoring

protocols will be utilized by MCWRA to implement their monitoring program. The monitoring protocols are included in Appendix 5.B. Groundwater elevation data are currently collected both by hand and using automated pressure transducers. The monitoring protocols established by MCWRA cover multiple monitoring methods for collection of data by hand and by automated pressure transducers. Data collected by MCWRA are anticipated to be provided to MGSA for this GSP.

5.2.6 USE OF GROUNDWATER ELEVATIONS AS PROXY FOR OTHER SUSTAINABILITY INDICATORS

Regulation Requirements:

§354.36(b) Groundwater elevations may be used as a proxy for monitoring other sustainability indicators if the Agency demonstrates the following:

1) Significant correlation exists between groundwater elevations and the sustainability indicators for which groundwater elevation measurements serve as a proxy.
2) Measurable objectives established for groundwater elevation shall include a reasonable margin of operational flexibility taking into consideration the basin setting to avoid undesirable results for the sustainability indicators for which groundwater elevation measurements serve as a proxy.

§354.36(c) The designation of a representative monitoring site shall be supported by adequate evidence demonstrating that the site reflects general conditions in the area.

MGSA will use groundwater elevations as a proxy to monitor for the Land Subsidence and Depletion of Interconnected Surface Water sustainability indicators. As discussed in Section 4.8.2, the risk of land subsidence results from lowered groundwater elevations, specifically when groundwater elevations decrease to levels below the lowest historical water elevations, which leads to the depressurization and consolidation of fine-grained sediments. When groundwater elevations fluctuate within the range of historical conditions, the alluvial layers are not subject to effective stress greater than historical conditions and therefore are generally not at significant risk of subsidence.

As discussed in Section 4.9.2, groundwater elevations in the Dune Sand Aquifer will be used to monitor potential effects to interconnected surface waters (ISW) and GDEs. Change in the potential relationship between groundwater and ISW is directly proportional to the induced gradient changes resulting from groundwater drawdown in shallow aquifers. Similarly, the interaction between groundwater elevations and GDEs is strongly correlated when the GDEs include wetlands, or when groundwater-dependent vegetation cannot adequately adapt to changing groundwater elevations.

5.2.7 DATA GAPS

Regulation Requirements:

§354.38(b) Each Agency shall identify data gaps wherever the basin does not contain a sufficient number of monitoring sites, does not monitor sites at a sufficient frequency, or utilizes monitoring sites that are unreliable, including those that do not satisfy minimum standards of the monitoring network adopted by the Agency.

(c) If the monitoring network contains data gaps, the Plan shall include a description of the following:
1) The location and reason for data gaps in the monitoring network.
2) Local issues and circumstances that limit or prevent monitoring.

(d) Each Agency shall describe steps that will be taken to fill data gaps before the next five-year assessment, including the location and purpose of newly added or installed monitoring sites.

(e) Each Agency shall adjust the monitoring frequency and density of monitoring sites to provide an adequate level of detail about site-specific surface water and groundwater conditions and to assess the effectiveness of management actions under circumstances that include the following:
1) Minimum threshold exceedances.
2) Highly variable spatial or temporal conditions
3) Adverse impacts to beneficial uses and users of groundwater.
4) The potential to adversely affect the ability of an adjacent basin to implement its Plan or impede achievement of sustainability goals in an adjacent basin.

The potential data gaps identified for the MGSA GSP groundwater elevation monitoring network are as follows:

- **Groundwater elevation and quality data in the MGSA Area** – The available data to characterize groundwater elevations and groundwater quality in the MGSA Area and vicinity are both spatially and temporally limited. Such data are needed to characterize groundwater flow patterns in the Dune Sand Aquifer, the 180-Foot Aquifer and the 400-Foot Aquifer and assess recent trends in seawater intrusion. The installation of monitoring well clusters at five additional locations by MCWRA as proposed (and as revised if necessary) will address this data gap spatially. Temporally, the limited duration of the temporal data set will be addressed as additional data are gathered over time.

- **Interconnection between the Salinas River and the Dune Sand Aquifer and 180-Foot Aquifer** – Limited data are available to assess the degree to which the Salinas River is connected to the underlying groundwater systems (Dune Sand Aquifer and 180-Foot Aquifer). This data gap will be addressed in collaboration with SVBGSA's efforts to assess surface-groundwater interaction along the river regionally through monitoring and use of the Salinas Valley Integrated Hydrologic Model (SVIHM). Locally, MGSA will evaluate potential interconnection between the Dune Sand Aquifer and the 180-Foot Aquifer and the Salinas River by examining river stage measurements and the groundwater elevations in the MW-6 and MW-9 well clusters.

- **Deep Aquifer system** – Deep Aquifer monitoring wells near the MGSA area are present at 10 locations, with multiple-depth completions at two locations. Although this network provides relatively well dispersed coverage laterally near the MGSA Area, the Deep Aquifer is relatively thick (1,300 feet) and the existing monitoring well network may be inadequate to reliably assess groundwater gradients. Groundwater extraction from the Deep Aquifer occurs outside the MGSA Area within the portions of the Subbasin managed by MCWD GSA and SVBGSA. These

agencies will play the primary role in investigating and monitoring the Deep Aquifer in this area, and MGSA will cooperate with and support their actions, including expansion of the monitoring well network, to incorporate new wells, if appropriate.

- **Depth discrete groundwater data** – Certain wells in the 180-Foot Aquifer and 400-Foot Aquifer were constructed with very long screened intervals (e.g., over 100 feet in many cases), which introduces uncertainty with respect to the specific aquifer horizon monitored by the well, and the interpretation of local groundwater gradients. This data gap will be addressed as necessary during implementation of the GSP, in collaboration with MCWD GSA. The need to address this data gap may depend on whether the monitoring data indicate that the triggers for the management actions described in Chapter 6 are being exceeded, and whether more vertically discrete data are needed for the implementation and monitoring of those management actions.

5.3 REDUCTION IN GROUNDWATER STORAGE

Regulation Requirements:
§354.34(c) Each monitoring network shall be designed to accomplish the following for each sustainability indicator:
(2) Reduction of Groundwater Storage. Provide an estimate of the change in annual groundwater in storage.

Regionally, reduction in storage in the Subbasin's aquifers has historically occurred and is ongoing due to groundwater production for agricultural, municipal, and domestic use that exceeds the long-term sustainable yield of the Subbasin and the absence of viable alternative sources of water supply. As described in Chapter 3, a large groundwater depression has developed north of Salinas and is apparent on both the 180-Foot/Shallow East Side Aquifers and 400-Foot/Deep East Side Aquifer maps, where elevations are generally -80 to -120 feet msl, and has led to other undesirable results. As a result, less groundwater in storage is available as a buffer against surface water supply shortfalls without causing undesirable results, most notably seawater intrusion. The sustainability indicator for Reduction in Groundwater Storage is evaluated by monitoring groundwater elevations, performing induction logging and collecting extraction data from groundwater users within the Subbasin on an annual basis. The regulations require a network of monitoring wells sufficient to provide an estimate of the change in annual groundwater in storage.

5.3.1 DESCRIPTION OF THE MONITORING APPROACH AND NETWORK

Regulation Requirements:
§354.34(g)(3) For each sustainability indicator, the quantitative values for the minimum threshold, measurable objective, and interim milestones that will be measured at each monitoring site or representative monitoring sites established pursuant to Section 354.36
§354.34(h) The location and type of each monitoring site within the basin displayed on a map, and reported in tabular format, including information regarding the monitoring site type, frequency of measurement, and the purposes for which the monitoring site is being used.

Because the local tools to further assess the MGSA Area component of the Subbasin-wide sustainable yield are not yet available, this GSP adopts SVBGSA's basin-wide sustainable yield estimate of 112,000 AFY as a minimum threshold, supplemented locally with the following interim minimum threshold

related to the low-TDS groundwater zone near the MGSA Area in order to prevent undesirable results from groundwater extraction in the MGSA Area:

- A decrease in the amount of low-TDS groundwater in storage in the Dune Sand, 180-Foot and 400-Foot Aquifers as measured by induction logging.

The regional minimum threshold applies to pumping of natural recharge only. Pumping of intentionally recharged water that is not part of the natural recharge is not considered when compared against the minimum threshold. SVBGSA's calculations account for current land use, future urban growth, and anticipated reasonable climate change. Seawater intrusion (i.e., seawater inflow volume) is not considered part of the sustainable yield. SVBGSA states the sustainable yield is an estimate only and will be updated as additional studies are undertaken and data are compiled (e.g., to address identified data gaps when the SVHM becomes available). The local interim minimum threshold is adopted to prevent significant and unreasonable impacts to GDEs, seawater intrusion, groundwater quality degradation, and potential harm to overlying groundwater right holders, while the data gaps regarding the sustainable yield are addressed as discussed in Chapters 6 and 7, and until a local sustainable yield volume can be determined. It is based on assessment of the amount of low-TDS groundwater in storage, which has been determined to be related to these other sustainability indicators.

The existing (and planned) MPWSP monitoring wells will serve as the MGSA GSP groundwater storage monitoring network. Well information is provided on Tables 5-1 through 5-3, the boring logs and well completion diagrams are provided in Appendix 5.A, and the locations of the MPWSP monitoring wells are shown on Figure 5-2. Groundwater extraction data for the MGSA Area will be obtained from pumpers and compiled. MGSA will prepare annual estimates of the changes in low-TDS groundwater in storage near the MGSA. This estimate will be conducted based on annual induction logging conducted by MCWRA, and will be used to assess changes in the amount of low-TDS water in storage in the aquifer system. Finally, MGSA will estimate of the amount of low-TDS groundwater withdrawn annually from the aquifer system based on pumping and water quality data provided by pumpers within the MGSA Area. The estimates will be made using volume and mass balance calculations, and supported by modeling and assessment of water quality data as necessary. Data will be provided to SVBGSA for consideration in their annual assessment of groundwater storage reduction.

5.3.2 Adequacy of Monitoring Network, Density of Monitoring Sites, and Frequency of Measurements

Regulation Requirements:

§354.34(d) The monitoring network shall be designed to ensure adequate coverage of sustainability indicators. If management areas are established, the quantity and density of monitoring sites in those areas shall be sufficient to evaluate conditions of the basin setting and sustainable management criteria specific to that area.

§354.34(e) A Plan may utilize site information and monitoring data from existing sources as part of the monitoring network

§354.34(f) The Agency shall determine the density of monitoring sites and frequency of measurements required to demonstrate short-term, seasonal, and long-term trends based upon the following factors:

1) Amount of current and projected groundwater use.
2) Aquifer characteristics, including confined or unconfined aquifer conditions, or other physical characteristics that affect groundwater flow.

3) Impacts to beneficial uses and users of groundwater and land uses and property interests affected by groundwater production, and adjacent basins that could affect the ability of that basin to meet the sustainability goal.
4) Whether the Agency has adequate long-term existing monitoring results or other technical information to demonstrate an understanding of aquifer response.

The adequacy of the groundwater elevation monitoring network is discussed in Section 5.2.2. Groundwater extraction within the MGSA Area will be metered and reported by extractors, and groundwater extraction from wells in the adjacent areas is reported to and complied by MCWRA. These components together result in an adequate monitoring network for the purpose of assessing potential groundwater storage changes. The density and frequency of groundwater elevation measurements in the MPWSP wells is discussed in Section 5.2.3. Groundwater extraction data is compiled annually, which is adequate to allow interpretation of the nature and cause of potential volume changes.

Procedures and examples of the use of induction logging to assess salinity contrast distributions and changes are provided by Zidar and Feeney (2019) and are included as Appendix 5.D. Induction logging will be conducted annually at each of the nested MPWSP monitoring well locations. Vertical contrasts from borehole geophysical logs can typically be identified to a resolution of approximately 5 feet. The inherent uncertainty in the storage change estimates will be assessed and discussed; the certainty of estimates may range from order of magnitude to more refined volume estimates.

5.3.3 Additional Monitoring Network Information

5.3.3.1 Scientific Rationale for Site Selection

Regulation Requirements:
§354.34(g) Each Plan shall describe the following information about the monitoring network:
(1) Scientific rationale for the monitoring site selection process.

The scientific rationale for the selection of sites for the groundwater storage monitoring network is the same as for the groundwater elevation monitoring network discussed in Section 5.2.4.1. Induction logging will be used to assess the vertical distribution of groundwater of varying salinity at each well cluster. Induction logging is a geophysical method analogous to AEM that is often used to assess salinity distribution and changes in wells. Induction logging each nested MPWSP well site will provide a vertical profile of salinity distribution in the upper aquifer system to the approximate maximum depth of the low-TDS zone across the MGSA Area and eastward, at a lateral spacing that is suitable for assessment of the approximate change of low-TDS water in storage.

5.3.3.2 Consistency with Data and Reporting Standards

Regulation Requirements:
§354.34(g) Each Plan shall describe the following information about the monitoring network:
(2) Consistency with data and reporting standards described in Section 352.4. If a site is not consistent with those standards, the Plan shall explain the necessity of the site to the monitoring network, and how any variation from the standards will not affect the usefulness of the results obtained.

As discussed in Section 5.2.4.2, the data associated with the MGSA GSP monitoring network are consistent with the reporting standards required by SGMA. Reductions in low-TDS groundwater storage

will be estimated based on the calculated changes in storage volumes in acre-feet of groundwater and pumping volumes will be reported in acre-feet per year. .

5.3.4 MONITORING PROTOCOLS

Regulation Requirements:

§352.2 Each Plan shall include monitoring protocols adopted by the Agency for data collection and management, as follows:

(a) Monitoring protocols shall be developed according to best management practices.

(b) The Agency may rely on monitoring protocols included as part of the best management practices developed by the Department, or may adopt similar monitoring protocols that will yield comparable data.

(c) Monitoring protocols shall be reviewed at least every five years as part of the periodic evaluation of the Plan, and modified as necessary.

§354.34(i) The monitoring protocols developed by each Agency shall include a description of technical standards, data collection methods, and other procedures or protocols pursuant to Water Code Section 10727.2(f) for monitoring sites or other data collection facilities to ensure that the monitoring network utilizes comparable data and methodologies.

Chapter 4 of the MCWRA CASGEM monitoring plan (MWCRA 2015) includes a description of the monitoring procedures employed by that agency. These CASGEM groundwater elevation monitoring protocols will be utilized by MCWRA to implement their monitoring program. The monitoring protocols are included in Appendix 5.B. Procedures and examples of the use of induction logging to assess salinity contrast distributions and changes are provided by Zidar and Feeney (2019) and are included as Appendix 5.D.

MGSA will coordinate with SVBGSA and MCWRA to acquire information regarding groundwater withdrawals that are relevant to the MGSA Area. Pumping volume and water quality data for groundwater extraction within the MGSA Area will be obtained directly from the extractors and from MCWRA. SVBGSA has stated that it will download data directly from the State's Drinking Water Information Clearinghouse website ("Drinking Water Information Clearinghouse") regarding municipal groundwater users and small water systems. No other protocols are required. For agricultural groundwater users, SVBGSA will work with MCWRA to develop a protocol for sharing data that is currently reported under County Ordinance 3717.

5.3.5 USE OF GROUNDWATER ELEVATIONS AS PROXY FOR OTHER SUSTAINABILITY INDICATORS

Regulation Requirements:

§354.36(b) Groundwater elevations may be used as a proxy for monitoring other sustainability indicators if the Agency demonstrates the following:

1) Significant correlation exists between groundwater elevations and the sustainability indicators for which groundwater elevation measurements serve as a proxy.
2) Measurable objectives established for groundwater elevation shall include a reasonable margin of operational flexibility taking into consideration the basin setting to avoid undesirable results for the sustainability indicators for which groundwater elevation measurements serve as a proxy.

§354.36(c) The designation of a representative monitoring site shall be supported by adequate evidence demonstrating that the site reflects general conditions in the area.

As discussed in Section 5.3.1, groundwater elevations will be used in combination with induction logging and extraction volumes to estimate changes in the volume of low-TDS groundwater in storage as an interim proxy for sustainable yield volume estimates. The relationship between the amount of low-TDS

groundwater in storage and potential local undesirable results related to chronic decline in groundwater levels (significant and unreasonable impacts to GDEs), seawater intrusion and water quality degradation is discussed in Section 3.5.1.

5.3.6 DATA GAPS

Regulation Requirements:

§354.38(b) Each Agency shall identify data gaps wherever the basin does not contain a sufficient number of monitoring sites, does not monitor sites at a sufficient frequency, or utilizes monitoring sites that are unreliable, including those that do not satisfy minimum standards of the monitoring network adopted by the Agency.

§354.38(c) If the monitoring network contains data gaps, the Plan shall include a description of the following:

1) The location and reason for data gaps in the monitoring network.
2) Local issues and circumstances that limit or prevent monitoring**.**

§354.38 (d) Each Agency shall describe steps that will be taken to fill data gaps before the next five-year assessment, including the location and purpose of newly added or installed monitoring sites.

§354.38(e) Each Agency shall adjust the monitoring frequency and density of monitoring sites to provide an adequate level of detail about site-specific surface water and groundwater conditions and to assess the effectiveness of management actions under circumstances that include the following:

1) Minimum threshold exceedances.
2) Highly variable spatial or temporal conditions
3) Adverse impacts to beneficial uses and users of groundwater.
4) The potential to adversely affect the ability of an adjacent basin to implement its Plan or impede achievement of sustainability goals in an adjacent basin.

The following data gaps associated with the monitoring network in the vicinity of the MGSA Area are relevant to this sustainability indicator:

- **Sustainable yield** – SVBGSA indicates that its Subbasin-wide minimum threshold and sustainable yield volume of 112,000 AFY is an estimate and subject to refinement and update after the SVIHM becomes available. Similarly, the modeling tools needed to assess the local sustainable yield in the MGSA Area are expected to become available during the early phases of GSP implementation and will be used to address data gaps in the local and regional sustainable yield estimates as discussed in Chapters 6 and 7.

- **Groundwater extraction data** – The CEMEX well is currently the only extraction well in the MGSA Area of the Subbasin. MGSA will coordinate with SVBGSA and MCWD GSA to determine the local contribution to the sustainable yield from groundwater extraction in the MGSA Area, which is the amount of groundwater that can be withdrawn annually over a period of time without causing undesirable results within or near the MGSA Area.

- **Groundwater elevation and quality data in the MGSA Area** – The available data to characterize groundwater elevations in the MGSA Area and vicinity are both spatially and temporally limited. Such data are needed to characterize groundwater flow patterns in the Dune Sand Aquifer, the 180-Foot Aquifer and the 400-Foot Aquifer and assess recent trends in seawater intrusion. The installation of monitoring well clusters at five additional locations by MCWRA as proposed (and as revised if necessary) will address this data gap spatially. Temporally, the limited duration of the temporal data set will be addressed as additional data are gathered over time.

- **Depth discrete groundwater data** – Certain wells in the 180-Foot Aquifer and 400-Foot Aquifer were constructed with very long screened intervals (e.g., over 100 feet in many cases), which introduces uncertainty with respect to the specific aquifer horizon monitored by the well, and the interpretation of local groundwater gradients. This data gap will be addressed as necessary during implementation of the GSP, in collaboration with MCWD GSA. The need to address this data gap may depend on whether the monitoring data indicate that the triggers for the management actions described in Chapter 6 are being exceeded, and whether more vertically discrete data are needed for the implementation and monitoring of those management actions.

5.4 SEAWATER INTRUSION

Regulation Requirements:
§354.34(c) Each monitoring network shall be designed to accomplish the following for each sustainability indicator:
(3) Seawater Intrusion. Monitor seawater intrusion using chloride concentrations, or other measurements convertible to chloride concentrations, so that the current and projected rate and extent of seawater intrusion for each applicable principal aquifer may be calculated.

Seawater intrusion will be evaluated using the MPWSP monitoring well network to collect a combination of groundwater quality and induction logging data to interpolate chloride isocontours and provide additional data regarding the nearshore processes that drive seawater intrusion regionally, including density-driven flow and preferential pathways for vertical migration.

5.4.1 DESCRIPTION OF THE MONITORING APPROACH AND NETWORK

Regulation Requirements:
§354.34(g)(3) For each sustainability indicator, the quantitative values for the minimum threshold, measurable objective, and interim milestones that will be measured at each monitoring site or representative monitoring sites established pursuant to Section 354.36
§354.34(h) The location and type of each monitoring site within the basin displayed on a map, and reported in tabular format, including information regarding the monitoring site type, frequency of measurement, and the purposes for which the monitoring site is being used.

MGSA established the following minimum thresholds for significant and unreasonable seawater intrusion in this GSP:

- **Dune Sand Aquifer**. In compliance with SWRCB Resolution Nos. 88-63 and 68-16, this GSP defines the minimum threshold for significant and unreasonable seawater intrusion into the Dune Sand Aquifer as migration of the 1,700 mg/L chloride isocontour (equivalent to 3,000 mg/L TDS) beyond the location determined by Gottschalk *et al.* (2018) (Figure 4-2).

- **180-Foot and 400-Foot Aquifers**. This GSP adopts the SVBGSA minimum threshold of significant unreasonable seawater intrusion beyond the position of the 500 mg/L chloride concentration isocontour interpolated by MCWRA in 2017 (Figure 4-2).

- **Deep Aquifer.** In compliance with SWRCB Resolution No. 68-16, this GSP defines significant and unreasonable seawater intrusion into the Deep Aquifer as migration of a 500 mg/L chloride isocontour into the Deep Aquifer landward of the western Subbasin boundary.

The following measurable objectives are established for Seawater Intrusion:

- **Dune Sand Aquifer**. The measurable objectives are established to equal the minimum threshold of maintaining the 1,700 mg/L chloride isocontour at its current location. The interim milestones are identical to the measurable objective.

- **180-Foot and 400-Foot Aquifers**. MGSA will collaborate with SVBGSA and support the measurable objective and interim milestones in the SVBGSA's GSP of moving the 500 mg/L chloride isocontour westward to Highway 1 by 2020.

- **Deep Aquifer.** The measurable objective for the Deep Aquifer will be to prevent significant and unreasonable seawater intrusion and maintain the location of the 500 mg/L chloride isocontour outside the seaward Subbasin Boundary. The interim milestones are identical to the measurable objective.

The following data are needed to assess compliance with the minimum thresholds:

- Groundwater quality data for chloride at various depths and locations over time form the primary basis for interpolation of chloride concentration isocontour maps to assess compliance related to this sustainability indicator.

To provide additional data regarding the nearshore processes that drive seawater intrusion regionally, including density-driven flow and preferential pathways for vertical migration, the following data will be collected:

- Groundwater elevation data are necessary to understand the lateral and vertical gradients that may drive seawater intrusion, and to assess gradients and drawdown in the area affected by pumping within the MGSA Area; and

- Induction logging data from each monitoring well location will be used as an additional data source to assess the lateral and vertical distribution of low-TDS and more highly saline groundwater.

As described in Section 5.2.1, the existing (and planned) MPWSP monitoring wells are included in the MGSA GSP seawater intrusion monitoring network. Well information is provided on Tables 5-1 through 5-4, the boring logs and well completion diagrams are provided in Appendix 5.A, and the locations of the MPWSP monitoring wells are shown on Figure 5-2.

5.4.2 Adequacy of Monitoring Network, Density of Monitoring Sites, and Frequency of Measurements

Regulation Requirements:

§354.34(d) The monitoring network shall be designed to ensure adequate coverage of sustainability indicators. If management areas are established, the quantity and density of monitoring sites in those areas shall be sufficient to evaluate conditions of the basin setting and sustainable management criteria specific to that area.

§354.34(e) A Plan may utilize site information and monitoring data from existing sources as part of the monitoring network

§354.34(f) The Agency shall determine the density of monitoring sites and frequency of measurements required to demonstrate short-term, seasonal, and long-term trends based upon the following factors:

1) Amount of current and projected groundwater use.
2) Aquifer characteristics, including confined or unconfined aquifer conditions, or other physical characteristics that affect groundwater flow.
3) Impacts to beneficial uses and users of groundwater and land uses and property interests affected by groundwater production, and adjacent basins that could affect the ability of that basin to meet the sustainability goal.
4) Whether the Agency has adequate long-term existing monitoring results or other technical information to demonstrate an understanding of aquifer response.

The adequacy of the groundwater elevation and quality monitoring network is discussed in Section 5.2.2, and adequacy of the induction logging monitoring network is discussed in 5.3.2. The density and frequency of groundwater elevation and groundwater quality measurements in the MPWSP wells is discussed in Section 5.2.3 and 5.3.3. Given the spatial distribution of the low-TDS groundwater zone and the saline water intrusion wedge in the vicinity of the MGSA Area (Figures 3-21, 3-22 and 3-23) and the use of continuous induction logging at each well cluster, the locations and completion depths of the existing and proposed monitoring wells will provide a generally adequate monitoring network to assess the potential migration of the wedge both laterally and vertically. The data gap related to long screen intervals will partly addressed through the use of induction logging, and the need for additional vertically-delineated monitoring zones will be evaluated in cooperation with MCWD GSA during GSP implementation. The collection of quarterly or more frequent data meets or exceeds the standards normally applied for the assessment of seawater intrusion or solute plume migration.

Monitoring data from the Deep Aquifer wells will provide an indication as to whether the Deep Aquifer system in this area is being affected by seawater intrusion; however, the existing monitoring well network in the Deep Aquifer system may be insufficient to interpret groundwater gradients. In addition, the potential vertical leakance from overlying seawater intruded aquifers remains unknown. These data gaps have been proposed to be addressed by SVBGSA, MCWRA and MCWD GSA. The MGSA will cooperate with these investigative activities.

5.4.3 Additional Monitoring Network Information

5.4.3.1 Scientific Rationale for Site Selection

Regulation Requirements:

§354.34(g) Each Plan shall describe the following information about the monitoring network:

(1) Scientific rationale for the monitoring site selection process.

As discussed above, the existing and proposed monitoring well network and monitoring frequency provide an adequate basis for assessment of chloride isocontour migration and potential water quality and gradient changes that could be indicative of active seawater intrusion in the vicinity of the saline water intrusion wedge in this area. The Deep Aquifer well location and completions were selected by USGS to optimally investigate the hydrostratigraphy of the Deep Aquifer at this location, and are supplemented by additional Deep Aquifer wells in MCWRA's monitoring program.

5.4.3.2 CONSISTENCY WITH DATA AND REPORTING STANDARDS

Regulation Requirements:

§354.34(g) Each Plan shall describe the following information about the monitoring network:

(2) Consistency with data and reporting standards described in Section 352.4. If a site is not consistent with those standards, the Plan shall explain the necessity of the site to the monitoring network, and how any variation from the standards will not affect the usefulness of the results obtained.

As discussed in Section 5.2.4.2, the data associated with the MGSA GSP groundwater elevation and quality monitoring network are consistent with the reporting standards required by SGMA. Increases in seawater intrusion will be assessed by determining whether interpolated chloride isocontours, reported in mg/L for each of the principal aquifers, have moved.

5.4.4 MONITORING PROTOCOLS

Regulation Requirements:

§352.2 Each Plan shall include monitoring protocols adopted by the Agency for data collection and management, as follows:

(a) Monitoring protocols shall be developed according to best management practices.

(b) The Agency may rely on monitoring protocols included as part of the best management practices developed by the Department, or may adopt similar monitoring protocols that will yield comparable data.

(c) Monitoring protocols shall be reviewed at least every five years as part of the periodic evaluation of the Plan, and modified as necessary.

§354.34(i) The monitoring protocols developed by each Agency shall include a description of technical standards, data collection methods, and other procedures or protocols pursuant to Water Code Section 10727.2(f) for monitoring sites or other data collection facilities to ensure that the monitoring network utilizes comparable data and methodologies.

MCWRA has established protocols for collecting groundwater quality data from monitoring wells and analyzing those data for seawater intrusion. These protocols are also applied to collection of groundwater quality data from the MPWSP monitoring wells and the USGS Deep Aquifer wells. The groundwater quality data monitoring protocols are available in the Monterey County Quality Assurance Project Plan (QAPP) and included in Appendix 5.B. MCWRA also established chloride data contouring protocols to develop the isoconcentration contour map, provided in Appendix 5.C. Data collected by MCWRA in accordance with these protocols is anticipated to be provided to MGSA for this GSP. Induction logging will be performed in accordance with the procedures presented in Zidar and Feeney (2019) and included in Appendix 5.D.

5.4.5 DATA GAPS

Regulation Requirements:

§354.38(b) Each Agency shall identify data gaps wherever the basin does not contain a sufficient number of monitoring sites, does not monitor sites at a sufficient frequency, or utilizes monitoring sites that are unreliable, including those that do not satisfy minimum standards of the monitoring network adopted by the Agency.

§354.38(c) If the monitoring network contains data gaps, the Plan shall include a description of the following:

1) The location and reason for data gaps in the monitoring network.
2) Local issues and circumstances that limit or prevent monitoring**.**

§354.38 (d) Each Agency shall describe steps that will be taken to fill data gaps before the next five-year assessment, including the location and purpose of newly added or installed monitoring sites.

§354.38(e) Each Agency shall adjust the monitoring frequency and density of monitoring sites to provide an adequate level of detail about site-specific surface water and groundwater conditions and to assess the effectiveness of management actions under circumstances that include the following:

1) Minimum threshold exceedances.
2) Highly variable spatial or temporal conditions
3) Adverse impacts to beneficial uses and users of groundwater.
4) The potential to adversely affect the ability of an adjacent basin to implement its Plan or impede achievement of sustainability goals in an adjacent basin.

The following potential data gaps identified for the MGSA GSP groundwater elevation monitoring network are applicable to the Seawater Intrusion sustainability indicator:

- **Groundwater elevation and quality data in the MGSA Area**: The available data to characterize groundwater elevations and groundwater quality in the MGSA Area and vicinity are both spatially and temporally limited. Such data are needed to characterize groundwater flow patterns in the Dune Sand Aquifer, the 180-Foot Aquifer and the 400-Foot Aquifer and assess recent trends in seawater intrusion. The installation of monitoring well clusters at five additional locations by MCWRA as proposed (and as revised if necessary) will address this data gap spatially. Temporally, the limited duration of the temporal data set will be addressed as additional data are gathered over time.

- **Interconnection between the Salinas River and the Dune Sand Aquifer and 180-Foot Aquifer**: Limited data are available to assess the degree to which the Salinas River is connected to the underlying groundwater systems (Dune Sand Aquifer and 180-Foot Aquifer). The available data suggest that seawater intrusion may be occurring through the bed of the Salinas River near the river mouth (Section 3.2.6.1, Figure 3-22), where the river may be tidally influenced. Decreased groundwater elevations in the Dune Sand Aquifer could result in additional seawater intrusion in this area. This data gap will be addressed in collaboration with SVBGSA's efforts to assess surface-groundwater interaction along the river regionally through monitoring and use of the SVIHM. Locally, MGSA will evaluate potential interconnection between the Dune Sand Aquifer and the 180-Foot Aquifer and the Salinas River by examining river stage measurements and the groundwater elevations in the MW-6 and MW-9 well clusters.

- **Deep Aquifer system:** The of Deep Aquifer monitoring wells may be insufficient to interpret groundwater gradients and may be insufficient to provide early warning of potential seawater intrusion. Groundwater extraction from the Deep Aquifer occurs outside the MGSA Area within

the portions of the Subbasin managed by MCWD GSA and SVBGSA. These agencies will play the primary role in investigating and monitoring the Deep Aquifer in this area, and MGSA will cooperate with and support their actions.

- **Depth discrete groundwater data** – Certain wells in the 180-Foot Aquifer and 400-Foot Aquifer were constructed with very long screened intervals (e.g., over 100 feet in many cases), which introduces uncertainty with respect to the specific aquifer horizon monitored by the well, and the interpretation of local groundwater gradients. This data gap will be addressed as necessary during implementation of the GSP, in collaboration with MCWD GSA. The need to address this data gap may depend on whether the monitoring data indicate that the triggers for the management actions described in Chapter 6 are being exceeded, and whether more vertically discrete data are needed for the implementation and monitoring of those management actions.

5.5 WATER QUALITY DEGRADATION

Regulation Requirements:
§354.34(c) Each monitoring network shall be designed to accomplish the following for each sustainability indicator:
(4) Degraded Water Quality. Collect sufficient spatial and temporal data from each applicable principal aquifer to determine groundwater quality trends for water quality indicators, as determined by the Agency, to address known water quality issues.

Groundwater quality degradation will be measured from the monitoring well network using groundwater quality monitoring, including groundwater sampling and analysis, the use of specific conductance sensors, and annual induction logging to assess the lateral and vertical distribution of TDS and chloride.

5.5.1 DESCRIPTION OF THE MONITORING APPROACH AND NETWORK

Regulation Requirements:
§354.34(g)(3) For each sustainability indicator, the quantitative values for the minimum threshold, measurable objective, and interim milestones that will be measured at each monitoring site or representative monitoring sites established pursuant to Section 354.36
§354.34(h) The location and type of each monitoring site within the basin displayed on a map, and reported in tabular format, including information regarding the monitoring site type, frequency of measurement, and the purposes for which the monitoring site is being used.

The following minimum thresholds were established for the groundwater quality degradation sustainability indicator:

- Significant and unreasonable degradation of water quality in the low-TDS groundwater zone in the Dune Sand, 180-Foot and 400-Foot Aquifers is defined as lateral or vertical migration of the 3,000 mg/L TDS isocontour beyond the location established by the 2018 AEM study (Gottschalk *et al.* 2018).

- Significant and unreasonable degradation of water quality in the Deep Aquifer is defined as exceedance of the TDS or chloride SMCL in one or more public supply wells completed in the Deep Aquifer near the MGSA Area.

- Significant and unreasonable migration of a contamination plume is defined by the following minimum threshold:
    - Migration or spread of the portion of a contamination plume that exceeds applicable water quality objectives by more than 100 feet toward the center of groundwater extraction in the MGSA Area, as documented by plume maps for the cleanup site.

The following measurable objectives have been established for groundwater quality degradation:

- The measurable objective for degradation of water quality in the low-TDS groundwater zone are defined to be the same as the minimum threshold, which is the 2018 vertical and lateral position of the 3,000 mg/L TDS isocontour in the Dune Sand, 180-Foot and 400-Foot Aquifers, as determined by the 2018 AEM survey (Gottschalk *et al.* 2018).
- The measurable objective for degradation of water quality in the Deep Aquifer is no supply wells with MCL or SMCL exceedances for TDS or chloride.
- The measurable objective for migration of a contamination plume is defined by the following:
    - An observable spread of the portion of a contamination plume that exceeds applicable water quality objectives over two or more consecutive monitoring events toward the center of groundwater extraction in the MGSA Area, as documented by plume maps for the cleanup site.

The following data are needed to assess compliance with these thresholds:

- Groundwater quality data for TDS and chloride at various depths and locations over time within the low-TDS groundwater zone form the primary basis for assessing compliance related to this sustainability indicator in the Dune Sand, 180-Foot and 400-Foot Aquifers;
- Induction logging data from each monitoring well location will be used to additionally assess the lateral and vertical distribution of TDS and chloride at each MPWSP monitoring well cluster and assess changes; and
- Groundwater level contour maps and plume maps for the OUCTP area of the Fort Ord Superfund Site.

Summary information for the groundwater elevation and quality monitoring network that will be used to assess this sustainability indicator is presented in Tables 5-1 through 5-3, and boring logs and well completion diagrams are provided in Appendix 5-A. The location of these monitoring wells is shown on Figure 5-2, which also presents the locations of five additional monitoring well clusters that are proposed to be installed by MCWRA.

5.5.2 Adequacy of Monitoring Network, Density of Monitoring Sites, and Frequency of Measurements

Regulation Requirements:

§354.34(d) The monitoring network shall be designed to ensure adequate coverage of sustainability indicators. If management areas are established, the quantity and density of monitoring sites in those areas shall be sufficient to evaluate conditions of the basin setting and sustainable management criteria specific to that area.
§354.34(e) A Plan may utilize site information and monitoring data from existing sources as part of the monitoring network.
§354.34(f) The Agency shall determine the density of monitoring sites and frequency of measurements required to demonstrate short-term, seasonal, and long-term trends based upon the following factors:
1) Amount of current and projected groundwater use.
2) Aquifer characteristics, including confined or unconfined aquifer conditions, or other physical characteristics that affect groundwater flow.
3) Impacts to beneficial uses and users of groundwater and land uses and property interests affected by groundwater production, and adjacent basins that could affect the ability of that basin to meet the sustainability goal.
4) Whether the Agency has adequate long-term existing monitoring results or other technical information to demonstrate an understanding of aquifer response.

The adequacy of the groundwater elevation and quality monitoring network is discussed in Section 5.2.2. The density and frequency of groundwater elevation and quality measurements in the MPWSP wells is discussed in Section 5.2.3 and 5.3.3, and the adequacy of the induction logging monitoring network is discussed in 5.3.2. Given the spatial distribution of the low-TDS zone in the vicinity of the MGSA Area (Figures 3-21, 3-22 and 3-23) and the use of continuous induction logging at each well cluster, the locations and completion depths of the existing and proposed monitoring wells will provide a generally adequate monitoring network to assess the potential migration of this zone both laterally and vertically. The data gap related to long screen intervals will partly addressed through the use of induction logging, and the need for additional vertically-delineated monitoring zones will be evaluated in cooperation with MCWD GSA during GSP implementation. The collection of quarterly or more frequent data meets or exceeds the standards normally applied for the assessment of seawater intrusion or solute plume migration.

5.5.3 Additional Monitoring Network Information

5.5.3.1 Scientific Rationale for Site Selection

Regulation Requirements:
§354.34(g) Each Plan shall describe the following information about the monitoring network:
(1) Scientific rationale for the monitoring site selection process.

As discussed above, the existing monitoring well network and monitoring frequency provide an adequate basis for assessment of potential water quality changes that could be indicative of water quality degradation in the low-TDS groundwater zone.

5.5.3.2 Consistency with Data and Reporting Standards

Regulation Requirements:
§354.34(g) Each Plan shall describe the following information about the monitoring network:
(2) Consistency with data and reporting standards described in Section 352.4. If a site is not consistent with those standards, the Plan shall explain the necessity of the site to the monitoring network, and how any variation from the standards will not affect the usefulness of the results obtained.

As discussed in Section 5.2.4.2, the data associated with the MGSA GSP groundwater elevation and quality monitoring network are consistent with the reporting standards required by SGMA. The

groundwater quality minimum thresholds specifically incorporate state and federal standards for drinking water and applicable Water Quality Standards incorporated into the Regional Water Quality Control Board's Water Quality Control Plan, including SWRCB Resolution Nos. 88-63 and 68-16.

5.5.4 MONITORING PROTOCOLS

Regulation Requirements:

§352.2 Each Plan shall include monitoring protocols adopted by the Agency for data collection and management, as follows:

(a) Monitoring protocols shall be developed according to best management practices.

(b) The Agency may rely on monitoring protocols included as part of the best management practices developed by the Department, or may adopt similar monitoring protocols that will yield comparable data.

(c) Monitoring protocols shall be reviewed at least every five years as part of the periodic evaluation of the Plan, and modified as necessary.

§354.34(i) The monitoring protocols developed by each Agency shall include a description of technical standards, data collection methods, and other procedures or protocols pursuant to Water Code Section 10727.2(f) for monitoring sites or other data collection facilities to ensure that the monitoring network utilizes comparable data and methodologies.

MCWRA has established protocols for collecting groundwater quality data from monitoring wells and analyzing those data for the water quality effects of seawater intrusion. These protocols are also applied to collection of groundwater quality data from the MPWSP monitoring wells and the USGS Deep Aquifer wells. The groundwater quality data monitoring protocols are available in the Monterey County Quality Assurance Project Plan (QAPP) and included in Appendix 5.B. Data collected by MCWRA in accordance with these protocols is anticipated to be provided to MGSA for this GSP. Induction logging will be performed in accordance with the procedures presented in Zidar and Feeney (2019) and included in Appendix 5.D.

5.5.5 DATA GAPS

Regulation Requirements:

§354.38(b) Each Agency shall identify data gaps wherever the basin does not contain a sufficient number of monitoring sites, does not monitor sites at a sufficient frequency, or utilizes monitoring sites that are unreliable, including those that do not satisfy minimum standards of the monitoring network adopted by the Agency.

§354.38(c) If the monitoring network contains data gaps, the Plan shall include a description of the following:

1) The location and reason for data gaps in the monitoring network.
2) Local issues and circumstances that limit or prevent monitoring**.**

§354.38 (d) Each Agency shall describe steps that will be taken to fill data gaps before the next five-year assessment, including the location and purpose of newly added or installed monitoring sites.

§354.38(e) Each Agency shall adjust the monitoring frequency and density of monitoring sites to provide an adequate level of detail about site-specific surface water and groundwater conditions and to assess the effectiveness of management actions under circumstances that include the following:

1) Minimum threshold exceedances.
2) Highly variable spatial or temporal conditions
3) Adverse impacts to beneficial uses and users of groundwater.
4) The potential to adversely affect the ability of an adjacent basin to implement its Plan or impede achievement of sustainability goals in an adjacent basin.

The following potential data gaps identified for the MGSA GSP groundwater elevation monitoring network are applicable to the Degradation of Groundwater Quality sustainability indicator:

- **Groundwater elevation and quality data in the MGSA Area**: The available data to characterize groundwater elevations and groundwater quality in the MGSA Area and vicinity are both spatially and temporally limited. Such data are needed to characterize groundwater flow patterns in the Dune Sand Aquifer, the 180-Foot Aquifer and the 400-Foot Aquifer and assess recent trends in seawater intrusion. The installation of monitoring well clusters at five additional locations by MCWRA as proposed (and as revised if necessary) will address this data gap spatially. Temporally, the limited duration of the temporal data set will be addressed as additional data are gathered over time.

- **Depth discrete groundwater data** – Certain wells in the 180-Foot Aquifer and 400-Foot Aquifer were constructed with very long screened intervals (e.g., over 100 feet in many cases), which introduces uncertainty with respect to the specific aquifer horizon monitored by the well, and the interpretation of local groundwater gradients. This data gap will be addressed as necessary during implementation of the GSP, in collaboration with MCWD GSA. The need to address this data gap may depend on whether the monitoring data indicate that the triggers for the management actions described in Chapter 6 are being exceeded, and whether more vertically discrete data are needed for the implementation and monitoring of those management actions.

5.6 LAND SUBSIDENCE

Regulation Requirements:
§354.34(c) Each monitoring network shall be designed to accomplish the following for each sustainability indicator:
(5) Land Subsidence. Identify the rate and extent of land subsidence, which may be measured by extensometers, surveying, remote sensing technology, or other appropriate method.

Section 354.28(d) of the Regulations states that "*an Agency may establish a representative minimum threshold for groundwater elevation to serve as the value for multiple sustainability indicators, where the Agency can demonstrate that the representative value is a reasonable proxy for multiple individual minimum thresholds as supported by adequate evidence*." The MGSA GSP uses groundwater elevation data as a proxy for land subsidence measurements based on the rationale described in Section 4.8.2. Groundwater elevation proxy minimum thresholds will be directly measured from the monitoring well network. In addition, in collaboration with SVBGSA, MGSA will obtain and review subsidence measurements and remote sensing data from DWR and other entities.

5.6.1 DESCRIPTION OF MONITORING APPROACH AND NETWORK

Regulation Requirements:
§354.34(g)(3) For each sustainability indicator, the quantitative values for the minimum threshold, measurable objective, and interim milestones that will be measured at each monitoring site or representative monitoring sites established pursuant to Section 354.36.
§354.34(h) The location and type of each monitoring site within the basin displayed on a map, and reported in tabular format, including information regarding the monitoring site type, frequency of measurement, and the purposes for which the monitoring site is being used.

This GSP adopts the following groundwater elevation minimum thresholds that serve as a proxy for land subsidence minimum thresholds:

- **Dune Sand Aquifer** – The minimum thresholds for the Dune Sand Aquifer are established as an elevation of 1 foot above the 2015 low groundwater levels recorded in Dune Sand Aquifer monitoring wells near identified GDEs in the vicinity of the MGSA Area, and presented for wells MW-4S, 7S and 8S in Table 4-1. These minimum thresholds will be updated as warranted based on future planned investigations to address existing data gaps in the relationship between groundwater level declines and GDE response, as discussed in Chapter 7.

- **180-Foot and 400-Foot Aquifers** – The minimum thresholds for the 180-Foot and 400-Foot Aquifers are 1 foot above historical low groundwater elevations measured in 2015 as determined from analysis of the hydrographs included in Appendix 3.D. For RMS located near well 14S/02E-08M02, which is approximately 1 mile northeast of the MGSA Area, minimum thresholds were adjusted to better match the minimum threshold adopted by SVBGSA for the 400-Foot Aquifer at this location, and in the overlying 180-Foot Aquifer in accordance with existing vertical gradients. Values for RMS are presented in Table 4-1.

- **Deep Aquifer** – Because groundwater is not currently extracted from the Deep Aquifer in the MGSA Area, minimum thresholds and measurable objectives were not established for the Chronic Lowering of Groundwater Levels sustainability indicator in this aquifer and none are therefore adopted for subsidence.

This GSP adopts the following groundwater elevation measurable objectives that serve as a proxy for land subsidence minimum thresholds:

- **Dune Sand Aquifer.** MGSA adopts the above minimum thresholds as measurable objectives on an interim basis as data gaps are addressed and sustainable management criteria for GDEs are updated early during the GSP implementation process. Based on the limited amplitude of seasonal and inter-annual fluctuation in groundwater levels in the Dune Sand Aquifer and the planned schedule for data gap analysis, this approach allows for protection of GDEs while allowing near-term flexibility in groundwater management.

180-Foot and 400-Foot Aquifers – For the 180-Foot Aquifer, measurable objectives were initially established at an elevation that is 7.0 feet above the minimum threshold and for the 400-Foot Aquifer measurable objectives were initially set at 6.1 feet above the minimum threshold, in accordance with the operating range adopted under SVBGSA's GSP in the westernmost portion of the Subbasin. Elevations were then adjusted based on proximity to well 14S/02E-08M02 and local gradient data. Given that land subsidence is directly related to groundwater elevations and that the subsidence risk near the MGSA Area is relatively low, the MGSA GSP monitoring network for Land Subsidence will be the same monitoring network as that for Chronic Lowering of Groundwater Levels described in Section 5.2. Well information for the wells in the MGSA GSP monitoring network is provided on Tables 5-2 and 5-3, the boring logs and well completion diagrams are provided in Appendix 5.A, and the locations of the MPWSP monitoring wells are shown on Figure 5-2. No other monitoring is proposed, except for periodic review of subsidence measurement maps published by USGS, DWR, Jet Propulsion Laboratories (JPL) and others, including remote sensing InSAR data.

5.6.2 Adequacy of Monitoring Network, Density of Monitoring Sites, and Frequency of Measurements

Regulation Requirements:

§354.34(d) The monitoring network shall be designed to ensure adequate coverage of sustainability indicators. If management areas are established, the quantity and density of monitoring sites in those areas shall be sufficient to evaluate conditions of the basin setting and sustainable management criteria specific to that area.

§354.34(e) A Plan may utilize site information and monitoring data from existing sources as part of the monitoring network.

§354.34(f) The Agency shall determine the density of monitoring sites and frequency of measurements required to demonstrate short-term, seasonal, and long-term trends based upon the following factors:

1) Amount of current and projected groundwater use.
2) Aquifer characteristics, including confined or unconfined aquifer conditions, or other physical characteristics that affect groundwater flow.
3) Impacts to beneficial uses and users of groundwater and land uses and property interests affected by groundwater production, and adjacent basins that could affect the ability of that basin to meet the sustainability goal.
4) Whether the Agency has adequate long-term existing monitoring results or other technical information to demonstrate an understanding of aquifer response.

The adequacy of the groundwater elevation monitoring network is discussed in Section 5.2.2. The density and frequency of groundwater elevation measurements in the existing and proposed MPWSP wells is discussed in Section 5.2.3. Given the anticipated spatial distribution of drawdown associated with groundwater extraction in the MGSA Area, the locations and completion depths of the existing monitoring wells will provide an adequate monitoring network to assess the potential for subsidence related to groundwater level decline.

5.6.3 Additional Monitoring Network Information

5.6.3.1 Scientific Rationale for Site Selection

Regulation Requirements:

§354.34(g) Each Plan shall describe the following information about the monitoring network:

(1) Scientific rationale for the monitoring site selection process.

In order to assess the potential for subsidence induced by pumping in the MGSA Area, groundwater elevation monitoring is needed at locations and depths where drawdown will be at maximum and where fine-grained aquitards could potentially be depressurized. The existing monitoring network of wells completed in the 180-Foot Aquifer and 400-Foot Aquifer meet this need.

5.6.3.2 Consistency with Data and Reporting Standards

Regulation Requirements:

§354.34(g) Each Plan shall describe the following information about the monitoring network:

(2) Consistency with data and reporting standards described in Section 352.4. If a site is not consistent with those standards, the Plan shall explain the necessity of the site to the monitoring network, and how any variation from the standards will not affect the usefulness of the results obtained.

As discussed in Section 5.2.4.2, the data associated with the MGSA GSP groundwater elevation and quality monitoring network are consistent with the reporting standards required by SGMA.

5.6.4 MONITORING PROTOCOLS

Regulation Requirements:

§352.2 Each Plan shall include monitoring protocols adopted by the Agency for data collection and management, as follows:

(a) Monitoring protocols shall be developed according to best management practices.

(b) The Agency may rely on monitoring protocols included as part of the best management practices developed by the Department, or may adopt similar monitoring protocols that will yield comparable data.

(c) Monitoring protocols shall be reviewed at least every five years as part of the periodic evaluation of the Plan, and modified as necessary.

§354.34(i) The monitoring protocols developed by each Agency shall include a description of technical standards, data collection methods, and other procedures or protocols pursuant to Water Code Section 10727.2(f) for monitoring sites or other data collection facilities to ensure that the monitoring network utilizes comparable data and methodologies.

Chapter 4 of the MCWRA CASGEM plan (MWCRA 2015) includes a description of the monitoring procedures employed by that agency. These CASGEM groundwater elevation monitoring protocols will be utilized by MCWRA to implement the monitoring program that is adopted by this GSP. The MCWRA monitoring protocols are included in Appendix 5.B. Groundwater elevation data are currently collected both by hand and using automated pressure transducers. The monitoring protocols established by MCWRA cover multiple monitoring methods for collection of data by hand and by automated pressure transducers.

5.6.5 DATA GAPS

Regulation Requirements:

§354.38(b) Each Agency shall identify data gaps wherever the basin does not contain a sufficient number of monitoring sites, does not monitor sites at a sufficient frequency, or utilizes monitoring sites that are unreliable, including those that do not satisfy minimum standards of the monitoring network adopted by the Agency.

§354.38(c) If the monitoring network contains data gaps, the Plan shall include a description of the following:

1) The location and reason for data gaps in the monitoring network.
2) Local issues and circumstances that limit or prevent monitoring**.**

§354.38 (d) Each Agency shall describe steps that will be taken to fill data gaps before the next five-year assessment, including the location and purpose of newly added or installed monitoring sites.

§354.38(e) Each Agency shall adjust the monitoring frequency and density of monitoring sites to provide an adequate level of detail about site-specific surface water and groundwater conditions and to assess the effectiveness of management actions under circumstances that include the following:

1) Minimum threshold exceedances.
2) Highly variable spatial or temporal conditions
3) Adverse impacts to beneficial uses and users of groundwater.
4) The potential to adversely affect the ability of an adjacent basin to implement its Plan or impede achievement of sustainability goals in an adjacent basin.

Although the available data suggest that the vicinity of the MGSA Area has not experienced significant subsidence, the data are reported to be insufficient to assess the potential future vulnerability of this area to future subsidence if groundwater extractions are increased. MGSA will work with SVBGSA to address this data gap as needed during GSP implementation. Given the relatively low risk of subsidence near the MGSA Area, the monitoring of groundwater elevations and review of remote sensing data periodically published by DWR, USGS or others should be an adequate monitoring program for this sustainability indicator.

5.7 DEPLETION OF INTERCONNECTED SURFACE WATER

Regulation Requirements:
§354.34(c) Each monitoring network shall be designed to accomplish the following for each sustainability indicator:
(6) Depletions of Interconnected Surface Water. Monitor surface water and groundwater, where interconnected surface water conditions exist, to characterize the spatial and temporal exchanges between surface water and groundwater, and to calibrate and apply the tools and methods necessary to calculate depletions of surface water caused by groundwater extractions.

Depletion of interconnected surface water is directly related to groundwater level decline in the uppermost aquifer system which is in contact with the stream or wetland being affected, in this case, the Dune Sand Aquifer. As such, the primary potential effect of concern associated with the decline of groundwater levels in the Dune Sand Aquifer is potential stress to GDEs. The minimum thresholds established for the groundwater level decline RMS are an adequate proxy for the depletion of interconnected surface water. Groundwater elevation minimum thresholds will be directly measured in shallow wells in the monitoring well network.

5.7.1 DESCRIPTION OF THE MONITORING APPROACH AND NETWORK

Regulation Requirements:
§354.34(c)(6) Depletions of Interconnected Surface Water. Monitor surface water and groundwater, where interconnected surface water conditions exist, to characterize the spatial and temporal exchanges between surface water and groundwater, and to calibrate and apply the tools and methods necessary to calculate depletions of surface water caused by groundwater extractions. The monitoring network shall be able to characterize the following:
A) Flow conditions including surface water discharge, surface water head, and baseflow contribution.
B) Identifying the approximate date and location where ephemeral or intermittent flowing streams and rivers cease to flow, if applicable.
C) Temporal change in conditions due to variations in stream discharge and regional groundwater extraction.
D) Other factors that may be necessary to identify adverse impacts on beneficial uses of the surface water. **§354.34(h)** The location and type of each monitoring site within the basin displayed on a map, and reported in tabular format, including information regarding the monitoring site type, frequency of measurement, and the purposes for which the monitoring site is being used.
§354.34(g)(3) For each sustainability indicator, the quantitative values for the minimum threshold, measurable objective, and interim milestones that will be measured at each monitoring site or representative monitoring sites established pursuant to Section 354.36.

This GSP adopts the following groundwater elevation minimum thresholds that serve as a proxy for depletion of surface water minimum thresholds:

- **Dune Sand Aquifer** – The minimum thresholds for the Dune Sand Aquifer are established as an elevation of 1 foot above the 2015 low groundwater levels recorded in Dune Sand Aquifer monitoring wells near identified GDEs in the vicinity of the MGSA Area, and presented for wells MW-4S, 7S and 8S in Table 4-1. These minimum thresholds will be updated as warranted based on future planned investigations to address existing data gaps in the relationship between groundwater level declines and GDE response, as discussed in Chapter 7. Measurable objectives are identical to minimum thresholds.

- **180-Foot, 400-Foot and Deep Aquifers** – Because these aquifers are not directly interconnected to surface water, no minimum thresholds or measurable objectives are established.

The following data are needed to assess compliance with these thresholds:

- To assess surface-groundwater interactions at the GDEs, shallow groundwater elevation data are needed proximal to the surface water resources being considered.
- The reliance by GDEs on groundwater, and their ability to adapt to groundwater elevation declines, is variable depending on the nature of the habitat and species involved. As discussed in Chapter 7, this has been identified as a data gap to be addressed during GSP implementation. The baseline biological conditions of the vernal ponds near the MGSA Area will be documented, and a biological monitoring program will be implemented to evaluate the effect of groundwater level changes on GDE habitat composition annually.

Summary information for the groundwater elevation and quality monitoring network that will be used to assess this sustainability indicator is presented in Table 5-1 and the boring logs and well completion diagrams are provided in Appendix 5.A. The locations of these monitoring wells are shown on Figure 5-2, which also presents the location of five additional monitoring well clusters that are proposed to be installed by MCWRA.

5.7.2 Adequacy of Monitoring Network, Density of Monitoring Sites, and Frequency of Measurements

Regulation Requirements:

§354.34(d) The monitoring network shall be designed to ensure adequate coverage of sustainability indicators. If management areas are established, the quantity and density of monitoring sites in those areas shall be sufficient to evaluate conditions of the basin setting and sustainable management criteria specific to that area.

§354.34(e) A Plan may utilize site information and monitoring data from existing sources as part of the monitoring network.

§354.34(f) The Agency shall determine the density of monitoring sites and frequency of measurements required to demonstrate short-term, seasonal, and long-term trends based upon the following factors:

1) Amount of current and projected groundwater use.
2) Aquifer characteristics, including confined or unconfined aquifer conditions, or other physical characteristics that affect groundwater flow.
3) Impacts to beneficial uses and users of groundwater and land uses and property interests affected by groundwater production, and adjacent basins that could affect the ability of that basin to meet the sustainability goal.
4) Whether the Agency has adequate long-term existing monitoring results or other technical information to demonstrate an understanding of aquifer response.

The adequacy of the groundwater elevation monitoring network is discussed in Section 5.2.2. The density and frequency of groundwater elevation measurements in the MPWSP wells is discussed in Section 5.2.3. The existing and proposed wells are sufficiently spread out through the area to assess drawdown distribution in the Dune Sand Aquifer that could affect vernal ponds.

The shallow Dune Sand Aquifer wells that are the RMS for this sustainability indicator are co-located with nested wells completed in the 180-Foot and upper 400-Foot Aquifers. In addition, two nested monitoring well clusters are located proximal to the Salinas River (MW-6 and MW-9). As discussed in Section 4.9.2, the potential undesirable results from surface water depletion associated with pumping in the MGSA Area are only anticipated to be associated with vernal ponds, and not with depletion of flow

in the Salinas River. For this reason, the RMS do not include the wells located near the Salinas River and the existing RMS are considered adequate for sustainable groundwater management. However, interaction of groundwater extraction with the Salinas River is designated as a data gap and will be assessed in coordination with SVBGSA as discussed in Chapter 7. Groundwater level data collected from these wells, and from deeper wells in the remaining well clusters, will be used to further assess vertical hydraulic communication between the principal aquifers and surface-groundwater interaction along the Salinas River. This information may be used to refine the Hydrogeologic Conceptual Model, and the sustainable management criteria and monitoring networks may be refined in future updates of the GSP.

5.7.3 Additional Monitoring Network Information

5.7.3.1 Scientific Rationale for Site Selection

Regulation Requirements:
§354.34(g) Each Plan shall describe the following information about the monitoring network:
(1) Scientific rationale for the monitoring site selection process.

The existing and proposed wells are sufficiently spread out in the Dune Sand Aquifer to assess groundwater level decline in areas that could be affected by groundwater extraction in the MGSA Area that are proximal to identified vernal pond GDEs. Biological surveys by a wetlands expert will allow assessments of GDE habitat composition and vigor to be made, as discussed in Chapter 7, will establish baseline conditions, and will allow correlations to be established between groundwater levels in the Dune Sand Aquifer and ecosystem responses in the GDEs .

5.7.3.2 Consistency with Data and Reporting Standards

Regulation Requirements:
§354.34(g) Each Plan shall describe the following information about the monitoring network:
(2) Consistency with data and reporting standards described in Section 352.4. If a site is not consistent with those standards, the Plan shall explain the necessity of the site to the monitoring network, and how any variation from the standards will not affect the usefulness of the results obtained.

As discussed in Section 5.2.4.2, the data associated with the MGSA GSP groundwater elevation monitoring network are consistent with the reporting standards required by SGMA. Reporting standards for biological survey data have not been established.

5.7.4 Monitoring Protocols

Regulation Requirements:
§352.2 Each Plan shall include monitoring protocols adopted by the Agency for data collection and management, as follows:
(a) Monitoring protocols shall be developed according to best management practices.
(b) The Agency may rely on monitoring protocols included as part of the best management practices developed by the Department, or may adopt similar monitoring protocols that will yield comparable data.
(c) Monitoring protocols shall be reviewed at least every five years as part of the periodic evaluation of the Plan, and modified as necessary.
§354.34(i) The monitoring protocols developed by each Agency shall include a description of technical standards, data collection methods, and other procedures or protocols pursuant to Water Code Section 10727.2(f) for monitoring sites or other data collection facilities to ensure that the monitoring network utilizes comparable data and methodologies.

Chapter 4 of the MCWRA CASGEM plan (MWCRA 2015) includes a description of the monitoring procedures employed by that agency. These CASGEM groundwater elevation monitoring protocols will be utilized by MCWRA to implement their monitoring program. The monitoring protocols are included in Appendix 5.B. Groundwater elevation data are currently collected both by hand and using automated pressure transducers. The monitoring protocols established by MCWRA cover multiple monitoring methods for collection of data by hand and by automated pressure transducers. Data collected by MCWRA are anticipated to be provided to MGSA for this GSP.

5.7.5 DATA GAPS

Regulation Requirements:

§354.38(b) Each Agency shall identify data gaps wherever the basin does not contain a sufficient number of monitoring sites, does not monitor sites at a sufficient frequency, or utilizes monitoring sites that are unreliable, including those that do not satisfy minimum standards of the monitoring network adopted by the Agency.

§354.38(c) If the monitoring network contains data gaps, the Plan shall include a description of the following:

1) The location and reason for data gaps in the monitoring network.
2) Local issues and circumstances that limit or prevent monitoring**.**

§354.38 (d) Each Agency shall describe steps that will be taken to fill data gaps before the next five-year assessment, including the location and purpose of newly added or installed monitoring sites.

§354.38(e) Each Agency shall adjust the monitoring frequency and density of monitoring sites to provide an adequate level of detail about site-specific surface water and groundwater conditions and to assess the effectiveness of management actions under circumstances that include the following:

1) Minimum threshold exceedances.
2) Highly variable spatial or temporal conditions
3) Adverse impacts to beneficial uses and users of groundwater.
4) The potential to adversely affect the ability of an adjacent basin to implement its Plan or impede achievement of sustainability goals in an adjacent basin.

Regionally, the SVBGSP has identified surface-groundwater interaction along the Salinas River as a data gap. The available data evaluated in this GSP indicate that the lower reach of the Salinas River is likely in hydraulic communication with the Dune Sand Aquifer; however, the tools to evaluate the extent and nature of the interaction between the Dune Sand Aquifer and the river do not exist at this time. SVBGSA noted that the release of the calibrated USGS SVIHM will provide an important new tool and valuable additional data regarding the interconnection between the Salinas River and the Dune Sand Aquifer and other shallow aquifers, and the underlying 180-Foot Aquifer (SVBGSA 2019). Furthermore, SVBGSA has proposed a regional investigation to assess the level of river interconnection using existing shallow wells located adjacent to the Salinas River in combination with the SVIHM. MGSA will review the results of SVBGSA's investigation, perform supplemental local evaluations as needed, and incorporate them into updates of the MGSA GSP.

The following specific data gaps identified for the MGSA GSP groundwater level monitoring network are applicable to the Depletion of Interconnected Surface Water sustainability indicator:

- **Biological survey data for GDEs**: Limited current data are available to characterize wetland vegetation and habitat in and around the vernal ponds in the City of Marina and within the MGSA Area, and their potential sensitivity to pumping-induced drawdown. Such data are needed to assess the wetland habitat and any special-status plant and animal species present

and to determine if drawdown of shallow groundwater is affecting, or may affect, the GDEs. Completion of a baseline biological survey and then performance of a biological survey by a wetlands expert once a year for the first five years will address this data gap.

- **Groundwater elevation and quality data in the vicinity of GDEs**: The available data to characterize groundwater elevations and groundwater quality in the MGSA Area and vicinity are both spatially and temporally limited. Such data are needed to assess surface water-groundwater interactions for GDEs in vernal ponds within the City of Marina and in the MGSA Area. The installation of monitoring well clusters at five additional locations by MCWRA will address this data gap spatially. Temporally, the limited duration of the temporal data set will be addressed as additional data are gathered over time.

- **Groundwater elevation and quality data in the MGSA Area**: The available data to characterize groundwater elevations and groundwater quality in the MGSA Area and vicinity are both spatially and temporally limited. Such data are needed to characterize groundwater flow patterns in the Dune Sand Aquifer and the 180-Foot Aquifer and assess spatial and temporal evidence for surface-groundwater interaction with the Salinas River and with GDEs (palustrine and emergent wetlands), especially to the northeast and southeast of the MGSA Area. The installation of monitoring well clusters at five additional locations by MCWRA will address this data gap spatially. Temporally, the limited duration of the temporal data set will be addressed as additional data are gathered over time.

5.8 REPORTING MONITORING DATA TO THE DEPARTMENT

Regulation Requirements:

§ 352.6 Data Management System

Each Agency shall develop and maintain a data management system that is capable of storing and reporting information relevant to the development or implementation of the Plan and monitoring of the basin.

§354.40 Reporting Monitoring Data to the Department

Monitoring data shall be stored in the data management system developed pursuant to Section 352.6. A copy of the monitoring data shall be included in the Annual Report and submitted electronically on forms provided by the Department.

A Microsoft Access DMS has been created to store GSP monitoring data in accordance with 23 CCR § 352.6, which requires that each GSA shall develop and maintain a data management system that is capable of storing and reporting information relevant to the development or implementation of the GSP and monitoring of the Subbasin. MGSA's database has a simple structure which is shared with the DMS being developed by MCWD GSA in support of its GSP for the Monterey Subbasin, which abuts the MGSA Area to the south. In addition, MGSA plans to coordinate with database personnel from SVBGSA to assure compatibility with the DMS being developed by that agency. Both GSAs will rely extensively on the same monitoring data collected by MCWRA; therefore, it is anticipated that very little data transfer will actually need to occur. SVBGSA is considering development of a web-based DMS to facilitate basin-wide groundwater management. MGSA will cooperate with this effort, but will retain a relatively simple structure for its DMS that is not web-based.

MGSA's Access DMS includes the following information:

- Physical well data, including location, elevation, type, depth, aquifer, construction date, and details, and ownership information;
- Depth to water measurements, reference point elevations and groundwater elevation elevations;
- Well production data;
- Well chemical data for TDS, chloride, specific conductance, and other selected general mineral parameters;
- Precipitation data including meteorological station location and monthly precipitation totals; and
- Gaging station location, stage, and discharge data.

MGSA's DMS will be periodically updated with monitoring data. It will be used to analyze and compare data, evaluate statistical relationships and trends, and provide model inputs and calibration datasets if needed, and create data tables and other outputs. In addition, information in the database has been migrated into a geodatabase in ESRI ArcGIS format to facilitate spatial analysis, production of graphics and communication with regional GIS users. The Geodatabase also includes various data for various mapped layers including:

- Topography, surface infrastructure, jurisdictional boundaries, land use designations, protected areas, and disadvantaged community areas;
- Hydrologic features and GDEs;
- Geologic and soils information;
- Groundwater elevation data;
- Groundwater chemical data including chloride and TDS isoconcentration contour data; and
- Geophysical investigation data.

The Access DMS and geodatabase will be used in combination to support adaptive management during GSP implementation and reporting to DWR. In accordance with 23 CCR § 352.6, a copy of the monitoring data will be included in the Annual Report and submitted electronically on forms provided by DWR.

TABLE 5-1. WELL INFORMATION AND DATA COLLECTED FOR WELLS IN THE DUNE SAND AQUIFER

Well Name	Latitude	Longitude	Well Type	Depth (ft bgs)	RP Elevation (ft msl)	Top of Perfs (ft bgs)	Bottom of Perfs (ft bgs)	Data Collected	Collection Frequency
MW-1S	36.71314	-121.80588	Monitoring	105	30.51	55	95	WL, WQ	C, C
MW-3S	36.71280	-121.80375	Monitoring	100	37.16	50	90	WL, WQ	C, C
MW-4S	36.71173	-121.79876	Monitoring	110	41.96	60	100	WL, WQ	C, C
MW-5S	36.71798	-121.77461	Monitoring	93	80.25	43	83	WL, WQ	C, C
MW-6S	36.67713	-121.74723	Monitoring	70	35.89	30	60	WL, WQ	C, C
MW-7S	36.70626	-121.78927	Monitoring	90	50.64	60	80	WL, WQ	C, C
MW-8S	36.72648	-121.78753	Monitoring	90	19.96	40	80	WL, WQ	C, C
MW-9S	36.73373	-121.77935	Monitoring	120	18.42	30	110	WL, WQ	C, C
MW-AS	*TBD*	*TBD*	*Monitoring*	*TBD*	*TBD*	*TBD*	*TBD*	*WL*	*C*
MW-BS	*TBD*	*TBD*	*Monitoring*	*TBD*	*TBD*	*TBD*	*TBD*	*WL*	*C*
MW-CS	*TBD*	*TBD*	*Monitoring*	*TBD*	*TBD*	*TBD*	*TBD*	*WL*	*C*
MW-DS	*TBD*	*TBD*	*Monitoring*	*TBD*	*TBD*	*TBD*	*TBD*	*WL*	*C*
MW-ES	*TBD*	*TBD*	*Monitoring*	*TBD*	*TBD*	*TBD*	*TBD*	*WL*	*C*
MW-5S	*TBD*	*TBD*	*Monitoring*	*TBD*	*TBD*	*TBD*	*TBD*	*WL*	*C*
MCWD MW#4	TBD	TBD	Monitoring	110	61	64	106	WL, WQ	C, C
MCWD MW#5	TBD	TBD	Monitoring	107	61	60	100	WL, WQ	C, C
MW-BW-76-A	TBD	TBD	Monitoring	50	17	20	50	TBD	TBD
MW-BW-84-A	TBD	TBD	Monitoring	65	19	24	64	TBD	TBD
MW-BW-83-A	TBD	TBD	Monitoring	68	24	26	66	TBD	TBD

Well Name	Latitude	Longitude	Well Type	Depth (ft bgs)	RP Elevation (ft msl)	Top of Perfs (ft bgs)	Bottom of Perfs (ft bgs)	Data Collected	Collection Frequency
MW-OU1-01-180	TBD	TBD	Monitoring	175	126	155	175	TBD	TBD
MW-OU1-02-180	TBD	TBD	Monitoring	195	138	175	195	TBD	TBD
MW-OU1-03-180	TBD	TBD	Monitoring	183	141	163	183	TBD	TBD
MW-BW-54-180	TBD	TBD	Monitoring	201	128	161	201	TBD	TBD
21667	TBD	TBD	Production	140	56	80	140	WL, WQ	M, A

Notes:
Proposed wells are italicized; MW-5S is a proposed replacement well for the existing well screened in a perched zone in the Dune Sand Aquifer.
Latitude and longitude in decimal degrees.
RP = Reference Point (top of casing), ft = feet, bgs = below ground surface, msl = mean sea level, Perfs = Perforations
Dune Sand Aquifer = Dune Sand Aquifer, (L) = Lower interval in 180-Foot Aquifer, WL = Water Level, WQ = Water Quality, IN = Induction Logging, C = Continuous, A = Annual
Source: Monterey Peninsula Water Supply Project (HWG 2016); Integrated Coastal Groundwater Monitoring Plan (MCRWA 2019)

TABLE 5-2. WELL INFORMATION AND DATA COLLECTED FOR WELLS IN THE 180-FOOT AQUIFER

Well Name	Latitude	Longitude	Well Use	Depth (ft bgs)	RP Elevation (ft msl)	Top of Perfs (ft bgs)	Bottom of Perfs (ft bgs)	Data Collected	Collection Frequency
MW-1M	36.71316	-121.80591	Monitoring	235	29.86	115	225	WL, WQ	C, C
MW-3M	36.71278	-121.80371	Monitoring	225	37.35	105	215	WL, WQ	C, C
MW-4M	36.71174	-121.79879	Monitoring	270	41.99	130	260	WL, WQ	C, C
MW-5M	36.71796	-121.77462	Monitoring	320	80.48	100	310	WL, WQ	C, C
MW-6M	36.67712	-121.74726	Monitoring	220	35.68	150	210	WL, WQ	C, C
MW-6M(L)	36.67710	-121.74729	Monitoring	335	35.82	255	325	WL, WQ	C, C
MW-7M	36.70629	-121.78928	Monitoring	230	50.29	130	220	WL, WQ	C, C
MW-8M	36.72645	-121.78755	Monitoring	225	19.99	125	215	WL, WQ	C, C
MW-9M	36.73375	-121.77932	Monitoring	235	18.32	145	225	WL, WQ	C, C
MW-AM	*TBD*	*TBD*	*Monitoring*	*TBD*	*TBD*	*TBD*	*TBD*	*WL*	*C*
MW-BM	*TBD*	*TBD*	*Monitoring*	*TBD*	*TBD*	*TBD*	*TBD*	*WL*	*C*
MW-CM	*TBD*	*TBD*	*Monitoring*	*TBD*	*TBD*	*TBD*	*TBD*	*WL*	*C*
MW-DM	*TBD*	*TBD*	*Monitoring*	*TBD*	*TBD*	*TBD*	*TBD*	*WL*	*C*
MW-EM	*TBD*	*TBD*	*Monitoring*	*TBD*	*TBD*	*TBD*	*TBD*	*WL*	*C*
MCWD DMW-1	TBD	TBD	Monitoring	240	60	190	230	WL, WQ	C, P
MCWD DMW-2	TBD	TBD	Monitoring	236	61	180	230	WL, WQ	C, P
MCWD Well #1	TBD	TBD	Production	225	84	124	NA	WL	C
MCWD Well #2	TBD	TBD	Production	200	75	128	NA	WL	C
14530	TBD	TBD	Production	350	103	260	340	WL	C

Well Name	Latitude	Longitude	Well Use	Depth (ft bgs)	RP Elevation (ft msl)	Top of Perfs (ft bgs)	Bottom of Perfs (ft bgs)	Data Collected	Collection Frequency
14531	TBD	TBD	Production	350	116	260	340	WL	C
MW-B-05-180	TBD	TBD	Production	210	120	175	205	WL, WQ	C, P
Airfield	TBD	TBD	Production	396	142	318	379	WL, WQ	C, P

Notes:
Proposed wells are italicized.
Latitude and longitude in decimal degrees
RP = Reference Point (top of casing), ft = feet, bgs = below ground surface, msl = mean sea level, Perfs = Perforations
Dune Sand Aquifer = Dune Sand Aquifer, (L) = Lower interval in 180-Foot Aquifer, WL = Water Level, WQ = Water Quality, IN = Induction Logging, C = Continuous, A = Annual
Source: Monterey Peninsula Water Supply Project (HWG 2016); Integrated Coastal Groundwater Monitoring Plan (MCRWA 2019)

TABLE 5-3. WELL INFORMATION AND DATA COLLECTED FOR WELLS IN THE 400-FOOT AQUIFER

Well Name	Latitude	Longitude	Well Type	Depth (ft bgs)	RP Elevation (ft msl)	Top of Perfs (ft bgs)	Bottom of Perfs (ft bgs)	Data Collected	Collection Frequency
MW-1D	36.71317	-121.80594	Monitoring	337	29.68	277	327	WL, WQ, IN	C, C, A
MW-3D	36.71277	-121.80367	Monitoring	340	36.93	285	330	WL, WQ, IN	C, C, A
MW-4D	36.71174	-121.79883	Monitoring	340	41.95	290	330	WL, WQ, IN	C, C, A
MW-5D	36.71793	-121.77463	Monitoring	445	80.06	395	435	WL, WQ, IN	C, C, A
MW-7D	36.70632	-121.78929	Monitoring	355	50.24	295	345	WL, WQ, IN	C, C, A
MW-8D	36.72642	-121.78757	Monitoring	360	20.08	300	350	WL, WQ, IN	C, C, A
MW-9D	36.73377	-121.77929	Monitoring	403	18.32	353	393	WL, WQ, IN	C, C, A
MW-AD	*TBD*	*TBD*	*Monitoring*	*TBD*	*TBD*	*TBD*	*TBD*	*WL, WQ-IN*	*C, A*
MW-BD	*TBD*	*TBD*	*Monitoring*	*TBD*	*TBD*	*TBD*	*TBD*	*WL, WQ-IN*	*C, A*
MW-CD	*TBD*	*TBD*	*Monitoring*	*TBD*	*TBD*	*TBD*	*TBD*	*WL, WQ-IN*	*C, A*
MW-DD	*TBD*	*TBD*	*Monitoring*	*TBD*	*TBD*	*TBD*	*TBD*	*WL, WQ-IN*	*C, A*
MW-ED	*TBD*	*TBD*	*Monitoring*	*TBD*	*TBD*	*TBD*	*TBD*	*WL, WQ-IN*	*C, A*
1032	TBD	TBD	Production	506	31	400	506	WQ	A
239	TBD	TBD	Production	500	14	314	456	WL	M
2791	TBD	TBD	Production	600	140	438	580	WL	A
2718	TBD	TBD	Production	615	19	330	600	WL	A
1466	TBD	TBD	Production	556	16	395	540	WL, WQ	A, A

Notes:
Proposed wells are italicized; Latitude and longitude in decimal degrees.
RP = Reference Point (top of casing), ft = feet, bgs = below ground surface, msl = mean sea level, Perfs = Perforations
Dune Sand Aquifer = Dune Sand Aquifer, (L) = Lower interval in 180-Foot Aquifer, WL = Water Level, WQ = Water Quality, IN = Induction Logging, C = Continuous, A = Annual
Source: Monterey Peninsula Water Supply Project (HWG 2016); Integrated Coastal Groundwater Monitoring Plan (MCRWA 2019)

TABLE 5-4. WELL INFORMATION AND DATA COLLECTED FOR WELLS IN THE DEEP AQUIFER

Well Name	Latitude	Longitude	Well Use	Depth (ft bgs)	Elevation (ft NAVD88)	Top of Perfs (ft bgs)	Bottom of Perfs (ft bgs)	Data Collected	Collection Frequency
DMW1-1	36.69917	-121.80750	Monitoring	960	60	930	950	WL, WQ	C, P
DMW1-2	36.69917	-121.80750	Monitoring	1070	60	1040	1060	WL, WQ	C, P
DMW1-3	36.69917	-121.80750	Monitoring	1440	60	1410	1430	WL, WQ	C, P
DMW1-4	36.69917	-121.80750	Monitoring	1890	60	1820	1860	WL, WQ, IN	C, P, A
DMW2-S	36.69917	-121.80750	Monitoring	1100	142	1040	1090	WL	C
DMW2-D	36.69917	-121.80750	Monitoring	1740	142	1680	1730	WL, IN	C, A
MCWD Well #10	TBD	TBD	Production	1500	153	930	1540	WL, WQ	P, A
MCWD Well #11	TBD	TBD	Production	1700	155	970	1650	WL, WQ	P, A
MCWD Well #12	TBD	TBD	Production	2023	109	1410	1960	WL, WQ	P, A
25973	TBD	TBD	Production	1780	132	1030	1780	WQ	A
21655	TBD	TBD	Production	825	105	670	805	WQ	A
22755	TBD	TBD	Production	1573	25	1450	1450	WQ	A
2691	TBD	TBD	Production	870	29	666	834	TBD	TBD
1672	TBD	TBD	Production	1560	6	880	1540	WL	M

Notes:
Latitude and longitude in decimal degrees; Perfs = Perforations
Ft = feet, bgs = below ground surface; NAVD88 = North American Vertical Datum of 1988
WL = Water Level, WQ = Water Quality, IN = Induction Logging, C = Continuous, P = Periodic, A = Annual
Source: Geohydrology of a Deep-Aquifer System Monitoring-Well Site (Hanson *et al.* 2002); Integrated Coastal Groundwater Monitoring Plan (MCRWA 2019)



FIGURE 5-1

Jurisdictional Areas Covered By GSAs

Groundwater Sustainability Plan for the City of Marina GSA Area of the 180/400 Foot Aquifer Subbasin

Legend

- City of Marina GSA (MGSA) Area
- Marina Coast Water District (MCWD) GSA Area
- Salinas Valley Basin GSA Area
- 180/400 Foot Aquifer Subbasin
- Salinas Valley Groundwater Basin
- City of Marina

Sources: ESRI Map Service Imagery, https://sgma.water.ca.gov/portal/gsa, montereycountyopendata

DATE: DEC, 31, 2019

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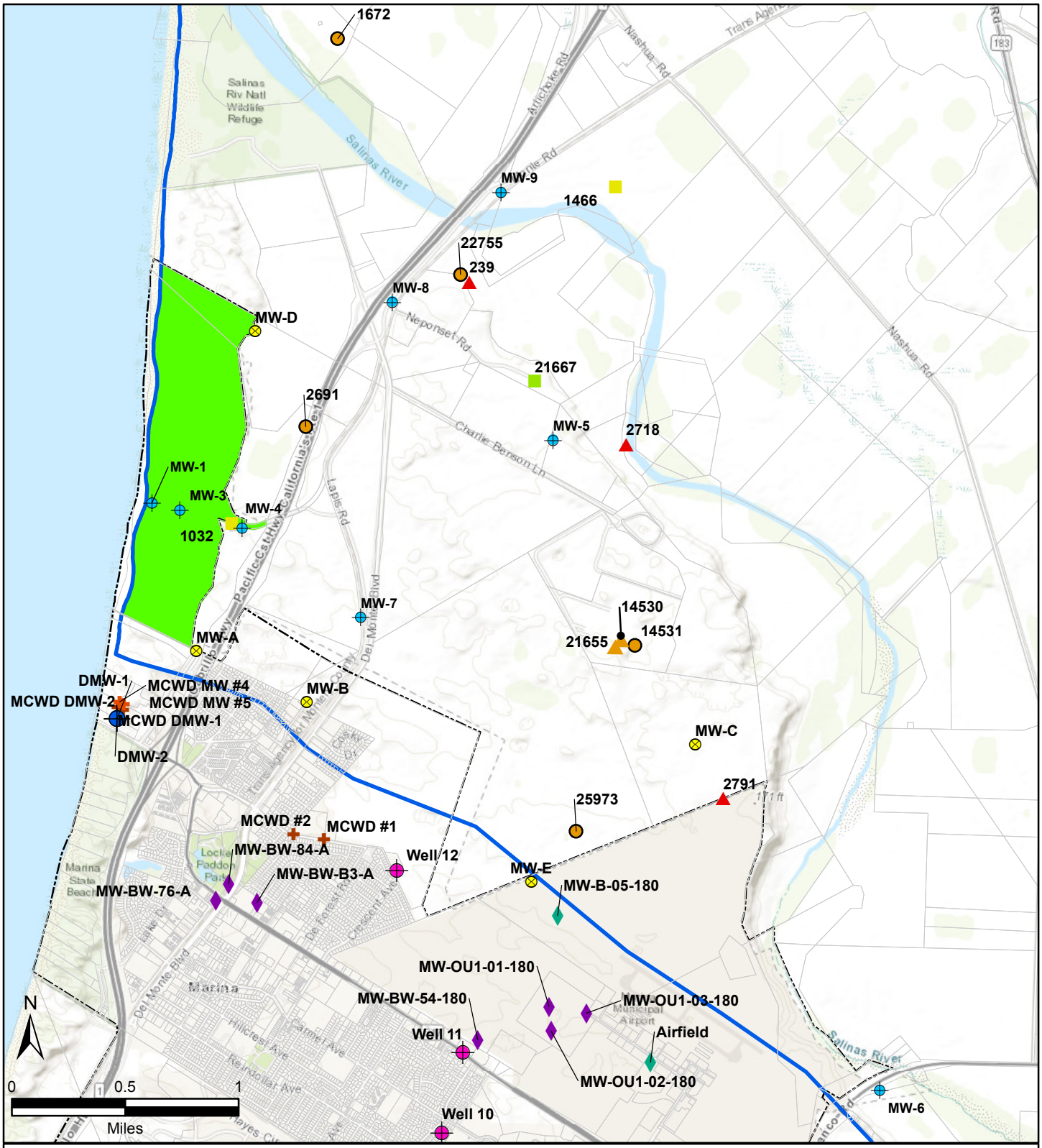


FIGURE 5-2

Locations of Wells in the MGSA GSP Monitoring Network

Groundwater Sustainability Plan for the City of Marina GSA Area of the 180/400 Foot Aquifer Subbasin

Legend

- MCWD Water Supply Wells
- Proposed Wells (Locations are approximate)
- MPWSP Wells
- MCWRA Water Quality Wells- Shallow
- MCWD Shallow Wells
- Fort Ord Monitoring Wells- Perforation Elevations: -50 to 0 ft
- MCWD Wells- 180 ft/FTE
- MCWRA Water Level Wells- Pressure 180
- Fort Ord Monitoring Wells- Perforation Elevations: -270 to -50 ft
- USGS Deep Wells
- MCWRA Water Level Wells- Pressure 400
- MCWRA Water Quality Wells- Pressure 400
- MCWD Other Deep Aquifer Wells
- City of Marina GSA (MGSA) Area
- 180/400 Foot Aquifer Subbasin
- City of Marina

Sources: ESRI Map Service Imagery, https://sgma.water.ca.gov/portal/gsa, MPWSP Monitoring Report #160 2019

DATE: DEC. 30, 2019

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APPENDIX 5.A – MPWSP LOGS AND WELL COMPLETION DIAGRAMS

APPENDIX C

Monitoring Well Information

GEOSCIENCE

APPENDIX C:

MONITORING WELL INFORMATION

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APPENDIX C: MONITORING WELL INFORMATION

PICTURES OF MONITORING WELL CLUSTER COMPLETIONS



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MW-8



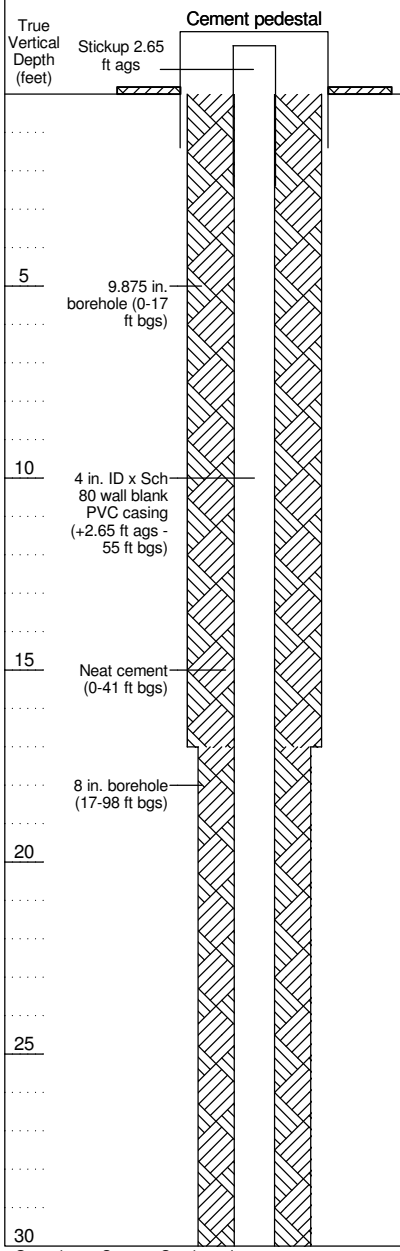
MW-9

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BOREHOLE LITHOLOGIC LOG

WELL NUMBER **MPWSP MW-1S**	
CLIENT: Cal Am	LOCATION: **Marina, CA**
PROJECT NUMBER: 14077-15	**CEMEX**
REPORT DATE:	
DRILLING CONTRACTOR: Cascade Drilling	LOGGED BY: **J. Sobolew**
DRILLER: A. Patricio	

		SCREEN / BLANK	TOP DEPTH (ft bgs)	BOTTOM DEPTH (ft bgs)	LENGTH (ft)	MATERIAL	WALL THICKNESS (in.)	DIAMETER (in.)	SCREEN TYPE	PERF. SIZE (in.)
DRILLING RIG TYPE	ProSonic 600T									
DRILLING METHOD	Sonic	**Blank**	**-2.65**	**55**	**57.65**	**PVC**	**Sch 80**	**4 / ID**		
SAMPLING METHOD	Core	**Screen**	**55**	**95**	**40**	**PVC**	**Sch 80**	**4 / ID**	**Slotted**	**0.04**
BOREHOLE DIAMETER	9.875, 8 in	**Blank**	**95**	**97.5**	**2.5**	**PVC**	**Sch 80**	**4 / ID**		
SURFACE ELEVATION	27.86 ft NAVD88									
TOC ELEVATION	30.51 ft NAVD88 (RP)									
START DATE	1/24/15									
FINISH DATE	1/26/15									



Graphic Log

Lithologic Log

NOTE: Grain size distribution percentages are approximate. Material code (e.g. SP) reference Unified Soil Classification visual method. Color code (e.g. 10YR 5/2) reference Munsell Soil Color Charts.

Depth bgs (feet)	Lithologic Log	Sieve Sample Number	Drill Rate (ft/hr)
0	SAND (SP): dark yellowish brown (10YR 4/4), 90% sand, subangular to subrounded, predominantly fine to medium grained; 5% fine to coarse gravel subangular to subrounded; 5% silt; well sorted; contains quartz, feldspar, amphibole, and other.		
5	SAND (SP): yellowish brown (10YR 5/4) and brownish yellow (10YR 6/6), 100% medium to coarse grained sand, subangular to subrounded, trace fine grained; trace silt; well sorted; contains quartz, feldspar, and amphibole.		
10			
15	SAND (SP): yellowish brown (10YR 5/4), 100% fine to coarse grained sand, subangular to subrounded; trace silt; well sorted; contains quartz, feldspar, and amphibole.		
20			
25	SAND (SP): pale brown (10YR 6/3), 100% fine to medium grained sand, subangular to subrounded; well sorted; contains quartz, feldspar, and amphibole; predominantly quartz; coarser with depth.		25
30			

WELL CONSTRUCTION LOG MPWSP MW TM LITH ALL WELLS.GPJ GEOSCIENCE.GDT 7/7/16

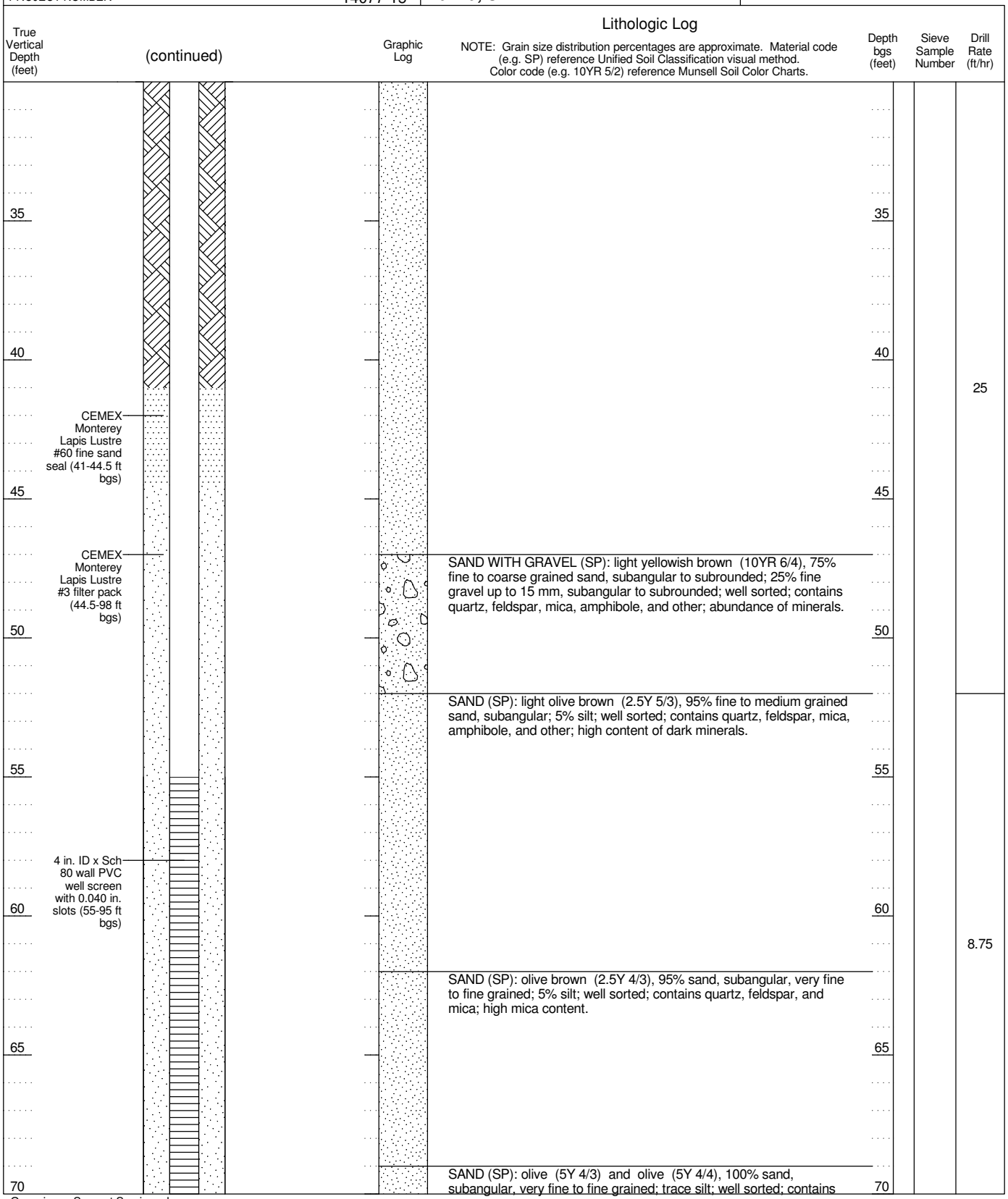
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WELL NUMBER **MPWSP MW-1S**

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am
PROJECT NUMBER 14077-15
LOCATION **Marina, CA**



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WELL NUMBER **MPWSP MW-1S**

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am
PROJECT NUMBER 14077-15
LOCATION **Marina, CA**

(continued)

Lithologic Log

NOTE: Grain size distribution percentages are approximate. Material code (e.g. SP) reference Unified Soil Classification visual method. Color code (e.g. 10YR 5/2) reference Munsell Soil Color Charts.

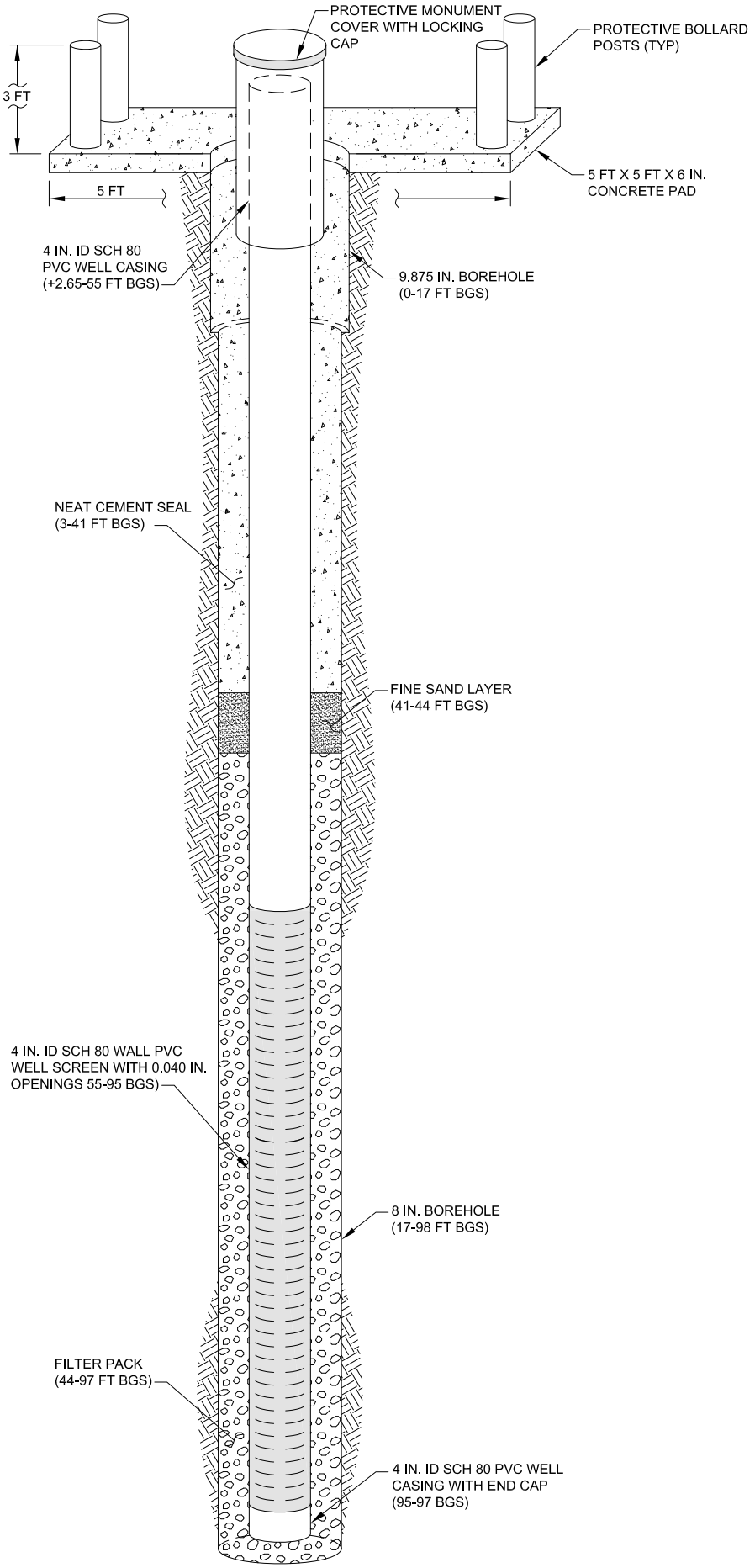
True Vertical Depth (feet)	Graphic Log	Depth bgs (feet)	Sieve Sample Number	Drill Rate (ft/hr)
	quartz, feldspar, and mica; high mica content.			
75		75		8.75
80		80		
85	SAND (SP): olive (5Y 4/4), 90% fine to coarse grained sand, subangular to subrounded; 5% fine gravel up to 10 mm, subangular to subrounded; 5% silt; medium sorted; contains quartz, feldspar, mica, and amphibole.	85		
	SAND WITH GRAVEL (SP): light olive brown (2.5Y 5/4), 75% fine to coarse grained sand, subangular to subrounded; 25% fine to coarse gravel up to 42 mm, subangular to subrounded; medium sorted; contains quartz, feldspar, mica, and amphibole.			
90		90		
	SAND (SP): light olive brown (2.5Y 5/3), 95% fine to medium grained sand, subangular; 5% silt; well sorted; contains quartz, feldspar, mica, and amphibole; high mica content.			10
95	SAND WITH GRAVEL (SP): yellowish brown (10YR 5/8), 85% fine to coarse grained sand, subangular to subrounded; 15% fine gravel up to 15 mm, subangular to subrounded; medium sorted; contains quartz, feldspar, and amphibole.	95		
	SAND WITH SILT (SP-SM): pale olive (5Y 6/3), 90% fine to medium grained sand, subangular to subrounded, trace coarse; 10% silt; trace fine gravel subangular to subrounded; well sorted; contains quartz, feldspar, mica, and amphibole.			
	Bottom of borehole at 98 feet.			

Blank casing with end cap (95-97.5 ft bgs)

TD 98 ft bgs

WELL CONSTRUCTION LOG MPWSP MW TM LITH ALL WELLS.GPJ GEOSCIENCE.GDT 7/7/16

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WELL PROFILE

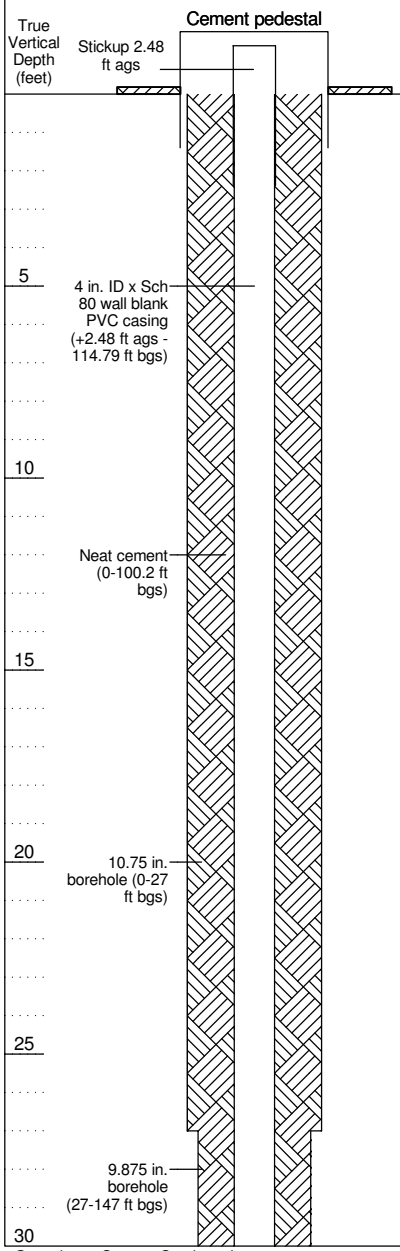
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BOREHOLE LITHOLOGIC LOG

WELL NUMBER **MPWSP MW-1M**	
CLIENT: Cal Am	LOCATION: **Marina, CA**
PROJECT NUMBER: 14077-15	**CEMEX**
REPORT DATE:	
DRILLING CONTRACTOR: Cascade Drilling	LOGGED BY: **J. Sobolew**
DRILLER: A. Patricio	

		SCREEN / BLANK	TOP DEPTH (ft bgs)	BOTTOM DEPTH (ft bgs)	LENGTH (ft)	MATERIAL	WALL THICKNESS (in.)	DIAMETER (in.)	SCREEN TYPE	PERF. SIZE (in.)
DRILLING RIG TYPE	ProSonic 600T									
DRILLING METHOD	Sonic	**Blank**	**-2.48**	**114.79**	**117.27**	**PVC**	**Sch 80**	**4 / ID**		
SAMPLING METHOD	Core	**Screen**	**114.79**	**224.79**	**110**	**PVC**	**Sch 80**	**4 / ID**	**Slotted**	**0.04**
BOREHOLE DIAMETER	10.75, 9.875, 8 in	**Blank**	**224.79**	**227.5**	**2.71**	**PVC**	**Sch 80**	**4 / ID**		
SURFACE ELEVATION	27.38 ft NAVD88									
TOC ELEVATION	29.86 ft NAVD88 (RP)									
START DATE	1/20/15									
FINISH DATE	1/24/15									



Lithologic Log

NOTE: Grain size distribution percentages are approximate. Material code (e.g. SP) reference Unified Soil Classification visual method. Color code (e.g. 10YR 5/2) reference Munsell Soil Color Charts.

Graphic Log	Lithologic Log	Depth bgs (feet)	Sieve Sample Number	Drill Rate (ft/hr)
	SAND (SP): dark yellowish brown (10YR 4/4), 100% fine to coarse grained sand, subangular to subrounded; trace silt; contains quartz, feldspar, and amphibole.			
	SAND (SP): yellowish brown (10YR 5/4), 100% fine to coarse grained sand, subangular to subrounded; trace clay, dark, low plasticity.	5		
	SAND (SP): brownish yellow (10YR 6/6) and brown (10YR 4/3), 100% medium to coarse grained sand, subangular to subrounded; trace silt; contains quartz, feldspar, and amphibole; grades finer with depth.	10		
		15		
		20		
		25		
	SAND (SP): pale brown (10YR 6/3), 100% fine to coarse grained sand, subangular to subrounded; contains quartz, feldspar, and amphibole.	30		

WELL CONSTRUCTION LOG MPWSP MW TM LITH ALL WELLS.GPJ GEOSCIENCE.GDT 7/7/16

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WELL NUMBER **MPWSP MW-1M**

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am
PROJECT NUMBER 14077-15
LOCATION **Marina, CA**

True Vertical Depth (feet)	(continued)	Graphic Log	Lithologic Log NOTE: Grain size distribution percentages are approximate. Material code (e.g. SP) reference Unified Soil Classification visual method. Color code (e.g. 10YR 5/2) reference Munsell Soil Color Charts.	Depth bgs (feet)	Sieve Sample Number	Drill Rate (ft/hr)
35				35		
			SAND (SP): pale brown (10YR 6/3), 95% fine to coarse grained sand, subangular to subrounded; 5% fine gravel subangular to subrounded; contains quartz, feldspar, and amphibole.			
40				40		
45				45		
			SAND WITH GRAVEL (SP): light yellowish brown (10YR 6/4), 80% fine to coarse grained sand, subangular to subrounded; 20% fine gravel up to 12 mm, subangular to subrounded; contains quartz, feldspar, mica, and amphibole; high amphibole content.			
50				50		30
			SAND (SP): light olive brown (2.5Y 5/3), 95% fine to medium grained sand, subangular; 5% silt; contains quartz, feldspar, mica, and amphibole; high dark mineral content.			
55				55		
60				60		
			SAND (SP): olive brown (2.5Y 4/3), 95% sand, subangular, very fine to fine grained; 5% silt; well sorted; contains quartz, mica, and amphibole; high mica content.			
65				65		
						13.3
70			SAND (SP): olive brown (2.5Y 4/3), 100% sand, subangular, very fine to fine grained; trace silt; well sorted; contains quartz, mica, and	70		

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WELL NUMBER **MPWSP MW-1M**

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am
PROJECT NUMBER 14077-15
LOCATION **Marina, CA**

True Vertical Depth (feet)	(continued)	Graphic Log	Lithologic Log NOTE: Grain size distribution percentages are approximate. Material code (e.g. SP) reference Unified Soil Classification visual method. Color code (e.g. 10YR 5/2) reference Munsell Soil Color Charts.	Depth bgs (feet)	Sieve Sample Number	Drill Rate (ft/hr)
			amphibole; high mica content.			
75				75		
						13.3
80				80		
			SAND (SP): light olive brown (2.5Y 5/3), 95% fine to coarse grained sand, subangular to subrounded, predominantly medium to coarse sand; 5% fine gravel subangular to subrounded; contrains feldspar, amphibole, and trace quartz.			
85			SAND WITH GRAVEL (SP): yellowish red (5YR 5/6), 80% fine to coarse grained sand, subangular to subrounded; 20% fine gravel up to 10 mm, subangular to subrounded; contains quartz, feldspar, mica, and amphibole.	85		
			SAND (SP): dark yellowish brown (10YR 4/4), 95% sand, subangular, very fine to fine grained; 5% silt; well sorted; contains quartz, feldspar, mica, and amphibole.			
90			SAND WITH GRAVEL (SP): light olive brown (2.5Y 5/4), 80% fine to coarse grained sand, subangular to subrounded; 20% fine to coarse gravel up to 45 mm, subangular to subrounded; trace cobbles; contains quartz, feldspar, mica, and amphibole.	90		
95			SAND (SP): light olive brown (2.5Y 5/3), 100% fine to medium grained sand, subangular; contains quartz, feldspar, mica, and amphibole; grades finer with depth; high mica content.	95		
			SAND WITH SILT (SP-SM): brown (10YR 4/3), 90% fine grained sand, subangular to subrounded, trace coarse grains; 10% silt; well sorted; contains quartz, feldspar, mica, and amphibole.			
100				100		
	CEMEX Monterey #60 fine sand seal (100.2-104 ft bgs)					
105				105		
	CEMEX Monterey #3 filter pack (104-227.5 ft bgs)					
110				110		

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WELL NUMBER **MPWSP MW-1M**

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am | LOCATION **Marina, CA**
PROJECT NUMBER 14077-15

(continued)

True Vertical Depth (feet)	Graphic Log	Lithologic Log	Depth bgs (feet)	Sieve Sample Number	Drill Rate (ft/hr)
		NOTE: Grain size distribution percentages are approximate. Material code (e.g. SP) reference Unified Soil Classification visual method. Color code (e.g. 10YR 5/2) reference Munsell Soil Color Charts.			
115		SAND (SP): brownish yellow (10YR 6/6) and gray (5Y 6/1), 100% fine to coarse grained sand, subangular to subrounded; trace silt; contains quartz, feldspar, and amphibole; iron oxidation.	115		
120		SILTY SAND (SM): strong brown (7.5YR 5/6), 85% fine to medium grained sand, subrounded, predominately fine sand; 15% silt; contains quartz, feldspar, mica, and amphibole.	120		
		SILTY SAND (SM): light yellowish brown (10YR 6/4), 75% fine grained sand, subangular; 25% silt; well sorted; contains quartz, feldspar, mica, and amphibole.			
125		SAND (SP): reddish yellow (7.5YR 6/8), 85% fine to coarse grained sand, angular to subangular; 10% fine to coarse gravel angular to subangular; 5% clay, low plasticity.	125		
		CLAYEY SAND (SC): pale olive (5Y 6/3), 85% fine grained sand, subangular; 15% clay, low plasticity; contains quartz, and amphibole.			
		SAND WITH GRAVEL (SP): brown (7.5YR 5/4), 80% fine to coarse grained sand, subangular to subrounded; 15% fine to coarse gravel subangular to subrounded; 5% clay, low to medium plasticity, clay balls.			
130			130		
		SILTY SAND (SM): dark yellowish brown (10YR 4/4), 85% fine to medium grained sand, subrounded; 15% silt; contains quartz, feldspar, and amphibole; high dark mineral content.			
135			135		
140			140		
145			145		
150		FAT CLAY WITH SAND (CH): light olive brown (2.5Y 5/4) and pale olive (5Y 6/3), 85% clay, medium plasticity; 15% fine to medium grained sand, subangular; contains quartz, mica, and amphibole.	150		

4 in. ID x Sch 80 wall PVC well screen with 0.040 in. slots (114.79-224.79 ft bgs)

8 in. borehole (147-227.5 ft

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WELL NUMBER **MPWSP MW-1M**

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am
PROJECT NUMBER 14077-15
LOCATION **Marina, CA**

True Vertical Depth (feet)	(continued)	Graphic Log	Lithologic Log NOTE: Grain size distribution percentages are approximate. Material code (e.g. SP) reference Unified Soil Classification visual method. Color code (e.g. 10YR 5/2) reference Munsell Soil Color Charts.	Depth bgs (feet)	Sieve Sample Number	Drill Rate (ft/hr)
	bgs)					
155			CLAYEY SAND (SC): light olive brown (2.5Y 5/4), 80% fine to medium grained sand, subangular; 20% clay, low plasticity; contains quartz, mica, and amphibole.	155		
160			CLAYEY SAND (SC): dark yellowish brown (10YR 4/4), 75% fine to medium grained sand, subangular to subrounded; 25% clay, low plasticity; contains quartz, feldspar, and amphibole.	160		
165				165		
170			SAND (SP): dark yellowish brown (10YR 4/4), 95% fine to medium grained sand, subangular, trace coarse sand; 5% silt.	170		
175				175		
180			CLAYEY SAND (SC): yellowish red (5YR 4/6) and olive gray (5Y 4/2), 85% fine to medium grained sand, subangular to subrounded; 15% clay, low plasticity; weak cementation; contains quartz, feldspar, and amphibole; high dark mineral content.	180		
185				185		
190			SAND (SP): dark brown (10YR 3/3), 95% fine to medium grained sand, subangular to subrounded; 5% silt; weak cementation; contains quartz, feldspar, and amphibole; high dark mineral content.	190		

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WELL NUMBER **MPWSP MW-1M**

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am | LOCATION **Marina, CA**
PROJECT NUMBER 14077-15

(continued)

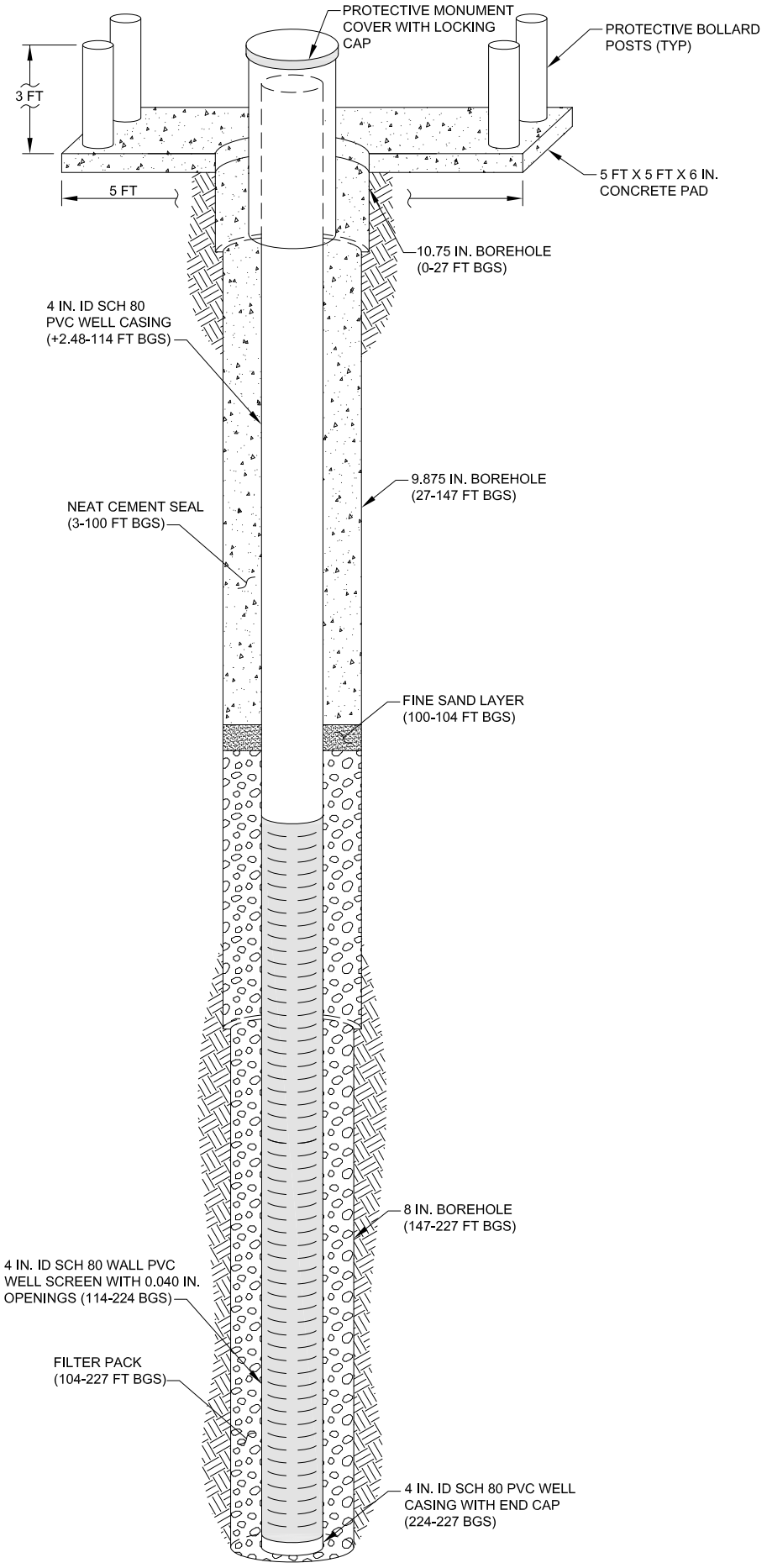
True Vertical Depth (feet)	Graphic Log	Lithologic Log NOTE: Grain size distribution percentages are approximate. Material code (e.g. SP) reference Unified Soil Classification visual method. Color code (e.g. 10YR 5/2) reference Munsell Soil Color Charts.	Depth bgs (feet)	Sieve Sample Number	Drill Rate (ft/hr)
195			195		
200		SAND WITH SILT (SP-SM): dark brown (10YR 3/3), 90% fine to medium grained sand, subangular to subrounded; 10% silt; contains quartz, feldspar, and amphibole; high dark mineral content.	200		
205		SILT (ML): light olive brown (2.5Y 5/3), 100% silt, brittle.	205		
210		SAND WITH CLAY (SP-SC): pale olive (5Y 6/3), 85% fine to coarse grained sand, subangular; 10% clay, low plasticity; 5% fine gravel subangular, trace coarse gravel; contains quartz, feldspar, mica, and amphibole.	210		
215		CLAYEY SAND (SC): light olive gray (5Y 6/2), 75% fine to coarse grained sand, subangular to subrounded; 15% clay, low plasticity; 10% fine to coarse gravel subangular to subrounded.	215		
		SAND (SP): olive (5Y 5/3) and light olive gray (5Y 6/2), 95% fine to coarse grained sand, subangular to subrounded; 5% silt; contains quartz, feldspar, mica, and amphibole; predominantly quartz.			
220			220		
		SILT (ML): light olive brown (2.5Y 5/4), 100% silt, low plasticity; contains mica.			
225			225		
		Bottom of borehole at 227.5 feet.			

Blank casing with end cap (224.79-227.5 ft bgs)

TD 227.5 ft bgs

WELL CONSTRUCTION LOG MPWSP MW TM LITH ALL WELLS.GPJ GEOSCIENCE.GDT 7/7/16

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WELL PROFILE

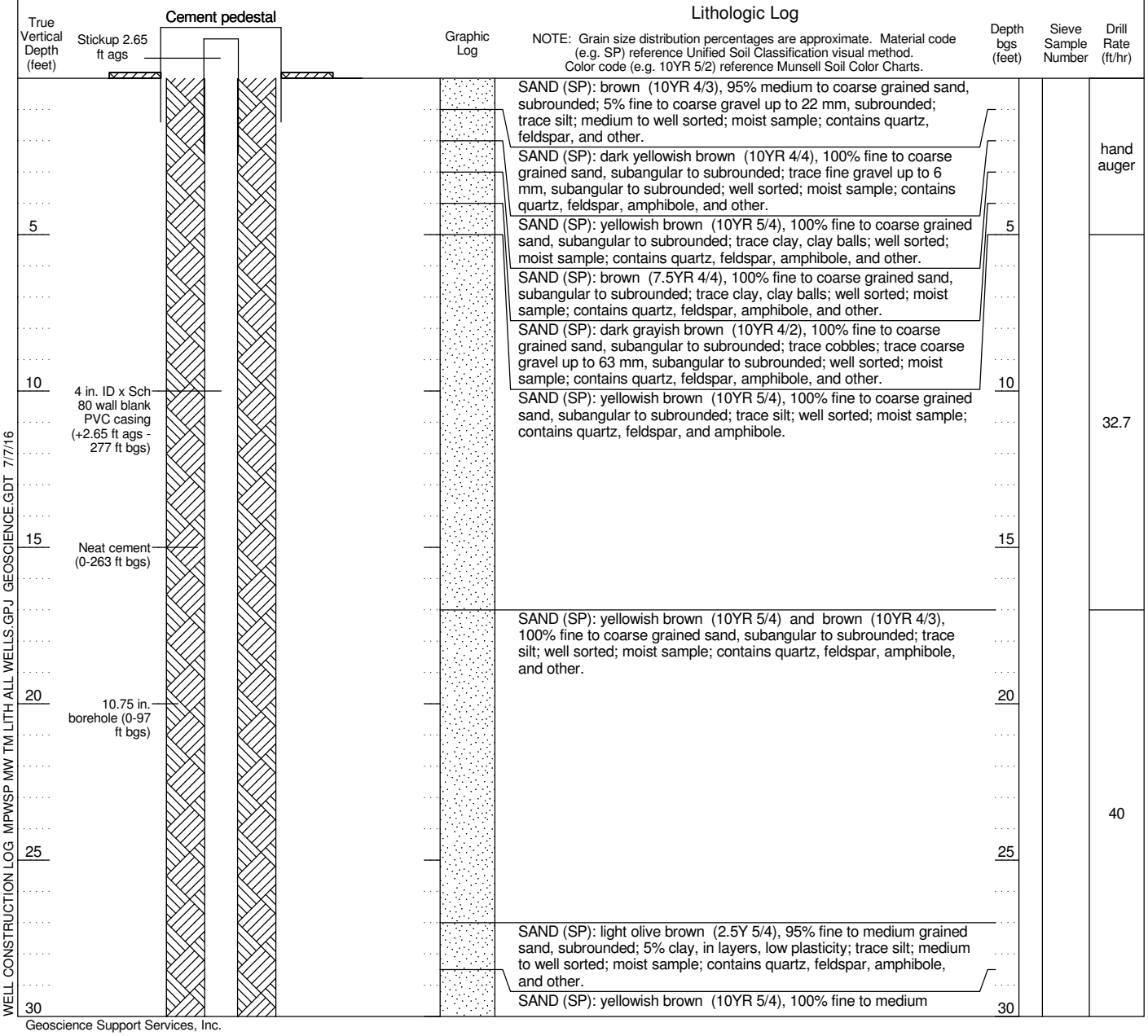
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BOREHOLE LITHOLOGIC LOG

WELL NUMBER **MPWSP MW-1D**	
CLIENT: Cal Am	LOCATION: **Marina, CA**
PROJECT NUMBER: 14077-15	**CEMEX**
REPORT DATE:	
DRILLING CONTRACTOR: Cascade Drilling	LOGGED BY
DRILLER: A. Patricio	**J. Sobolew**

		SCREEN / BLANK	TOP DEPTH (ft bgs)	BOTTOM DEPTH (ft bgs)	LENGTH (ft)	MATERIAL	WALL THICKNESS (in.)	DIAMETER (in.)	SCREEN TYPE	PERF. SIZE (in.)
DRILLING RIG TYPE	ProSonic 600T	**Blank**	**-2.65**	**277**	**279.65**	**PVC**	**Sch 80**	**4 / ID**		
DRILLING METHOD	Sonic	**Screen**	**277**	**327**	**50**	**PVC**	**Sch 80**	**4 / ID**	**Slotted**	**0.04**
SAMPLING METHOD	Core	**Blank**	**327**	**329.55**	**2.55**	**PVC**	**Sch 80**	**4 / ID**		
BOREHOLE DIAMETER	10.75, 9.875, 8 in									
SURFACE ELEVATION	27.03 ft NAVD88									
TOC ELEVATION	29.68 ft NAVD88 (RP)									
START DATE	12/10/14									
FINISH DATE	12/19/14									



WELL CONSTRUCTION LOG MPWSP MW TM LITH ALL WELLS.GPJ GEOSCIENCE.GDT 7/7/16

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WELL NUMBER **MPWSP MW-1D**

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am
PROJECT NUMBER 14077-15
LOCATION **Marina, CA**

True Vertical Depth (feet)	(continued)	Graphic Log	Lithologic Log NOTE: Grain size distribution percentages are approximate. Material code (e.g. SP) reference Unified Soil Classification visual method. Color code (e.g. 10YR 5/2) reference Munsell Soil Color Charts.	Depth bgs (feet)	Sieve Sample Number	Drill Rate (ft/hr)
			grained sand, subrounded; trace silt; well sorted; moist sample; contains quartz, feldspar, amphibole, and other.			
35			SAND (SP): pale brown (10YR 6/3), 100% fine to coarse grained sand, angular to subangular; well sorted; moist sample; contains quartz, feldspar, mica, amphibole, and other.	35	1	
			SAND (SP): pale brown (10YR 6/3), 100% fine to coarse grained sand, angular to subangular; well sorted; moist sample; contains quartz, feldspar, mica, amphibole, and other; saturated at 41 ft bgs.		2	
40				40		
45				45		
			SAND WITH GRAVEL (SP): light yellowish brown (10YR 6/4), 85% fine to coarse grained sand, subangular to subrounded; 15% fine to coarse gravel up to 27 mm, subangular to subrounded; medium sorted; saturated sample; contains quartz, feldspar, amphibole, and other.		3	
50				50		40
			SAND (SP): light olive brown (2.5Y 5/3), 95% fine to medium grained sand, subangular to subrounded; 5% clay, clay balls, low plasticity; trace fine gravel up to 5 mm, subangular to subrounded; poorly to medium sorted; contains quartz, feldspar, mica, amphibole, and other.			
55			SAND (SP): light olive brown (2.5Y 5/3), 100% fine to coarse grained sand, subangular to subrounded; trace fine gravel up to 5 mm, subangular to subrounded; medium to well sorted; contains quartz, feldspar, mica, amphibole, and other.	55		
60				60		
			SAND (SP): brown (10YR 4/3), 100% fine grained sand, subrounded; trace silt; well sorted; contains quartz, feldspar, mica, amphibole, and other.			
65				65		
			SAND (SP): brown (10YR 5/3), 90% fine to coarse grained sand, subangular to subrounded; 10% fine gravel up to 10 mm, subangular to subrounded; trace silt; poorly to medium sorted; contains quartz, feldspar, mica, amphibole, and other; very fine sand with gravel and trace silt at 69-70 ft bgs.		4	
70				70		

WELL CONSTRUCTION LOG MPWSP MW TM LITH ALL WELLS.GPJ GEOSCIENCE.GDT 7/7/16

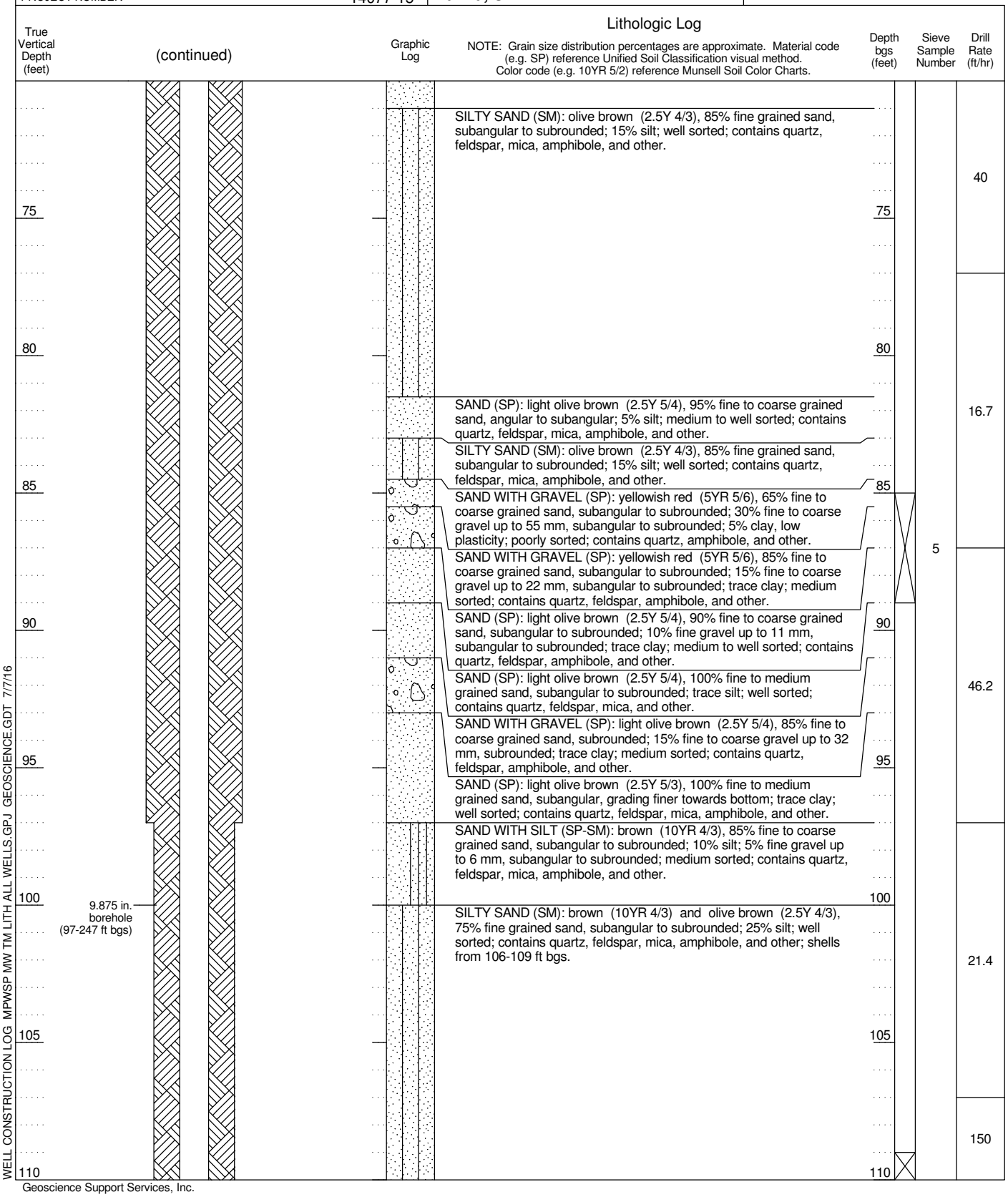
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WELL NUMBER **MPWSP MW-1D**

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am
PROJECT NUMBER 14077-15
LOCATION **Marina, CA**



WELL CONSTRUCTION LOG MPWSP MW TM LITH ALL WELLS.GPJ GEOSCIENCE.GDT 7/7/16

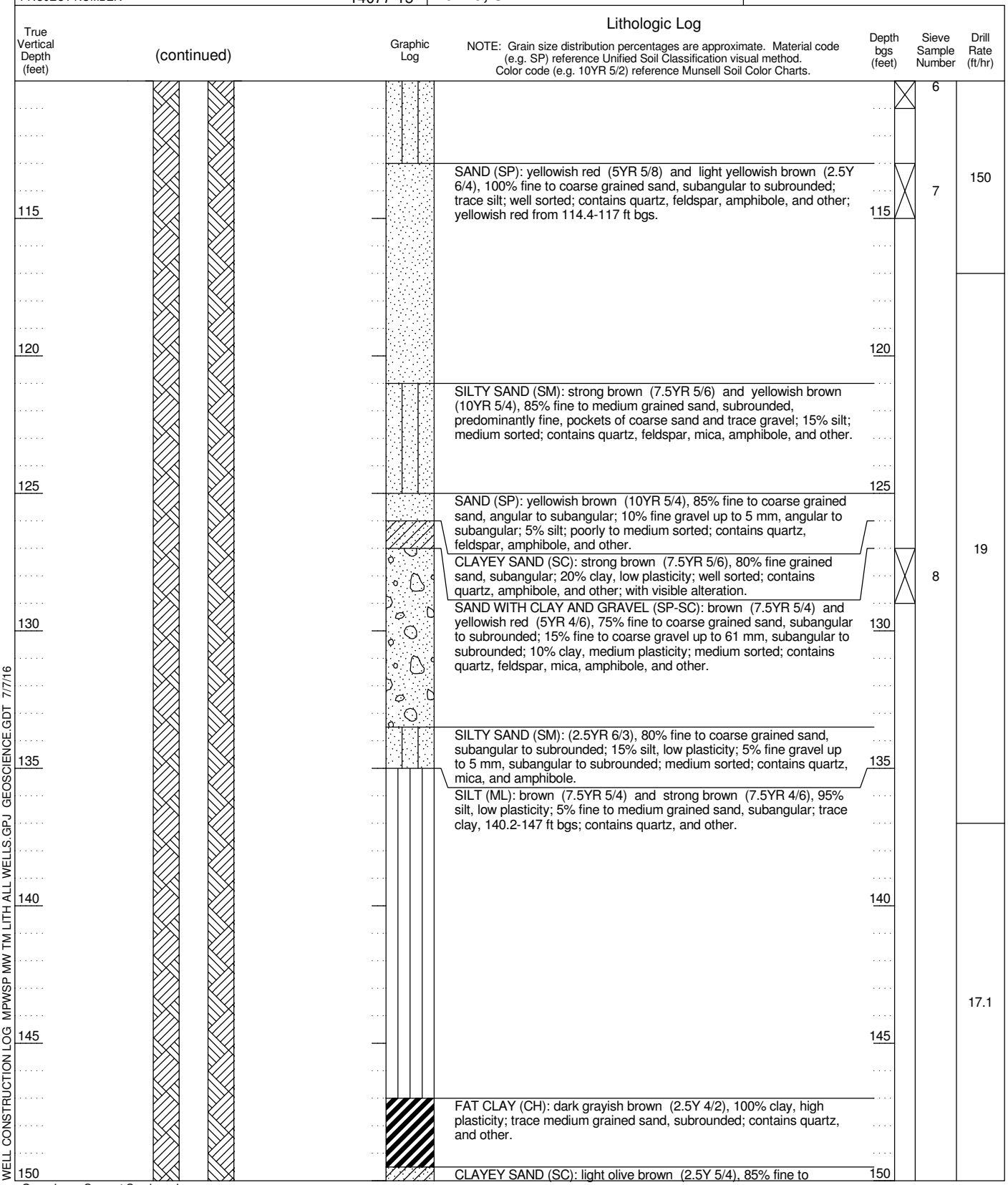
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WELL NUMBER **MPWSP MW-1D**

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am
PROJECT NUMBER 14077-15
LOCATION **Marina, CA**



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WELL NUMBER **MPWSP MW-1D**

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am
PROJECT NUMBER 14077-15
LOCATION **Marina, CA**

True Vertical Depth (feet)	(continued)	Graphic Log	Lithologic Log NOTE: Grain size distribution percentages are approximate. Material code (e.g. SP) reference Unified Soil Classification visual method. Color code (e.g. 10YR 5/2) reference Munsell Soil Color Charts.	Depth bgs (feet)	Sieve Sample Number	Drill Rate (ft/hr)
155			medium grained sand, subangular; 15% clay, low plasticity; medium sorted; contains quartz, amphibole, and other.	155	9	17.1
160			CLAYEY SAND (SC): dark yellowish brown (10YR 4/4), 85% fine grained sand, subangular; 15% clay, low to medium plasticity; medium sorted; contains quartz, amphibole, and other.	160		11.8
165				165		
170			SAND (SP): dark yellowish brown (10YR 4/4), 95% fine to medium grained sand, subangular, trace coarse; 5% silt; well sorted; contains quartz, feldspar, amphibole, and other.	170	10	
175				175		34.3
180			CLAYEY SAND (SC): yellowish red (5YR 4/6) and olive gray (5Y 4/2), 85% fine to medium grained sand, subangular to subrounded; 15% clay, low to high plasticity; medium sorted; contains quartz, feldspar, amphibole, and other; with visible alteration.	180		
185				185		
190				190	11	8.6

WELL CONSTRUCTION LOG MPWSP MW TM LITH ALL WELLS.GPJ GEOSCIENCE.GDT 7/7/16

Geoscience Support Services, Inc.

GEOSCIENCE
P.O. Box 220
Claremont, CA 91711
Telephone: (909) 451-6650
Fax: (909) 451-6638
www.gssiwater.com

WELL NUMBER **MPWSP MW-1D**

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am
PROJECT NUMBER 14077-15
LOCATION **Marina, CA**

(continued)

Lithologic Log

NOTE: Grain size distribution percentages are approximate. Material code (e.g. SP) reference Unified Soil Classification visual method. Color code (e.g. 10YR 5/2) reference Munsell Soil Color Charts.

True Vertical Depth (feet)	Graphic Log	Depth bgs (feet)	Sieve Sample Number	Drill Rate (ft/hr)
195		195		8.6
	SILTY SAND (SM): dark brown (10YR 3/3), 85% fine to medium grained sand, subangular to subrounded, predominantly fine; 15% silt; medium sorted; contains quartz, amphibole, and other.			
200		200		
205		205		16
210		210		
	FAT CLAY (CH): light olive brown (2.5Y 5/3), 100% clay, high plasticity; trace fine grained sand, subangular; contains quartz, and other.			
215		215		
220		220	12	
	FAT CLAY WITH SAND (CH): olive yellow (2.5Y 6/6), 85% clay, medium to high plasticity; 15% fine to medium grained sand, subangular; contains quartz, feldspar, mica, amphibole, and other.			20
225		225		
	FAT CLAY (CH): olive gray (5Y 5/2), 100% clay, high plasticity; with visible alteration.			
230		230		

WELL CONSTRUCTION LOG MPWSP MW TM LITH ALL WELLS.GPJ GEOSCIENCE.GDT 7/7/16

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WELL NUMBER **MPWSP MW-1D**

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am
PROJECT NUMBER 14077-15
LOCATION **Marina, CA**

True Vertical Depth (feet)	(continued)	Graphic Log	Lithologic Log NOTE: Grain size distribution percentages are approximate. Material code (e.g. SP) reference Unified Soil Classification visual method. Color code (e.g. 10YR 5/2) reference Munsell Soil Color Charts.	Depth bgs (feet)	Sieve Sample Number	Drill Rate (ft/hr)
235				235		20
240				240		
			SANDY CLAY (CL): light olive gray (5Y 6/2), 65% clay, low to medium plasticity; 35% fine to medium grained sand, subangular; contains quartz, mica, amphibole, and other.			
245			SAND WITH GRAVEL (SP): light yellowish brown (2.5Y 6/3), 55% fine to coarse grained sand, subangular; 40% fine to coarse gravel up to 46 mm, subangular, one large cobble; 5% clay; poorly sorted; contains quartz, feldspar, mica, amphibole, and other.	245	13 14	
			FAT CLAY (CH): pale olive (5Y 6/3) and dark gray (N4), 100% clay, high plasticity.			
250	8 in. borehole (247-337 ft bgs)			250		3.7
255				255		
260				260		17
	CEMEX Monterey Lapis Lustre #60 fine sand seal (263-267 ft bgs)		SANDY FAT CLAY (CH): light olive brown (2.5Y 5/3), 60% clay, medium to high plasticity; 30% fine to coarse grained sand, subangular to subrounded; 10% fine to coarse gravel up to 53 mm, subangular to subrounded; contains quartz, amphibole, and other.			
265	CEMEX Monterey Lapis Lustre #3 filter pack (267-337 ft bgs)		CLAY WITH SAND (CL): olive gray (5Y 5/2), 85% clay, medium plasticity; 10% fine to coarse grained sand, subangular to subrounded; 5% fine gravel up to 5 mm, subangular to subrounded; contains quartz, feldspar, mica, amphibole, and other.	265		14.6
270			SAND WITH CLAY AND GRAVEL (SP-SC): light brownish gray (2.5Y	270		

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WELL NUMBER **MPWSP MW-1D**

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am
PROJECT NUMBER 14077-15
LOCATION **Marina, CA**

True Vertical Depth (feet)	(continued)	Graphic Log	Lithologic Log NOTE: Grain size distribution percentages are approximate. Material code (e.g. SP) reference Unified Soil Classification visual method. Color code (e.g. 10YR 5/2) reference Munsell Soil Color Charts.	Depth bgs (feet)	Sieve Sample Number	Drill Rate (ft/hr)
			6/2), 75% fine to coarse grained sand, subangular; 15% fine to coarse gravel up to 19 mm, subangular; 10% clay, low to medium plasticity; poorly sorted; contains quartz, feldspar, amphibole, and other; predominantly quartz.			
			CLAYEY GRAVEL WITH SAND (GC): light yellowish brown (10YR 6/4) and dark gray (N4), 45% fine to coarse gravel up to 75 mm, subangular; 40% fine to coarse grained sand, subangular; 15% clay, low to medium plasticity; trace cobbles; poorly sorted; contains quartz, feldspar, mica, amphibole, and other; trace cobbles to 81mm; chert.			
275			FAT CLAY (CH): olive brown (2.5Y 4/3), 100% clay, medium plasticity, brittle; trace fine to medium grained sand, subangular to subrounded.	275		
			SAND (SP): pale brown (10YR 6/3), 90% fine to coarse grained sand, subangular to subrounded; 10% fine gravel up to 7 mm, subangular to subrounded; medium sorted; contains quartz, feldspar, mica, amphibole, and other; some grading.		15	
280	4 in. ID x Sch 80 wall PVC well screen with 0.040 in. slots (277-327 ft bgs)			280		
			SAND WITH GRAVEL (SP): grayish brown (10YR 5/2), 65% fine to coarse grained sand, subangular to subrounded; 30% fine to coarse gravel up to 21 mm, subangular to subrounded; 5% clay, low plasticity; poorly sorted; contains quartz, feldspar, amphibole, and other.		16	
285				285		
			SANDY SILT (ML): brown (7.5YR 5/4), 70% silt; 30% fine grained sand, subrounded, very fine; contains quartz, feldspar, mica, and other.		17	
290				290		14.6
			SAND (SP): light yellowish brown (10YR 6/4), 95% fine to coarse grained sand, subangular to subrounded; 5% fine gravel up to 5 mm, subangular to subrounded; trace silt; medium sorted; contains quartz, feldspar, mica, amphibole, and other.			
295				295		
300				300		
			SAND WITH CLAY AND GRAVEL (SW-SC): yellowish brown (10YR 5/4), 65% medium to coarse grained sand, subangular to subrounded, predominantly fine to medium; 25% fine to coarse gravel up to 20 mm, subangular to subrounded; 10% clay, low plasticity; poorly sorted; contains quartz, feldspar, mica, amphibole, and other.			
305				305		
310				310		

WELL CONSTRUCTION LOG MPWSP MW TM LITH ALL WELLS.GPJ GEOSCIENCE.GDT 7/7/16

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WELL NUMBER
MPWSP MW-1D

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am
PROJECT NUMBER 14077-15
LOCATION **Marina, CA**

(continued)

True Vertical Depth (feet)	Graphic Log	Lithologic Log NOTE: Grain size distribution percentages are approximate. Material code (e.g. SP) reference Unified Soil Classification visual method. Color code (e.g. 10YR 5/2) reference Munsell Soil Color Charts.	Depth bgs (feet)	Sieve Sample Number	Drill Rate (ft/hr)
315			315	18	14.6
		SAND (SP): brown (7.5YR 4/2), 95% fine to medium grained sand, subrounded, predominantly very fine to fine; 5% silt; well sorted; contains quartz, amphibole, and other.		19	
320		SILT (ML): brown (7.5YR 4/4), 100% silt, low plasticity; trace fine grained sand, subrounded; contains quartz, mica, and other.	320		
325		SAND (SP): brown (10YR 5/3), 100% fine to medium grained sand, subangular to subrounded; trace silt; well sorted; contains quartz, mica, amphibole, and other.	325		7.9
		FAT CLAY (CH): dark yellowish brown (10YR 4/4) and olive gray (5Y 5/2), 100% clay, high plasticity, brittle from 327-329.3 ft bgs.			
330			330		
335			335		

Blank casing with end cap (327-329.5 ft bgs)

TD 337 ft bgs

Bottom of borehole at 337 feet.

WELL CONSTRUCTION LOG MPWSP MW TM LITH ALL WELLS.GPJ GEOSCIENCE.GDT 7/7/16

Geoscience Support Services, Inc.

PACIFIC SURVEYS

TEMPERATURE
DELTA TEMPERATURE
FLUID RESISTIVITY
DELTA FLUID RESISTIVITY

Job No.	19027
File No.	

Company	CASCADE DRILLING
Well	MPWSP MW-1D
Field	MARINA
County	MONTEREY
State	CA

Location

CEMEX PLANT OFF OF LAPIS RD.
GPS: N 36o 42.787' W 121o 48.350'

Other Services:

DUAL INDUCTION
GAMMA-RAY

Permanent Datum	G.L.	Elevation	Elevation
Log Measured From	G.L.	0' above perm. datum	K.B.:
Drilling Measured From	G.L.		D.F.:
			G.L.:

Date	12-14-2014
Run Number	ONE
Depth Driller	334'
Depth Logger	334'
Bottom Logged Interval	334'
Top Log Interval	0'
Open Hole Size	9" (97'-247')
Type Fluid	WATER
Density / Viscosity	N/A
Fluid Level	26'
Bentonite Seal	N/A
Time Well Ready	1200
Time Logger on Bottom	1330
Equipment Number	PS-7
Location	LA
Recorded By	SCHUMACHER
Witnessed By	J. SOBOLEW

Borehole Record

Run Number	Bit	From	To
ONE	10"	0'	97'
TWO	9"	97'	247'
THREE	8"	247'	337'

Tubing Record

Size	Wgt/Ft	Top	Bottom
8" (247'-337')		0'	334'

	Size	Wgt/Ft	Top	Bottom
Casing Record	10"	N/A	0'	97'
Surface String				
Prot. String				
Production String	4" PVC	SCH 80	0'	334'
Liner				

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All interpretations are opinions based on inferences from electrical or other measurements and Pacific Surveys cannot and do not guarantee the accuracy or correctness of any interpretation, and we shall not, except in the case of gross or willful negligence on our part, be liable or responsible for any loss, costs, damages, or expenses incurred or sustained by anyone resulting from any interpretation made by any of our officers, agents or employees. These interpretations are also subject to Pacific Surveys' general terms and conditions set out in our current Price Schedule.

Comments

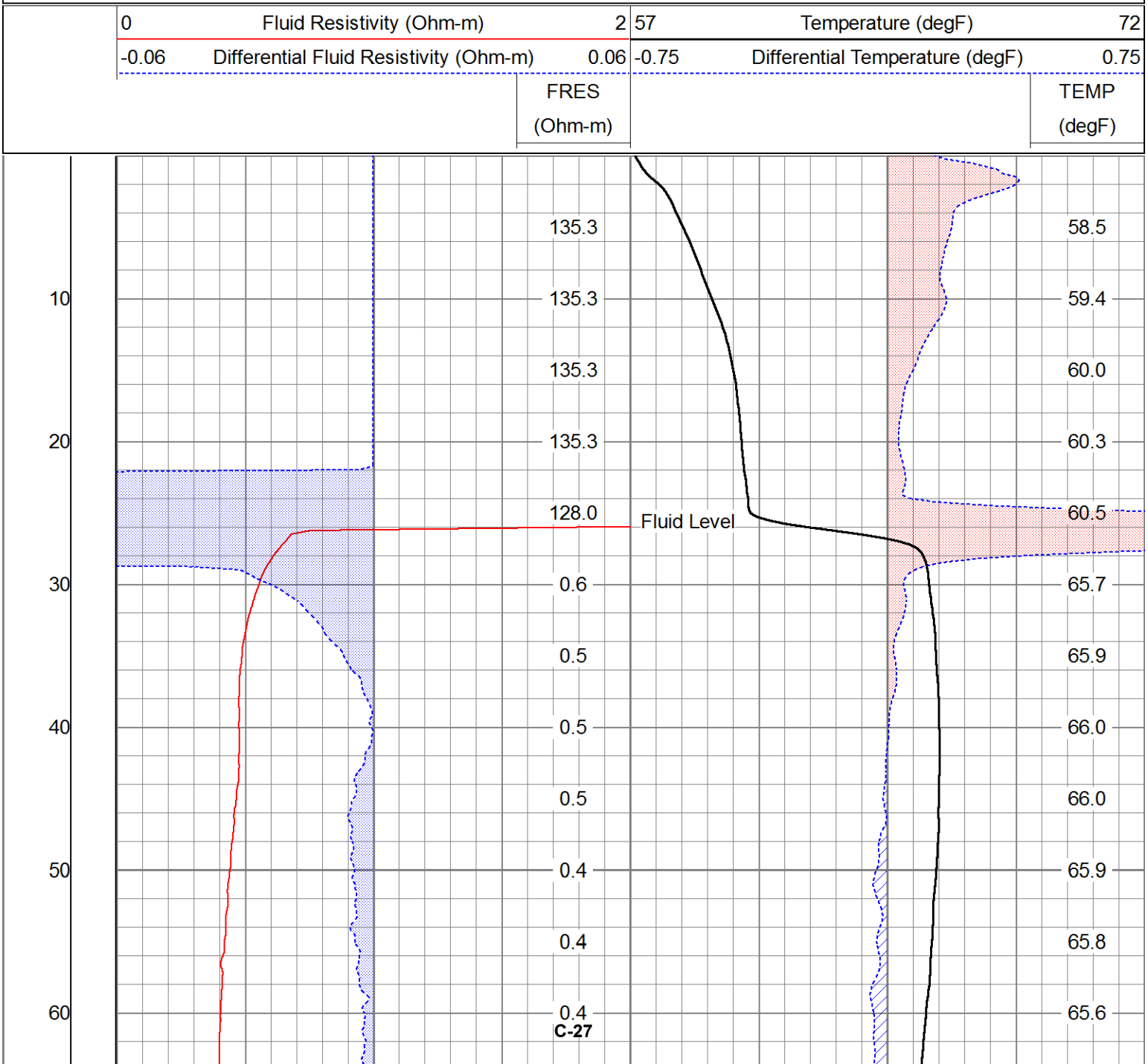
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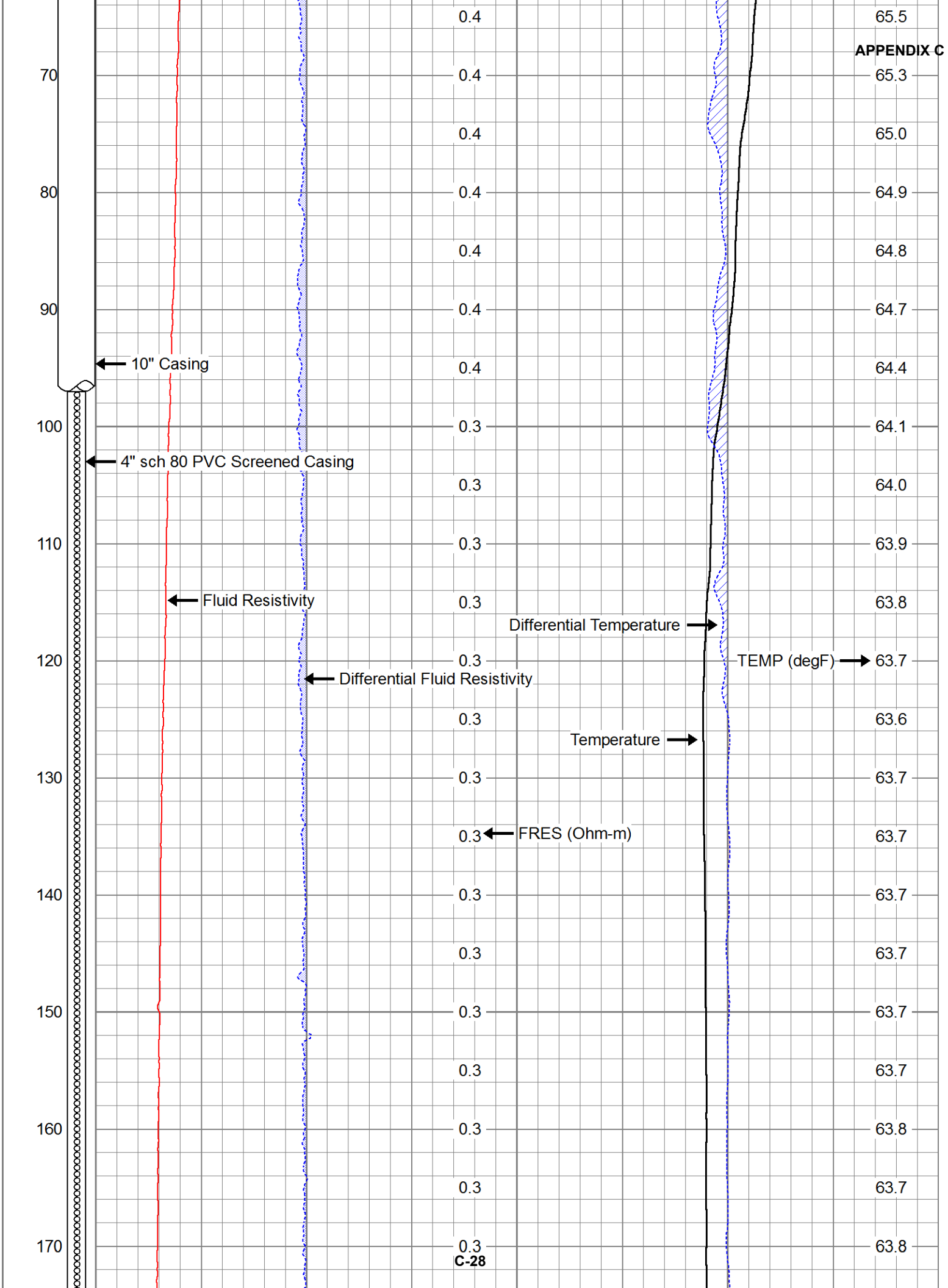
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Dataset Creation	Sun Dec 14 13:47:01 2014

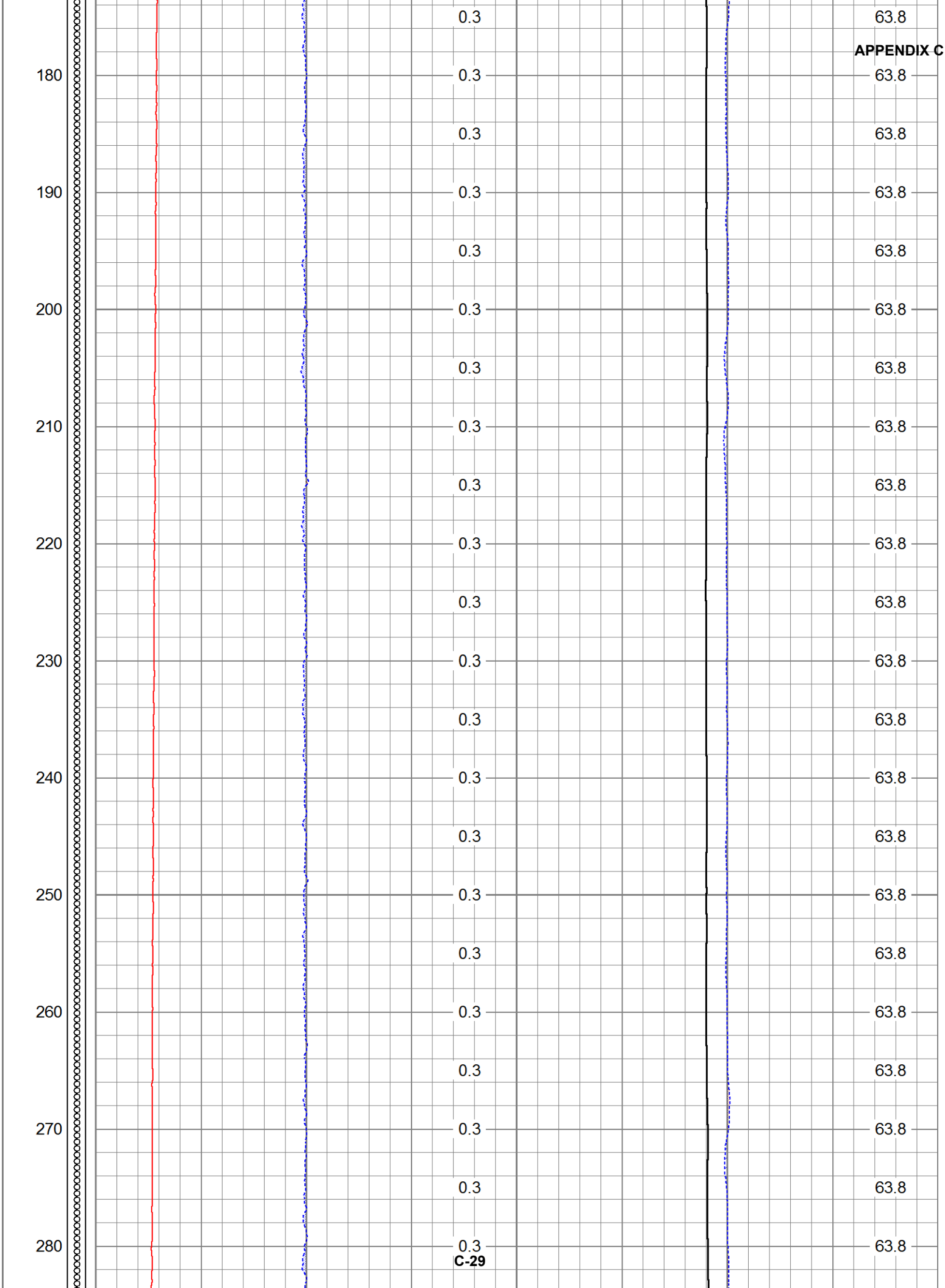
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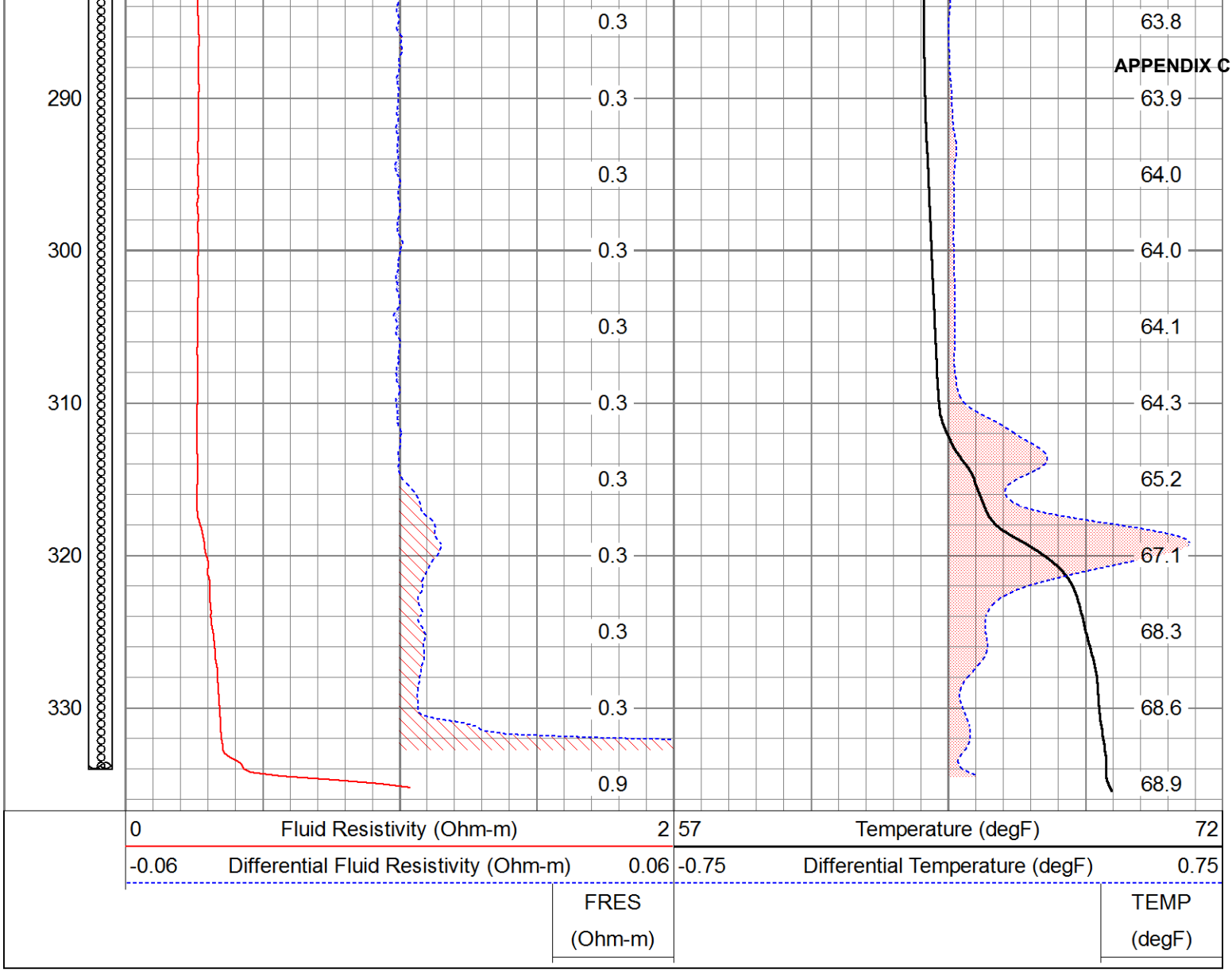
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Tool Model:	MLS		
Performed:	Wed Aug 29 07:13:35 2012		
	Reference		Reading
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High Reference:	149.00	degF	4545.00cps
Gain:	0.03		
Offset:	-5.71		
Delta Spacing	2		

Database File	19027.db
Dataset Pathname	TEMP
Presentation Format	frttemp2
Dataset Creation	Sun Dec 14 13:47:01 2014
Charted by	Depth in Feet scaled 1:120




70
80
90
100
110
120
130
140
150
160
170
0.4
0.4
0.4
0.4
0.4
0.4
0.3
0.3
0.3
0.3
0.3
0.3
0.3
0.3
0.3
0.3
0.3
0.3
65.5
65.3
65.0
64.9
64.8
64.7
64.4
64.1
64.0
63.9
63.8
63.7
63.6
63.7
63.7
63.7
63.7
63.7
63.8
63.7
63.8
10" Casing
4" sch 80 PVC Screened Casing
Fluid Resistivity
Differential Fluid Resistivity
Differential Temperature
TEMP (degF)
Temperature
FRES (Ohm-m)


180
190
200
210
220
230
240
250
260
270
280
0.3
63.8


290
300
310
320
330
0.3
0.3
0.3
0.3
0.3
0.3
0.3
0.9
63.8
63.9
64.0
64.0
64.1
64.3
65.2
67.1
68.3
68.6
68.9
0
Fluid Resistivity (Ohm-m)
2
-0.06
Differential Fluid Resistivity (Ohm-m)
0.06
FRES
(Ohm-m)
57
Temperature (degF)
72
-0.75
Differential Temperature (degF)
0.75
TEMP
(degF)

APPENDIX C

PACIFIC SURVEYS

DUAL INDUCTION GAMMA-RAY

Job No. 19027

File No.

Company CASCADE DRILLING

Well MPWSP MW-1D

Field MARINA

County MONTEREY State CA

Location

CEMEX PLANT OFF OF LAPIS RD.
GPS: N 36o 42.787' W 121o 48.350'

Other Services:

TEMPERATURE
FLUID RESISTIVITY

Permanent Datum	G.L.	Elevation above perm. datum	Elevation K.B.
Log Measured From	G.L. 0'		D.F.
Drilling Measured From	G.L.		G.L.

Date	12-14-2014		
Run Number	ONE		
Depth Driller	334'		
Depth Logger	334'		
Bottom Logged Interval	334'		
Top Log Interval	0'		
Open Hole Size	9" (97'-247')	8" (247'-337')	
Type Fluid	WATER		
Density / Viscosity	N/A		
Fluid Level	26'		
Bentonite Seal	N/A		
Time Well Ready	1200		
Time Logger on Bottom	1330		
Equipment Number	PS-7		
Location	LA		
Recorded By	SCHUMACHER		
Witnessed By	J. SOBOLEW		

Borehole Record				Tubing Record			
Run Number	Bit	From	To	Size	Weight	From	To
ONE	10"	0'	97'				
TWO	9"	97'	247'				
THREE	8"	247'	337'				

Casing Record	Size	Wgt/Ft	Top	Bottom
Surface String	10"	N/A	0'	97'
Prot. String				
Production String	4" PVC	SCH 80	0'	334'
Liner				

<<< Fold Here >>>

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Comments

Calibration Report

Database File 19027.db
Dataset Pathname dil
Dataset Creation Sun Dec 14 14:35:19 2014

Dual Induction Calibration Report

Serial-Model:	0001-ALT	
Surface Cal Performed:	Sat Dec 13 17:32:36 2014	

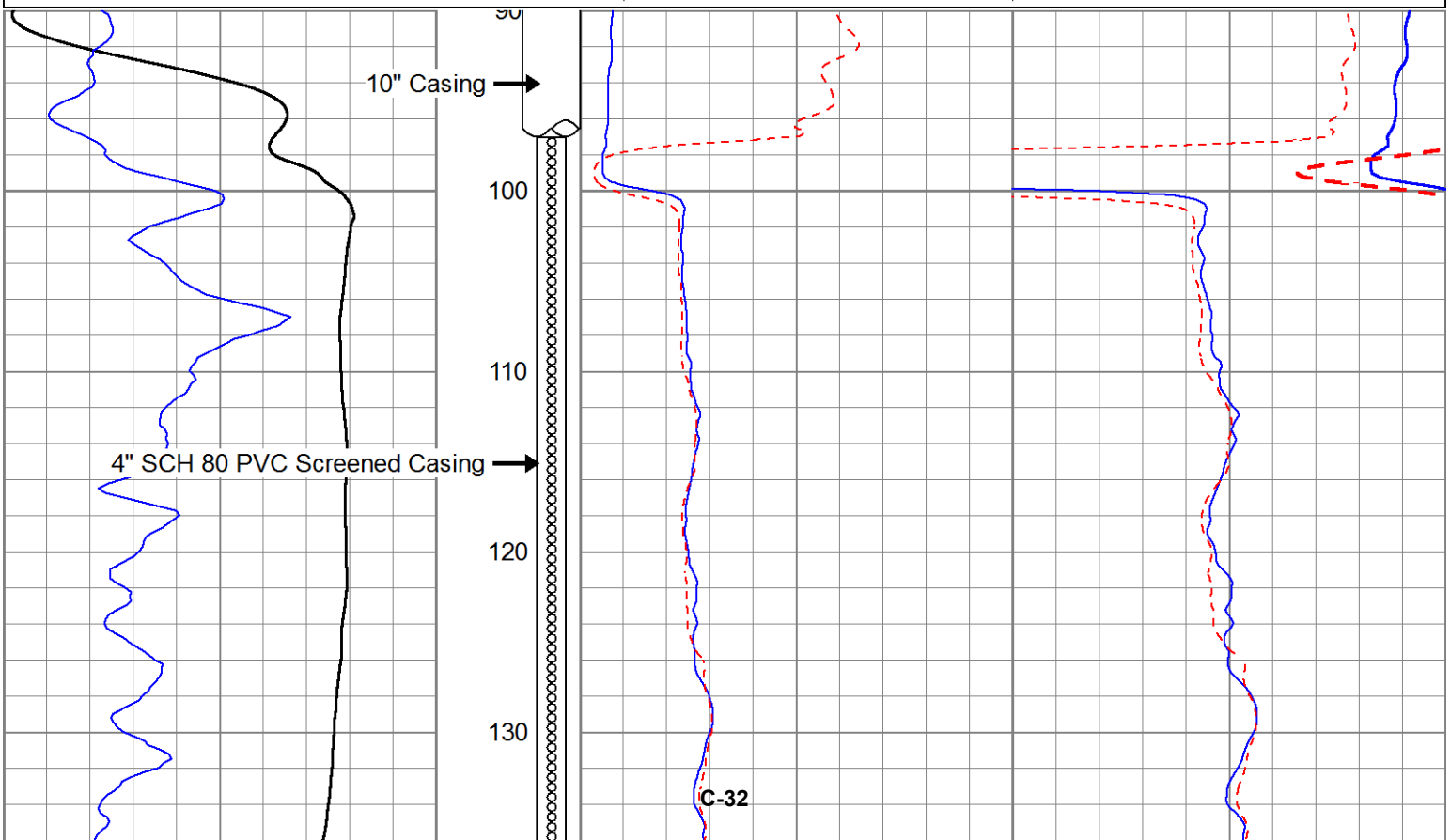
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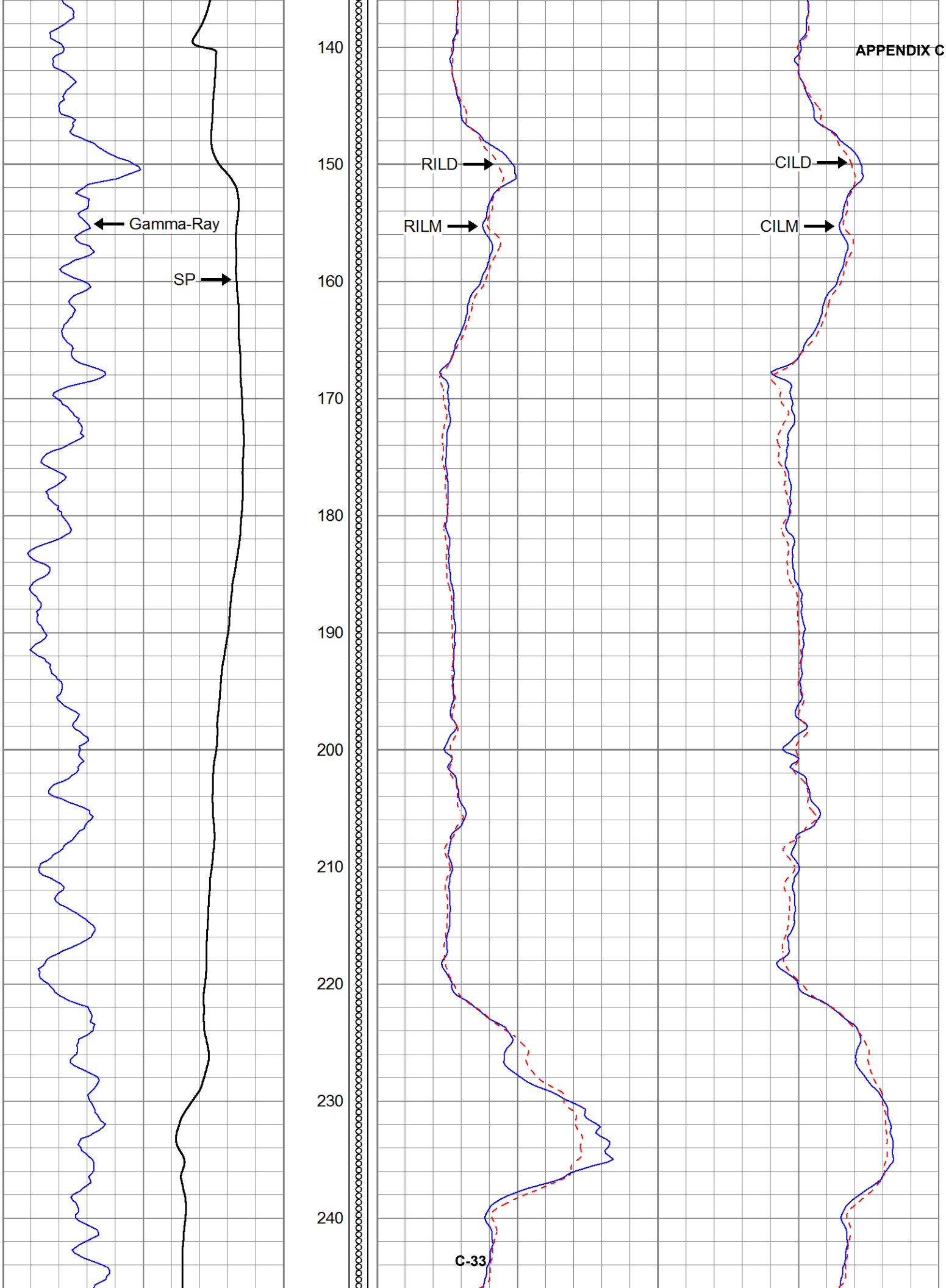
Gamma Ray Calibration Report

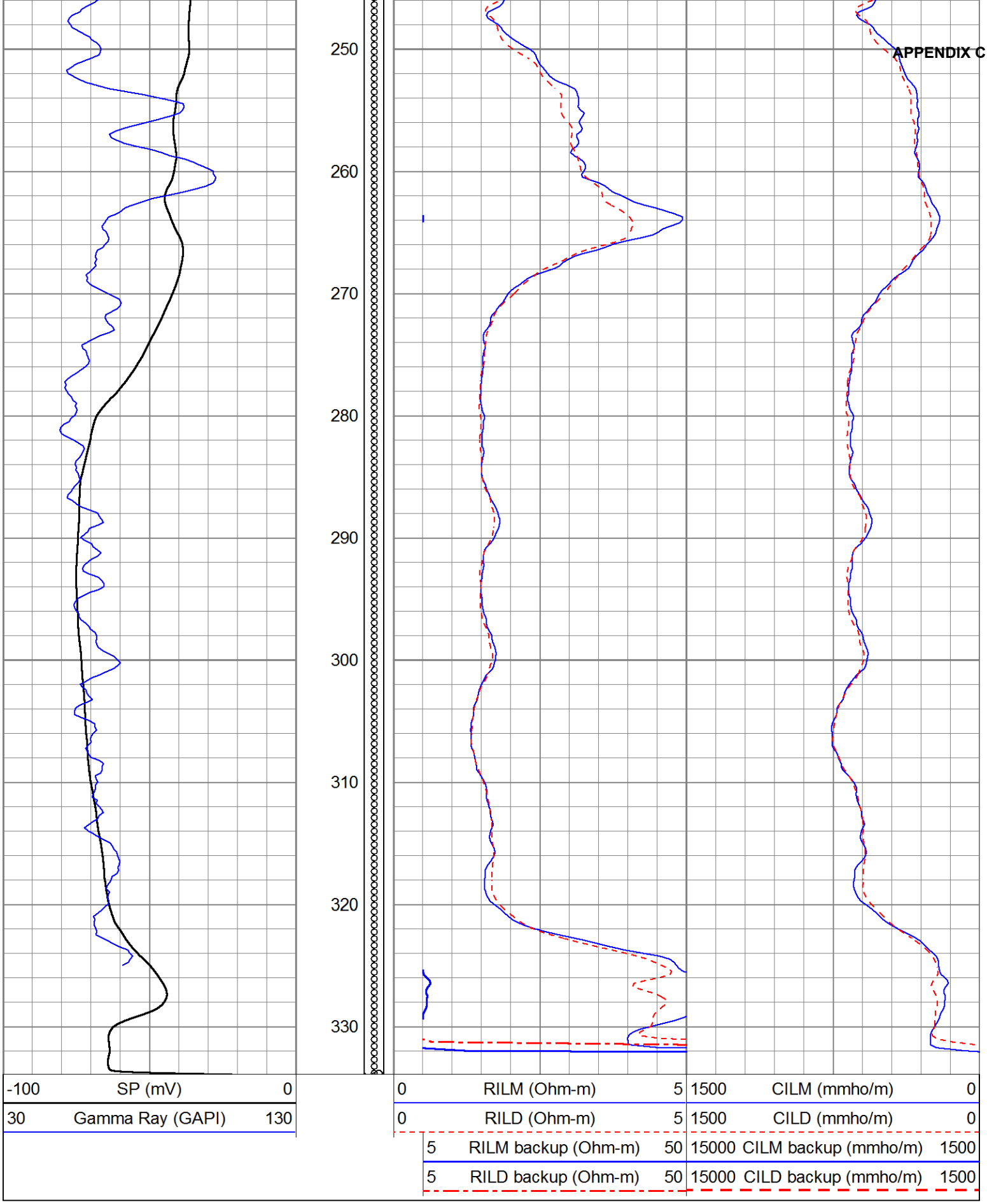
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Tool Model:	01	
Performed:	Sat Dec 13 17:32:47 2014	
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Sensitivity:	1.2020	GAPI/cps

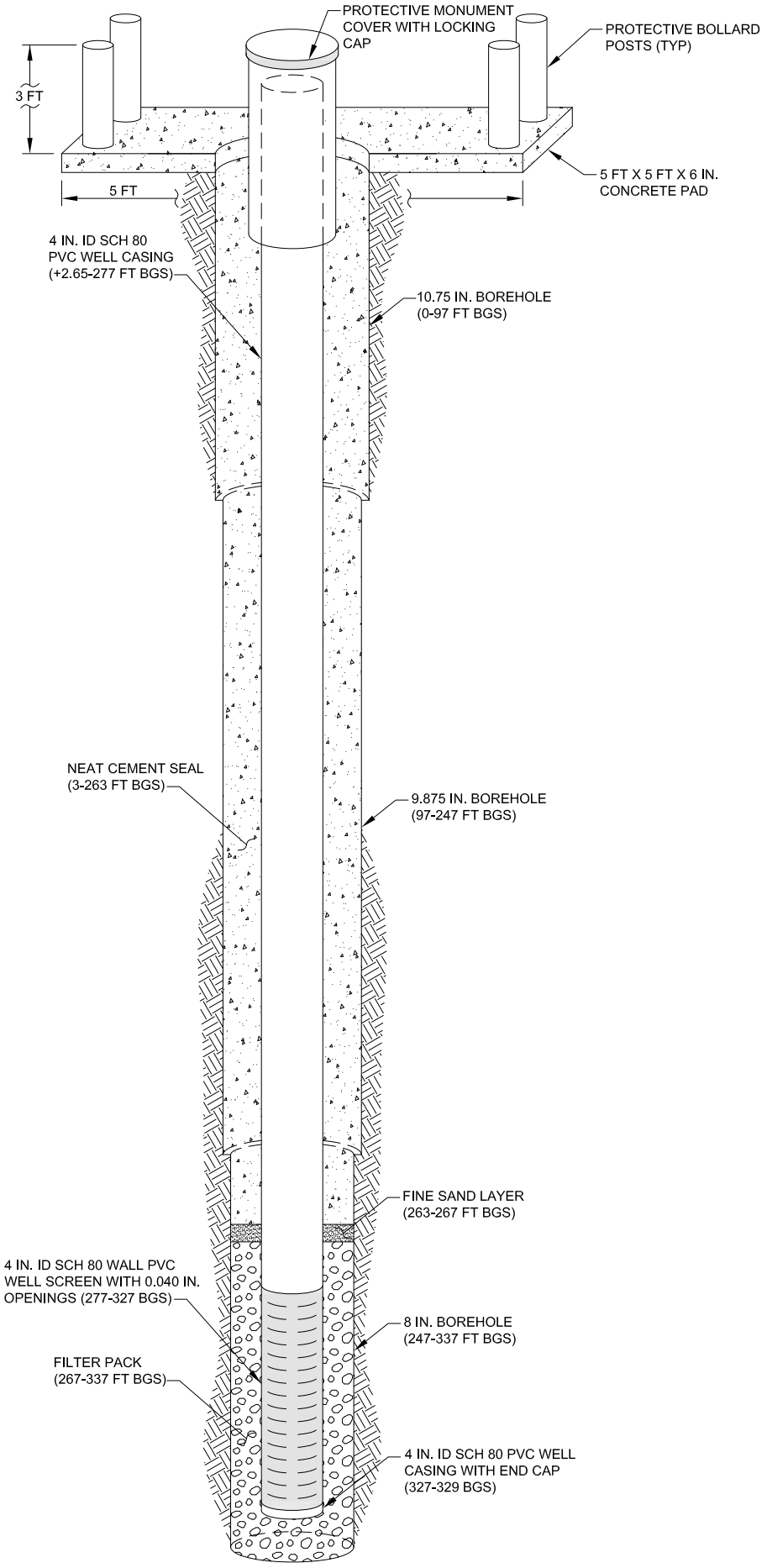
Database File	19027.db
Dataset Pathname	dil
Presentation Format	dil_ps
Dataset Creation	Sun Dec 14 14:35:19 2014
Charted by	Depth in Feet scaled 1:120

-100	SP (mV)	0	0	RILM (Ohm-m)	5	1500	CILM (mmho/m)	0
30	Gamma Ray (GAPI)	130	0	RILD (Ohm-m)	5	1500	CILD (mmho/m)	0
			5	RILM backup (Ohm-m)	50	15000	CILM backup (mmho/m)	1500
			5	RILD backup (Ohm-m)	50	15000	CILD backup (mmho/m)	1500




140
150
160
170
180
190
200
210
220
230
240
Gamma-Ray
SP
RILD
RILM
CILD
CILM


250
260
270
280
290
300
310
320
330
-100 SP (mV) 0
30 Gamma Ray (GAPI) 130
0 RILM (Ohm-m) 5
0 RILD (Ohm-m) 5
5 RILM backup (Ohm-m) 50
5 RILD backup (Ohm-m) 50
1500 CILM (mmho/m) 0
1500 CILD (mmho/m) 0
15000 CILM backup (mmho/m) 1500
15000 CILD backup (mmho/m) 1500



WELL PROFILE

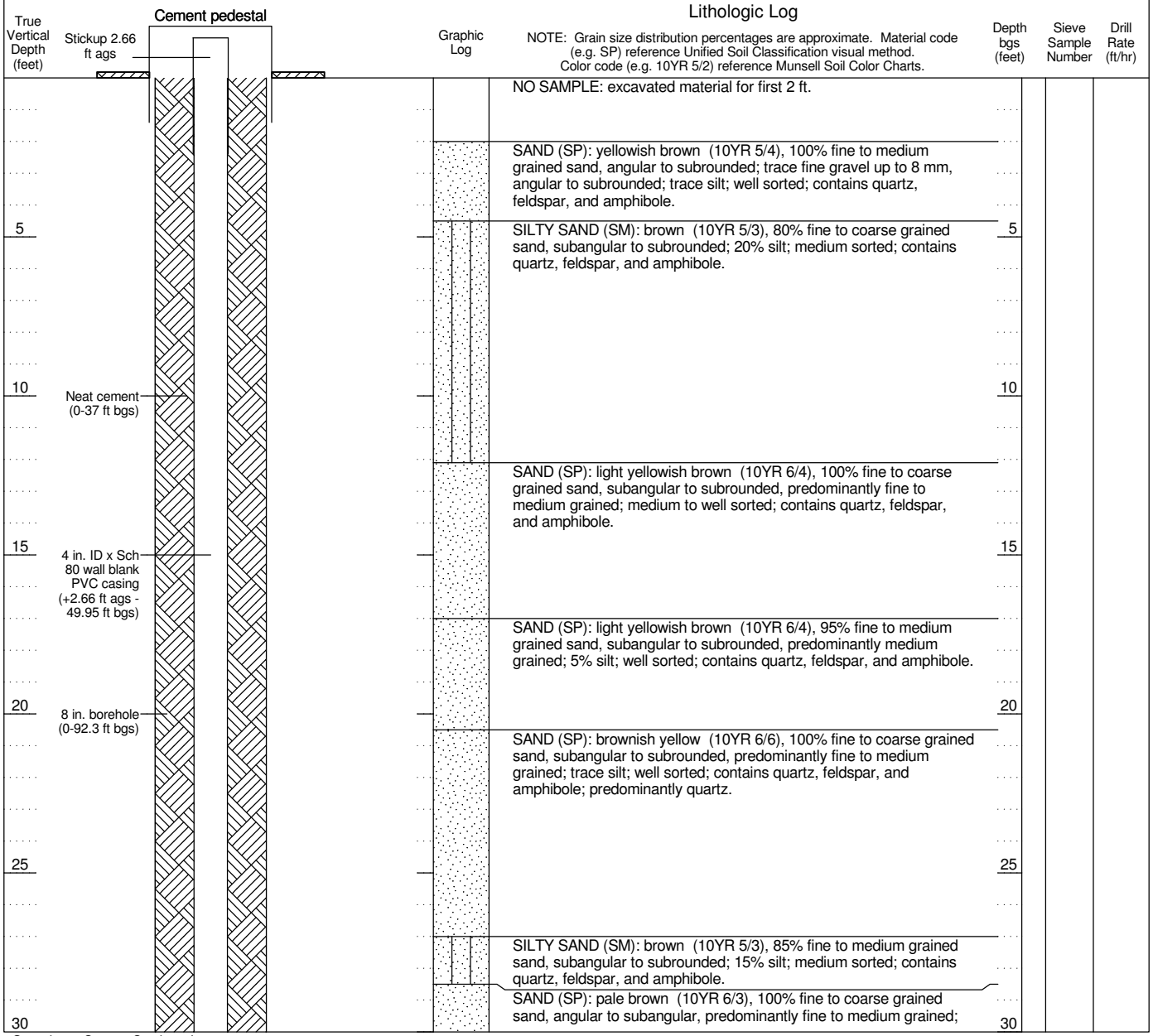
NOT TO SCALE

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BOREHOLE LITHOLOGIC LOG

WELL NUMBER **MPWSP MW-3S**	
CLIENT / PROJECT NUMBER: Cal Am 14077-15	LOCATION: **Marina, CA** **CEMEX**
REPORT DATE	
DRILLING CONTRACTOR / DRILLER: Cascade Drilling	LOGGED BY: **J. Sobolew**

		SCREEN / BLANK	TOP DEPTH (ft bgs)	BOTTOM DEPTH (ft bgs)	LENGTH (ft)	MATERIAL	WALL THICKNESS (in.)	DIAMETER (in.)	SCREEN TYPE	PERF. SIZE (in.)
DRILLING RIG TYPE	ProSonic 600T									
DRILLING METHOD	Sonic	**Blank**	**-2.66**	**49.95**	**52.61**	**PVC**	**Sch 80**	**4 / ID**		
SAMPLING METHOD	Core	**Screen**	**49.95**	**89.95**	**40**	**PVC**	**Sch 80**	**4 / ID**	**Slotted**	**0.04**
BOREHOLE DIAMETER	8 in	**Blank**	**89.95**	**92.3**	**2.35**	**PVC**	**Sch 80**	**4 / ID**		
SURFACE ELEVATION	34.50 ft NAVD88									
TOC ELEVATION	37.16 ft NAVD88 (RP)									
START DATE	2/18/15									
FINISH DATE	2/19/15									



WELL CONSTRUCTION LOG MPWSP MW TM LITH ALL WELLS.GPJ GEOSCIENCE.GDT 7/7/16

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WELL NUMBER **MPWSP MW-3S**

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am
PROJECT NUMBER 14077-15
LOCATION **Marina, CA**

(continued)

True Vertical Depth (feet)	Graphic Log	Lithologic Log NOTE: Grain size distribution percentages are approximate. Material code (e.g. SP) reference Unified Soil Classification visual method. Color code (e.g. 10YR 5/2) reference Munsell Soil Color Charts.	Depth bgs (feet)	Sieve Sample Number	Drill Rate (ft/hr)
		medium sorted; contains quartz, feldspar, and amphibole; water level at approximately 33 ft bgs.			
35			35		
		SAND (SP): pale brown (10YR 6/3), 90% fine to coarse grained sand, subangular to subrounded; 10% fine gravel subangular to subrounded; medium sorted; contains quartz, feldspar, and amphibole.			
40			40		
45			45		
50			50		
55		SAND (SP): light olive gray (5Y 6/2), 90% fine to coarse grained sand, subangular; 10% fine gravel; trace silt; medium sorted; contains quartz, feldspar, mica, and amphibole.	55		8.6
60			60		
65		SAND (SP): olive (5Y 5/3), 100% sand, subangular to subrounded, very fine to fine grained; trace silt; well sorted; contains quartz, feldspar, mica, and amphibole; high mica content.	65		
70		SAND (SP): olive brown (2.5Y 4/3), 95% sand, subrounded, fine to very fine, trace medium grained; 5% silt; well sorted; contains quartz, mica, and amphibole; high mica content.	70		

CEMEX Monterey Lapis Lustre #60 fine sand seal (37-40 ft bgs)

CEMEX Monterey Lapis Lustre #3 filter pack (40-92.3 ft bgs)

4 in. ID x Sch 80 wall PVC well screen with 0.040 in. slots (49.95-89.95 ft bgs)

WELL CONSTRUCTION LOG MPWSP MW TM LITH ALL WELLS.GPJ GEOSCIENCE.GDT 7/7/16

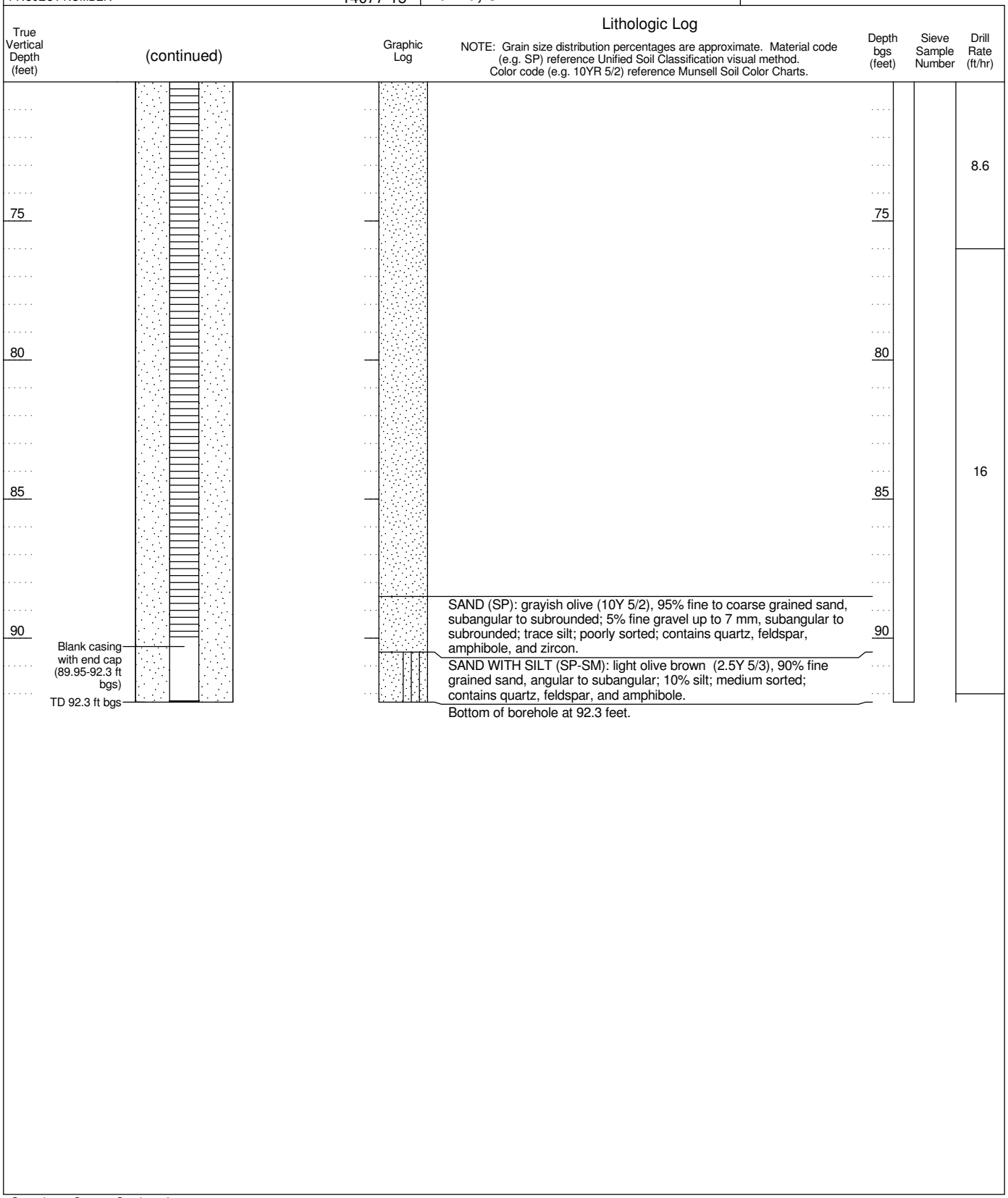
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WELL NUMBER **MPWSP MW-3S**

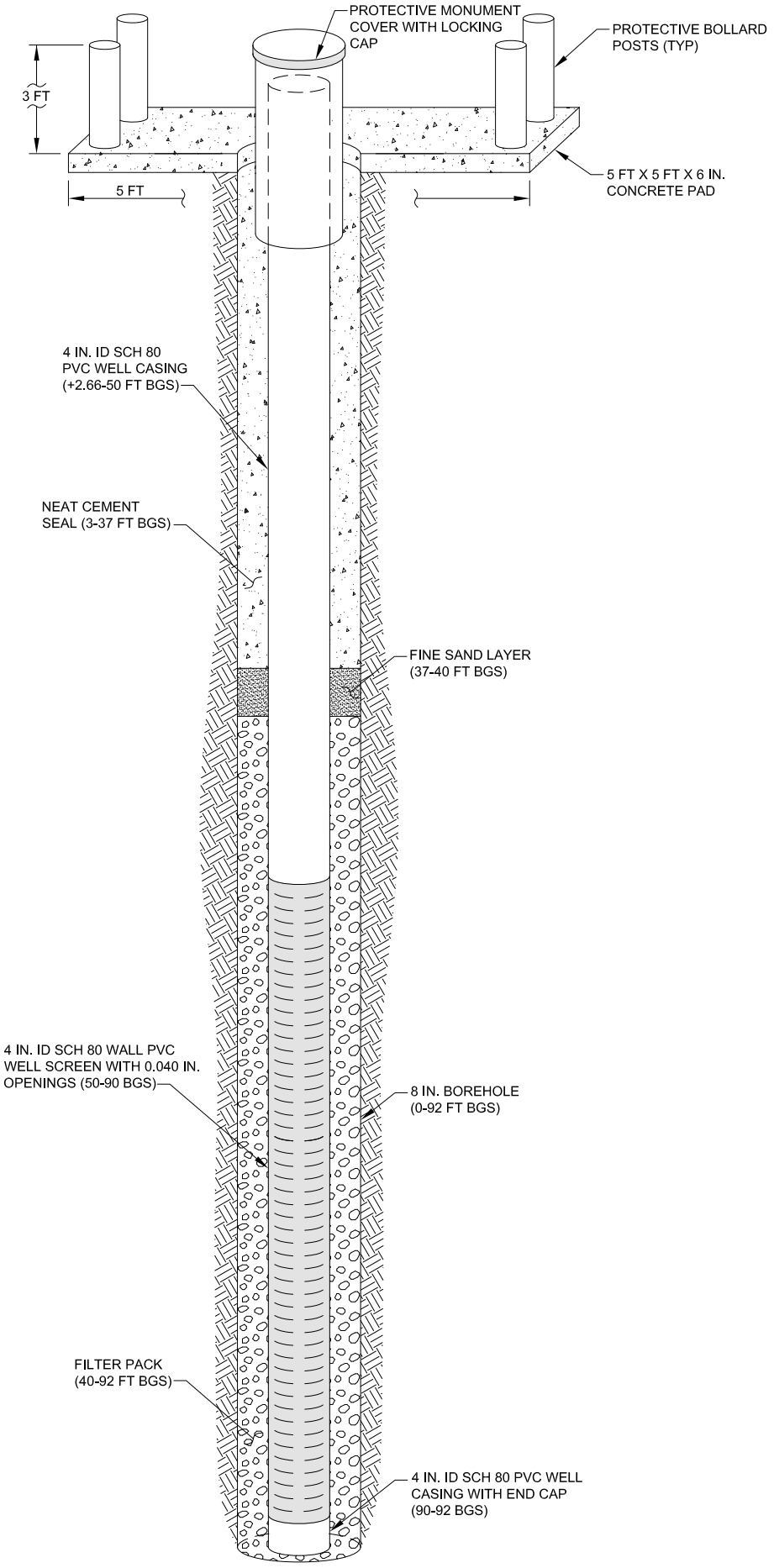
BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am
PROJECT NUMBER 14077-15
LOCATION **Marina, CA**



WELL CONSTRUCTION LOG MPWSP MW TM LITH ALL WELLS.GPJ GEOSCIENCE.GDT 7/7/16

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WELL PROFILE

NOT TO SCALE

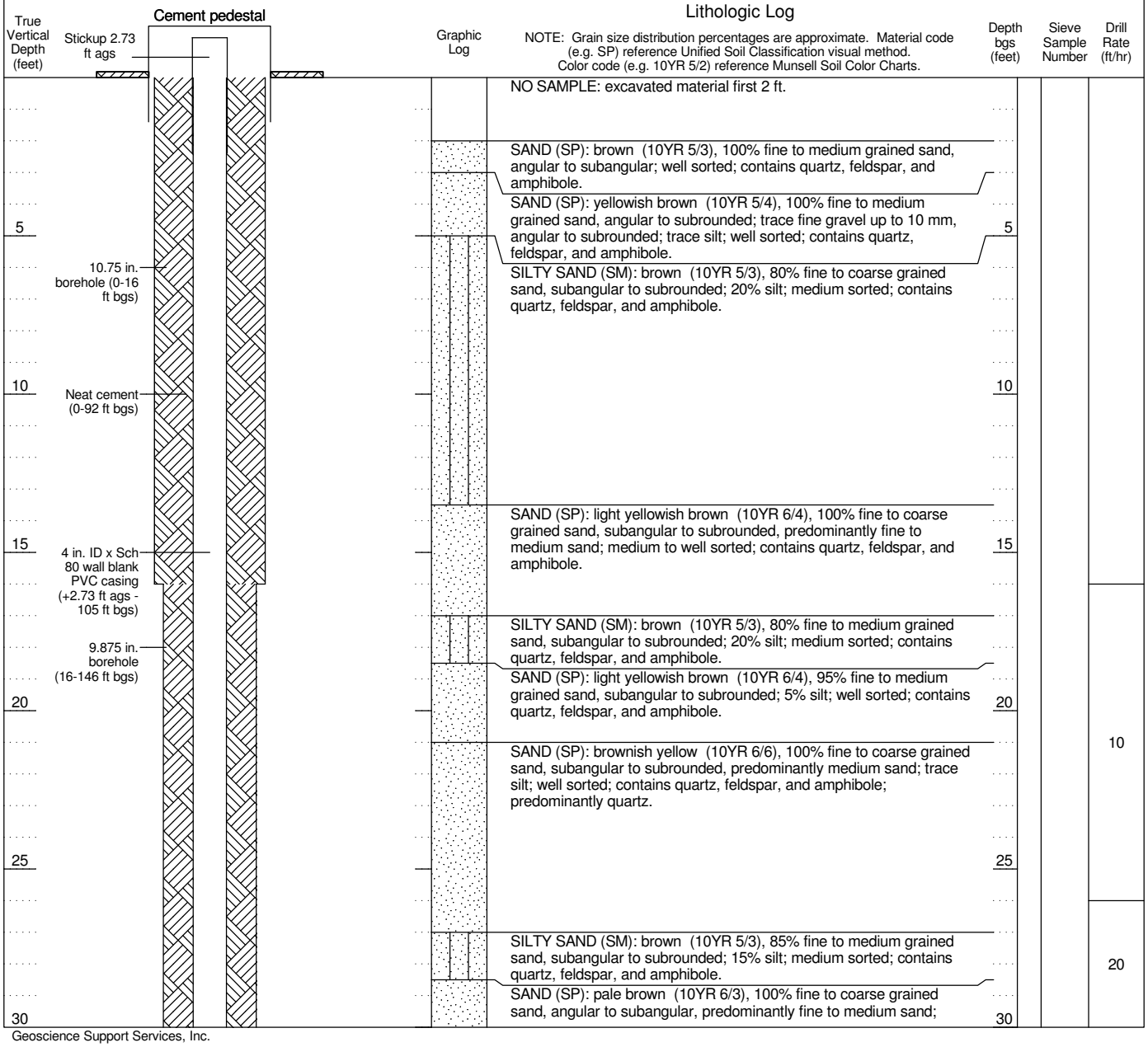
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WELL NUMBER **MPWSP MW-3M**

BOREHOLE LITHOLOGIC LOG

CLIENT	Cal Am	LOCATION	**Marina, CA**
PROJECT NUMBER	14077-15		**CEMEX**
REPORT DATE			
DRILLING CONTRACTOR	Cascade Drilling	LOGGED BY	**J. Sobolew**
DRILLER			

		SCREEN / BLANK	TOP DEPTH (ft bgs)	BOTTOM DEPTH (ft bgs)	LENGTH (ft)	MATERIAL	WALL THICKNESS (in.)	DIAMETER (in.)	SCREEN TYPE	PERF. SIZE (in.)
DRILLING RIG TYPE	ProSonic 600T	**Blank**	**-2.73**	**105**	**107.73**	**PVC**	**Sch 80**	**4 / ID**		
DRILLING METHOD	Sonic	**Screen**	**105**	**215**	**110**	**PVC**	**Sch 80**	**4 / ID**	**Slotted**	**0.04**
SAMPLING METHOD	Core	**Blank**	**215**	**217.345**	**2.345**	**PVC**	**Sch 80**	**4 / ID**		
BOREHOLE DIAMETER	10.75, 9.875, 8 in									
SURFACE ELEVATION	34.62 ft NAVD88									
TOC ELEVATION	37.35 ft NAVD88 (RP)									
START DATE	2/09/15									
FINISH DATE	2/17/15									



WELL CONSTRUCTION LOG MPWSP MW TM LITH ALL WELLS.GPJ GEOSCIENCE.GDT 7/7/16

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WELL NUMBER **MPWSP MW-3M**

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am
PROJECT NUMBER 14077-15
LOCATION **Marina, CA**

True Vertical Depth (feet)	(continued)	Graphic Log	Lithologic Log NOTE: Grain size distribution percentages are approximate. Material code (e.g. SP) reference Unified Soil Classification visual method. Color code (e.g. 10YR 5/2) reference Munsell Soil Color Charts.	Depth bgs (feet)	Sieve Sample Number	Drill Rate (ft/hr)
			medium sorted; contains quartz, feldspar, and amphibole; water level at approximately 30 ft bgs.			
35				35		
			SAND (SP): pale brown (10YR 6/3), 95% fine to coarse grained sand, subangular to subrounded; 5% fine gravel subangular to subrounded; trace silt; medium sorted; contains quartz, feldspar, and amphibole.			20
40				40		
45				45		
50				50		
			SAND (SP): light olive gray (5Y 6/2), 100% fine to coarse grained sand, subangular; trace silt; medium sorted; contains quartz, feldspar, mica, and amphibole.			
55				55		
60				60		
			SAND (SP): olive (5Y 5/3), 100% fine grained sand, subangular to subrounded, very fine to fine sand; trace silt; well sorted; contains quartz, feldspar, mica, and amphibole; high biotite mica content.		
65				65		
			SAND (SP): olive brown (2.5Y 4/3), 95% sand, subrounded, very fine to fine and trace medium sand; 5% silt; well sorted; contains quartz, mica, and amphibole; high mica content.			
70				70		

WELL CONSTRUCTION LOG MPWSP MW TM LITH ALL WELLS.GPJ GEOSCIENCE.GDT 7/7/16

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WELL NUMBER **MPWSP MW-3M**

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am
PROJECT NUMBER 14077-15
LOCATION **Marina, CA**

(continued)

True Vertical Depth (feet)	Graphic Log	Lithologic Log NOTE: Grain size distribution percentages are approximate. Material code (e.g. SP) reference Unified Soil Classification visual method. Color code (e.g. 10YR 5/2) reference Munsell Soil Color Charts.	Depth bgs (feet)	Sieve Sample Number	Drill Rate (ft/hr)
75			75		
80			80		
85			85		
		SAND (SP): grayish olive (10Y 5/2), 100% fine to coarse grained sand, subangular to subrounded; trace fine gravel up to 7 mm, subangular to subrounded; trace silt; poorly sorted; contains feldspar; contains quartz, feldspar, amphibole, and zircon.			
90		SAND (SP): light yellowish brown (2.5Y 6/4), 95% fine to coarse grained sand, subangular to subrounded, predominantly medium to coarse sand; 5% fine gravel up to 9 mm, subangular to subrounded; trace silt; medium sorted; contains quartz, feldspar, mica, and amphibole.	90		
		SAND WITH SILT (SP-SM): light olive brown (2.5Y 5/3), 90% fine grained sand, angular to subangular; 10% silt; well sorted; contains quartz, feldspar, and amphibole; contains shells.			10
95			95		
		SAND (SP): light yellowish brown (2.5Y 6/3), 85% fine to coarse grained sand, subangular to subrounded; 10% fine gravel up to 12 mm, subangular to subrounded; 5% silt; medium sorted; contains quartz, feldspar, and amphibole; alternates grain size from fine to medium to fine to coarse to fine to medium from 96 to 107 ft bgs.			
100			100		
105			105		
		SILTY SAND (SM): light olive brown (2.5Y 5/3), 80% fine grained sand, angular to subangular; 20% silt; contains quartz, feldspar, mica, and amphibole; contains shells from 114 to 116 ft.			
110			110		

CEMEX Monterey Lapis Lustre #60 fine sand seal (92-94 ft bgs)

CEMEX Monterey Lapis Lustre #3 filter pack (94-218.5 ft bgs)

4 in. ID x Sch 80 wall PVC well screen with 0.040 in. slots (105-215 ft bgs)

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WELL NUMBER **MPWSP MW-3M**

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am
PROJECT NUMBER 14077-15
LOCATION **Marina, CA**

(continued)

Lithologic Log

NOTE: Grain size distribution percentages are approximate. Material code (e.g. SP) reference Unified Soil Classification visual method. Color code (e.g. 10YR 5/2) reference Munsell Soil Color Charts.

True Vertical Depth (feet)	Graphic Log	Lithologic Log	Depth bgs (feet)	Sieve Sample Number	Drill Rate (ft/hr)
115			115		
		SAND (SP): light olive brown (2.5Y 5/3) and olive (5Y 5/4), 95% fine to medium grained sand, subangular to subrounded, trace coarse sand; 5% clay; well sorted; contains quartz, feldspar, and amphibole; 10% fine to coarse gravel from 116 to 119 ft; becomes finer with increasing depth; oxidation.			
120			120		10
125			125		
		FAT CLAY (CH): olive (5Y 5/3), 100% clay, medium plasticity.			
		SAND (SP): light gray (2.5Y 7/2), 95% fine to medium grained sand, subangular to subrounded, trace coarse sand; 5% silt; well sorted; contains some amphibole but predominantly quartz; oxidation.			
130			130		
135		CLAYEY SAND (SC): light olive brown (2.5Y 5/4), 75% fine grained sand, subangular; 25% clay; medium to well sorted; contains quartz, mica, and amphibole.	135		
		SILTY SAND (SM): pale olive (5Y 6/3), 80% fine to coarse grained sand, subangular to subrounded; 15% silt; 5% fine gravel up to 10 mm, subangular to subrounded; poorly to medium sorted; contains quartz, feldspar, mica, and amphibole.			
140		CLAYEY SAND (SC): pale olive (5Y 6/3), 85% fine grained sand, subangular to subrounded; 15% clay, low plasticity; well sorted; contains quartz, feldspar, and amphibole.	140		
		CLAYEY SAND WITH GRAVEL (SC): dark yellowish brown (10YR 4/4), 65% fine to coarse grained sand, subangular to subrounded; 20% clay, low plasticity; 15% fine to coarse gravel up to 20 mm, subangular to subrounded; poorly sorted; contains quartz, feldspar, and amphibole; gravel grades finer with depth.			
145		SAND WITH CLAY AND GRAVEL (SP-SC): pale olive (5Y 6/3), 70% fine to coarse grained sand, subangular to subrounded; 20% fine to coarse gravel up to 20 mm, subangular to subrounded; 10% clay; poorly to medium sorted; contains quartz, feldspar, and amphibole.	145		
150		SAND WITH SILT (SP-SM): yellowish brown (10YR 5/6), 90% fine grained sand, subrounded; 10% silt; well sorted; contains quartz, feldspar, and amphibole.	150		

8 in. borehole (146-230 ft bgs)

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WELL NUMBER **MPWSP MW-3M**

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am
PROJECT NUMBER 14077-15
LOCATION **Marina, CA**

True Vertical Depth (feet)	(continued)	Graphic Log	Lithologic Log NOTE: Grain size distribution percentages are approximate. Material code (e.g. SP) reference Unified Soil Classification visual method. Color code (e.g. 10YR 5/2) reference Munsell Soil Color Charts.	Depth bgs (feet)	Sieve Sample Number	Drill Rate (ft/hr)
155				155		
160			SAND (SP): dark yellowish brown (10YR 4/6), 95% sand, subangular to subrounded, fine to very fine sand; 5% silt; well sorted; weak cementation; contains quartz, feldspar, and amphibole.	160		
			FAT CLAY (CH): brown (10YR 4/3), 100% clay, high plasticity; trace fine grained sand; up to 10% fine to medium sand from 165 to 166 ft bgs.			
165				165		
			SAND WITH SILT (SP-SM): pale olive (5Y 6/3), 90% fine to medium grained sand, subangular to subrounded; 10% silt; well sorted; contains quartz, mica, and amphibole.			
170				170		
			SAND (SP): olive (5Y 5/3), 95% fine to medium grained sand; 5% silt; well sorted; contains quartz, mica, and amphibole; interbeds of medium to high plasticity.			
175			SAND (SP): pale olive (5Y 6/3), 95% fine to medium grained sand, subangular to subrounded, interbeds of coarse sand; 5% silt; well sorted; contains quartz, feldspar, mica, and amphibole.	175		12
180			SAND (SP): dark yellowish brown (10YR 4/4), 100% fine to medium grained sand, subangular to subrounded; trace silt; well sorted; weak cementation; contains quartz, mica, and amphibole; high dark mineral content.	180		
185				185		
190				190		

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WELL NUMBER **MPWSP MW-3M**

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am
PROJECT NUMBER 14077-15
LOCATION **Marina, CA**

(continued)

True Vertical Depth (feet)	Lithologic Log	Depth bgs (feet)	Sieve Sample Number	Drill Rate (ft/hr)
	NOTE: Grain size distribution percentages are approximate. Material code (e.g. SP) reference Unified Soil Classification visual method. Color code (e.g. 10YR 5/2) reference Munsell Soil Color Charts.			
				12
195	CLAYEY SAND (SC): brown (7.5YR 4/4), 70% fine grained sand, subrounded; 30% clay, low plasticity; well sorted; weak cementation; contains quartz, feldspar, and amphibole.	195		
	SANDY CLAY (CL): yellowish brown (10YR 5/6), 60% clay, low to medium plasticity; 40% fine grained sand, subangular to subrounded; contains quartz, feldspar, and amphibole.			
200	CLAYEY SAND (SC): dark yellowish brown (10YR 4/6), 65% fine grained sand, subangular to subrounded; 35% clay, low plasticity; well sorted; contains quartz, feldspar, and amphibole; high content dark mineral content.	200		
	SILTY SAND (SM): brown (10YR 5/3), 60% fine grained sand, subangular to subrounded; 40% silt; well sorted; weak cementation; contains quartz, feldspar, and amphibole; high dark mineral content.			
205		205		
	SAND WITH SILT (SP-SM): olive brown (2.5Y 4/3), 90% fine to medium grained sand, subangular to subrounded; 10% silt; well sorted; weak cementation; contains quartz, feldspar, and amphibole; high dark mineral content; oxidation.			
210	SANDY CLAY (CL): olive brown (2.5Y 4/3), 70% clay, low to high plasticity; 30% fine to medium grained sand, subangular to subrounded; contains quartz, feldspar, and amphibole.	210		
	CLAY (CL): olive (5Y 5/3), 100% clay, medium plasticity; oxidation from 213 to 214.5 ft.			
215		215		
	SAND (SP): pale olive (5Y 6/3), 95% fine to coarse grained sand, subangular to subrounded; 5% silt; trace gravel subangular to subrounded; medium sorted; contains quartz, feldspar, mica, and amphibole.			
	SAND (SP): olive (5Y 4/3), 90% fine to coarse grained sand, subangular to subrounded; 5% fine gravel subangular to subrounded; 5% silt; well sorted; contains quartz, feldspar, mica, and amphibole.			
220	SAND (SP): light olive gray (5Y 6/2), 85% fine to coarse grained sand, angular to subrounded; 10% fine gravel up to 16 mm, angular to subrounded; 5% silt; medium sorted; contains quartz, feldspar, mica, and amphibole.	220		
225		225		
	SILT WITH SAND (ML): olive (5Y 5/3), 85% silt; 15% fine to medium grained sand, subrounded; contains quartz.			
	SANDY SILT (ML): light olive brown (2.5Y 5/4), 70% silt; 30% fine to medium grained sand, subangular to subrounded; contains quartz, feldspar, mica, and amphibole.			
230	Bottom of borehole at 230 feet.	230		

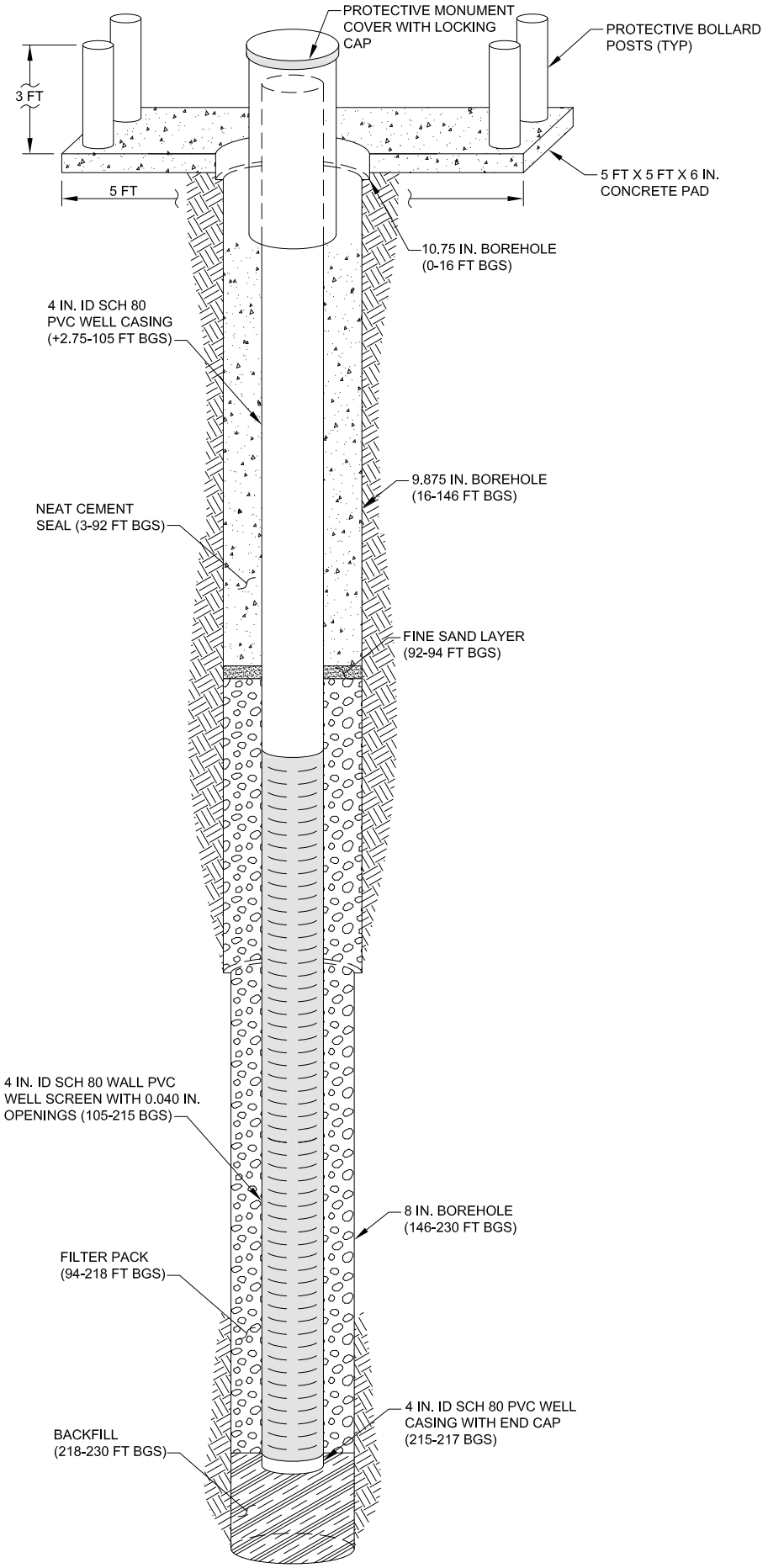
Blank casing with end cap (215-217.345 ft bgs)

Backfill with native material (218.5-230 ft bgs)

TD 230 ft bgs

WELL CONSTRUCTION LOG MPWSP MW TM LITH ALL WELLS.GPJ GEOSCIENCE.GDT 7/7/16

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WELL PROFILE

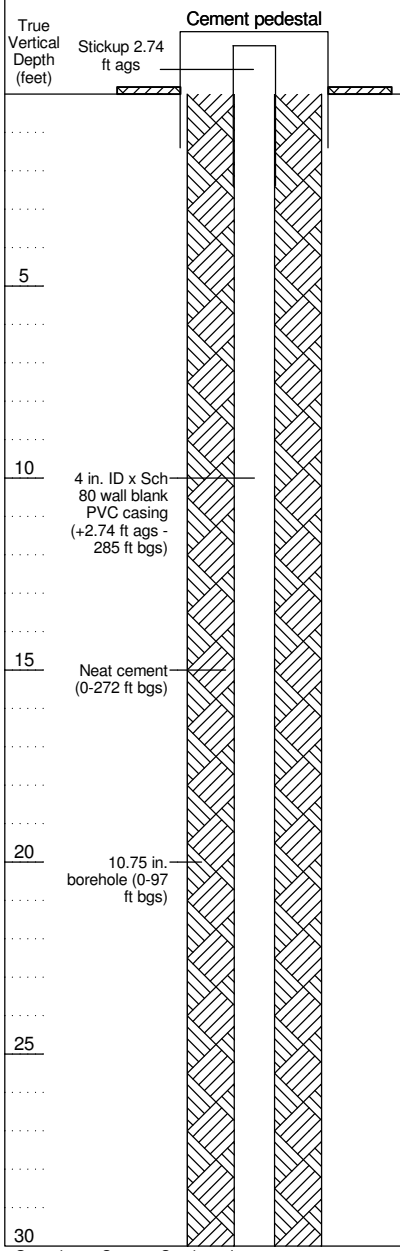
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BOREHOLE LITHOLOGIC LOG

WELL NUMBER **MPWSP MW-3D**	
CLIENT: Cal Am	LOCATION: **Marina, CA**
PROJECT NUMBER: 14077-15	**CEMEX**
REPORT DATE:	
DRILLING CONTRACTOR: Cascade Drilling	LOGGED BY: **J. Sobolew**
DRILLER: A. Patricio	

		SCREEN / BLANK	TOP DEPTH (ft bgs)	BOTTOM DEPTH (ft bgs)	LENGTH (ft)	MATERIAL	WALL THICKNESS (in.)	DIAMETER (in.)	SCREEN TYPE	PERF. SIZE (in.)
DRILLING RIG TYPE	ProSonic 600T									
DRILLING METHOD	Sonic	**Blank**	**-2.74**	**285**	**287.74**	**PVC**	**Sch 80**	**4 / ID**		
SAMPLING METHOD	Core	**Screen**	**285**	**330**	**45**	**PVC**	**Sch 80**	**4 / ID**	**Slotted**	**0.04**
BOREHOLE DIAMETER	10.75, 9.875, 8 in	**Blank**	**330**	**332.26**	**2.26**	**PVC**	**Sch 80**	**4 / ID**		
SURFACE ELEVATION	34.19 ft NAVD88									
TOC ELEVATION	36.93 ft NAVD88 (RP)									
START DATE	2/02/15									
FINISH DATE	2/09/15									



Lithologic Log

Graphic Log

NOTE: Grain size distribution percentages are approximate. Material code (e.g. SP) reference Unified Soil Classification visual method. Color code (e.g. 10YR 5/2) reference Munsell Soil Color Charts.

Depth bgs (feet) | Sieve Sample Number | Drill Rate (ft/hr)

NO SAMPLE: excavated material recompacted for first 2 ft.

SAND (SP): brown (10YR 5/3), 100% fine to medium grained sand, angular to subangular; well sorted; dry sample; contains quartz, feldspar, amphibole, and other.

SAND (SP): yellowish brown (10YR 5/4), 100% fine to medium grained sand, angular to subrounded; trace fine gravel up to 10 mm, angular to subrounded; trace silt; well sorted; dry sample; contains quartz, feldspar, amphibole, and other.

SILTY SAND (SM): brown (10YR 5/3), 80% fine to coarse grained sand, subangular to subrounded; 20% silt; medium sorted; moist sample; contains quartz, feldspar, amphibole, and other.

SAND (SP): light yellowish brown (10YR 6/4), 100% fine to coarse grained sand, subangular to subrounded, predominantly fine to medium grains; medium to well sorted; dry sample; contains quartz, feldspar, amphibole, and other.

SILTY SAND (SM): brown (10YR 5/3), 85% fine to medium grained sand, subangular to subrounded; 15% silt; medium sorted; moist sample; contains quartz, feldspar, amphibole, and other.

SAND (SP): light yellowish brown (10YR 6/4), 95% fine to medium grained sand, subangular to subrounded; 5% silt; well sorted; dry sample; contains quartz, feldspar, amphibole, and other.

SAND (SP): brownish yellow (10YR 6/6), 100% fine to coarse grained sand, subangular to subrounded, predominantly medium grains; trace silt; well sorted; moist sample; contains quartz, amphibole, and other.

SAND WITH SILT (SP-SM): brown (10YR 5/3), 90% fine to medium grained sand, subangular to subrounded; 10% silt; medium sorted; moist sample; contains quartz, feldspar, amphibole, and other.

SAND (SP): pale brown (10YR 6/3), 100% fine to coarse grained sand, angular to subangular; medium sorted; wet sample; contains

Drill Rate (ft/hr): 12, 22

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WELL NUMBER **MPWSP MW-3D**

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am
PROJECT NUMBER 14077-15
LOCATION **Marina, CA**

True Vertical Depth (feet)	(continued)	Graphic Log	Lithologic Log NOTE: Grain size distribution percentages are approximate. Material code (e.g. SP) reference Unified Soil Classification visual method. Color code (e.g. 10YR 5/2) reference Munsell Soil Color Charts.	Depth bgs (feet)	Sieve Sample Number	Drill Rate (ft/hr)
			quartz, feldspar, amphibole, and other.			
35				35		22
			SAND (SP): pale brown (10YR 6/3), 95% fine to coarse grained sand, angular to subangular; 5% fine gravel up to 5 mm, angular to subangular; trace silt; medium to well sorted; wet sample; contains quartz, feldspar, amphibole, and other; 10% gravel from 50.1-50.2 ft bgs.			
40				40		
45				45		
50				50		
			SAND (SP): light olive gray (5Y 6/2), 100% fine to coarse grained sand, subangular; trace silt; medium to well sorted; wet sample; contains quartz, feldspar, mica, amphibole, and other; fine to medium sand (52.4 to 54.6 ft bgs) grading to coarse sand (54.6 to 60.7 ft bgs).			
55				55	1	
60				60		
			SAND (SP): olive (5Y 5/3), 100% sand, subangular to subrounded, very fine to fine; trace silt; well sorted; moist sample; contains quartz, feldspar, mica, amphibole, and other; high mica and biotite content.			
65				65		
			SAND (SP): olive brown (2.5Y 4/3), 95% sand, subrounded, very fine to fine with trace medium grains; 5% silt; well sorted; wet sample; contains quartz, mica, amphibole, and other; high mica content.			
70				70		

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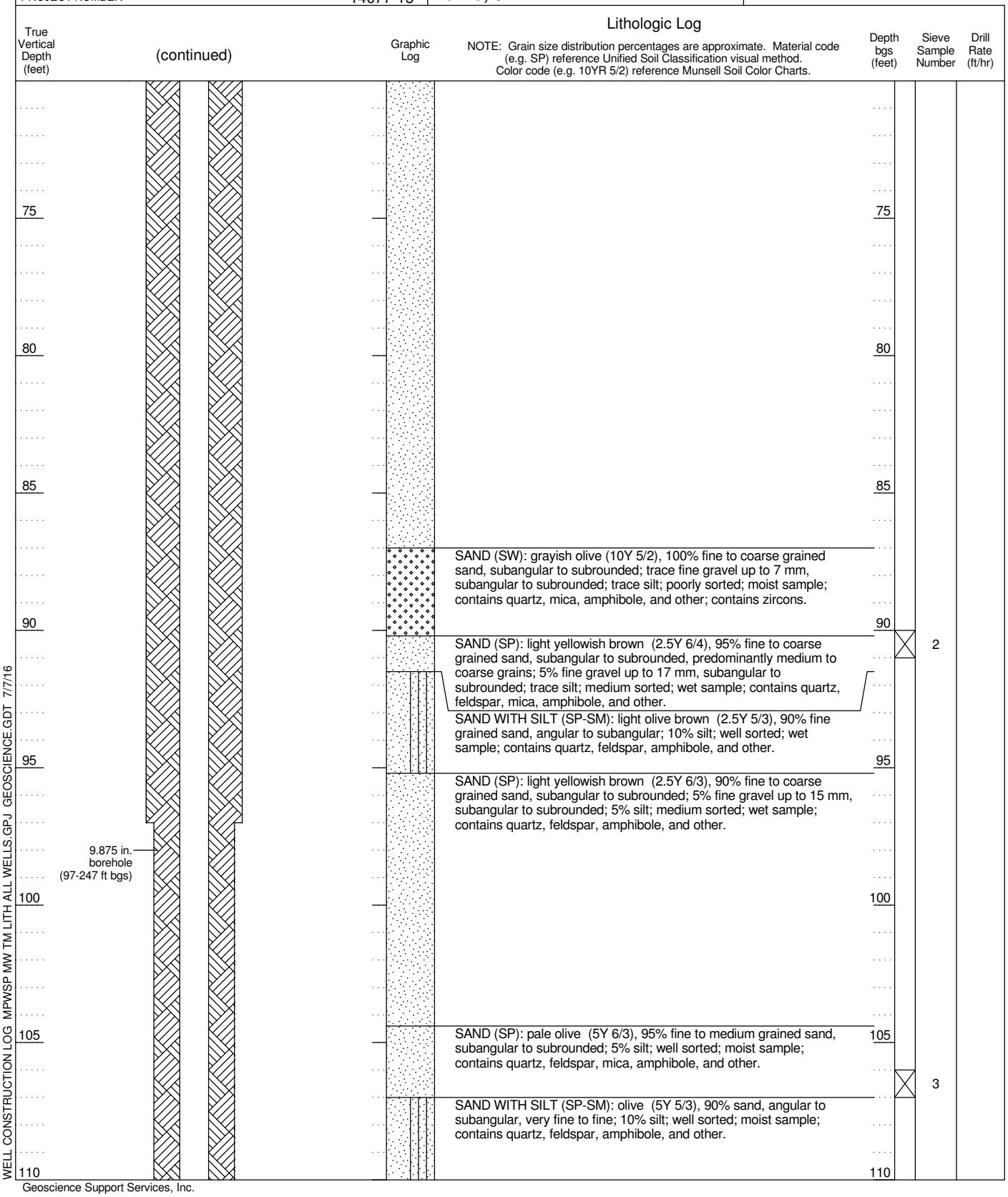
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WELL NUMBER **MPWSP MW-3D**

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am
PROJECT NUMBER 14077-15
LOCATION **Marina, CA**



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WELL NUMBER **MPWSP MW-3D**

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am
PROJECT NUMBER 14077-15
LOCATION **Marina, CA**

True Vertical Depth (feet)	(continued)	Graphic Log	Lithologic Log NOTE: Grain size distribution percentages are approximate. Material code (e.g. SP) reference Unified Soil Classification visual method. Color code (e.g. 10YR 5/2) reference Munsell Soil Color Charts.	Depth bgs (feet)	Sieve Sample Number	Drill Rate (ft/hr)
115				115		
			SAND (SP): light olive brown (2.5Y 5/3) and pale olive (5Y 6/3), 95% fine to medium grained sand, subangular to subrounded; 5% silt; well sorted; contains quartz, feldspar, amphibole, and other; pale olive from 112.5 to 117 ft.			
120				120		
125				125	4	20
			SAND (SP): light gray (2.5Y 7/2), 95% fine to medium grained sand, subangular to subrounded, trace coarse; 5% silt; well sorted; contains quartz, and amphibole; predominantly quartz.			
130				130		
135				135		
			CLAYEY SAND (SC): light olive brown (2.5Y 5/4), 85% fine grained sand, subangular; 15% clay, low plasticity; well sorted; contains quartz, mica, amphibole, and other.			
			SILTY SAND (SM): pale olive (5Y 6/3), 80% fine to coarse grained sand, subangular to subrounded; 15% silt; 5% fine gravel up to 38 mm, subangular to subrounded; poorly to medium sorted; contains quartz, feldspar, mica, and amphibole.			
140				140		
			CLAYEY SAND (SC): pale olive (5Y 6/3), 85% fine grained sand, subangular to subrounded; 15% clay, low plasticity; well sorted; contains quartz, feldspar, and amphibole.			
			CLAYEY SAND WITH GRAVEL (SC): dark yellowish brown (10YR 4/4), 65% fine to coarse grained sand, subangular to subrounded; 20% clay, low plasticity; 15% fine to coarse gravel up to 20 mm, subangular to subrounded; poorly sorted; contains quartz, feldspar, amphibole, and other.			15
145			CLAY (CH): light olive brown (2.5Y 5/3), 100% clay, high plasticity.	145		
			SAND WITH CLAY AND GRAVEL (SP-SC): pale olive (5Y 6/3), 70% fine to coarse grained sand, subangular to subrounded; 20% fine to coarse gravel up to 20 mm, subangular to subrounded; 10% clay, low to medium plasticity; poorly to medium sorted; contains quartz, feldspar, amphibole, and other.		5	
			SAND WITH GRAVEL (SP): light olive gray (5Y 6/2), 75% fine to coarse grained sand, subangular to subrounded; 25% fine to coarse gravel; medium sorted; contains quartz, feldspar, amphibole, and			
150				150		

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WELL NUMBER **MPWSP MW-3D**

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am
PROJECT NUMBER 14077-15
LOCATION **Marina, CA**

True Vertical Depth (feet)	(continued)	Graphic Log	Lithologic Log NOTE: Grain size distribution percentages are approximate. Material code (e.g. SP) reference Unified Soil Classification visual method. Color code (e.g. 10YR 5/2) reference Munsell Soil Color Charts.	Depth bgs (feet)	Sieve Sample Number	Drill Rate (ft/hr)
			other.			
			SAND WITH SILT (SP-SM): yellowish brown (10YR 5/6), 90% sand, subrounded, very fine to fine; 10% silt; well sorted; contains quartz, feldspar, amphibole, and other.			
155				155		15
160			SAND (SP): dark yellowish brown (10YR 4/6), 95% sand, subangular to subrounded, very fine to fine; 5% silt; well sorted; weak cementation; contains quartz, feldspar, amphibole, and other.	160		
			CLAY (CH): brown (10YR 4/3), 100% clay, high plasticity; contains mica; trace fine mica.			
165				165		
			SILTY SAND (SM): pale olive (5Y 6/3), 85% fine grained sand, subangular to subrounded; 15% silt; well sorted; contains quartz, mica, amphibole, and other.			
170				170	6	
			SILT (ML): light olive brown (2.5Y 5/4), 100% silt, brittle; low plasticity; thin interbeds of medium to coarse sand from 170.5 to 171 ft bgs.			
			SAND (SP): olive (5Y 5/3), 95% fine to medium grained sand; 5% silt; well sorted; contains quartz, mica, and amphibole; interbeds of high to medium plasticity clay.			
175				175		
			SAND (SP): dark yellowish brown (10YR 4/4), 100% fine to medium grained sand, subangular to subrounded; trace silt; well sorted; weak cementation; contains quartz, mica, amphibole, and other; high dark mineral content.			
180				180		
185				185		
190				190		

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WELL NUMBER **MPWSP MW-3D**

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am
PROJECT NUMBER 14077-15
LOCATION **Marina, CA**

True Vertical Depth (feet)	Lithologic Log (continued)	Graphic Log	NOTE: Grain size distribution percentages are approximate. Material code (e.g. SP) reference Unified Soil Classification visual method. Color code (e.g. 10YR 5/2) reference Munsell Soil Color Charts.	Depth bgs (feet)	Sieve Sample Number	Drill Rate (ft/hr)
195			CLAYEY SAND (SC): brown (7.5YR 4/4), 60% fine grained sand, subrounded; 40% clay, low plasticity; well sorted; weak cementation; contains quartz, feldspar, amphibole, and other.	195		
			SANDY CLAY (CL): yellowish brown (10YR 5/6), 60% clay, low to medium plasticity; 40% fine grained sand, subangular to subrounded; contains quartz, feldspar, amphibole, and other.			
200			SANDY CLAY (CL): dark yellowish brown (10YR 4/6), 60% clay, low plasticity; 40% fine grained sand, subangular to subrounded; contains quartz, feldspar, amphibole, and other; high dark mineral content.	200		
			SANDY SILT (ML): brown (10YR 5/3), 55% silt; 45% fine grained sand, subangular to subrounded; weak cementation; contains quartz, feldspar, amphibole, and other; high dark mineral content.		7	
205			SILTY SAND (SM): light olive brown (2.5Y 5/3), 60% fine to medium grained sand, subangular to subrounded; 40% silt; well sorted; weak cementation; contains quartz, feldspar, amphibole, and other; high dark mineral content.	205	8	
			SAND WITH SILT (SP-SM): olive brown (2.5Y 4/3), 90% fine to medium grained sand, subangular to subrounded; 10% silt; well sorted; weak cementation; contains quartz, feldspar, amphibole, and other; oxidation; high dark mineral content.			
210				210		
			SILTY SAND (SM): olive (5Y 5/3), 80% fine to medium grained sand, subangular to subrounded; 20% silt; well sorted; contains quartz, feldspar, amphibole, and other; high abundance of minerals; oxidation from 215 to 216 ft.			
215				215		
			SILT (ML): olive (5Y 5/3), 100% silt, brittle; low plasticity.			15
220			SAND (SP): pale olive (5Y 6/3), 95% fine to coarse grained sand, subangular to subrounded; 5% silt; medium sorted; contains quartz, feldspar, mica, amphibole, and other.	220		
			SAND WITH CLAY AND GRAVEL (SP-SC): pale olive (5Y 6/3), 75% fine to coarse grained sand, subangular to subrounded; 15% fine to coarse gravel up to 25 mm, subangular to subrounded; 10% clay, low plasticity; poorly sorted; contains quartz, feldspar, mica, amphibole, and other.			
225			SAND (SP): light olive gray (5Y 6/2), 85% fine to coarse grained sand, angular to subangular; 10% fine gravel angular to subangular; 5% clay; medium sorted; contains quartz, feldspar, mica, and amphibole.	225	9	
			SANDY SILT (ML): olive (5Y 5/3), 65% silt, low plasticity; 35% fine grained sand, subangular; contains quartz, and mica.			5
230				230		

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WELL NUMBER **MPWSP MW-3D**

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am
PROJECT NUMBER 14077-15
LOCATION **Marina, CA**

(continued)

True Vertical Depth (feet)	Graphic Log	Lithologic Log NOTE: Grain size distribution percentages are approximate. Material code (e.g. SP) reference Unified Soil Classification visual method. Color code (e.g. 10YR 5/2) reference Munsell Soil Color Charts.	Depth bgs (feet)	Sieve Sample Number	Drill Rate (ft/hr)
		SAND WITH SILT (SP-SM): light olive brown (2.5Y 5/4), 90% fine to medium grained sand, subangular to subrounded; 10% silt; medium sorted; contains quartz, feldspar, mica, amphibole, and other.		10	
235		SILT (ML): light olive brown (2.5Y 5/3), 100% silt; medium plasticity; trace mica.	235		
240			240		
		CLAY (CH): olive brown (2.5Y 4/4), 100% clay, medium to high plasticity.			5
245		CLAY (CH): dark greenish gray (10Y 4/1), 100% clay, high plasticity; olive (5Y 5/3) from 247-249.3 ft bgs.	245		
250		CLAYEY SAND (SC): olive (5Y 4/3), 85% fine grained sand, subangular; 15% clay, low plasticity; well sorted; weak cementation; contains quartz, feldspar, mica, amphibole, and other.	250		
		SAND WITH CLAY (SP-SC): olive (5Y 5/3), 85% fine to coarse grained sand, subangular to subrounded; 10% clay; 5% fine to coarse gravel up to 19 mm, subangular to subrounded; medium sorted; contains quartz, mica, amphibole, and other.			
255		SAND (SP): olive gray (5Y 5/2), 85% medium to coarse grained sand, subangular to subrounded; 10% gravel up to 12 mm, subangular to subrounded; 5% clay; medium sorted; contains quartz, feldspar, mica, amphibole, and other.	255	11	
		SAND (SP): light brownish gray (2.5Y 6/2), 80% fine to coarse grained sand, subangular to subrounded; 15% fine to coarse gravel up to 26 mm; 5% clay; medium sorted; contains quartz, feldspar, mica, amphibole, and other.			
260			260		
					15
265		CLAY (CH): olive (5Y 5/3), 100% clay, high plasticity.	265		
270			270		

8 in. borehole (247 - 332.5 ft bgs)

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WELL NUMBER **MPWSP MW-3D**

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am | LOCATION **Marina, CA**
PROJECT NUMBER 14077-15

True Vertical Depth (feet)	(continued)	Graphic Log	Lithologic Log NOTE: Grain size distribution percentages are approximate. Material code (e.g. SP) reference Unified Soil Classification visual method. Color code (e.g. 10YR 5/2) reference Munsell Soil Color Charts.	Depth bgs (feet)	Sieve Sample Number	Drill Rate (ft/hr)
275	CEMEX Monterey Lapis Lustre #60 fine sand seal (272-275 ft bgs)		CLAY (CL): olive gray (5Y 5/2), 80% clay, low to medium plasticity; 15% fine to coarse grained sand, subangular to subrounded; 5% fine gravel up to 15 mm; contains quartz, feldspar, amphibole, and other.	275		
			GRAVELLY CLAY (CL): pale olive (5Y 6/3), 60% clay, medium plasticity; 30% fine to coarse gravel up to 45 mm, subrounded; 10% fine to coarse grained sand, subrounded; contains quartz, feldspar, amphibole, and other.			
	CEMEX Monterey Lapis Lustre #3 filter pack (275-332.5 ft bgs)		SAND WITH CLAY (SP-SC): olive gray (5Y 5/2), 90% fine grained sand, subangular to subrounded, trace medium grains; 10% clay, no to low plasticity; medium to well sorted; contains quartz, mica, amphibole, and other.		12	15
280			SANDY CLAY (CL): pale olive (5Y 6/3), 55% clay, low plasticity; 30% fine to coarse grained sand, subangular to subrounded; 15% fine to coarse gravel up to 60 mm, subangular to subrounded; contains quartz, mica, and amphibole; increased gravel with depth to 35%.	280		
			CLAY (CH): light olive brown (2.5Y 5/4), 100% clay, medium to high plasticity.			
285			SAND (SP): light olive brown (2.5Y 5/4), 95% fine to medium grained sand, subangular to subrounded, trace coarse; 5% clay; contains quartz, feldspar, mica, and amphibole.	285		
	4 in. ID x Sch 80 wall PVC well screen with 0.040 in. slots (285-330 ft bgs)		SAND (SP): grayish brown (2.5Y 5/2), 95% fine to coarse grained sand, subangular to subrounded; 5% fine to coarse gravel up to 40 mm; trace clay; contains quartz, feldspar, mica, and amphibole.			
290				290		
			SAND WITH GRAVEL (SP): light yellowish brown (2.5Y 6/3), 70% medium to coarse grained sand, subangular to subrounded; 25% fine to coarse gravel up to 35 mm, subangular to subrounded; 5% clay; contains quartz, feldspar, mica, and amphibole.			
295			CLAY (CH): yellowish brown (10YR 5/6), 100% clay, medium plasticity; trace interbeds of medium to coarse sand.	295		
			SAND WITH CLAY AND GRAVEL (SP-SC): light olive brown (2.5Y 5/3), 65% fine to coarse grained sand, subangular to subrounded; 25% fine to coarse gravel up to 22 mm, subangular to subrounded; 10% clay, low plasticity; medium sorted; contains quartz, feldspar, mica, and amphibole.		13	
300			SAND (SP): light olive brown (2.5Y 5/6), 95% fine to medium grained sand, subangular to subrounded; 5% clay; well sorted; contains quartz, feldspar, mica, and amphibole.	300		
305				305	14	
			SAND (SP): olive brown (2.5Y 4/3), 85% fine to coarse grained sand; 10% fine gravel up to 6 mm; 5% clay; medium sorted; contains quartz, feldspar, mica, and amphibole.			
310				310		

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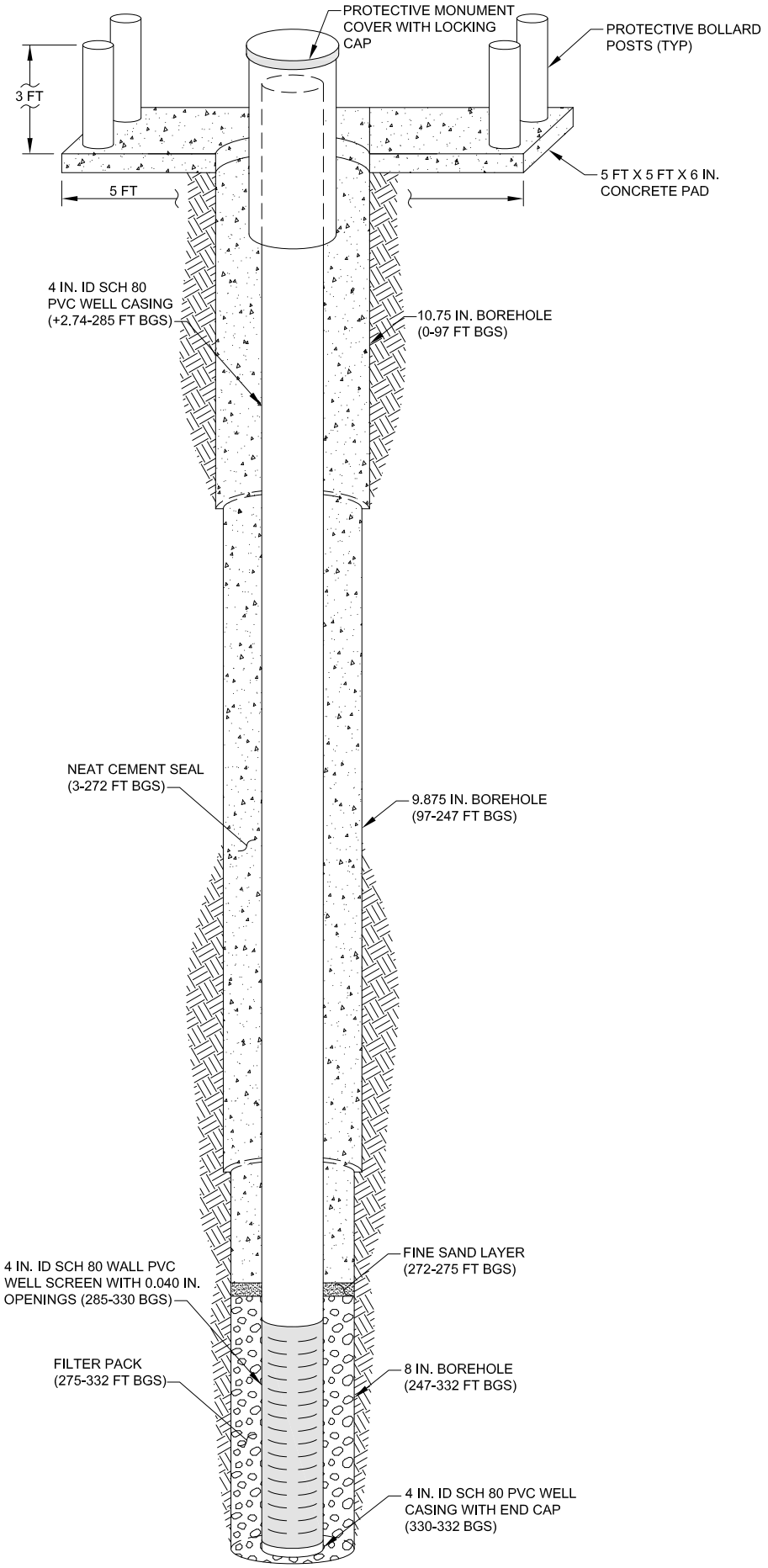
BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am
PROJECT NUMBER 14077-15
LOCATION **Marina, CA**

True Vertical Depth (feet)	(continued)	Graphic Log	Lithologic Log NOTE: Grain size distribution percentages are approximate. Material code (e.g. SP) reference Unified Soil Classification visual method. Color code (e.g. 10YR 5/2) reference Munsell Soil Color Charts.	Depth bgs (feet)	Sieve Sample Number	Drill Rate (ft/hr)
			SAND WITH GRAVEL (SP): olive brown (2.5Y 4/4), 80% fine to coarse grained sand, angular to subangular; 15% fine to coarse gravel up to 15 mm, angular to subangular; 5% clay; medium sorted; contains quartz, feldspar, mica, and amphibole.			
315			CLAYEY GRAVEL WITH SAND (GC): light olive brown (2.5Y 5/4), 45% fine to coarse gravel up to 15 mm, subrounded; 30% clay, medium plasticity; 25% fine to coarse grained sand, subrounded; poorly sorted; contains quartz, feldspar, and amphibole.	315		
			SAND (SP): light olive brown (2.5Y 5/3), 85% fine to coarse grained sand, subangular to subrounded; 10% fine gravel up to 7 mm, subangular to subrounded; 5% clay, low plasticity; medium sorted; contains quartz, feldspar, mica, and amphibole; gravel up to 45 mm from 315.2 to 315.5 ft.			
320			SAND WITH GRAVEL (SP): light olive brown (2.5Y 5/4), 75% fine to coarse grained sand, subangular to subrounded; 20% fine to coarse gravel up to 60 mm; 5% clay; medium to well sorted; contains quartz, feldspar, mica, amphibole, and other.	320		
			GRAVEL WITH CLAY AND SAND (GP-GC): pale olive (5Y 6/3), 55% fine to coarse gravel up to 29 mm, subangular to subrounded; 35% fine to coarse grained sand; 10% clay, low plasticity; poorly to medium sorted; contains quartz, feldspar, mica, and amphibole.			
			SAND (SP): pale olive (5Y 6/3), 85% fine to coarse grained sand; 10% fine gravel up to 7 mm; 5% clay; medium to well sorted; contains quartz, feldspar, mica, and amphibole.			
325				325		
			SAND (SP): light olive brown (2.5Y 5/3), 95% fine to medium grained sand, subangular to subrounded; 5% clay; well sorted; contains quartz, feldspar, mica, and amphibole.			
330				330		
	Blank casing with end cap (330-332.26 ft bgs) TD 332.5 ft bgs		Bottom of borehole at 332.5 feet.			

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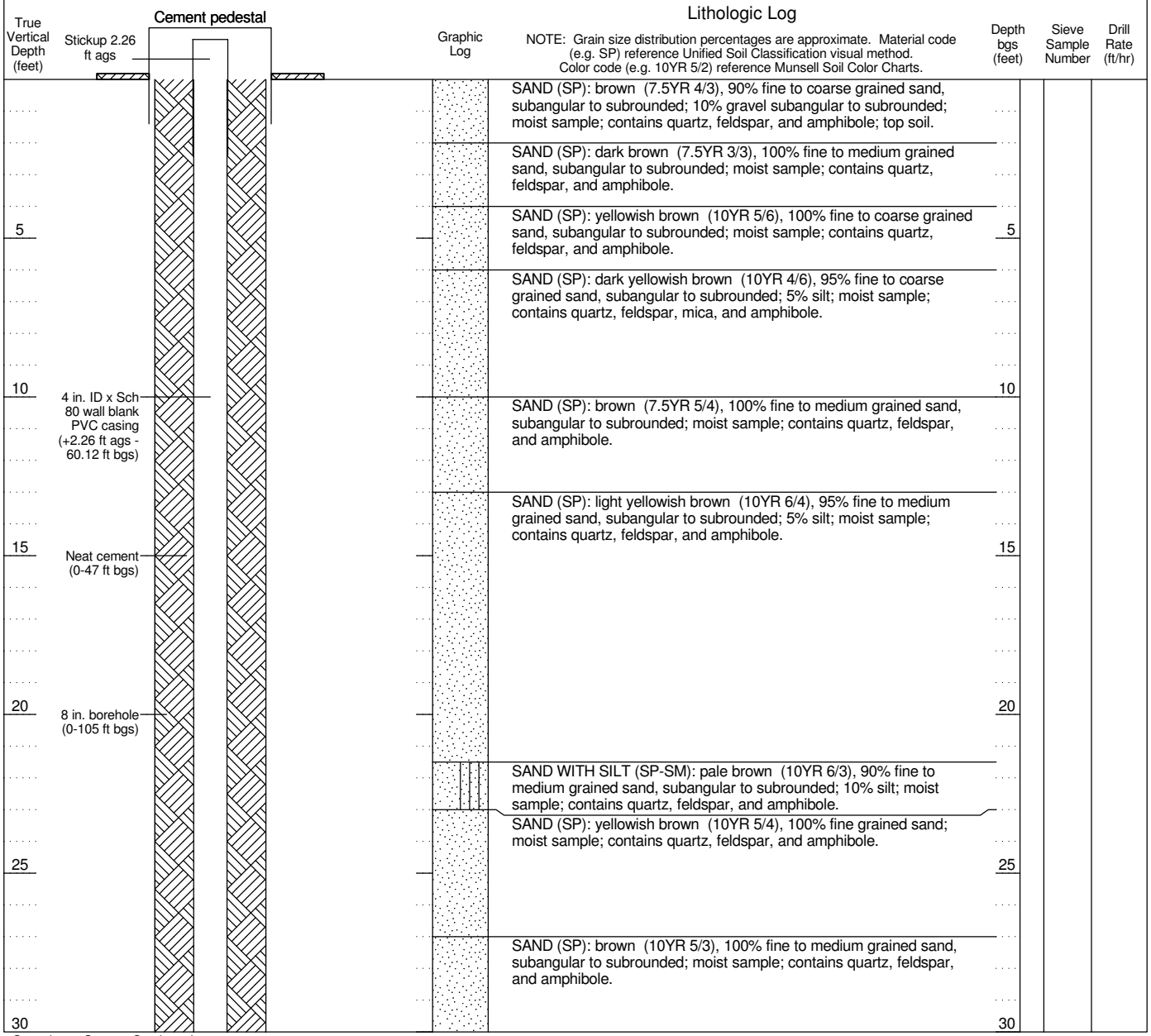
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BOREHOLE LITHOLOGIC LOG

WELL NUMBER **MPWSP MW-4S**	
CLIENT: Cal Am	LOCATION: **Marina, CA**
PROJECT NUMBER: 14077-15	**Entrance to CEMEX**
REPORT DATE:	
DRILLING CONTRACTOR: Cascade Drilling	LOGGED BY: **A. Khalighi**
DRILLER: D. King	

		SCREEN / BLANK	TOP DEPTH (ft bgs)	BOTTOM DEPTH (ft bgs)	LENGTH (ft)	MATERIAL	WALL THICKNESS (in.)	DIAMETER (in.)	SCREEN TYPE	PERF. SIZE (in.)
DRILLING RIG TYPE	ProSonic 600T									
DRILLING METHOD	Sonic	**Blank**	**-2.26**	**60.12**	**62.38**	**PVC**	**Sch 80**	**4 / ID**		
SAMPLING METHOD	Core	**Screen**	**60.12**	**100.12**	**40**	**PVC**	**Sch 80**	**4 / ID**	**Slotted**	**0.04**
BOREHOLE DIAMETER	8 in	**Blank**	**100.12**	**102.5**	**2.38**	**PVC**	**Sch 80**	**4 / ID**		
SURFACE ELEVATION	39.70 ft NAVD88									
TOC ELEVATION	41.96 ft NAVD88 (RP)									
START DATE	2/10/15									
FINISH DATE	2/11/15									



WELL CONSTRUCTION LOG MPWSP MW TM LITH ALL WELLS.GPJ GEOSCIENCE.GDT 7/7/16

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WELL NUMBER **MPWSP MW-4S**

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am
PROJECT NUMBER 14077-15
LOCATION **Marina, CA**

True Vertical Depth (feet)	(continued)	Graphic Log	Lithologic Log NOTE: Grain size distribution percentages are approximate. Material code (e.g. SP) reference Unified Soil Classification visual method. Color code (e.g. 10YR 5/2) reference Munsell Soil Color Charts.	Depth bgs (feet)	Sieve Sample Number	Drill Rate (ft/hr)
35			SAND (SP): light brown (7.5YR 6/3), 95% fine to coarse grained sand, subangular to subrounded; 5% silt; moist sample; contains quartz, feldspar, mica, and amphibole.	35		
40			SAND (SP): brown (7.5YR 5/4), 95% fine to coarse grained sand, subangular to subrounded; 5% silt; moist sample; contains quartz, feldspar, mica, and amphibole; contains coarse sand layers.	40		
45				45		
50	CEMEX Monterey Lapis Lustre #60 fine sand seal (47-50 ft bgs)		SAND (SP): yellowish brown (10YR 5/4), 100% fine to coarse grained sand, subangular to subrounded; moist sample; contains quartz, feldspar, mica, and amphibole.	50		
			SAND (SP): brown (10YR 5/3), 95% fine to medium grained sand, subangular to subrounded; 5% silt; moist sample; contains quartz, feldspar, mica, and amphibole.			19
55	CEMEX Monterey Lapis Lustre #3 filter pack (50-105 ft bgs)			55		
60				60		
	4 in. ID x Sch 80 wall PVC well screen with 0.040 in. slots (60.12-100.12 ft bgs)		SAND (SW): brown (10YR 5/3), 100% fine to coarse grained sand, subangular to subrounded; trace fine gravel subangular to subrounded; moist sample; contains quartz, feldspar, mica, and amphibole.			
65			SAND WITH GRAVEL (SP): brown (10YR 5/3), 75% fine to coarse grained sand, subangular to subrounded, mostly coarse grained; 25% fine gravel subangular to subrounded; moist to wet sample; contains quartz, feldspar, mica, and amphibole.	65		
70			SAND (SP): brown (10YR 5/3), 95% fine grained sand, very fine grained; 5% silt; wet sample; contains quartz, feldspar, mica, and	70		

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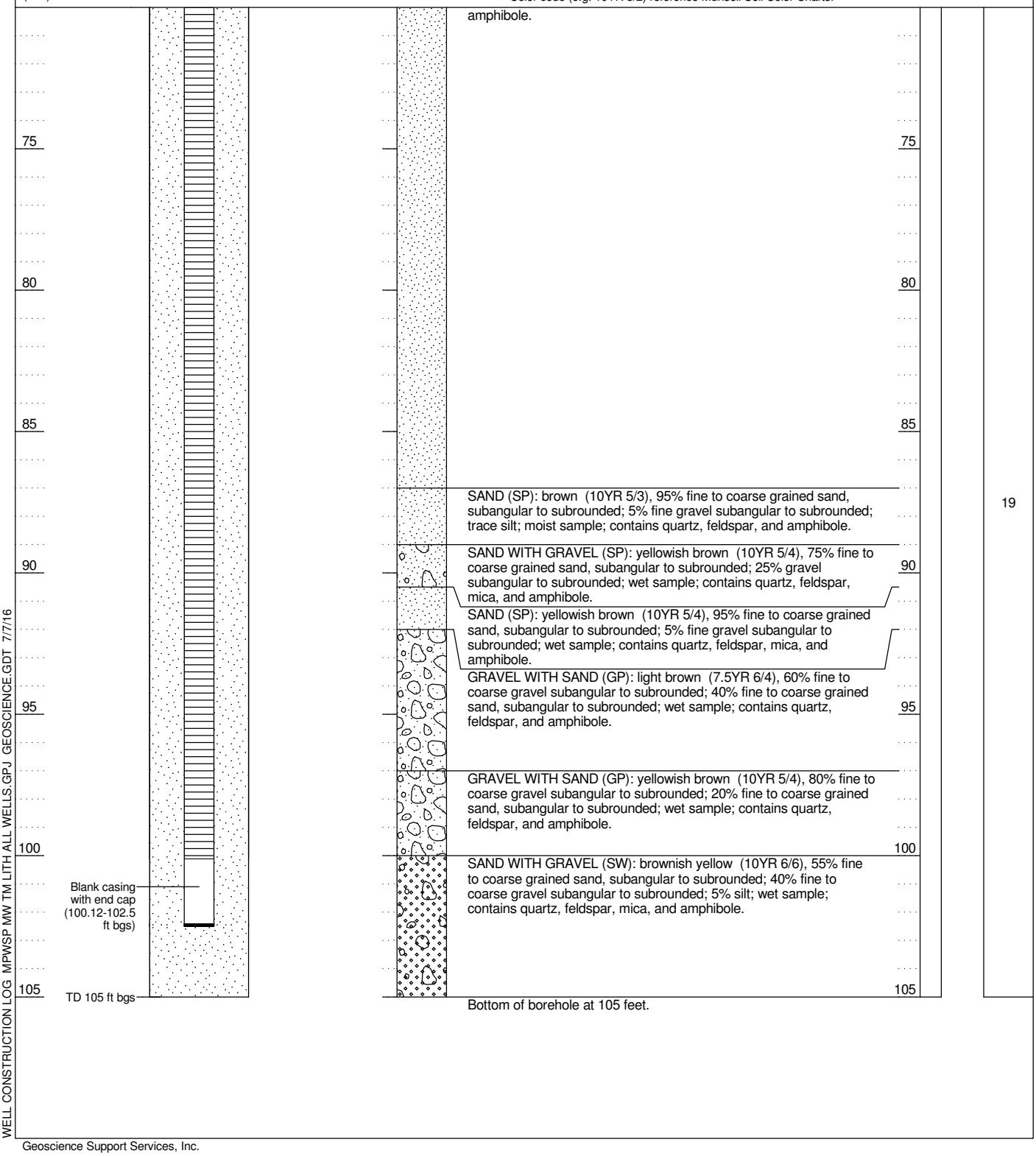
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WELL NUMBER **MPWSP MW-4S**

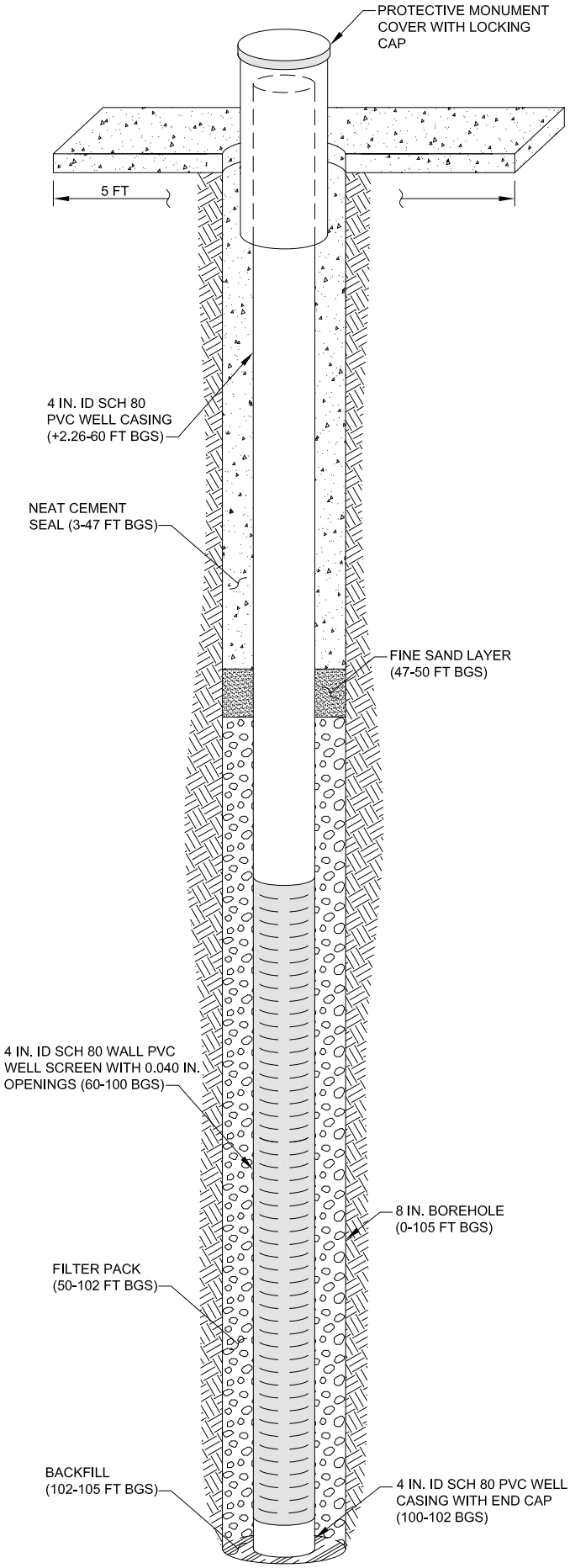
BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am
PROJECT NUMBER 14077-15
LOCATION **Marina, CA**



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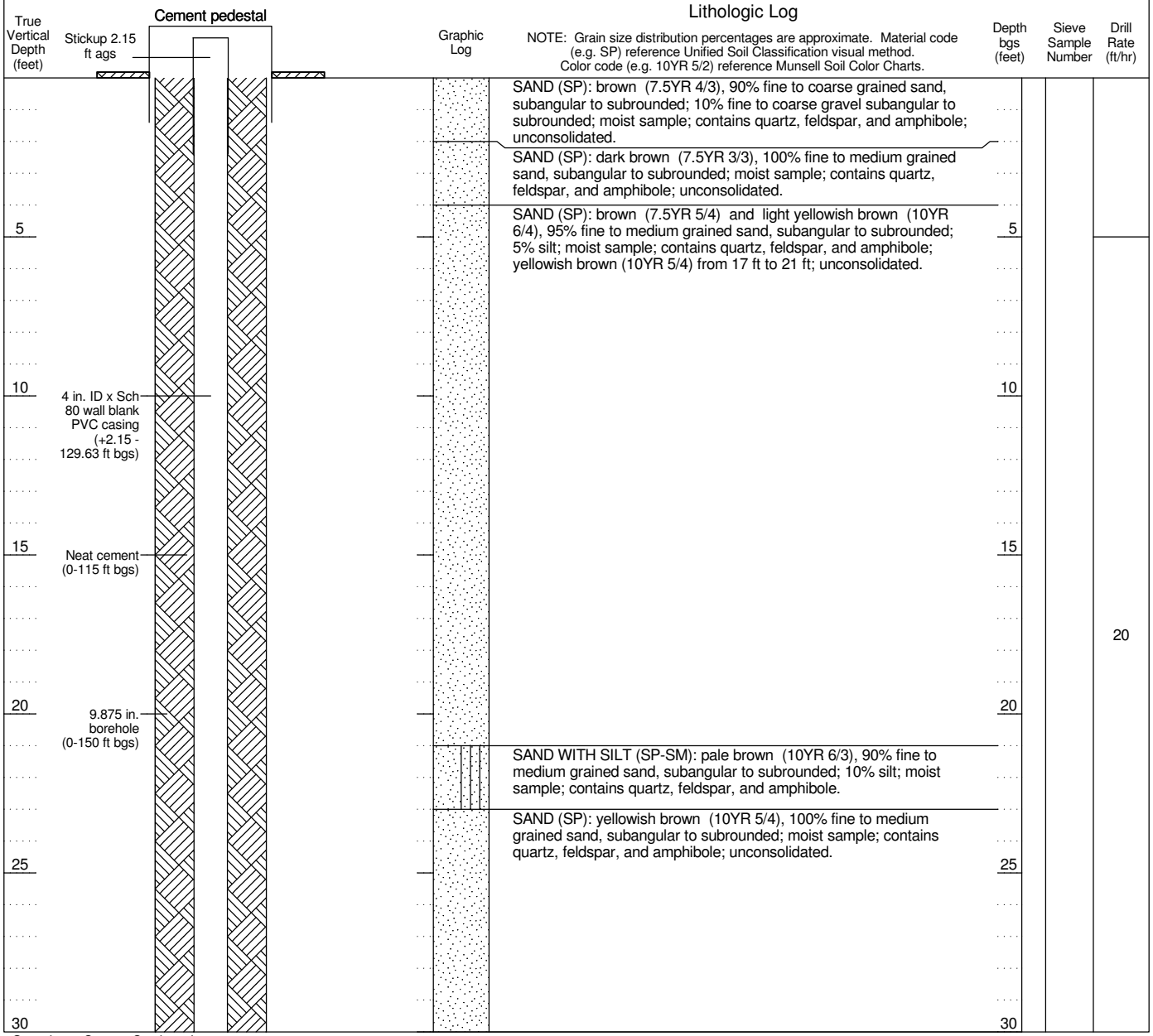
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BOREHOLE LITHOLOGIC LOG

WELL NUMBER **MPWSP MW-4M**	
CLIENT: Cal Am	LOCATION: **Marina, CA**
PROJECT NUMBER: 14077-15	**Entrance to CEMEX**
REPORT DATE:	
DRILLING CONTRACTOR: Cascade Drilling	LOGGED BY: **A. Khalighi**
DRILLER: D. King	

		SCREEN / BLANK	TOP DEPTH (ft bgs)	BOTTOM DEPTH (ft bgs)	LENGTH (ft)	MATERIAL	WALL THICKNESS (in.)	DIAMETER (in.)	SCREEN TYPE	PERF. SIZE (in.)
DRILLING RIG TYPE	ProSonic 600T									
DRILLING METHOD	Sonic	**Blank**	**-2.15**	**129.63**	**131.78**	**PVC**	**Sch 80**	**4 / ID**		
SAMPLING METHOD	Core	**Screen**	**129.63**	**259.63**	**130**	**PVC**	**Sch 80**	**4 / ID**	**Slotted**	**0.04**
BOREHOLE DIAMETER	9.875, 8 in	**Blank**	**259.63**	**262**	**2.37**	**PVC**	**Sch 80**	**4 / ID**		
SURFACE ELEVATION	39.84 ft NAVD88									
TOC ELEVATION	41.99 ft NAVD88 (RP)									
START DATE	2/06/15									
FINISH DATE	2/09/15									



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WELL NUMBER **MPWSP MW-4M**

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am
PROJECT NUMBER 14077-15
LOCATION **Marina, CA**

True Vertical Depth (feet)	(continued)	Graphic Log	Lithologic Log NOTE: Grain size distribution percentages are approximate. Material code (e.g. SP) reference Unified Soil Classification visual method. Color code (e.g. 10YR 5/2) reference Munsell Soil Color Charts.	Depth bgs (feet)	Sieve Sample Number	Drill Rate (ft/hr)
			SAND (SP): brown (7.5YR 5/3), 100% fine to medium grained sand, subangular to subrounded; moist sample; contains quartz, feldspar, and amphibole.			
35			SAND (SP): light brown (7.5YR 6/3), 100% fine to coarse grained sand, subangular to subrounded; moist to wet sample; contains quartz, feldspar, mica, and amphibole; unconsolidated.	35		
40				40		
45			SAND (SP): brown (7.5YR 5/4), 100% fine to coarse grained sand, subangular to subrounded; moist to wet sample; contains quartz, feldspar, mica, and amphibole; unconsolidated.	45		
50			SAND (SW): yellowish brown (10YR 5/4), 100% fine to coarse grained sand, angular to subangular; moist to wet sample; contains quartz, feldspar, and amphibole; unconsolidated.	50		20
55			SAND (SP): brown (10YR 5/3), 95% fine to medium grained sand, subangular to subrounded; 5% silt; moist to wet sample; contains quartz, feldspar, and amphibole; unconsolidated.	55		
60				60		
65			SAND (SW): brown (10YR 5/3), 95% fine to coarse grained sand; 5% silt; moist to wet sample; contains quartz, feldspar, mica, and amphibole.	65		
			SAND WITH GRAVEL (SP): brown (10YR 5/3), 75% fine to coarse grained sand, subangular to subrounded; 25% fine gravel subangular to subrounded; moist to wet sample; contains quartz, feldspar, mica, and amphibole; unconsolidated.			
70			SAND (SP): brown (10YR 5/3), 100% sand, subangular to subrounded, very fine to fine grained; moist to wet sample; contains quartz, feldspar, mica, and amphibole; unconsolidated.	70		

WELL CONSTRUCTION LOG MPWSP MW TM LITH ALL WELLS.GPJ GEOSCIENCE.GDT 7/7/16

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WELL NUMBER **MPWSP MW-4M**

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am
PROJECT NUMBER 14077-15
LOCATION **Marina, CA**

True Vertical Depth (feet)	(continued)	Graphic Log	Lithologic Log NOTE: Grain size distribution percentages are approximate. Material code (e.g. SP) reference Unified Soil Classification visual method. Color code (e.g. 10YR 5/2) reference Munsell Soil Color Charts.	Depth bgs (feet)	Sieve Sample Number	Drill Rate (ft/hr)
75				75		
80				80		
85				85		
90			SAND (SP): light yellowish brown (10YR 6/4), 95% fine to coarse grained sand, subangular to subrounded; 5% fine gravel subangular to subrounded; moist to wet sample; contains quartz, feldspar, mica, and amphibole; unconsolidated.	90		20
			SAND WITH GRAVEL (SP): yellowish brown (10YR 5/4), 80% fine to coarse grained sand, subangular to subrounded; 20% fine to coarse gravel subangular to subrounded; contains quartz, feldspar, mica, and amphibole; unconsolidated.			
			SAND (SP): yellowish brown (10YR 5/4), 95% fine to coarse grained sand, subangular to subrounded; 5% fine gravel subangular to subrounded; moist sample; contains quartz, feldspar, mica, and amphibole; unconsolidated.			
95			GRAVEL WITH SAND (GP): light brown (7.5YR 6/4), 60% fine gravel subangular to subrounded; 40% fine to coarse grained sand, subangular to subrounded; moist to wet sample; contains quartz, feldspar, mica, and amphibole; transitions to approximately 80% gravel and 20% sand with increasing depth; unconsolidated.	95		
100			SAND WITH GRAVEL (SP): brownish yellow (10YR 6/6), 55% fine to coarse grained sand, subangular to subrounded; 40% fine to coarse gravel subangular to subrounded; 5% silt; moist to wet sample; contains quartz, feldspar, mica, and amphibole; unconsolidated.	100		
105			SAND (SP): light brown (7.5YR 6/4), 95% fine to medium grained sand, subangular to subrounded; 5% fine to coarse gravel subangular to subrounded; moist to wet sample; contains quartz, feldspar, mica, and amphibole; unconsolidated.	105		
110			SAND (SP): light brown (7.5YR 6/4), 100% fine to medium grained sand, subangular to subrounded; moist to wet sample; contains quartz, feldspar, mica, and amphibole.	110		

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WELL NUMBER **MPWSP MW-4M**

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am
PROJECT NUMBER 14077-15
LOCATION **Marina, CA**

(continued)

True Vertical Depth (feet)	Graphic Log	Lithologic Log NOTE: Grain size distribution percentages are approximate. Material code (e.g. SP) reference Unified Soil Classification visual method. Color code (e.g. 10YR 5/2) reference Munsell Soil Color Charts.	Depth bgs (feet)	Sieve Sample Number	Drill Rate (ft/hr)
115		SAND (SP): brown (7.5YR 5/3), 100% sand, subangular to subrounded, very fine to fine grained; moist to wet sample; contains quartz, feldspar, mica, and amphibole.	115		
		CEMEX Monterey Lapis Lustre #60 fine sand seal (115-119.5 ft bgs)			
120			120		
		CEMEX Monterey Lapis Lustre #3 filter pack (119.5-265.5 ft bgs)			
		CLAY (CL): yellowish brown (10YR 5/6), 90% clay, high plasticity; 5% medium grained sand, subangular to subrounded; 5% silt; moist sample; contains quartz, feldspar, and amphibole.			
125		SAND WITH CLAY (SP-SC): pale olive (5Y 6/3), 90% fine to medium grained sand, subangular to subrounded; 5% silt; 5% clay; moist sample; contains quartz, mica, and amphibole; low plasticity.	125		
		CLAY (CL): brownish yellow (10YR 6/6), 95% clay, medium plasticity; 5% medium grained sand, subangular to subrounded; moist sample; contains quartz, mica, and amphibole.			20
130		SAND WITH SILT (SP-SM): pale yellow (5Y 7/3), 90% fine to medium grained sand, subangular to subrounded; 10% silt; moist to wet sample; contains quartz, feldspar, mica, and amphibole.	130		
		SAND (SP): brownish yellow (10YR 6/6), 95% sand, subangular to subrounded, very fine to fine grained; 5% silt, low plasticity; moist sample; contains quartz, feldspar, mica, and amphibole; unconsolidated.			
		4 in. ID x Sch 80 wall PVC well screen with 0.040 in. slots (129.63-259.63 ft bgs)			
		SAND WITH CLAY (SP-SC): light brown (7.5YR 6/3), 90% sand, subangular to subrounded, very fine to fine grained; 10% clay, low plasticity; moist sample; oxidation.			
135		SAND (SP): light brown (7.5YR 6/3), 90% sand; 5% gravel; 5% silt.	135		
		SAND WITH SILT (SP-SM): very pale brown (10YR 7/4), 90% fine to coarse grained sand, subangular to subrounded; 10% silt; moist to wet sample; contains quartz, feldspar, mica, and amphibole; unconsolidated.			
140			140		
145			145		23.7
150			150		

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WELL NUMBER **MPWSP MW-4M**

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am
PROJECT NUMBER 14077-15
LOCATION **Marina, CA**

(continued)

True Vertical Depth (feet)	Graphic Log	Lithologic Log NOTE: Grain size distribution percentages are approximate. Material code (e.g. SP) reference Unified Soil Classification visual method. Color code (e.g. 10YR 5/2) reference Munsell Soil Color Charts.	Depth bgs (feet)	Sieve Sample Number	Drill Rate (ft/hr)
8 in. borehole (150-265.5)		SILTY SAND (SM): light yellowish brown (10YR 6/4), 85% fine to medium grained sand, subangular to subrounded; 15% silt, low plasticity; moist to wet sample; contains quartz, mica, and amphibole.			
		SAND (SP): light brownish gray (2.5Y 6/2), 95% fine to coarse grained sand, subangular to subrounded; 5% clay, low plasticity; moist to wet sample; contains quartz, feldspar, and amphibole.			
155		SAND (SP): light yellowish brown (10YR 6/4), 85% fine to coarse grained sand, subangular to subrounded; 10% fine to coarse gravel subangular to subrounded; 5% clay; moist to wet sample; contains quartz, feldspar, and amphibole.	155		
		SAND (SP): reddish yellow (7.5YR 6/6), 90% fine to coarse grained sand, subangular to subrounded; 10% fine to coarse gravel subangular to subrounded; moist to wet sample; contains quartz, feldspar, mica, and amphibole; unconsolidated.			
160			160		
		GRAVEL WITH SILT AND SAND (GP-GM): pale brown (10YR 6/3), 55% fine to coarse gravel subangular to subrounded, rounded coarse gravel; 35% fine to coarse grained sand, subangular to subrounded; 10% silt; moist to wet sample; contains quartz, feldspar, mica, and amphibole; unconsolidated.			
165			165		
		SAND WITH SILT (SP-SM): dark yellowish brown (10YR 4/4), 90% sand, subangular to subrounded, very fine to fine grained; 10% silt; moist to wet sample.			
		FAT CLAY (CH): yellowish brown (10YR 5/8), 90% clay, high plasticity; 5% sand, very fine; 5% silt; moist sample.			
170			170		23.7
175			175		
		CLAYEY SAND (SC): brown (7.5YR 5/3), 70% fine to medium grained sand, subrounded to rounded; 25% clay, low to medium plasticity; 5% fine to coarse gravel subrounded to rounded; moist to wet sample; contains quartz, feldspar, mica, and amphibole.			
180		SAND (SP): light brown (7.5YR 6/3), 95% fine to coarse grained sand, angular to subangular; 5% silt; moist to wet sample; contains quartz, feldspar, mica, and amphibole; unconsolidated.	180		
		SILTY SAND (SM): brown (10YR 5/3), 85% fine to medium grained sand, subangular to subrounded; 15% silt, low plasticity; moist sample; contains quartz, mica, and amphibole; unconsolidated.			
		SAND (SP): light brownish gray (10YR 6/2), 95% fine to coarse grained sand, subangular to subrounded; 5% silt; moist to wet sample; contains quartz, feldspar, mica, and amphibole; unconsolidated.			
185			185		
190			190		

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WELL NUMBER
MPWSP MW-4M

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am
PROJECT NUMBER 14077-15
LOCATION **Marina, CA**

True Vertical Depth (feet)	(continued)	Graphic Log	Lithologic Log NOTE: Grain size distribution percentages are approximate. Material code (e.g. SP) reference Unified Soil Classification visual method. Color code (e.g. 10YR 5/2) reference Munsell Soil Color Charts.	Depth bgs (feet)	Sieve Sample Number	Drill Rate (ft/hr)
195			SAND (SP): dark yellowish brown (10YR 4/6) and brown (10YR 4/3), 95% fine to coarse grained sand, subangular to subrounded, higher concentration of coarse sand; 5% silt; moist to wet sample; contains quartz, feldspar, mica, and amphibole.	195		
200				200		
205				205		
210				210		23.7
215				215		
220			SAND (SP): brown (7.5YR 4/2) and red (2.5YR 4/6), 100% sand, subangular to subrounded, very fine to fine grained; moist to wet sample; contains quartz, feldspar, mica, and amphibole; unconsolidated.	220		
225				225		
230			SILT (ML): pale olive (5Y 6/4), 100% silt, very dense, medium plasticity; moist sample; oxidized staining; black ash.	230		

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WELL NUMBER **MPWSP MW-4M**

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am
PROJECT NUMBER 14077-15
LOCATION **Marina, CA**

(continued)

Lithologic Log

NOTE: Grain size distribution percentages are approximate. Material code (e.g. SP) reference Unified Soil Classification visual method. Color code (e.g. 10YR 5/2) reference Munsell Soil Color Charts.

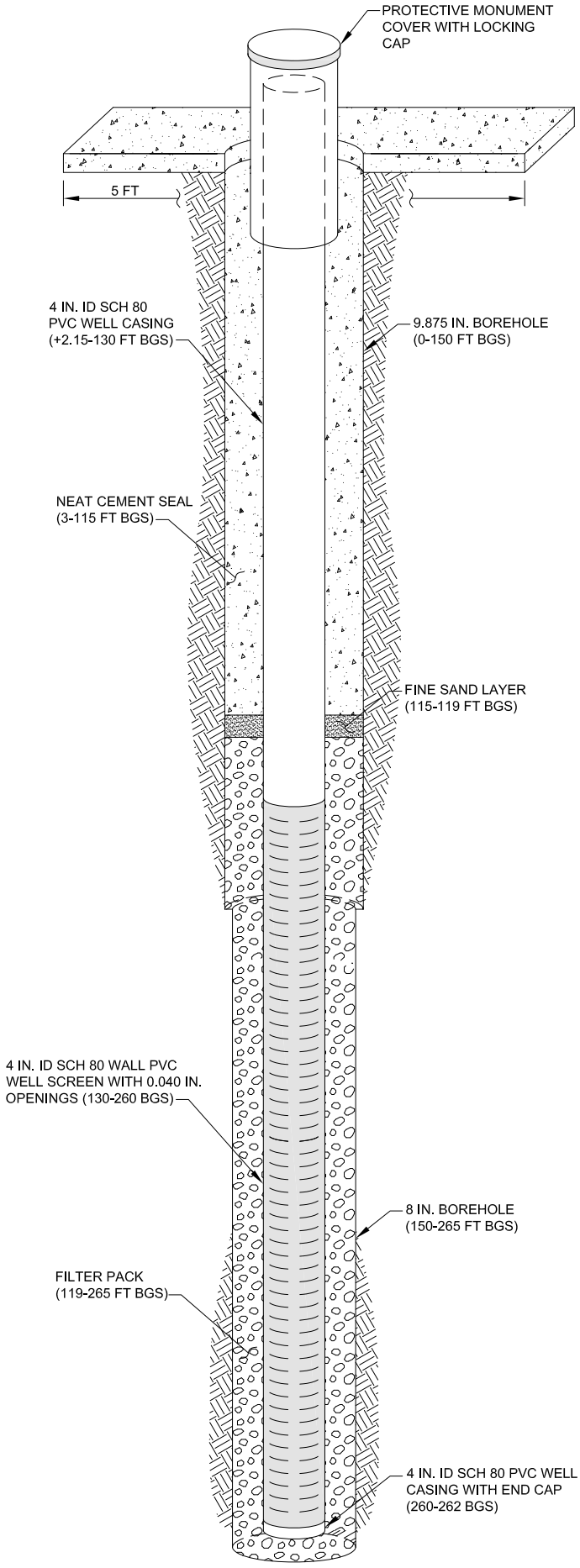
True Vertical Depth (feet)	Graphic Log	Lithologic Log	Depth bgs (feet)	Sieve Sample Number	Drill Rate (ft/hr)
235		SAND WITH SILT (SP-SM): pale olive (5Y 6/3), 90% fine to medium grained sand, subangular to subrounded; 10% silt; moist to wet sample; contains quartz, feldspar, mica, and amphibole; unconsolidated.	235		
		SAND (SP): light olive brown (2.5Y 5/3), 100% fine to coarse grained sand, subangular to subrounded; moist to wet sample; unconsolidated.			
240		SAND (SP): brown (7.5YR 5/3), 90% medium to coarse grained sand, subangular to subrounded; 10% fine to coarse gravel subrounded; moist to wet sample; contains quartz, feldspar, mica, and amphibole; unconsolidated.	240		
		SAND (SP): light yellowish brown (2.5Y 6/3), 95% fine to medium grained sand, subangular to subrounded; 5% silt; moist sample; unconsolidated.			
245		SAND (SP): pale brown (10YR 6/3), 100% fine to medium grained sand, subangular to subrounded; moist to wet sample; contains quartz, feldspar, mica, and amphibole; unconsolidated.	245		23.7
250			250		
255		GRAVEL WITH CLAY AND SAND (GP-GC): pale olive (5Y 6/3), 50% fine to coarse gravel subangular to subrounded; 40% fine to coarse grained sand, subangular to subrounded; 10% clay, low plasticity; moist to wet sample; contains quartz, feldspar, mica, and amphibole.	255		
260		SILT (ML): olive (5Y 5/3), 85% silt; 15% clay; moist sample; medium to high plasticity.	260		
265		Bottom of borehole at 265.5 feet.	265		

Blank casing with end cap (259.63-262 ft bgs)

TD 265.5 ft bgs

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WELL PROFILE

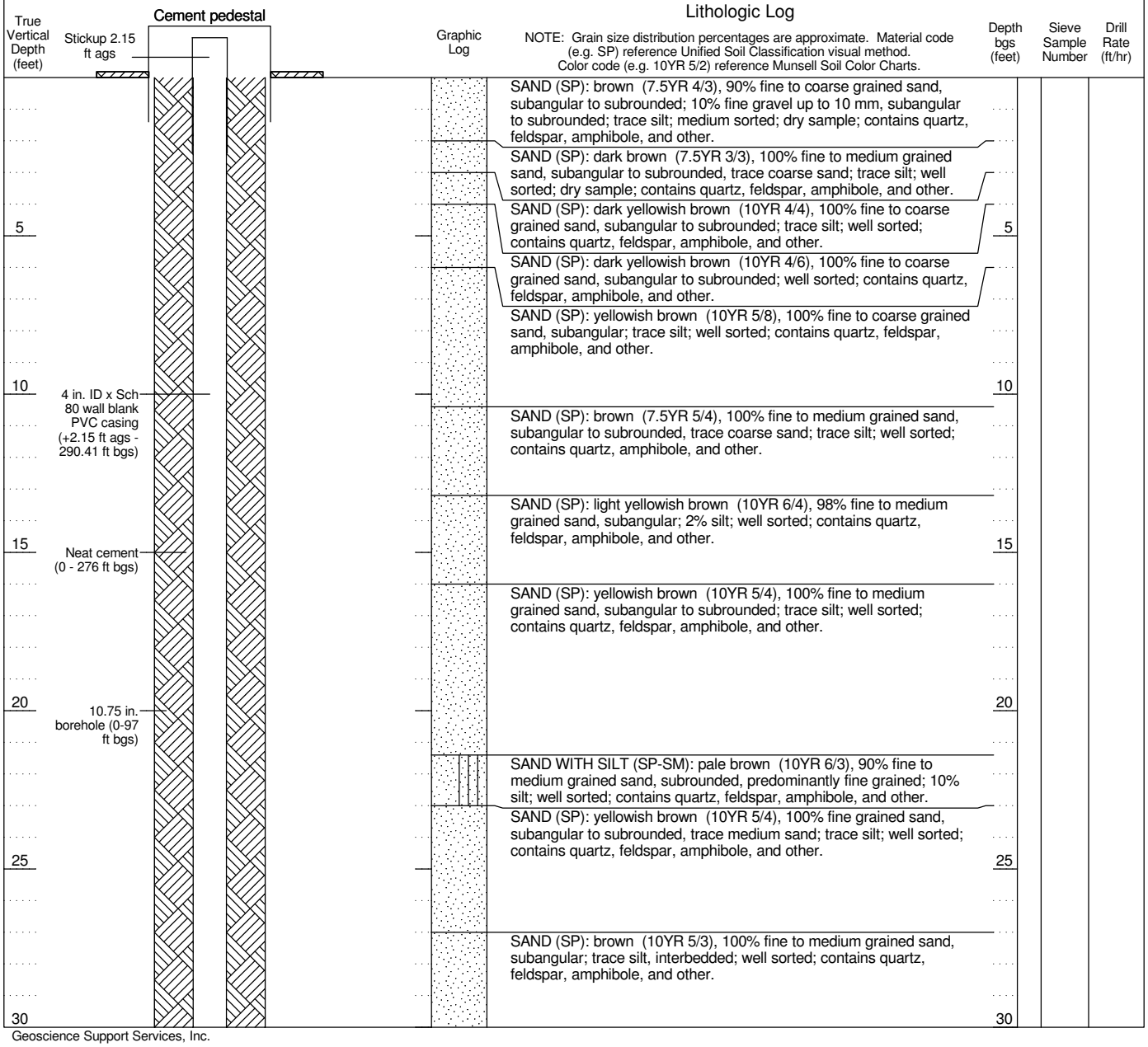
NOT TO SCALE

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BOREHOLE LITHOLOGIC LOG

WELL NUMBER **MPWSP MW-4D**	
CLIENT: Cal Am	LOCATION: **Marina, CA**
PROJECT NUMBER: 14077-15	**Entrance to CEMEX**
REPORT DATE:	
DRILLING CONTRACTOR: Cascade Drilling	LOGGED BY: **J. Sobolew**
DRILLER: A. Patricio	

		SCREEN / BLANK	TOP DEPTH (ft bgs)	BOTTOM DEPTH (ft bgs)	LENGTH (ft)	MATERIAL	WALL THICKNESS (in.)	DIAMETER (in.)	SCREEN TYPE	PERF. SIZE (in.)
DRILLING RIG TYPE	ProSonic 600T									
DRILLING METHOD	Sonic	**Blank**	**-2.15**	**290.41**	**292.56**	**PVC**	**Sch 80**	**4 / ID**		
SAMPLING METHOD	Core	**Screen**	**290.41**	**330.41**	**40**	**PVC**	**Sch 80**	**4 / ID**	**Slotted**	**0.04**
BOREHOLE DIAMETER	10.75, 9.875, 8 in	**Blank**	**330.41**	**332.41**	**2**	**PVC**	**Sch 80**	**4 / ID**		
SURFACE ELEVATION	39.80 ft NAVD88									
TOC ELEVATION	41.95 ft NAVD88 (RP)									
START DATE	12/20/14									
FINISH DATE	1/19/15									



WELL CONSTRUCTION LOG MPWSP MW TM LITH ALL WELLS.GPJ GEOSCIENCE.GDT 7/7/16

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WELL NUMBER **MPWSP MW-4D**

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am
PROJECT NUMBER 14077-15
LOCATION **Marina, CA**

True Vertical Depth (feet)	Lithologic Log (continued)	Graphic Log	NOTE: Grain size distribution percentages are approximate. Material code (e.g. SP) reference Unified Soil Classification visual method. Color code (e.g. 10YR 5/2) reference Munsell Soil Color Charts.	Depth bgs (feet)	Sieve Sample Number	Drill Rate (ft/hr)
35				35		
			SAND (SP): light brown (7.5YR 6/3), 100% fine to coarse grained sand, subangular to subrounded; trace silt; medium to well sorted; contains quartz, feldspar, mica, amphibole, and other.			
40				40	1	
			SAND (SP): brown (7.5YR 5/4), 95% fine to medium grained sand, subangular to subrounded; 5% silt; well sorted; contains quartz, feldspar, mica, amphibole, and other.			
45				45		
					2	
50			SAND (SW): yellowish brown (10YR 5/4), 100% fine to coarse grained sand, subangular to subrounded; poorly sorted; contains quartz, feldspar, mica, amphibole, and other.	50		
			SAND (SP): brown (10YR 5/3), 95% fine to coarse grained sand, subangular to subrounded, predominantly fine to medium grained; 5% silt; well sorted; contains quartz, feldspar, mica, amphibole, and other; high mica content.			20
55				55		
60				60		
			SAND (SW): brown (10YR 5/3), 95% fine to coarse grained sand, subangular to subrounded; 5% silt; trace fine gravel up to 5 mm, subangular to subrounded; poorly sorted; contains quartz, feldspar, mica, amphibole, and other.			
65				65		
			SAND WITH GRAVEL (SP): brown (10YR 5/3), 75% fine to coarse grained sand, subangular to subrounded, predominantly coarse; 25% fine to coarse gravel up to 9 mm, subangular to subrounded, predominantly fine; trace silt; poorly to medium sorted; contains quartz, feldspar, mica, amphibole, and other.		3	
70			SAND (SP): brown (10YR 5/3), 95% fine grained sand, subangular;	70		

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WELL NUMBER
MPWSP MW-4D

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am
PROJECT NUMBER 14077-15
LOCATION **Marina, CA**

True Vertical Depth (feet)	(continued)	Graphic Log	Lithologic Log NOTE: Grain size distribution percentages are approximate. Material code (e.g. SP) reference Unified Soil Classification visual method. Color code (e.g. 10YR 5/2) reference Munsell Soil Color Charts.	Depth bgs (feet)	Sieve Sample Number	Drill Rate (ft/hr)
			5% silt; well sorted; contains quartz, feldspar, mica, amphibole, and other.			20
75				75	4	
80				80		
85				85		
			SAND (SP): light yellowish brown (10YR 6/4), 95% fine to coarse grained sand, subangular to subrounded; 5% fine gravel up to 5 mm, subangular to subrounded; trace silt; medium to well sorted; contains quartz, feldspar, amphibole, and other.			
90			SAND WITH GRAVEL (SP): yellowish brown (10YR 5/4), 75% fine to coarse grained sand, subangular to subrounded; 25% fine gravel up to 16 mm, subangular to subrounded; trace silt; medium sorted; contains quartz, amphibole, and other; contains chert.	90	5	
			SAND (SP): yellowish brown (10YR 5/4), 95% fine to coarse grained sand, subangular to subrounded; 5% fine gravel up to 5 mm, subangular to subrounded; trace silt; well sorted; contains quartz, feldspar, mica, amphibole, and other.			10
95			GRAVEL WITH SAND (GP): light brown (7.5YR 6/4), 60% fine gravel up to 13 mm, subangular to subrounded; 40% fine to coarse grained sand, subangular to subrounded; medium sorted; contains quartz, feldspar, amphibole, and other.	95	6	
	9.875 in. borehole (97-247 ft bgs)		GRAVEL WITH SAND (GP): yellowish brown (10YR 5/4), 80% fine to coarse gravel up to 56 mm, subangular to rounded; 20% medium to coarse grained sand, subangular to rounded; trace silt; medium sorted; contains quartz, feldspar, amphibole, and other.			
100			SAND WITH GRAVEL (SW): brownish yellow (10YR 6/6), 55% fine to coarse grained sand, subangular to subrounded; 40% fine to coarse gravel up to 53 mm, subangular to subrounded; 5% silt; poorly to medium sorted; contains quartz, feldspar, amphibole, and other.	100	7	
105			SAND (SP): light brown (7.5YR 6/4), 95% fine to medium grained sand, subangular to subrounded, trace coarse sand; 5% fine gravel up to 18 mm, subangular to subrounded; trace silt; medium to well sorted; contains quartz, feldspar, mica, amphibole, and other.	105		
110			SAND (SP): light brown (7.5YR 6/4), 100% fine to medium grained sand, subangular to subrounded; trace fine gravel up to 6 mm, subangular to subrounded; trace silt; well sorted; contains quartz,	110		

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WELL NUMBER **MPWSP MW-4D**

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am | LOCATION **Marina, CA**
PROJECT NUMBER 14077-15

True Vertical Depth (feet)	(continued)	Graphic Log	Lithologic Log NOTE: Grain size distribution percentages are approximate. Material code (e.g. SP) reference Unified Soil Classification visual method. Color code (e.g. 10YR 5/2) reference Munsell Soil Color Charts.	Depth bgs (feet)	Sieve Sample Number	Drill Rate (ft/hr)
			feldspar, mica, amphibole, and other.			
115			SAND (SP): brown (7.5YR 5/3), 100% fine grained sand, subangular to subrounded; trace silt; well sorted; contains quartz, feldspar, mica, amphibole, and other.	115	8	
120			FAT CLAY (CH): pale olive (5Y 6/3), 95% clay, medium plasticity; 5% medium grained sand, subrounded; contains quartz, and other.	120		
125			SAND WITH CLAY (SP-SC): yellowish brown (10YR 5/6), 90% fine to medium grained sand, subrounded; 5% silt; 5% clay, low plasticity; well sorted; contains quartz, mica, amphibole, and other. FAT CLAY (CH): pale olive (5Y 6/3), 100% clay, medium plasticity; trace fine grained sand, subrounded; contains quartz, and mica.	125		
130			SAND WITH SILT (SP-SM): brownish yellow (10YR 6/6), 90% fine to medium grained sand, subangular; 10% silt; medium to well sorted; contains quartz, mica, and other; predominantly quartz. SAND (SP): pale yellow (5Y 7/3), 95% fine grained sand, subangular, very fine to fine grains; 5% silt; well sorted; contains quartz, mica, amphibole, and other; high mica content. SAND (SP): brownish yellow (10YR 6/6), 100% fine to medium grained sand, subangular to subrounded; trace silt; medium to well sorted; contains quartz, feldspar, mica, amphibole, and other.	130		
135			SAND WITH CLAY (SP-SC): pale yellow (2.5Y 7/3), 90% fine grained sand, subangular, very fine to fine grains; 10% clay, low plasticity; well sorted; contains quartz, mica, amphibole, and other; oxidation in layers. SAND (SP): light brown (7.5YR 6/3), 100% fine to coarse grained sand, angular to subrounded; trace fine gravel up to 6 mm, angular to subrounded; trace silt; trace clay; well sorted; contains quartz, feldspar, amphibole, and other; layer of clay with shells.	135		
140			SAND WITH SILT (SP-SM): very pale brown (10YR 7/4), 90% fine to medium grained sand, subrounded to rounded; 10% silt; well sorted; contains quartz, amphibole, and other; predominantly rounded quartz.	140		20
145				145	9	
150				150		

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WELL NUMBER **MPWSP MW-4D**

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am
PROJECT NUMBER 14077-15
LOCATION **Marina, CA**

(continued)

Lithologic Log

NOTE: Grain size distribution percentages are approximate. Material code (e.g. SP) reference Unified Soil Classification visual method. Color code (e.g. 10YR 5/2) reference Munsell Soil Color Charts.

True Vertical Depth (feet)	Depth bgs (feet)	Sieve Sample Number	Drill Rate (ft/hr)
	SILTY SAND (SM): light yellowish brown (10YR 6/4), 85% fine to medium grained sand, subangular to subrounded; 15% silt, low plasticity; medium sorted; contains quartz, mica, amphibole, and other.		
	SAND (SP): light brownish gray (2.5Y 6/2), 95% fine to coarse grained sand, subangular to subrounded; 5% clay, low plasticity; well sorted; contains quartz, mica, amphibole, and other; high mica content.		
155	155	10	
	SAND (SP): light yellowish brown (10YR 6/4), 85% fine to coarse grained sand, subangular to subrounded; 10% fine to coarse gravel up to 34 mm, subangular to subrounded; 5% clay, no to low plasticity; poorly to medium sorted; contains quartz, feldspar, mica, amphibole, and other; oxidation apparent.		
	SAND (SP): reddish yellow (7.5YR 6/6), 90% fine to coarse grained sand, subangular to subrounded; 10% fine to coarse gravel up to 29 mm, subangular to subrounded; trace silt; medium sorted; contains quartz, feldspar, mica, amphibole, and other; oxidation apparent.		
160	160		
	GRAVEL WITH CLAY AND SAND (GP-GC): pale brown (10YR 6/3), 55% fine to coarse gravel up to 55 mm, subangular to subrounded; 35% fine to coarse grained sand, subangular to subrounded; 10% clay, no to low plasticity; medium sorted; contains quartz, feldspar, mica, amphibole, and other; rounded clasts of gravel.		20
165	165		
		11	
	SAND WITH SILT (SP-SM): dark yellowish brown (10YR 4/4), 90% fine grained sand, subrounded; 10% silt; well sorted; contains quartz, mica, amphibole, and other.	12	
	FAT CLAY (CH): yellowish brown (10YR 5/8), 100% clay, high plasticity; trace fine grained sand, subrounded; trace silt; contains quartz, and mica; transition silt to clay from 168.4 to 177 ft bgs.		
170	170		
175	175		
	CLAYEY SAND (SC): brown (7.5YR 5/3), 75% fine to medium grained sand, subangular; 25% clay, low to medium plasticity; trace fine gravel up to 15 mm, subangular; well sorted; contains quartz, mica, amphibole, and other; trace chert.		
	SAND (SP): light brown (7.5YR 6/3), 95% fine to coarse grained sand, angular to subangular; 5% silt; well sorted; contains quartz, feldspar, mica, amphibole, and other; predominantly quartz.		
180	180		
	SILTY SAND (SM): brown (10YR 5/3), 85% fine to medium grained sand, subangular, predominantly fine grained; 15% silt, low plasticity; medium sorted; contains quartz, mica, amphibole, and other.		
	SAND (SP): light brownish gray (10YR 6/2), 95% fine to coarse grained sand, subangular to subrounded, coarser grained from 187 to 189 ft bgs; 5% silt; well sorted; contains quartz, feldspar, mica, amphibole, and other.		
185	185	13	
		14	
			10
190	SAND (SP): dark yellowish brown (10YR 4/6), 95% fine grained sand, subangular to subrounded; 5% silt; well sorted; contains quartz,	190	

WELL CONSTRUCTION LOG MPWSP MW TM LITH ALL WELLS.GPJ GEOSCIENCE.GDT 7/7/16

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WELL NUMBER **MPWSP MW-4D**

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am
PROJECT NUMBER 14077-15
LOCATION **Marina, CA**

True Vertical Depth (feet)	(continued)	Graphic Log	Lithologic Log NOTE: Grain size distribution percentages are approximate. Material code (e.g. SP) reference Unified Soil Classification visual method. Color code (e.g. 10YR 5/2) reference Munsell Soil Color Charts.	Depth bgs (feet)	Sieve Sample Number	Drill Rate (ft/hr)
			feldspar, amphibole, and other; predominantly dark-colored minerals.			
195				195		10
200				200		
205				205		
210				210		10
215				215		
			SAND (SP): brown (7.5YR 4/2), 100% fine grained sand, subrounded; trace silt; well sorted; weak cementation; contains quartz, feldspar, amphibole, and other; higher quartz content.		15	
220			SAND (SP): strong brown (7.5YR 4/6), 95% fine grained sand, subangular to subrounded; 5% silt; well sorted; weak cementation; contains quartz, feldspar, amphibole, and other; abundant dark minerals; faint rusty color.	220		
225			SAND (SP): olive brown (2.5Y 4/3), 100% fine grained sand, subangular to subrounded; trace silt; well sorted; weak cementation; contains quartz, feldspar, amphibole, and other; abundant dark minerals.	225		
230			SILT (ML): pale olive (5Y 6/4), 100% silt, dense, low plasticity; horizontal, dark, oxidized laminations 227-227.5 ft bgs.	230		6

WELL CONSTRUCTION LOG MPWSP MW TM LITH ALL WELLS.GPJ GEOSCIENCE.GDT 7/7/16

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WELL NUMBER **MPWSP MW-4D**

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am | LOCATION **Marina, CA**
PROJECT NUMBER 14077-15

(continued)

True Vertical Depth (feet)	Lithologic Log	Depth bgs (feet)	Sieve Sample Number	Drill Rate (ft/hr)
	NOTE: Grain size distribution percentages are approximate. Material code (e.g. SP) reference Unified Soil Classification visual method. Color code (e.g. 10YR 5/2) reference Munsell Soil Color Charts.			
235	SAND WITH SILT (SP-SM): pale olive (5Y 6/3), 90% fine to medium grained sand, subangular to subrounded, trace coarse grains; 10% silt; medium sorted; contains quartz, mica, amphibole, and other; no to low plasticity.	235		
	SAND (SP): light olive brown (2.5Y 5/3), 100% fine to coarse grained sand, subangular to subrounded, predominantly medium to coarse grains; trace fine gravel up to 6 mm, subangular to subrounded; medium to well sorted; contains quartz, feldspar, mica, amphibole, and other.		16	6
240	SAND (SP): brown (7.5YR 5/3), 90% fine to coarse grained sand, subangular to subrounded, predominantly medium to coarse grains; 10% fine to coarse gravel up to 35 mm, subangular to subrounded; trace silt; poorly to medium sorted; contains quartz, feldspar, mica, amphibole, and other.	240		
	SAND WITH GRAVEL (SW): light yellowish brown (2.5Y 6/3), 85% fine to coarse grained sand, subangular to subrounded; 15% fine to coarse gravel up to 26 mm, subrounded; trace silt; poorly sorted; contains quartz, feldspar, mica, amphibole, and other.			
245	SAND (SP): light yellowish brown (2.5Y 6/3), 95% fine to medium grained sand, subangular to subrounded; 5% silt; well sorted; contains quartz, feldspar, mica, amphibole, and other.	245		
	SAND (SP): pale brown (10YR 6/3), 100% fine to medium grained sand, subangular, predominantly medium grained; trace silt; well sorted; contains quartz, feldspar, mica, amphibole, and other.		17	
250	8 in. borehole (247-332.8 ft bgs)	250		
255	GRAVEL WITH CLAY AND SAND (GP-GC): pale olive (5Y 6/3), 50% fine to coarse gravel up to 38 mm, subangular to subrounded; 40% fine to coarse grained sand, subangular to subrounded; 10% clay, low plasticity; poorly sorted; contains quartz, feldspar, mica, amphibole, and other.	255	18	
260	SILT (ML): olive (5Y 5/3), 100% silt, dense, low to medium plasticity.	260		
265		265		
	SILTY SAND (SM): olive (5Y 5/3), 65% fine grained sand, subrounded; 35% silt, low plasticity; well sorted; contains quartz, mica, and other.			20
270	SAND (SP): olive gray (5Y 5/2), 95% fine to coarse grained sand, subangular to subrounded; 5% silt; trace fine gravel up to 6 mm,	270		

WELL CONSTRUCTION LOG MPWSP MW TM LITH ALL WELLS.GPJ GEOSCIENCE.GDT 7/7/16

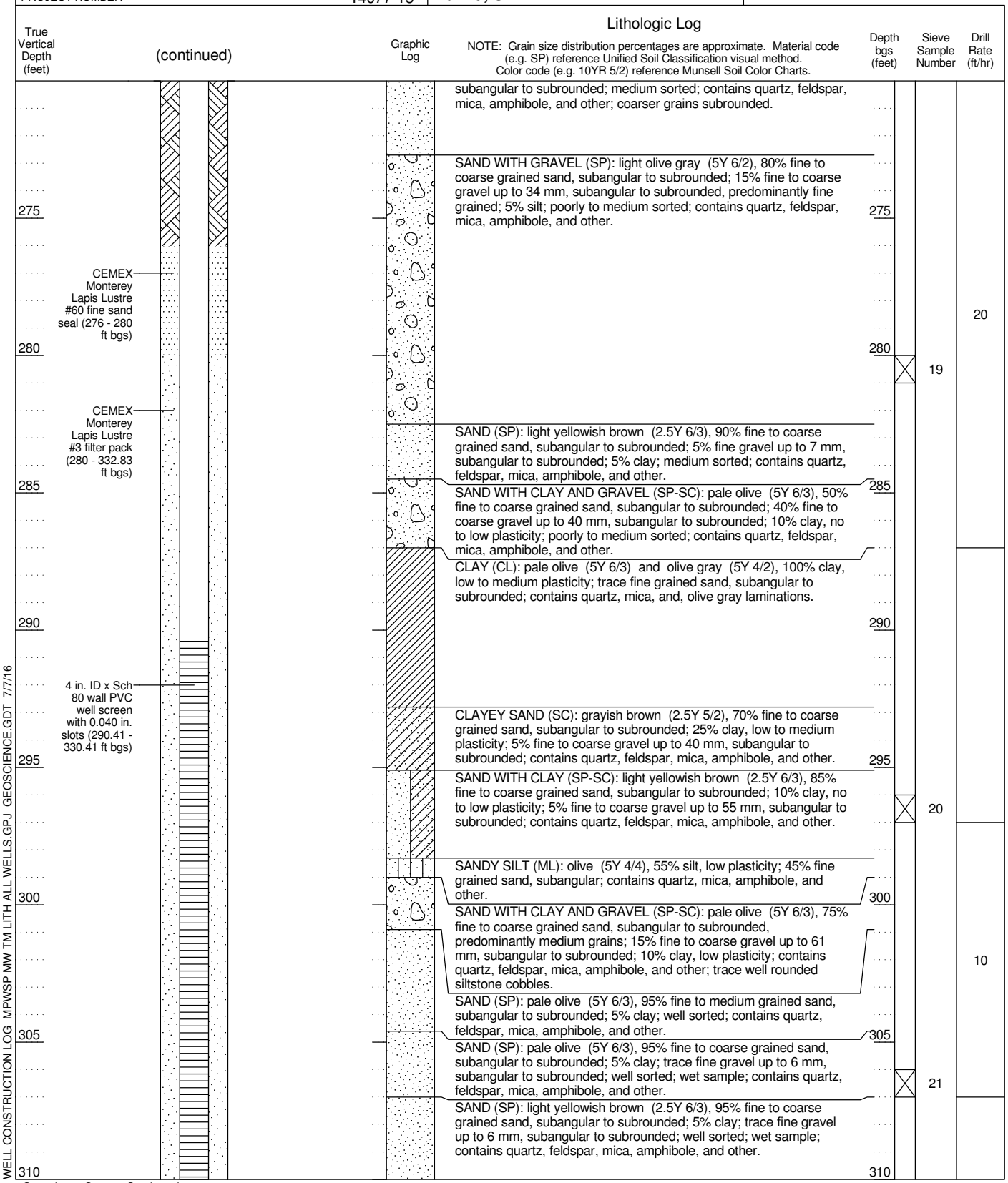
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WELL NUMBER **MPWSP MW-4D**

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am
PROJECT NUMBER 14077-15
LOCATION **Marina, CA**



WELL CONSTRUCTION LOG MPWSP MW TM LITH ALL WELLS.GPJ GEOSCIENCE.GDT 7/7/16

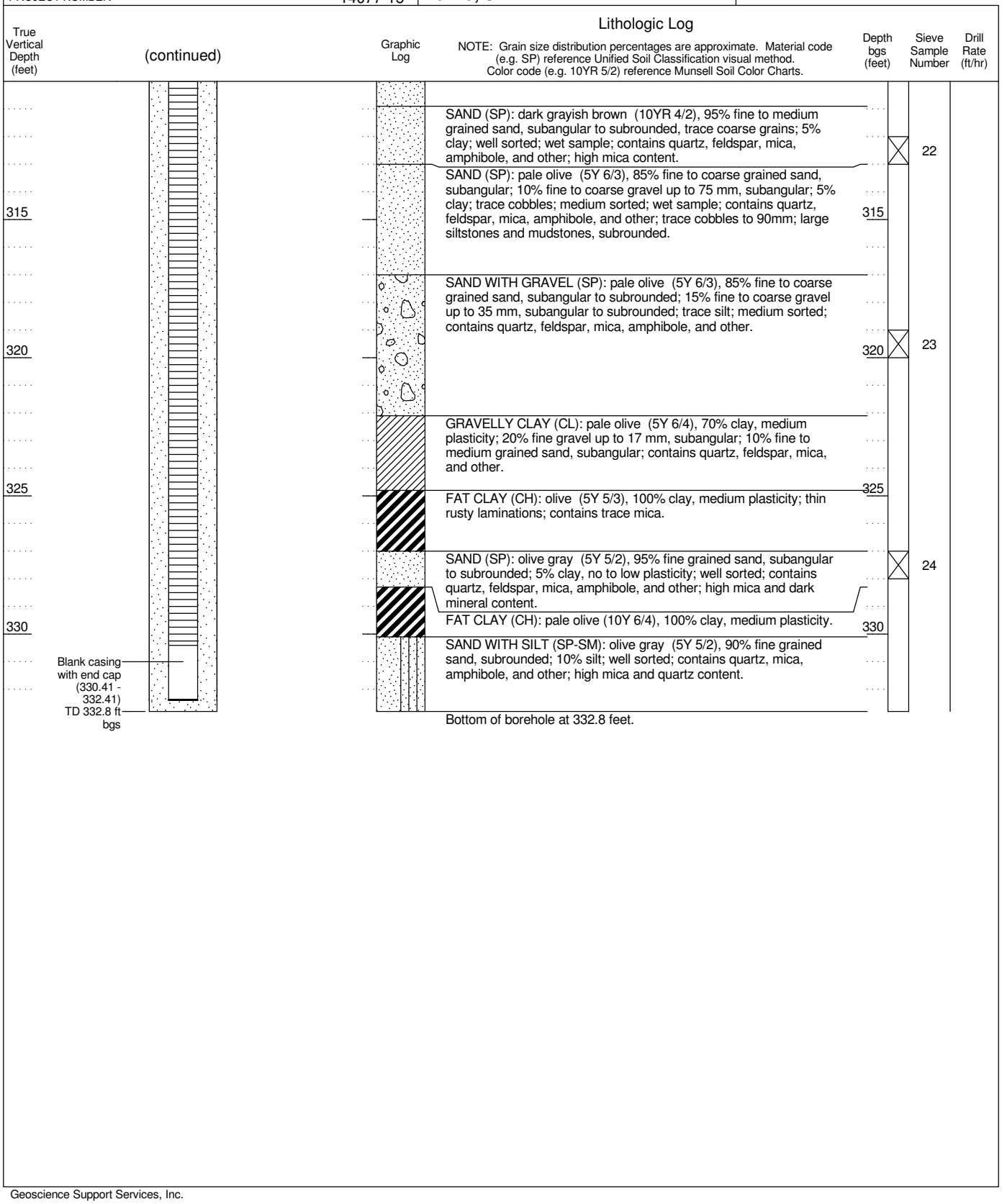
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WELL NUMBER
MPWSP MW-4D

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am
PROJECT NUMBER 14077-15
LOCATION **Marina, CA**



WELL CONSTRUCTION LOG MPWSP MW TM LITH ALL WELLS.GPJ GEOSCIENCE.GDT 7/7/16

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PACIFIC SURVEYS

TEMPERATURE
DELTA TEMPERATURE
FLUID RESISTIVITY
DELTA FLUID RESISTIVITY

Job No. 19138

File No.

Company CASCADE DRILLING

Well MW-4D

Field MARINA

County MONTEREY State CA

Location

CEMEX PLANT OFF OF LAPIS RD.
GPS: N36o 42' 42" W121o 47' 55"

Other Services:

DIL/GR

		Elevation above perm. datum	Elevation
Permanent Datum	G.L.		K.B.:
Log Measured From	G.L.	0'	D.F.:
Drilling Measured From	G.L.		G.L.:

Date	01-10-2014										
Run Number	ONE										
Depth Driller	332'										
Depth Logger	332.2'										
Bottom Logged Interval	332'										
Top Log Interval	10'										
Open Hole Size	10"										
Type Fluid	WATER										
Density / Viscosity	N/A										
Fluid Level	34'										
Bentonite Seal	N/A										
Time Well Ready	10:30										
Time Logger on Bottom	12:30										
Equipment Number	PS-8										
Location	L.A.										
Recorded By	RIDDER										
Witnessed By	J. SOBOLEW										

Borehole Record				Tubing Record			
Run Number	Bit	From	To	Size	Weight	From	To
ONE	10"	0'	97'				
	9"	97'	247'				
	8"	247'	332'				

Casing Record	Size	Wgt/Ft	Top	Bottom
Surface String	12"	N/A	0'	17'
Prot. String				
Production String				
Liner				

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All interpretations are opinions based on inferences from electrical or other measurements and Pacific Surveys cannot and do not guarantee the accuracy or correctness of any interpretation, and we shall not, except in the case of gross or willful negligence on our part, be liable or responsible for any loss, costs, damages, or expenses incurred or sustained by anyone resulting from any interpretation made by any of our officers, agents or employees. These interpretations are also subject to Pacific Surveys' general terms and conditions set out in our current Price Schedule.

Comments

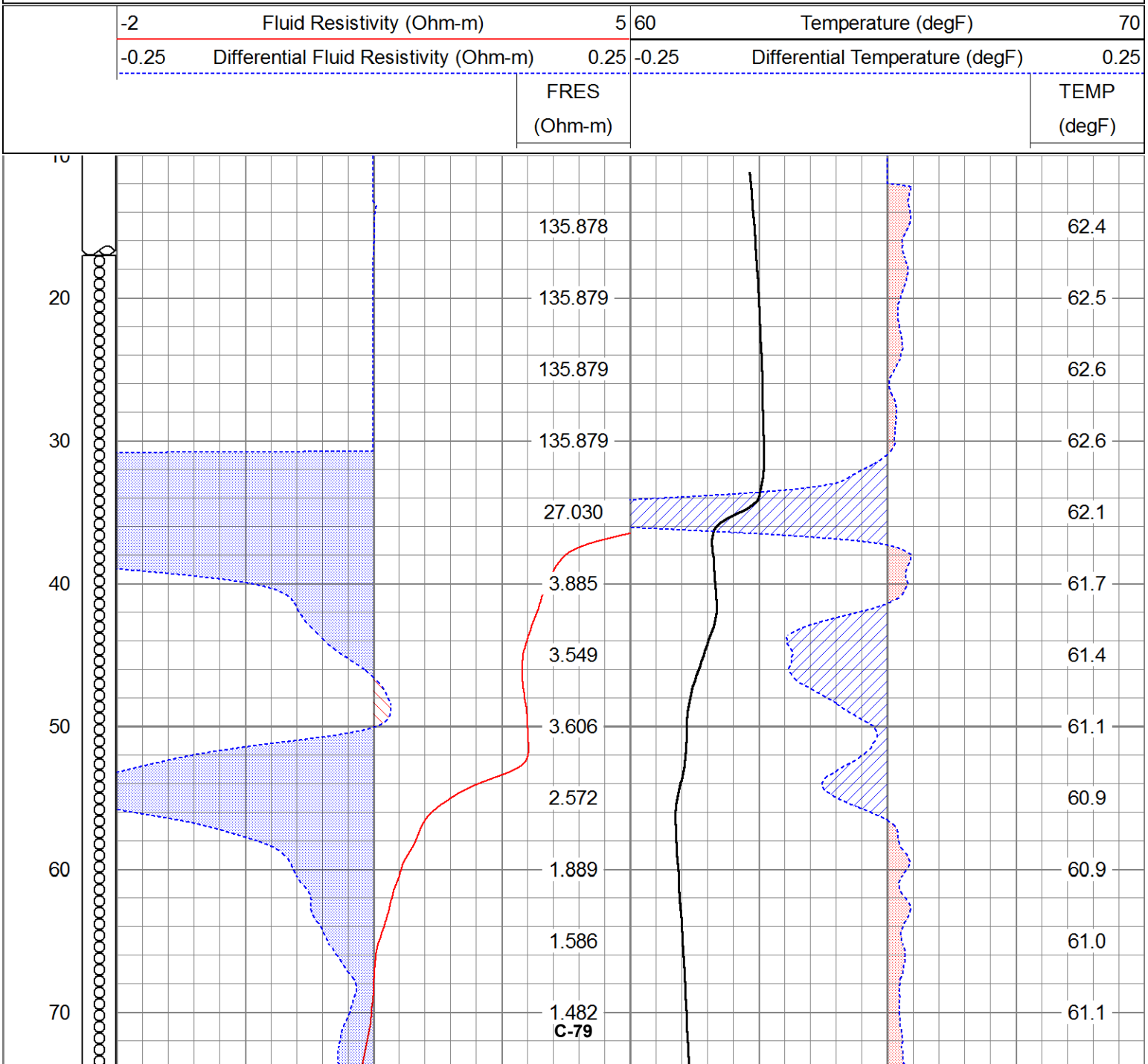
Calibration Report

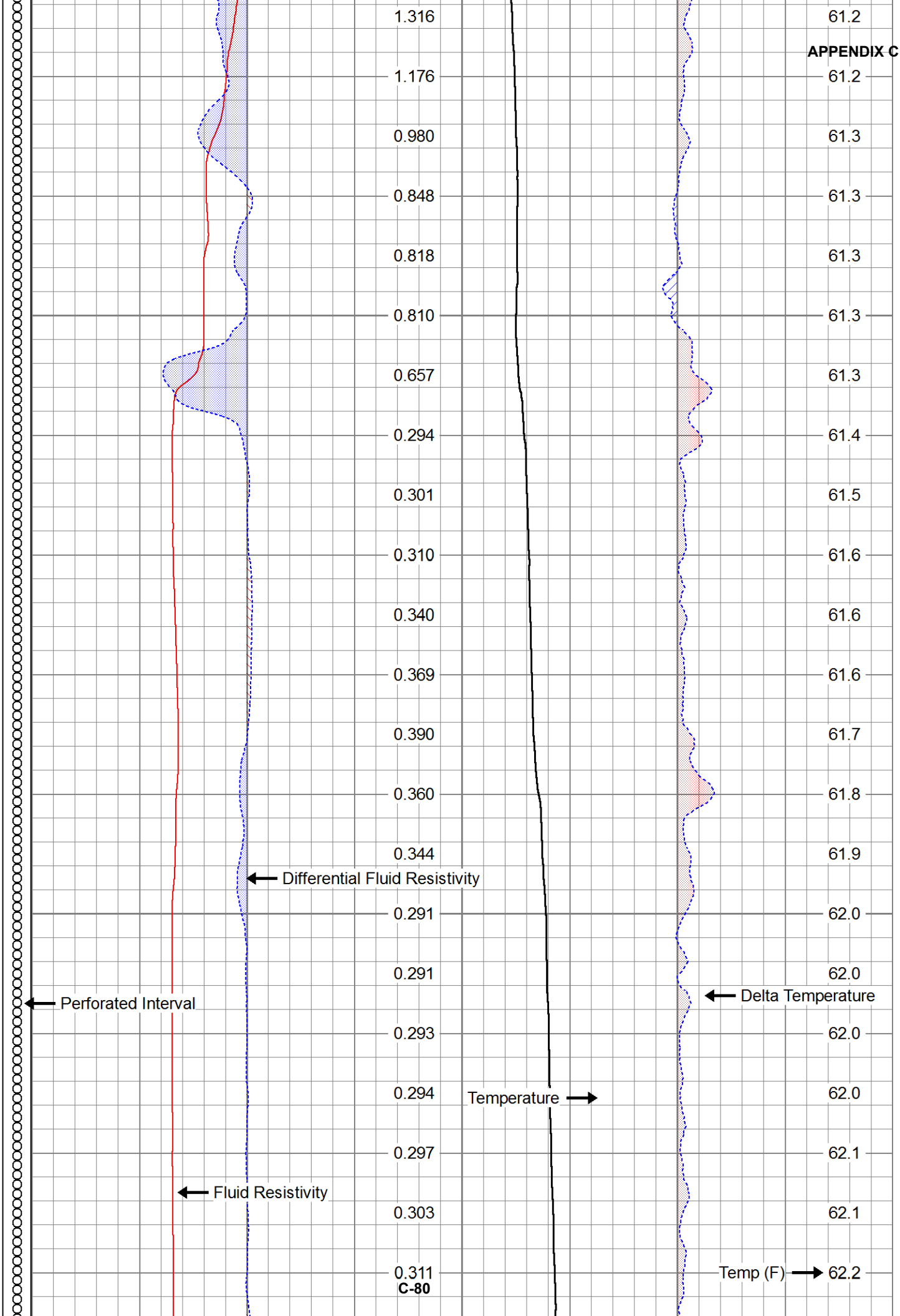
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Dataset Pathname	temp2
Dataset Creation	Sat Jan 10 14:33:28 2015

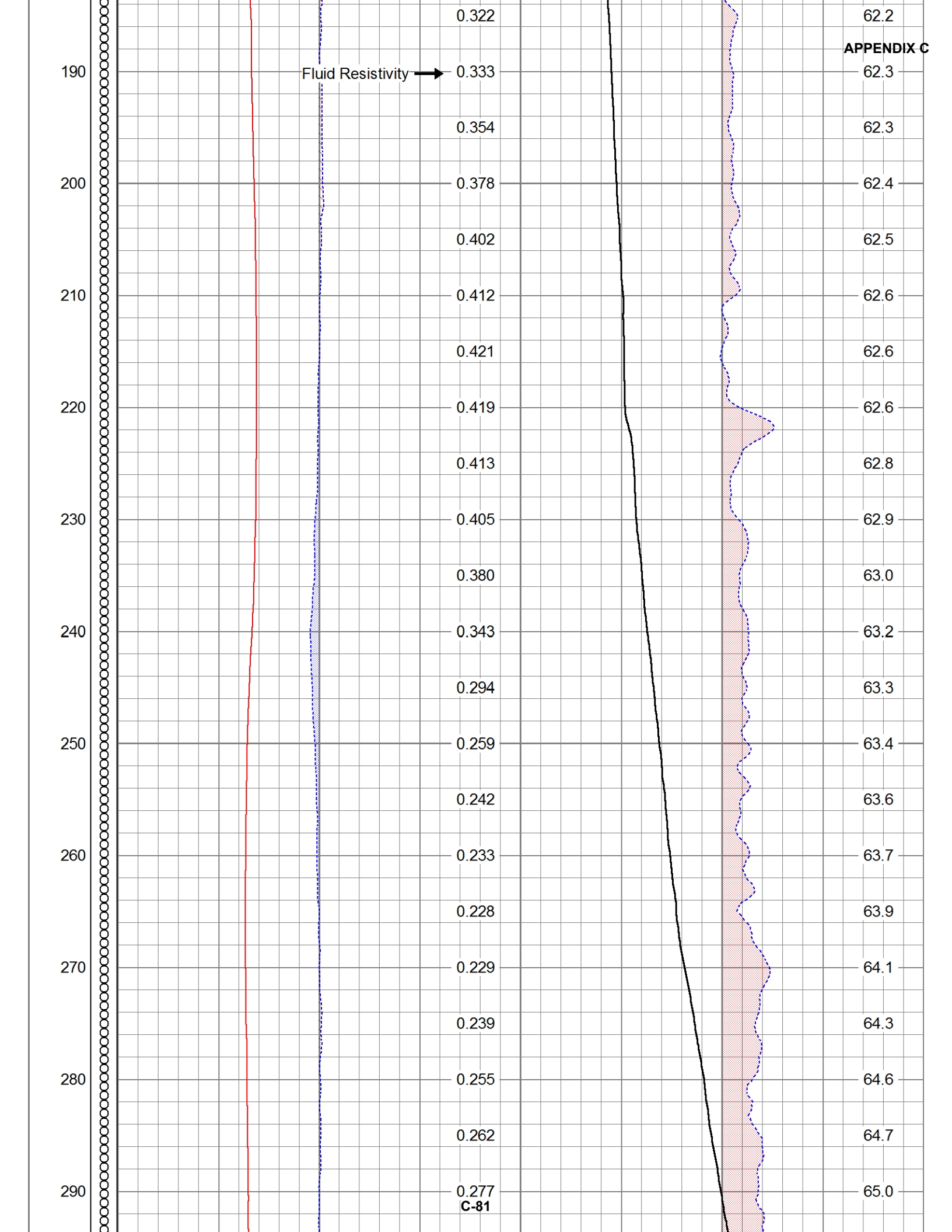
Temperature Calibration Report

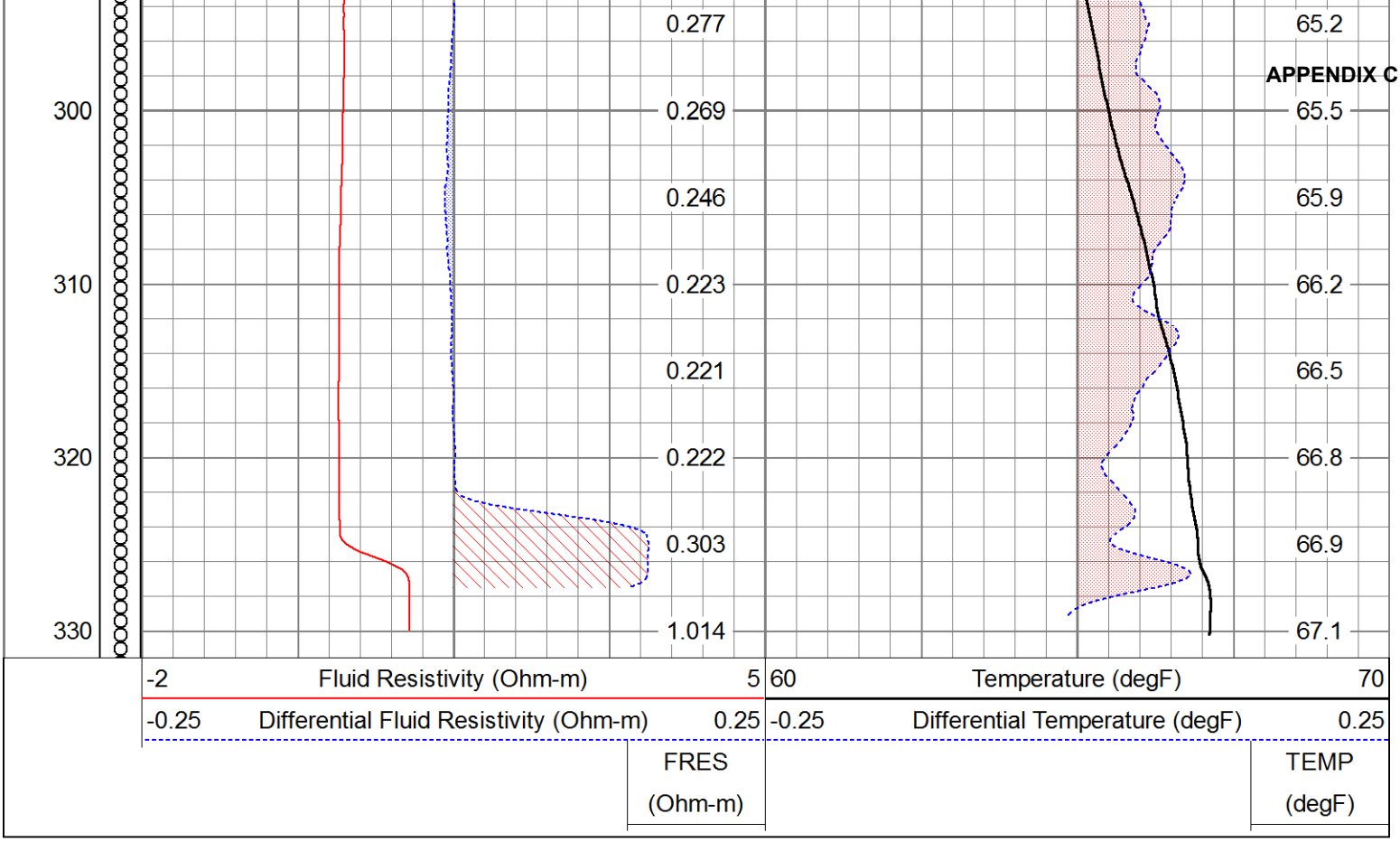
Serial Number:	3553	
Tool Model:	MLS	
Performed:	Sat Jan 10 12:25:28 2015	
	Reference	Reading
Low Reference:	43.34 degF	1441.00cps
High Reference:	149.00 degF	4545.00cps
Gain:	0.03	
Offset:	-9.71	
Delta Spacing	2	

Database File	19138.db
Dataset Pathname	temp2
Presentation Format	frttemp2
Dataset Creation	Sat Jan 10 14:33:28 2015
Charted by	Depth in Feet scaled 1:120




APPENDIX C
80
90
100
110
120
130
140
150
160
170
180
1.316
1.176
0.980
0.848
0.818
0.810
0.657
0.294
0.301
0.310
0.340
0.369
0.390
0.360
0.344
0.291
0.291
0.293
0.294
0.297
0.303
0.311
61.2
61.2
61.3
61.3
61.3
61.3
61.4
61.5
61.6
61.6
61.6
61.7
61.8
61.9
62.0
62.0
62.0
62.0
62.1
62.1
62.2
Differential Fluid Resistivity
Perforated Interval
Delta Temperature
Temperature
Fluid Resistivity
Temp (F)


Fluid Resistivity
190
200
210
220
230
240
250
260
270
280
290
0.322
0.333
0.354
0.378
0.402
0.412
0.421
0.419
0.413
0.405
0.380
0.343
0.294
0.259
0.242
0.233
0.228
0.229
0.239
0.255
0.262
0.277
62.2
62.3
62.3
62.4
62.5
62.6
62.6
62.6
62.8
62.9
63.0
63.2
63.3
63.4
63.6
63.7
63.9
64.1
64.3
64.6
64.7
65.0


300
310
320
330
0.277
0.269
0.246
0.223
0.221
0.222
0.303
1.014
65.2
65.5
65.9
66.2
66.5
66.8
66.9
67.1
-2
Fluid Resistivity (Ohm-m)
5
-0.25
Differential Fluid Resistivity (Ohm-m)
0.25
FRES
(Ohm-m)
60
Temperature (degF)
70
-0.25
Differential Temperature (degF)
0.25
TEMP
(degF)

PACIFIC SURVEYS

DUAL INDUCTION GAMMA-RAY

Job No. 19138

File No.

Company CASCADE DRILLING

Well MW-4D

Field MARINA

County MONTEREY State CA

Location

CEMEX PLANT OFF OF LAPIS RD.
GPS: N36o 42' 42" W121o 47' 55"

Other Services:

TEMP/FR

				Elevation	
Permanent Datum	G.L.		Elevation above perm. datum	K.B.:	
Log Measured From	G.L.	0'		D.F.:	
Drilling Measured From	G.L.			G.L.:	

Date	01-10-2014							
Run Number	ONE							
Depth Driller	332'							
Depth Logger	332.2'							
Bottom Logged Interval	332'							
Top Log Interval	10'							
Open Hole Size	10"							
Type Fluid	WATER							
Density / Viscosity	N/A							
Fluid Level	34'							
Bentonite Seal	N/A							
Time Well Ready	10:30							
Time Logger on Bottom	12:30							
Equipment Number	PS-8							
Location	LA							
Recorded By	RIDDER							
Witnessed By	J. SOBOLEW							

Borehole Record				Tubing Record			
Run Number	Bit	From	To	Size	Weight	From	To
ONE	10"	0'	97'				
	9"	97'	247'				
	8"	247'	332'				

Casing Record	Size	Wgt/Ft	Top	Bottom
Surface String	12"	N/A	0'	17'
Prot. String				
Production String				
Liner				

<<< Fold Here >>>

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Comments

Calibration Report

Database File	19138.db
Dataset Pathname	DIL
Dataset Creation	Sat Jan 10 13:34:14 2015

Serial-Model: 0001-ALT
Surface Cal Performed:

APPENDIX C

Loop:	Readings Air	Readings Loop		References Air	References Loop		Results m	Results b
Deep	1405.080	3665.050	cps	0.000	612.000	mmho/m	0.271	-380.496
Medium	2052.170	14102.500	cps	0.000	1960.000	mmho/m	0.163	-333.788

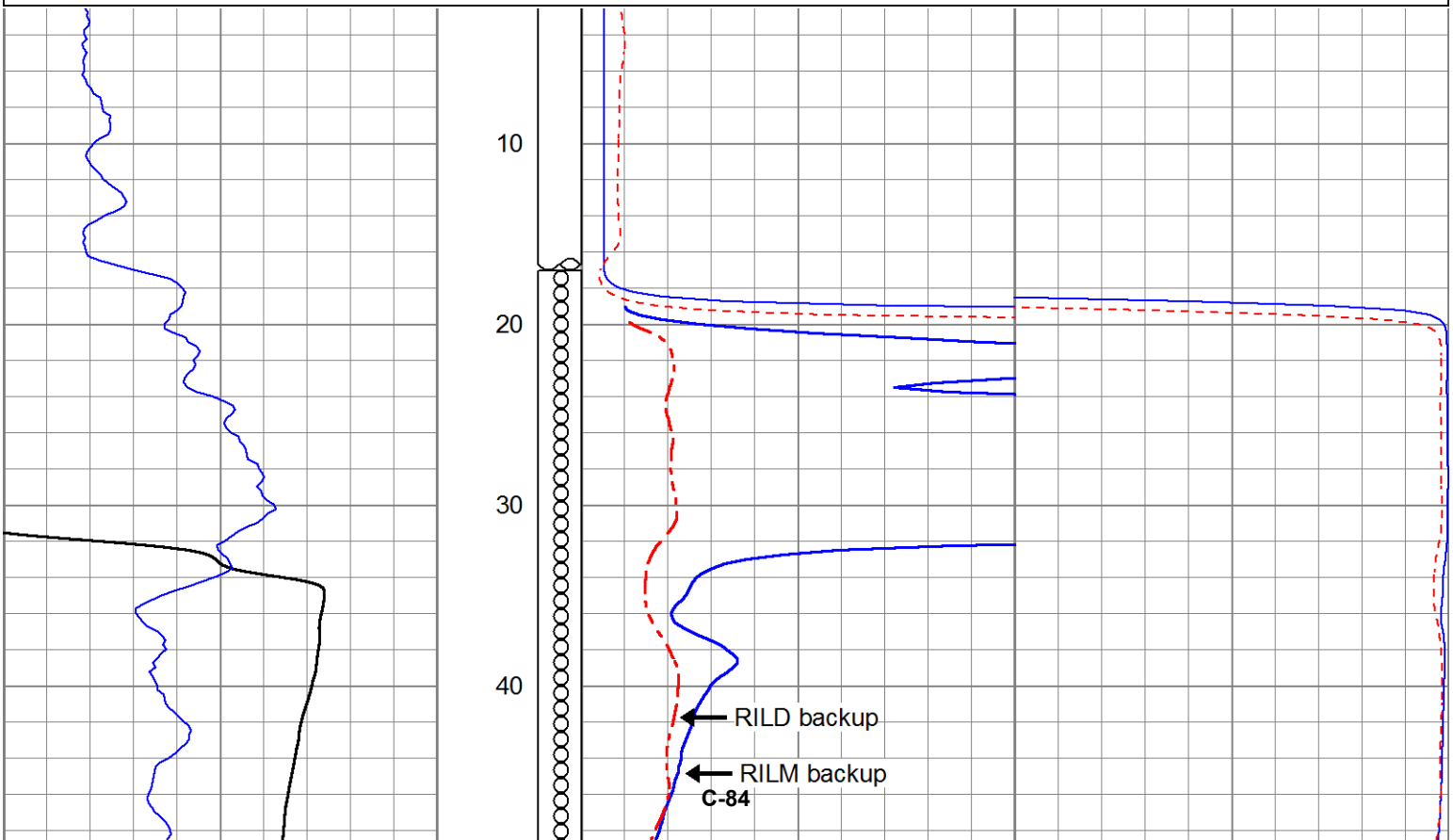
Gamma Ray Calibration Report

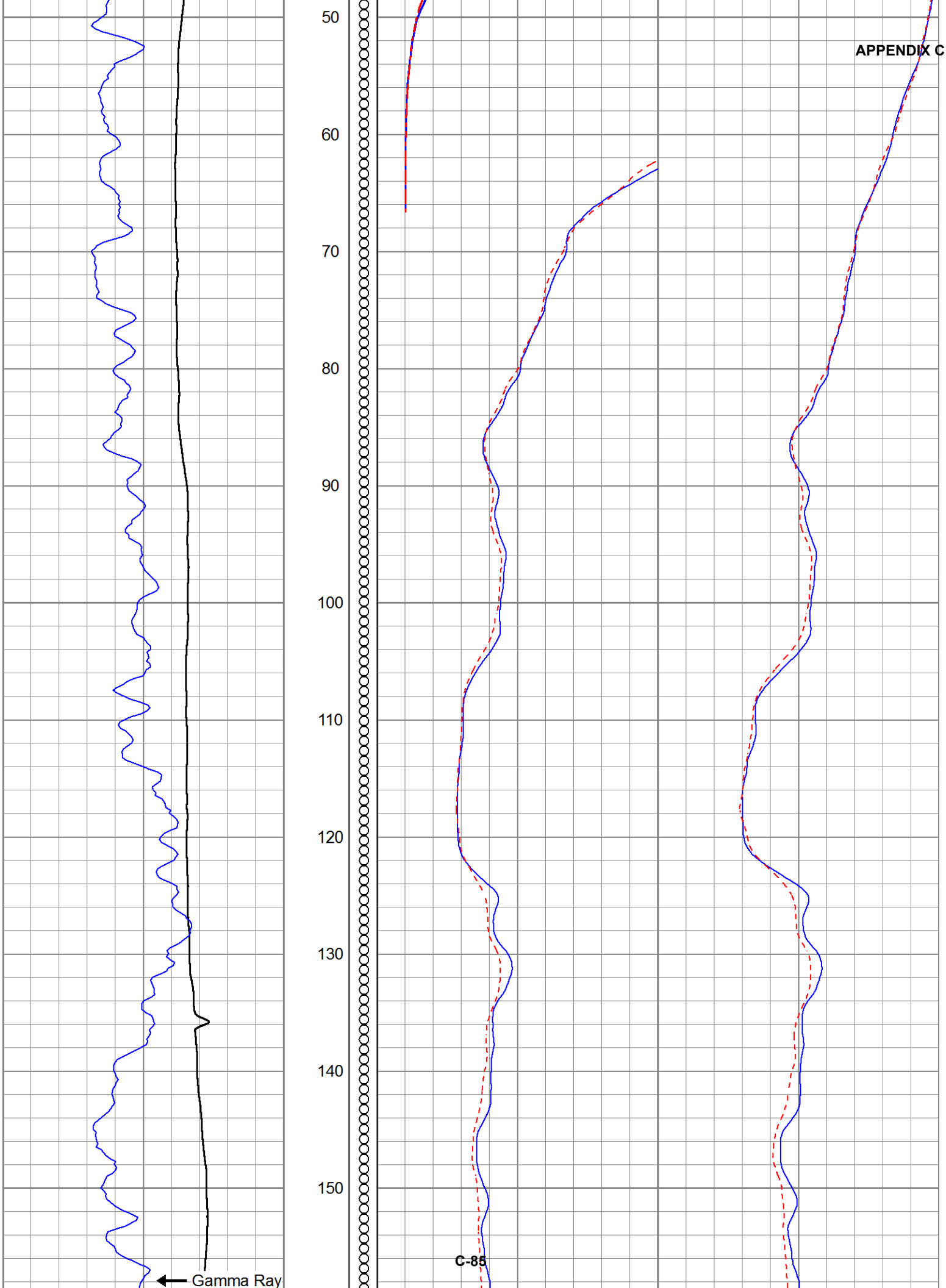
Serial Number:	PS_1	
Tool Model:	01	
Performed:	Sat Jan 10 13:10:57 2015	
Calibrator Value:	162.0	GAPI
Background Reading:	46.1	cps
Calibrator Reading:	180.8	cps
Sensitivity:	1.2020	GAPI/cps

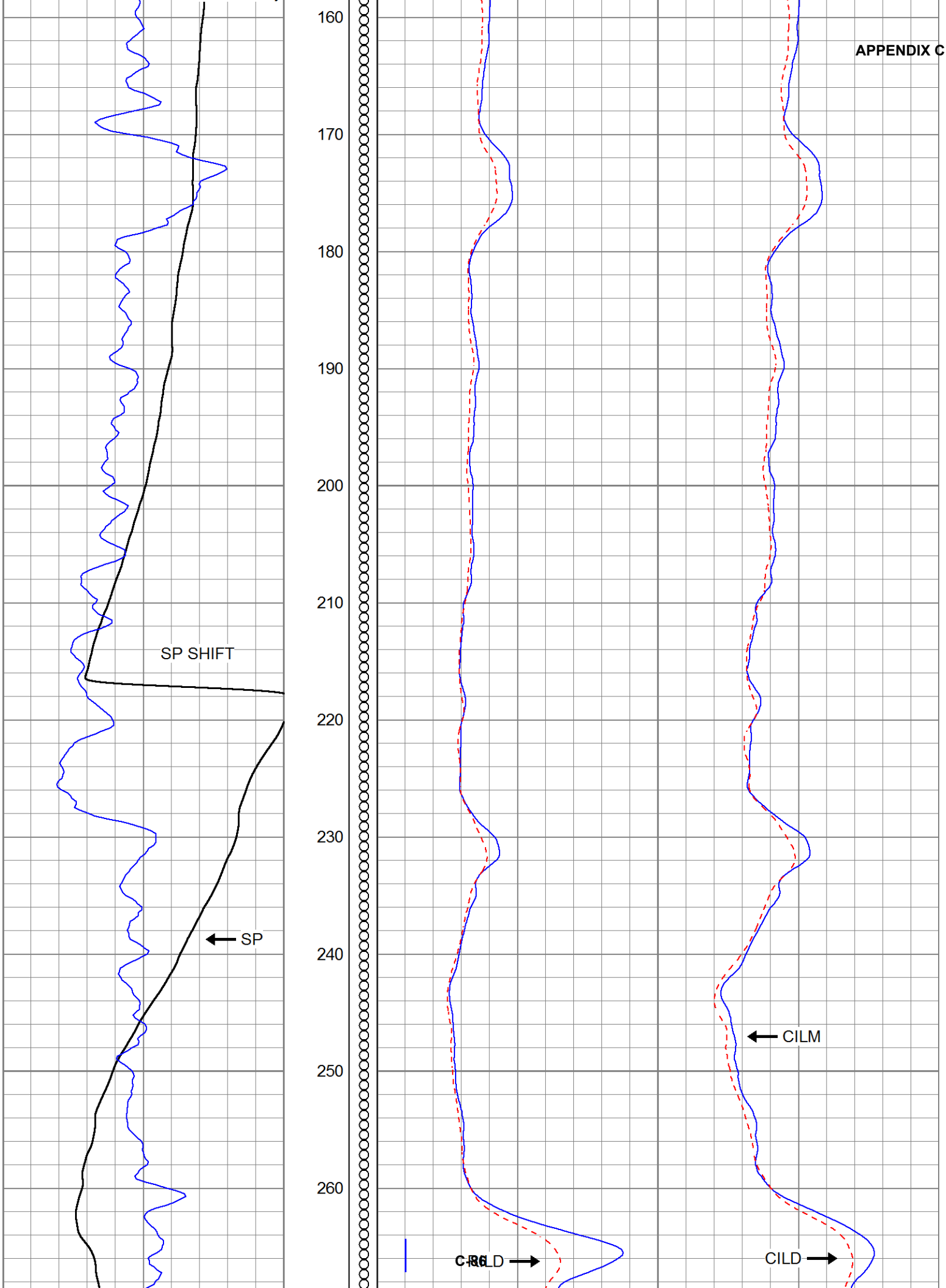
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Dataset Pathname	DIL
Presentation Format	dil
Dataset Creation	Sat Jan 10 13:34:14 2015
Charted by	Depth in Feet scaled 1:120

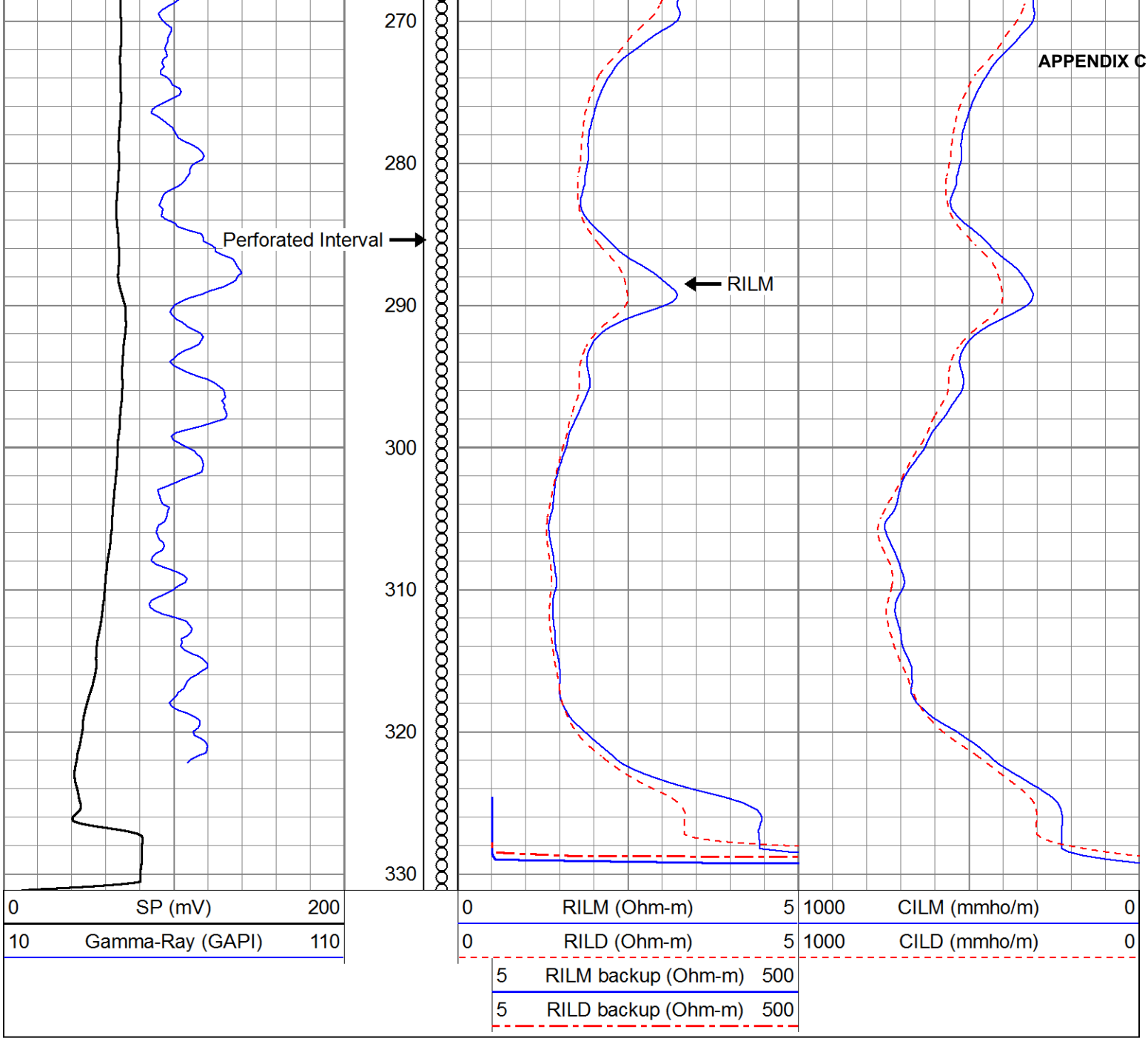
0	SP (mV)	200	0	RILM (Ohm-m)	5
10	Gamma-Ray (GAPI)	110	0	RILD (Ohm-m)	5
			5	RILM backup (Ohm-m)	500
			5	RILD backup (Ohm-m)	500

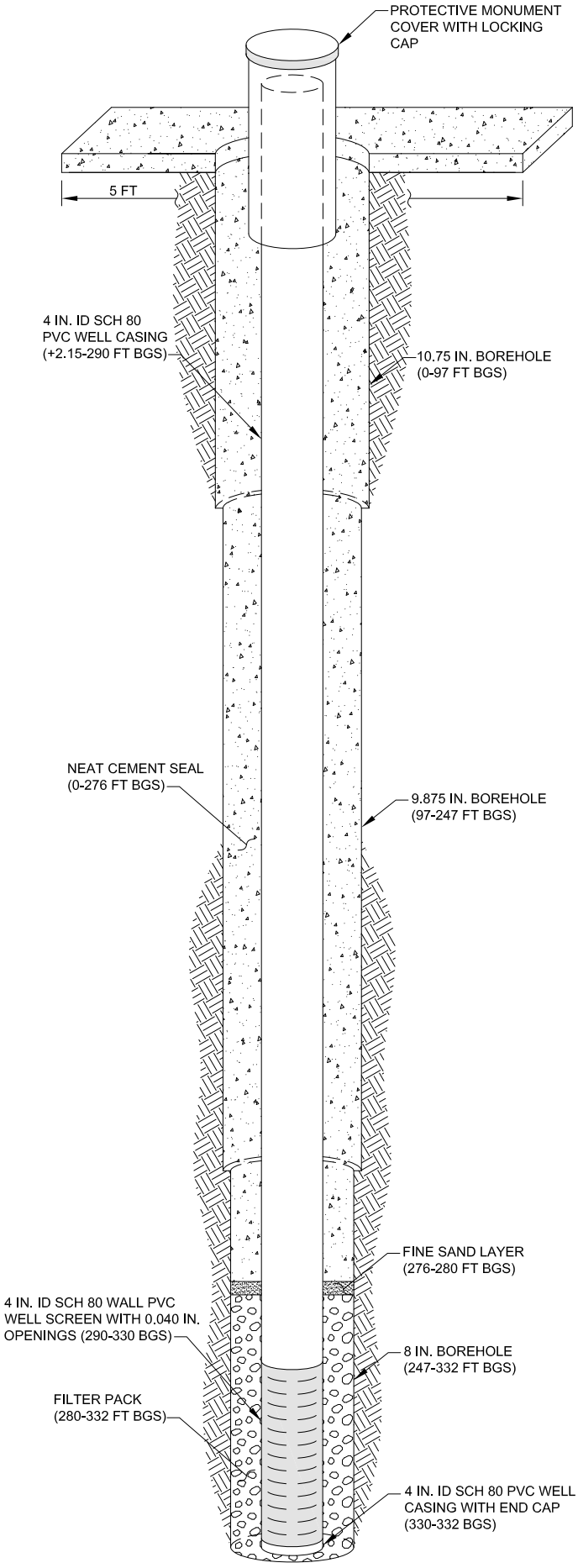
1000	CILM (mmho/m)	0
1000	CILD (mmho/m)	0




50
60
70
80
90
100
110
120
130
140
150
Gamma Ray


160
170
180
190
200
210
220
230
240
250
260
SP SHIFT
SP
CILM
CILD
CILD


270
280
290
300
310
320
330
Perforated Interval
RILM
0 SP (mV) 200
10 Gamma-Ray (GAPI) 110
0 RILM (Ohm-m) 5
0 RILD (Ohm-m) 5
5 RILM backup (Ohm-m) 500
5 RILD backup (Ohm-m) 500
1000 CILM (mmho/m) 0
1000 CILD (mmho/m) 0



WELL PROFILE

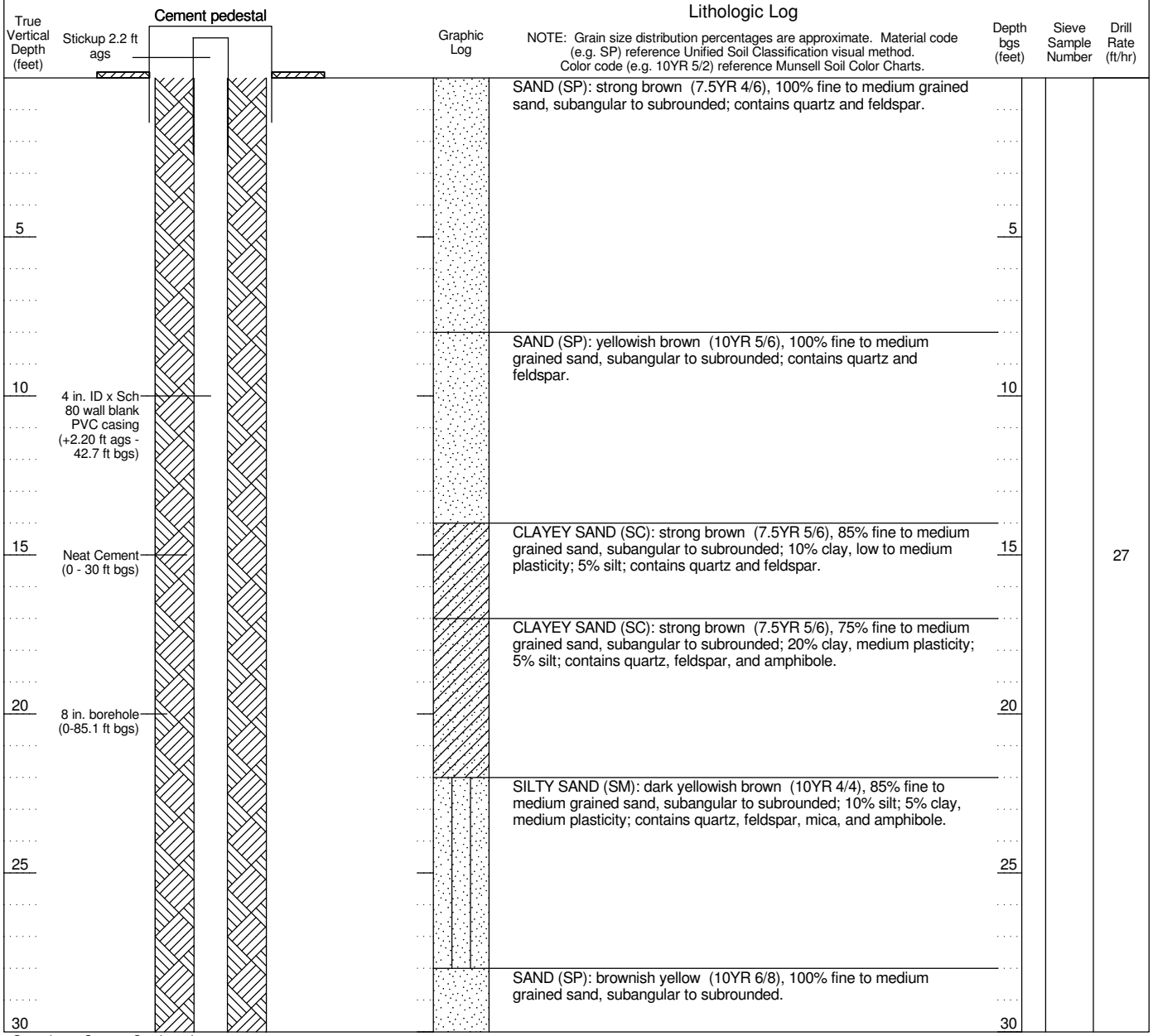
NOT TO SCALE

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www.gssiwater.com

BOREHOLE LITHOLOGIC LOG

WELL NUMBER **MPWSP MW-5S**	
CLIENT: Cal Am	LOCATION: **Marina, CA**
PROJECT NUMBER: 14077-15	**Neponset Rd**
REPORT DATE:	
DRILLING CONTRACTOR: Cascade Drilling	LOGGED BY: **A. Khalighi**
DRILLER: D. King	

		SCREEN / BLANK	TOP DEPTH (ft bgs)	BOTTOM DEPTH (ft bgs)	LENGTH (ft)	MATERIAL	WALL THICKNESS (in.)	DIAMETER (in.)	SCREEN TYPE	PERF. SIZE (in.)
DRILLING RIG TYPE	ProSonic 600T									
DRILLING METHOD	Sonic	**Blank**	**-2.2**	**42.7**	**44.9**	**PVC**	**Sch 80**	**4 / ID**		
SAMPLING METHOD	Core	**Screen**	**42.7**	**82.7**	**40**	**PVC**	**Sch 80**	**4 / ID**	**Slotted**	**0.04**
BOREHOLE DIAMETER	8 in	**Blank**	**82.7**	**85.1**	**2.4**	**PVC**	**Sch 80**	**4 / ID**		
SURFACE ELEVATION	78.05 ft NAVD88									
TOC ELEVATION	80.25 ft NAVD88 (RP)									
START DATE	1/28/15									
FINISH DATE	2/02/15									



WELL CONSTRUCTION LOG MPWSP MW TM LITH ALL WELLS.GPJ GEOSCIENCE.GDT 7/7/16

Geoscience Support Services, Inc.

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WELL NUMBER **MPWSP MW-5S**

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am | LOCATION **Marina, CA**
PROJECT NUMBER 14077-15

(continued)

True Vertical Depth (feet)	Graphic Log	Lithologic Log NOTE: Grain size distribution percentages are approximate. Material code (e.g. SP) reference Unified Soil Classification visual method. Color code (e.g. 10YR 5/2) reference Munsell Soil Color Charts.	Depth bgs (feet)	Sieve Sample Number	Drill Rate (ft/hr)
		CEMEX Monterey Lapis Lustre #60 fine sand seal (30 - 33 ft bgs)			
35			35		
		CEMEX Monterey Lapis Lustre #3 filter pack (33 - 85.1 ft bgs)			
		SAND (SP): dark yellowish brown (10YR 4/6), 95% fine grained sand, subangular to subrounded; 5% silt; contains quartz, feldspar, and mica.			
40			40		
45			45		
		4 in. ID x Sch 80 wall PVC well screen with 0.040 in. slots (42.7 - 82.7 ft bgs)			
		SILTY SAND (SM): dark gray (10YR 4/1), 80% fine grained sand, subangular to subrounded; 20% silt; contains quartz, feldspar, and mica.			
50			50		27
		SILT (ML): gray (10YR 5/1), 60% silt; 30% clay, medium plasticity; 10% fine grained sand, subangular to subrounded; contains quartz, feldspar, and mica; black ash spots.			
55			55		
		SILTY SAND (SM): greenish gray (10GY 5/1), 70% fine grained sand, subangular to subrounded; 30% silt; contains quartz, feldspar, and mica.			
		CLAY (CL): greenish gray (10GY 5/1), 90% clay, medium to high plasticity; 5% fine grained sand, subangular to subrounded; 5% silt.			
60			60		
65			65		
70			70		

WELL CONSTRUCTION LOG MPWSP MW TM LITH ALL WELLS.GPJ GEOSCIENCE.GDT 7/7/16

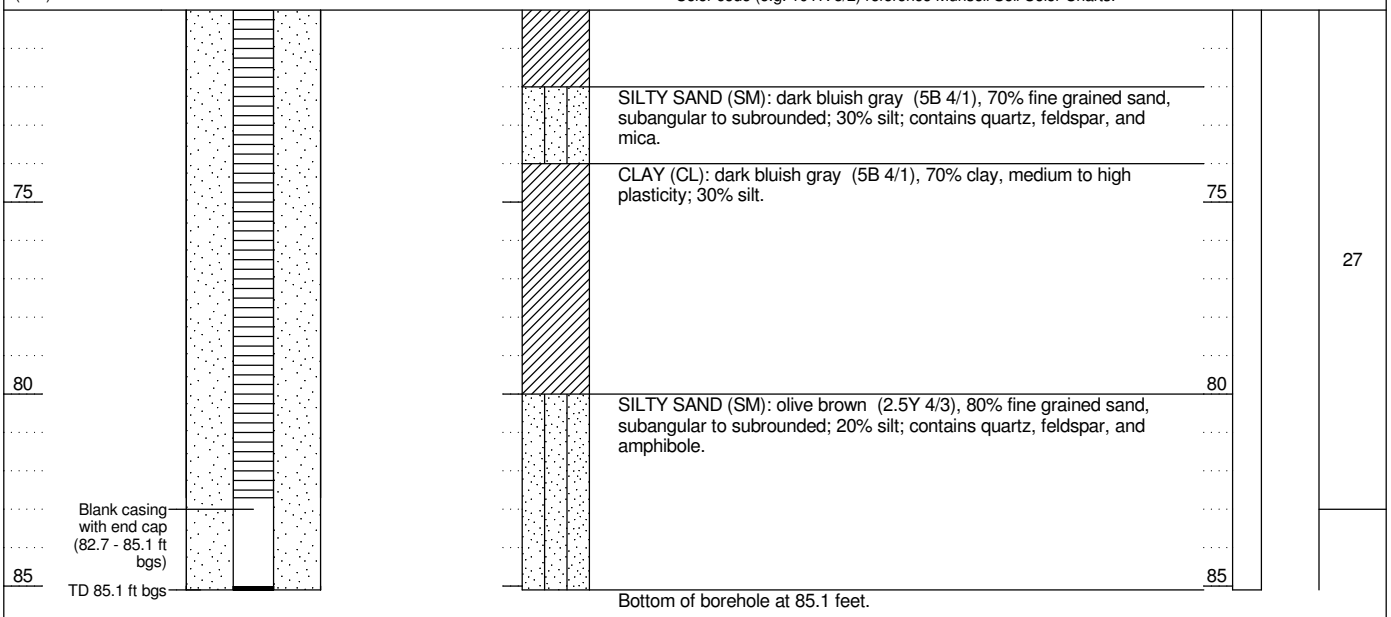
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WELL NUMBER **MPWSP MW-5S**

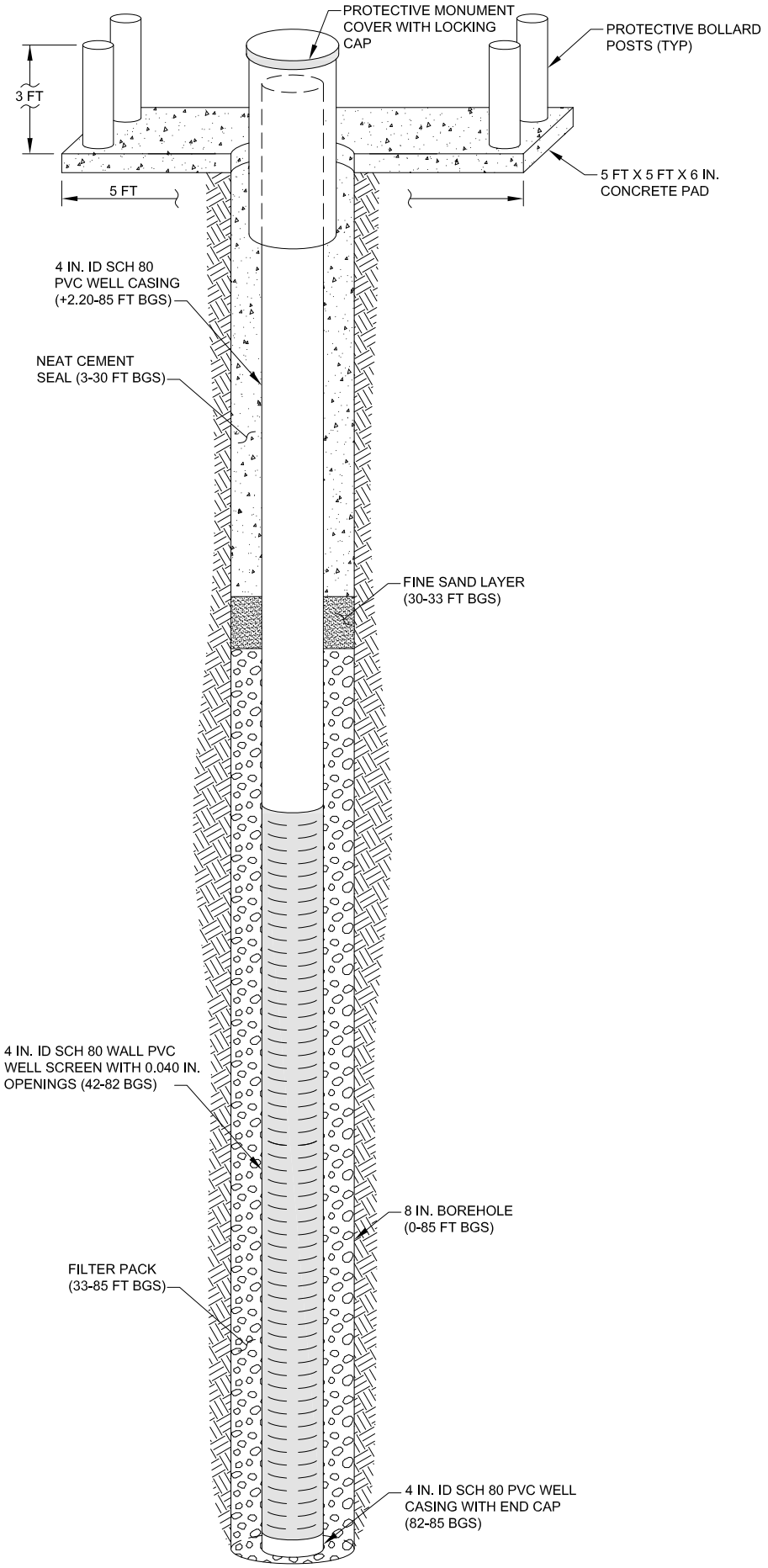
BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am
PROJECT NUMBER 14077-15
LOCATION **Marina, CA**



WELL CONSTRUCTION LOG MPWSP MW TM LITH ALL WELLS.GPJ GEOSCIENCE.GDT 7/7/16

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WELL PROFILE

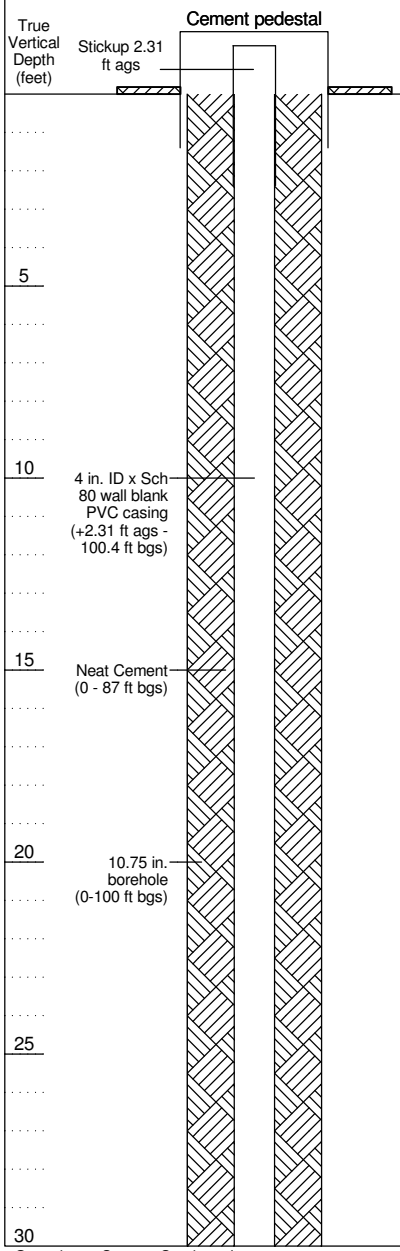
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BOREHOLE LITHOLOGIC LOG

WELL NUMBER **MPWSP MW-5M**	
CLIENT: Cal Am	LOCATION: **Marina, CA**
PROJECT NUMBER: 14077-15	**Neponset Rd**
REPORT DATE:	
DRILLING CONTRACTOR: Cascade Drilling	LOGGED BY: **A. Khalighi**
DRILLER: D. King	

		SCREEN / BLANK	TOP DEPTH (ft bgs)	BOTTOM DEPTH (ft bgs)	LENGTH (ft)	MATERIAL	WALL THICKNESS (in.)	DIAMETER (in.)	SCREEN TYPE	PERF. SIZE (in.)
DRILLING RIG TYPE	ProSonic 600T									
DRILLING METHOD	Sonic	**Blank**	**-2.31**	**100.4**	**102.71**	**PVC**	**Sch 80**	**4 / ID**		
SAMPLING METHOD	Core	**Screen**	**100.4**	**310.4**	**210**	**PVC**	**Sch 80**	**4 / ID**	**Slotted**	**0.04**
BOREHOLE DIAMETER	10.75, 9.875, 8 in	**Blank**	**310.4**	**312.7**	**2.3**	**PVC**	**Sch 80**	**4 / ID**		
SURFACE ELEVATION	78.17 ft NAVD88									
TOC ELEVATION	80.48 ft NAVD88 (RP)									
START DATE	1/21/15									
FINISH DATE	1/27/15									



Lithologic Log

NOTE: Grain size distribution percentages are approximate. Material code (e.g. SP) reference Unified Soil Classification visual method. Color code (e.g. 10YR 5/2) reference Munsell Soil Color Charts.

Graphic Log | Depth bgs (feet) | Sieve Sample Number | Drill Rate (ft/hr)

SAND (SP): strong brown (7.5YR 4/6), 100% fine to medium grained sand, subangular to subrounded; moist sample; contains quartz and feldspar; unconsolidated.

SAND (SP): yellowish brown (10YR 5/6), 100% fine to medium grained sand, subangular to subrounded, trace coarse grains; moist sample; contains quartz and feldspar; unconsolidated.

CLAYEY SAND (SC): strong brown (7.5YR 4/6), 85% fine to medium grained sand, subangular to subrounded; 10% clay, low to medium plasticity; 5% silt; moist sample; contains quartz, feldspar, and amphibole; unconsolidated.

CLAYEY SAND (SC): strong brown (7.5YR 5/6), 75% fine to medium grained sand, subangular to subrounded; 20% clay, medium plasticity; 5% silt; moist sample; contains quartz, feldspar, and amphibole; unconsolidated.

SILTY SAND (SM): dark yellowish brown (10YR 4/4), 85% fine to medium grained sand, subangular to subrounded; 10% silt; 5% clay, medium plasticity; moist sample; contains quartz, feldspar, mica, and amphibole; unconsolidated.

SAND (SP): brownish yellow (10YR 6/8), 100% sand, subangular to subrounded, very fine to fine; moist sample; contains quartz, feldspar, and mica; unconsolidated.

WELL CONSTRUCTION LOG MPWSP MW TM LITH ALL WELLS.GPJ GEOSCIENCE.GDT 7/7/16

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WELL NUMBER **MPWSP MW-5M**

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am
PROJECT NUMBER 14077-15
LOCATION **Marina, CA**

(continued)

Lithologic Log

NOTE: Grain size distribution percentages are approximate. Material code (e.g. SP) reference Unified Soil Classification visual method. Color code (e.g. 10YR 5/2) reference Munsell Soil Color Charts.

True Vertical Depth (feet)	Graphic Log	Depth bgs (feet)	Lithologic Log	Sieve Sample Number	Drill Rate (ft/hr)
35		35			
40		40	SAND (SP): dark yellowish brown (10YR 4/6), 95% sand, subangular to subrounded, very fine to fine; 5% silt; moist to wet sample; contains quartz, feldspar, and mica; unconsolidated.		
45		45			
50		50	SILTY SAND (SM): dark gray (10YR 4/1), 80% sand, subangular to subrounded, very fine to fine; 20% silt; moist to wet sample; contains quartz, feldspar, and mica; unconsolidated.		
55		55	SILT (ML): gray (10YR 5/1), 60% silt; 30% clay, medium plasticity; 10% sand, subangular to subrounded, very fine; moist sample; contains quartz, feldspar, and mica.		
60		60	SILTY SAND (SM): very dark gray (10YR 3/1), 70% sand, subangular to subrounded, very fine to fine; 30% silt; moist sample; contains quartz, feldspar, and mica; unconsolidated. SAND (SP): dark yellowish brown (10YR 3/4), 100% sand, subangular to subrounded, very fine to fine; moist to wet sample; contains quartz, feldspar, and mica; unconsolidated. SANDY CLAY (CL): greenish gray (10GY 5/1), 65% clay, medium plasticity; 30% sand, subangular to subrounded, very fine to fine; 5% silt; moist sample; contains quartz, feldspar, and mica. CLAY (CL): greenish gray (10GY 5/1), 90% clay, medium to high plasticity; 5% sand, subangular to subrounded, very fine to fine; 5% silt; moist sample.		15
65		65	CLAY (CL): dark bluish gray (5B 4/1), 95% clay, high plasticity; 5% silt; moist sample.		
70		70			

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WELL NUMBER **MPWSP MW-5M**

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am
PROJECT NUMBER 14077-15
LOCATION **Marina, CA**

(continued)

True Vertical Depth (feet)	Graphic Log	Lithologic Log NOTE: Grain size distribution percentages are approximate. Material code (e.g. SP) reference Unified Soil Classification visual method. Color code (e.g. 10YR 5/2) reference Munsell Soil Color Charts.	Depth bgs (feet)	Sieve Sample Number	Drill Rate (ft/hr)
75		SILTY SAND (SM): dark bluish gray (5B 4/1), 70% sand, subangular to subrounded, very fine to fine; 30% silt; moist sample; contains quartz, feldspar, and mica; unconsolidated.	75		
80		CLAY (CL): dark bluish gray (5B 4/1), 70% clay, medium to high plasticity; 30% silt; moist sample.	80		
85		SILTY SAND (SM): olive brown (2.5Y 4/3), 80% sand, subangular to subrounded, very fine to fine; 20% silt; contains quartz, feldspar, and amphibole; unconsolidated.	85		
90		CLAY (CL): very dark greenish gray (5GY 3/1), 95% clay, high plasticity; 5% silt; moist sample. SAND (SP): light olive brown (2.5Y 5/6), 100% fine to medium grained sand, subangular to subrounded; moist sample; contains quartz, feldspar, mica, and amphibole; unconsolidated.	90		15
95		SAND (SP): dark yellowish brown (10YR 4/4), 100% fine to medium grained sand, subangular to subrounded; moist sample; contains quartz, feldspar, and amphibole; unconsolidated.	95		
100		SAND (SP): light olive brown (2.5Y 5/3), 100% fine to medium grained sand, subangular to subrounded; moist to wet sample; contains quartz, feldspar, and amphibole; unconsolidated.	100		
105			105		
110			110		

CEMEX Monterey Lapis Lustre #60 fine sand seal (87 - 90 ft bgs)

CEMEX Monterey Lapis Lustre #3 filter pack (90 - 315 ft bgs)

9.875 in. borehole (100-250 ft bgs)

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WELL NUMBER **MPWSP MW-5M**

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am
PROJECT NUMBER 14077-15
LOCATION **Marina, CA**

True Vertical Depth (feet)	(continued)	Graphic Log	Lithologic Log NOTE: Grain size distribution percentages are approximate. Material code (e.g. SP) reference Unified Soil Classification visual method. Color code (e.g. 10YR 5/2) reference Munsell Soil Color Charts.	Depth bgs (feet)	Sieve Sample Number	Drill Rate (ft/hr)
	4 in. ID x Sch 80 wall PVC well screen with 0.040 in. slots (100.4 - 310.4 ft bgs)					15
115				115		
120			SAND (SP): light olive brown (2.5Y 5/4), 100% medium grained sand, subangular to subrounded, trace fine and course grains; moist to wet sample; contains quartz, feldspar, and amphibole; unconsolidated.	120		
125				125		
130			SAND WITH GRAVEL (SP): light olive brown (2.5Y 5/3), 70% fine to coarse grained sand, subangular to subrounded; 25% fine to coarse gravel subangular to subrounded; 5% cobbles; wet sample; contains quartz, feldspar, mica, and amphibole; unconsolidated.	130		
135			SAND WITH GRAVEL (SP): light olive brown (2.5Y 5/3), 75% medium to coarse grained sand; 20% fine to coarse gravel; 5% cobbles; wet sample; contains quartz, feldspar, mica, and amphibole; unconsolidated.	135		12.6
140			SAND (SP): olive brown (2.5Y 4/4), 100% fine grained sand, subangular to subrounded; moist to wet sample; contains quartz, feldspar, mica, and amphibole; unconsolidated.	140		
145				145		
150				150		

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WELL NUMBER
MPWSP MW-5M

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am
PROJECT NUMBER 14077-15
LOCATION **Marina, CA**

True Vertical Depth (feet)	(continued)	Graphic Log	Lithologic Log NOTE: Grain size distribution percentages are approximate. Material code (e.g. SP) reference Unified Soil Classification visual method. Color code (e.g. 10YR 5/2) reference Munsell Soil Color Charts.	Depth bgs (feet)	Sieve Sample Number	Drill Rate (ft/hr)
155				155		
			SAND WITH GRAVEL (SP): olive brown (2.5Y 4/4), 80% medium to coarse grained sand, subangular to subrounded; 15% fine to coarse gravel subangular to subrounded; 5% cobbles; moist to wet sample; contains quartz, feldspar, mica, and amphibole; unconsolidated.			
160				160		
			SAND WITH GRAVEL (SP): yellowish brown (10YR 5/4), 50% coarse grained sand, subangular to subrounded; 40% fine to coarse gravel subangular to subrounded; 10% cobbles; wet sample; contains quartz, feldspar, mica, and amphibole; unconsolidated.			12.6
165				165		
			SAND (SP): light yellowish brown (2.5Y 6/4), 100% fine to medium grained sand, subangular to subrounded; contains quartz and feldspar; unconsolidated.			
170				170		
175				175		
			FAT CLAY (CH): light olive brown (2.5Y 5/3), 80% clay, medium to high plasticity; 20% silt; moist sample; contains reddish iron staining.			
			SILT (ML): grayish brown (2.5Y 5/2), 80% silt; 20% clay, low to medium plasticity; moist sample; contains red and black staining.			
180				180		
			SAND WITH GRAVEL (SP): olive brown (2.5Y 4/3), 80% medium to coarse grained sand, subangular to subrounded; 15% fine to coarse gravel subangular to subrounded; 5% cobbles; contains quartz and feldspar; unconsolidated.			
185				185		
190				190		

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WELL NUMBER **MPWSP MW-5M**

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am
PROJECT NUMBER 14077-15
LOCATION **Marina, CA**

True Vertical Depth (feet)	(continued)	Graphic Log	Lithologic Log NOTE: Grain size distribution percentages are approximate. Material code (e.g. SP) reference Unified Soil Classification visual method. Color code (e.g. 10YR 5/2) reference Munsell Soil Color Charts.	Depth bgs (feet)	Sieve Sample Number	Drill Rate (ft/hr)
195			CLAYEY SAND WITH GRAVEL (SC): strong brown (7.5YR 5/6), 55% fine to coarse grained sand, subangular to rounded; 25% clay, no to low plasticity; 15% fine gravel subangular to rounded; 5% silt; moist sample; contains quartz, feldspar, and amphibole; moderate to high cementation.	195		
			SAND (SP): 95% fine grained sand, subangular to subrounded, some medium to coarse grains; 5% fine gravel subangular to subrounded; moist to wet sample; contains quartz and feldspar; unconsolidated.			
200			SAND WITH GRAVEL (SP): dark yellowish brown (10YR 4/6), 70% coarse grained sand, subangular to subrounded; 25% fine to coarse gravel subangular to subrounded; 5% cobbles; moist to wet sample; moderate cementation; contains quartz, feldspar, and amphibole.	200		
205				205		
210				210		
215				215		
			FAT CLAY (CH): grayish brown (2.5Y 5/2), 60% clay, medium to high plasticity; 30% silt; 10% sand, very fine with trace coarse grains; moist sample.		
220				220		
			SILT (ML): light olive brown (2.5Y 5/3), 60% silt; 30% clay, medium to high plasticity; 10% fine to coarse grained sand, subrounded; trace fine gravel subrounded; moist sample.			
225				225		
			SAND (SP): strong brown (7.5YR 4/6), 95% fine to coarse grained sand, subangular to rounded; 5% fine gravel subangular to rounded; wet sample; contains quartz, feldspar, and amphibole; unconsolidated.			
			SAND (SP): dark brown (10YR 3/3), 100% fine grained sand, subangular to subrounded; moist sample; contains quartz, feldspar, mica, and amphibole; unconsolidated.			4.6
230				230		

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WELL NUMBER **MPWSP MW-5M**

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am
PROJECT NUMBER 14077-15
LOCATION **Marina, CA**

True Vertical Depth (feet)	(continued)	Graphic Log	Lithologic Log NOTE: Grain size distribution percentages are approximate. Material code (e.g. SP) reference Unified Soil Classification visual method. Color code (e.g. 10YR 5/2) reference Munsell Soil Color Charts.	Depth bgs (feet)	Sieve Sample Number	Drill Rate (ft/hr)
235				235		
240				240		4.6
			SAND (SP): dark brown (10YR 3/3), 100% fine grained sand, subangular to subrounded; wet sample; contains quartz, feldspar, mica, and amphibole; unconsolidated.			
245				245		
250				250		
	8 in. borehole (250-315 ft bgs)					
255				255		
260				260		18.5
			SILTY SAND (SM): dark brown (7.5YR 3/3), 80% fine grained sand, subangular to subrounded; 20% silt; moist to wet sample; contains quartz, feldspar, mica, and amphibole; unconsolidated.			
265				265		
270				270		

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WELL NUMBER **MPWSP MW-5M**

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am
PROJECT NUMBER 14077-15
LOCATION **Marina, CA**

True Vertical Depth (feet)	(continued)	Graphic Log	Lithologic Log NOTE: Grain size distribution percentages are approximate. Material code (e.g. SP) reference Unified Soil Classification visual method. Color code (e.g. 10YR 5/2) reference Munsell Soil Color Charts.	Depth bgs (feet)	Sieve Sample Number	Drill Rate (ft/hr)
275			SAND (SP): dark brown (7.5YR 3/2), 95% sand, subangular to subrounded, very fine to fine grained; 5% silt; moist to wet sample; contains quartz, feldspar, mica, and amphibole; unconsolidated.	275		
280				280		
			SILTY SAND (SM): dark brown (7.5YR 3/4), 85% sand, subangular to subrounded, very fine to fine grained; 15% silt; moist to wet sample; contains quartz, feldspar, mica, and amphibole; unconsolidated.			
285			SAND (SP): dark brown (7.5YR 3/3), 95% sand, subangular to subrounded, very fine to fine grained; 5% silt; moist to wet sample; contains quartz, feldspar, mica, and amphibole; unconsolidated.	285		
290				290		18.5
295				295		
300				300		
305				305		
310			CLAYEY SAND (SC): olive (5Y 5/4), 60% sand, subangular to subrounded, very fine to fine grained; 30% clay, low plasticity; 10%	310		

WELL CONSTRUCTION LOG MPWSP MW TM LITH ALL WELLS.GPJ GEOSCIENCE.GDT 7/7/16

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WELL NUMBER **MPWSP MW-5M**

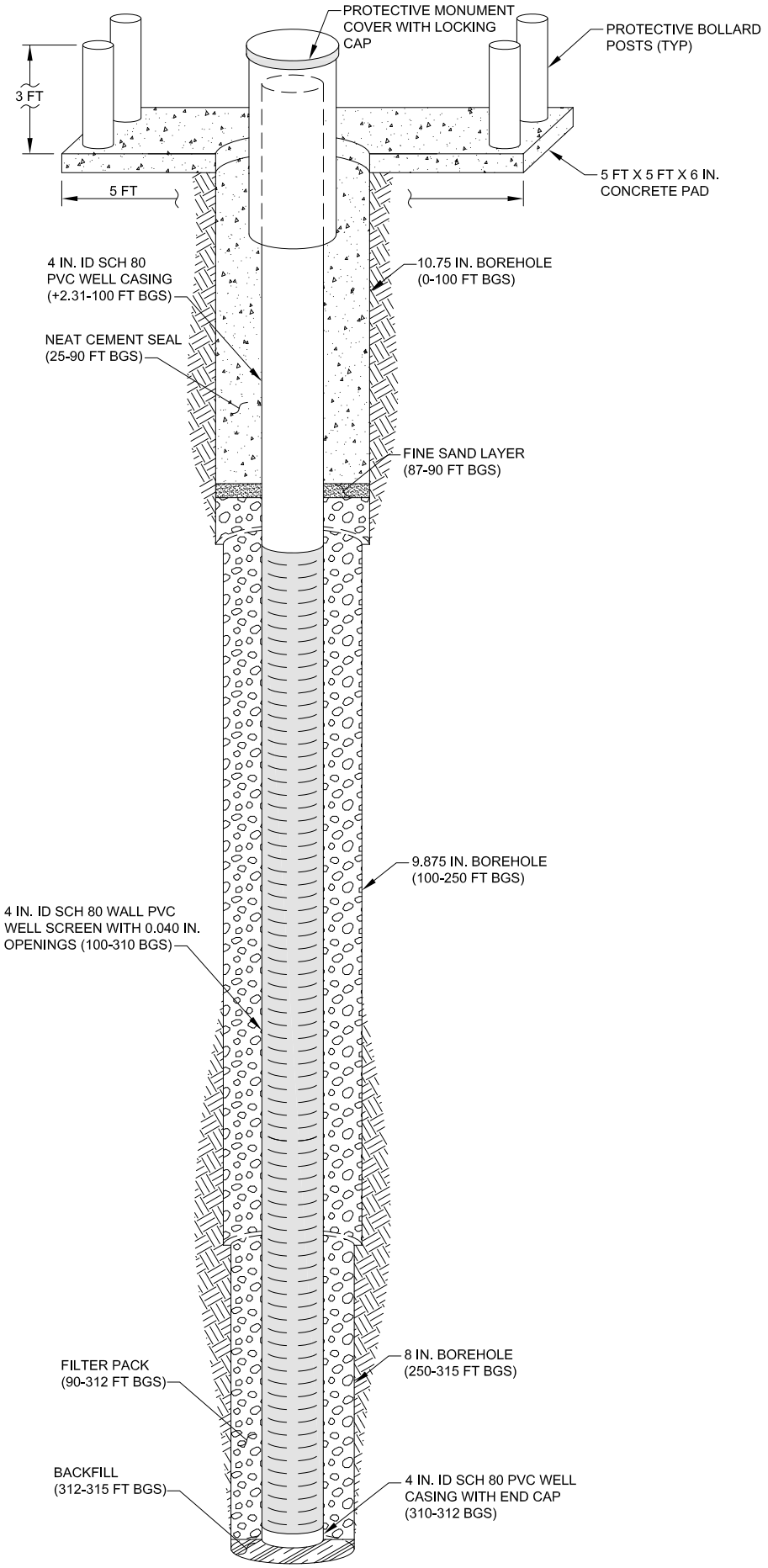
BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am
PROJECT NUMBER 14077-15
LOCATION **Marina, CA**

True Vertical Depth (feet)	(continued)	Graphic Log	Lithologic Log NOTE: Grain size distribution percentages are approximate. Material code (e.g. SP) reference Unified Soil Classification visual method. Color code (e.g. 10YR 5/2) reference Munsell Soil Color Charts.	Depth bgs (feet)	Sieve Sample Number	Drill Rate (ft/hr)
	Blank casing with end cap (310.4 - 312.7 ft bgs)		silt; moist to wet sample; contains quartz, feldspar, mica, and amphibole; unconsolidated.			18.5
315	TD 315 ft bgs			315		

Bottom of borehole at 315 feet.

WELL CONSTRUCTION LOG MPWSP MW TM LITH ALL WELLS.GPJ GEOSCIENCE.GDT 7/7/16



WELL PROFILE

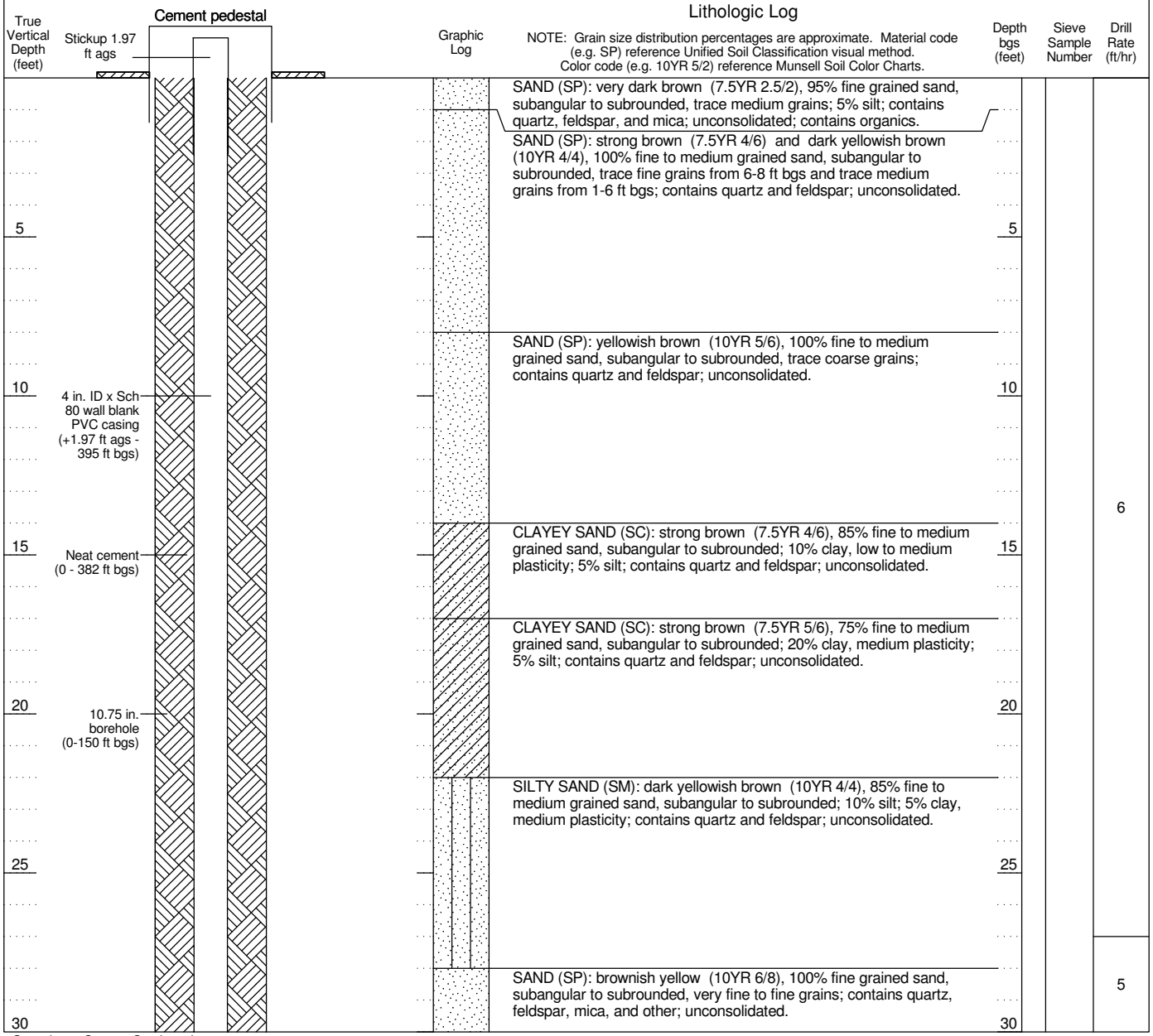
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BOREHOLE LITHOLOGIC LOG

WELL NUMBER **MPWSP MW-5D**	
CLIENT: Cal Am	LOCATION: **Marina, CA**
PROJECT NUMBER: 14077-15	**Neponset Rd**
REPORT DATE:	
DRILLING CONTRACTOR: Cascade Drilling	LOGGED BY: **A. Khalighi**
DRILLER: D. King	

		SCREEN / BLANK	TOP DEPTH (ft bgs)	BOTTOM DEPTH (ft bgs)	LENGTH (ft)	MATERIAL	WALL THICKNESS (in.)	DIAMETER (in.)	SCREEN TYPE	PERF. SIZE (in.)
DRILLING RIG TYPE	ProSonic 600T									
DRILLING METHOD	Sonic	**Blank**	**-1.97**	**395**	**383.97**	**PVC**	**Sch 80**	**4 / ID**		
SAMPLING METHOD	Core	**Screen**	**395**	**435**	**40**	**PVC**	**Sch 80**	**4 / ID**	**Slotted**	**0.04**
BOREHOLE DIAMETER	10.75, 9.875, 8 in	**Blank**	**435**	**437.3**	**2.3**	**PVC**	**Sch 80**	**4 / ID**		
SURFACE ELEVATION	78.09 ft NAVD88									
TOC ELEVATION	80.06 ft NAVD88 (RP)									
START DATE	12/16/14									
FINISH DATE	1/21/15									



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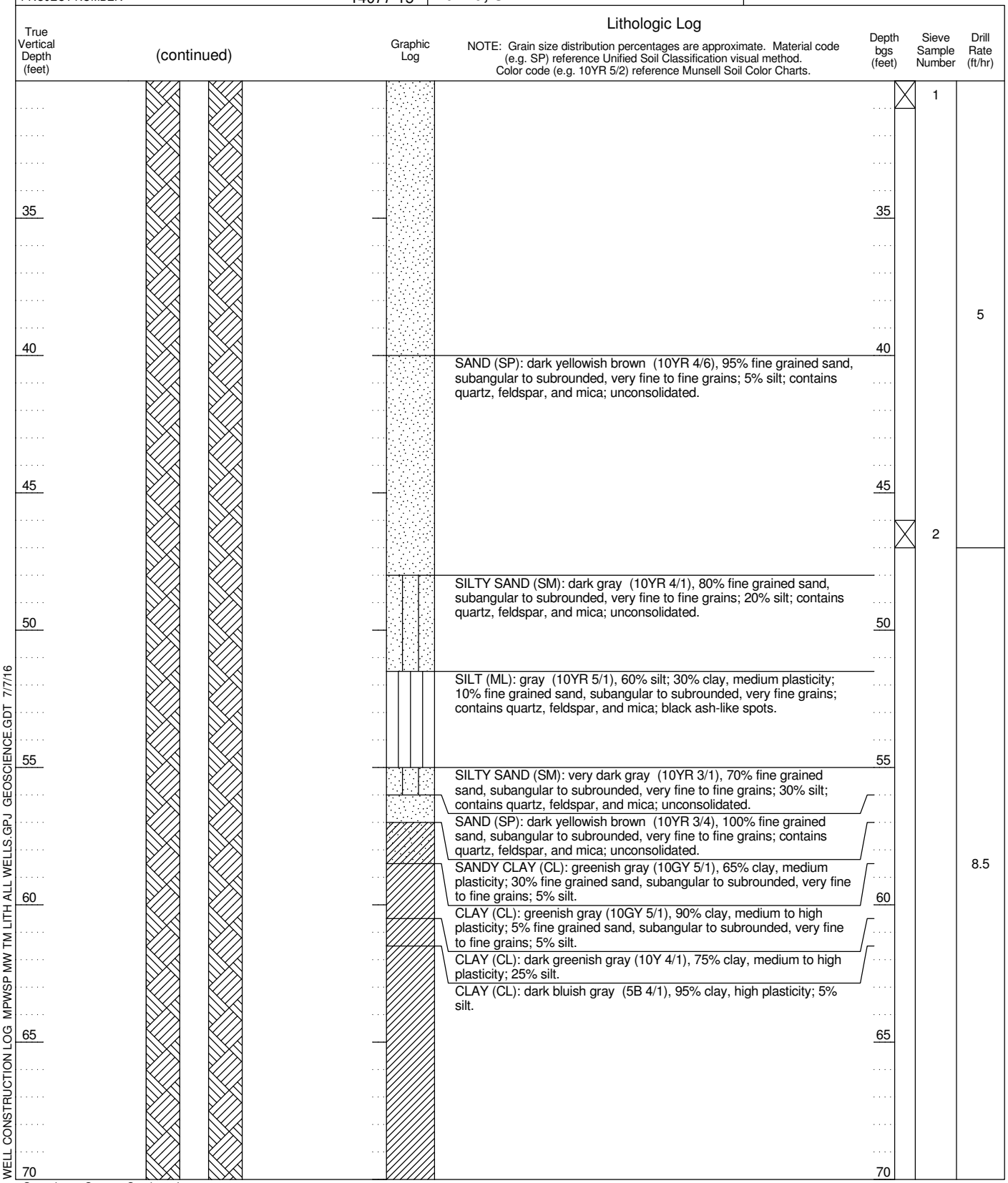
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WELL NUMBER **MPWSP MW-5D**

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am
PROJECT NUMBER 14077-15
LOCATION **Marina, CA**



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WELL NUMBER **MPWSP MW-5D**

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am
PROJECT NUMBER 14077-15
LOCATION **Marina, CA**

True Vertical Depth (feet)	(continued)	Graphic Log	Lithologic Log NOTE: Grain size distribution percentages are approximate. Material code (e.g. SP) reference Unified Soil Classification visual method. Color code (e.g. 10YR 5/2) reference Munsell Soil Color Charts.	Depth bgs (feet)	Sieve Sample Number	Drill Rate (ft/hr)
75			SAND (SP): olive brown (2.5Y 4/3), 100% fine grained sand, subangular to subrounded, very fine to fine grains; contains quartz, feldspar, and mica.	75		8.5
			SILTY SAND (SM): dark bluish gray (5B 4/1), 70% fine grained sand, subangular to subrounded, very fine to fine grains; 30% silt; contains quartz, feldspar, and mica.			
			CLAY (CL): dark bluish gray (5B 4/1), 70% clay, medium to high plasticity; 30% silt; clay content increases with depth.			
80			SILTY SAND (SM): olive brown (2.5Y 4/3), 80% fine grained sand, subangular to subrounded, very fine to fine grains; 20% silt; contains quartz, feldspar, and mica; with visible alteration; iron oxide staining; 20% clay and 30% silt from 84-85 ft bgs.	80		
85			CLAY (CL): very dark greenish gray (5GY 3/1), 95% clay, high plasticity; 5% silt; black ash-like spots.	85		10
90			SAND (SP): light olive brown (2.5Y 5/6), 100% fine to medium grained sand, subangular to subrounded; contains quartz, feldspar, and amphibole; shell fragments to 2mm.	90		
95			SAND (SP): dark yellowish brown (10YR 4/4), 100% fine to medium grained sand, subangular to subrounded; contains quartz, feldspar, and amphibole; trace shell fragments to 2mm.	95	3	
100			SAND (SP): light olive brown (2.5Y 5/3), 100% fine to medium grained sand, subangular to subrounded; contains quartz, feldspar, and amphibole; shell fragments to 0.43mm.	100		
105				105	4	
110				110		

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WELL NUMBER **MPWSP MW-5D**

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am
PROJECT NUMBER 14077-15
LOCATION **Marina, CA**

True Vertical Depth (feet)	(continued)	Graphic Log	Lithologic Log NOTE: Grain size distribution percentages are approximate. Material code (e.g. SP) reference Unified Soil Classification visual method. Color code (e.g. 10YR 5/2) reference Munsell Soil Color Charts.	Depth bgs (feet)	Sieve Sample Number	Drill Rate (ft/hr)
115				115	5	
			SAND (SP): light olive brown (2.5Y 5/4), 100% fine to coarse grained sand, subangular to subrounded, predominantly medium grained; contains quartz, feldspar, and amphibole; shell fragments to 4.8mm.			
120				120	6	
125				125		
			SAND WITH GRAVEL (SP): light olive brown (2.5Y 5/3), 70% fine to coarse grained sand, subangular to subrounded; 25% fine to coarse gravel up to 75 mm, subangular to subrounded; 5% cobbles; contains quartz, feldspar, mica, and amphibole; shell fragments to 4.8mm.			
130				130	7	
			SILTY SAND (SM): light olive brown (2.5Y 5/6), 80% fine to coarse grained sand, subangular to subrounded; 15% silt; 5% fine to coarse gravel subangular to subrounded; contains quartz, feldspar, mica, and amphibole; shell fragments to 2mm.			
135			SAND WITH GRAVEL (SP): light olive brown (2.5Y 5/3), 75% medium to coarse grained sand, subrounded to rounded; 20% fine to coarse gravel subrounded to rounded; 5% cobbles; contains quartz, feldspar, mica, and amphibole; shell fragments to 4.8mm.	135	8	
			SAND (SP): light olive brown (2.5Y 5/4), 100% fine to coarse grained sand, subangular to subrounded; trace fine gravel subangular to subrounded; contains quartz, feldspar, mica, and amphibole; shell fragments to 4.8mm.			
140				140	9	
			SAND (SP): olive brown (2.5Y 4/4), 100% fine grained sand, subangular to subrounded; contains quartz, feldspar, mica, and amphibole.			
145				145	10	
150				150		

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WELL NUMBER
MPWSP MW-5D

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am
PROJECT NUMBER 14077-15
LOCATION **Marina, CA**

True Vertical Depth (feet)	(continued)	Graphic Log	Lithologic Log NOTE: Grain size distribution percentages are approximate. Material code (e.g. SP) reference Unified Soil Classification visual method. Color code (e.g. 10YR 5/2) reference Munsell Soil Color Charts.	Depth bgs (feet)	Sieve Sample Number	Drill Rate (ft/hr)
	9.875 in. borehole (150-300 ft bgs)					
155			SAND WITH GRAVEL (SP): olive brown (2.5Y 4/4), 80% medium to coarse grained sand, subangular to subrounded; 20% fine to coarse gravel subangular to subrounded; contains quartz, feldspar, mica, and amphibole; trace cobbles; shell fragments to 2mm.	155	11	
160			SAND WITH GRAVEL (SP): yellowish brown (10YR 5/4), 55% fine to coarse grained sand, angular to rounded; 45% fine to coarse gravel angular to rounded; contains quartz, feldspar, mica, and amphibole; trace cobbles.	160	12	
165				165		
170			SAND (SP): light reddish brown (2.5YR 6/4), 100% fine to medium grained sand, subangular to subrounded; contains quartz and feldspar.	170	13	
175				175		
180			FAT CLAY (CH): light olive brown (2.5Y 5/3), 80% clay, medium to high plasticity; 20% silt; with visible alteration; iron oxide staining. SAND (SP): light olive brown (2.5Y 5/4), 100% medium to coarse grained sand, subangular to subrounded; contains quartz, feldspar, and mica; shell fragments to 2mm. SILT (ML): grayish brown (2.5Y 5/2), 80% silt; 20% clay; red and black staining; low to medium plasticity.	180		9
185			SAND WITH GRAVEL (SP): olive brown (2.5Y 4/3), 80% medium to coarse grained sand, subangular to subrounded; 20% fine to coarse gravel subangular to subrounded; contains quartz and feldspar; trace cobbles; clay lens from 190-190.5; chert; gravel content increases with depth.	185	14	
190				190		

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WELL NUMBER **MPWSP MW-5D**

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am | LOCATION **Marina, CA**
PROJECT NUMBER 14077-15

True Vertical Depth (feet)	(continued)	Graphic Log	Lithologic Log NOTE: Grain size distribution percentages are approximate. Material code (e.g. SP) reference Unified Soil Classification visual method. Color code (e.g. 10YR 5/2) reference Munsell Soil Color Charts.	Depth bgs (feet)	Sieve Sample Number	Drill Rate (ft/hr)
			CLAYEY SAND WITH GRAVEL (SC): strong brown (7.5YR 4/6), 55% fine to coarse grained sand, subrounded to rounded, medium to coarse grained from 197-198 ft bgs; 25% clay, no to low plasticity; 15% fine gravel subrounded to rounded; 5% silt; moderate cementation; contains quartz, feldspar, and amphibole.			
195			SAND (SP): gray (7.5YR 5/1), 95% fine to coarse grained sand, subrounded to rounded, predominantly fine; 5% fine gravel subrounded to rounded; contains quartz and feldspar.	195		
			SAND WITH GRAVEL (SP): grayish brown (10YR 5/2), 65% fine to coarse grained sand, subrounded to rounded, predominantly medium to coarse; 35% fine to coarse gravel subrounded to rounded; weak cementation; contains quartz, feldspar, and amphibole; trace cobbles; trace clay; iron oxide staining.			
200				200	15	
			SAND WITH GRAVEL (SP): dark yellowish brown (10YR 4/6), 70% coarse grained sand, subangular to rounded; 30% fine to coarse gravel subangular to rounded; moderate cementation; contains quartz, feldspar, and amphibole; trace cobbles.			
205				205	16	
			SAND (SP): grayish brown (10YR 5/2), 88% fine to coarse grained sand, subrounded to rounded, trace fine grained; 12% fine to coarse gravel subrounded to rounded; contains quartz, feldspar, and amphibole; trace cobbles; trace shell fragments to 2mm.			
210			SAND (SP): grayish brown (10YR 5/2), 85% fine to coarse grained sand, subrounded to rounded, trace fine grained; 15% fine to coarse gravel subrounded to rounded; moderate cementation; contains quartz, feldspar, and amphibole; trace cobbles.	210		9
			SAND (SP): dark grayish brown (10YR 4/2), 100% fine grained sand, subangular to subrounded; contains quartz, feldspar, mica, and amphibole.			
			SAND WITH GRAVEL (SP): grayish brown (2.5Y 5/2), 70% medium to coarse grained sand, subrounded to rounded; 30% fine to coarse gravel subrounded to rounded; contains quartz, and feldspar; trace cobbles; trace clay from 217-217.5 ft bgs.			
215				215	17	
			FAT CLAY (CH): brown (10YR 5/3), 95% clay, high plasticity; 5% silt.			
220			FAT CLAY (CH): brown (10YR 4/3), 60% clay, medium to high plasticity; 30% silt; 10% fine grained sand, trace coarse grains.	220		
			SILT (ML): light olive brown (2.5Y 5/3), 60% silt; 30% clay, medium to high plasticity; 10% sand, subrounded, fine and coarse; trace fine gravel subrounded.			
225				225		
			SAND WITH GRAVEL (SP): strong brown (7.5YR 4/6), 85% fine to coarse grained sand, subrounded to rounded, predominantly fine grained; 15% fine gravel subrounded to rounded; weak cementation; contains quartz, feldspar, and amphibole; trace shell fragments to 2mm; red iron oxide staining.			
			SAND (SP): dark brown (10YR 3/3), 100% fine grained sand, subangular to subrounded; contains quartz, feldspar, mica, and amphibole; trace silt at 240 ft bgs; friable sandstone to 75mm.			
230				230		

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WELL NUMBER
MPWSP MW-5D

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am
PROJECT NUMBER 14077-15
LOCATION **Marina, CA**

True Vertical Depth (feet)	(continued)	Graphic Log	Lithologic Log NOTE: Grain size distribution percentages are approximate. Material code (e.g. SP) reference Unified Soil Classification visual method. Color code (e.g. 10YR 5/2) reference Munsell Soil Color Charts.	Depth bgs (feet)	Sieve Sample Number	Drill Rate (ft/hr)
235				235	18	
240				240	19	9
245				245		
250				250		
255				255	20	
260				260		
265			SILTY SAND (SM): dark brown (7.5YR 3/3), 80% fine grained sand, subangular to subrounded; 20% silt; contains quartz, feldspar, mica, and amphibole.	265		16
270				270		

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WELL NUMBER **MPWSP MW-5D**

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am
PROJECT NUMBER 14077-15
LOCATION **Marina, CA**

(continued)

True Vertical Depth (feet)	Lithologic Log	Depth bgs (feet)	Sieve Sample Number	Drill Rate (ft/hr)
	NOTE: Grain size distribution percentages are approximate. Material code (e.g. SP) reference Unified Soil Classification visual method. Color code (e.g. 10YR 5/2) reference Munsell Soil Color Charts.			
275	SAND (SP): dark brown (7.5YR 3/2), 95% fine grained sand, subangular to subrounded, very fine to fine grains; 5% silt; contains quartz, feldspar, mica, and amphibole.	275	21	
280	SILTY SAND (SM): dark brown (7.5YR 3/4), 85% fine grained sand, subangular to subrounded, very fine to fine grains; 15% silt; contains quartz, feldspar, mica, and amphibole.	280		16
285	SAND (SP): dark brown (7.5YR 3/3), 95% fine grained sand, subangular to subrounded, very fine to fine grains; 5% silt; contains quartz, feldspar, mica, and amphibole.	285		
290		290	22	
295		295		
300	8 in. borehole (300-440 ft bgs)	300		3.6
305		305	23	
310	CLAY WITH SAND (CL): olive (5Y 5/4), 80% clay, medium to high plasticity; 15% fine grained sand, subangular to subrounded, very fine to fine grains; 5% silt; contains quartz, feldspar, mica, and amphibole.	310		

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BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am
PROJECT NUMBER 14077-15
LOCATION **Marina, CA**

(continued)

True Vertical Depth (feet)	Lithologic Log	Depth bgs (feet)	Sieve Sample Number	Drill Rate (ft/hr)
	NOTE: Grain size distribution percentages are approximate. Material code (e.g. SP) reference Unified Soil Classification visual method. Color code (e.g. 10YR 5/2) reference Munsell Soil Color Charts.			
	CLAYEY SAND (SC): olive (5Y 4/4), 60% fine grained sand, subangular to subrounded, very fine to fine grains; 30% clay, low plasticity; 10% silt; contains quartz, feldspar, mica, and amphibole.			
315		315		
	SAND (SP): dark brown (7.5YR 3/3), 100% fine grained sand, subangular to subrounded; contains quartz, feldspar, mica, and amphibole.			
	SILTY SAND (SM): olive brown (2.5Y 4/3), 80% fine to medium grained sand, subangular to subrounded; 15% silt; 5% clay; contains quartz, feldspar, mica, and amphibole.			
320		320		
	SAND WITH GRAVEL (SP): very dark grayish brown (2.5Y 3/2), 80% fine to medium grained sand, subangular to subrounded; 20% fine to coarse gravel subangular to subrounded; contains quartz, feldspar, mica, and amphibole; trace cobbles; chert; trace shell fragments to 4.8mm.			
325		325		
	CLAYEY SAND (SC): light olive brown (2.5Y 5/3), 75% fine grained sand, subangular to subrounded; 20% clay, low plasticity; 5% silt; contains quartz, feldspar, mica, and amphibole.			
	CLAY (CL): dark greenish gray (10Y 4/1), 90% clay, medium plasticity; 10% silt; gray and black ash-like spots.			
330		330		
	SILTY SAND (SM): dark yellowish brown (10YR 4/4), 65% fine grained sand, subangular to subrounded, very fine to fine grains; 35% silt.			
	SILT WITH SAND (ML): greenish gray (10Y 5/1), 60% silt; 25% clay, low plasticity; 15% fine grained sand, very fine grains.			
335	SANDY CLAY (CL): greenish black (10GY 2.5/1), 60% clay, medium plasticity; 40% fine to medium grained sand, subangular to subrounded; contains quartz, feldspar, mica, and amphibole.	335		
340		340		6
	CLAYEY SAND (SC): olive (5Y 4/4), 60% fine to coarse grained sand, subangular to subrounded; 30% clay, low plasticity; 10% fine to coarse gravel subangular to subrounded; contains quartz, feldspar, mica, and amphibole; chert.			
345	SILT (ML): dark greenish gray (10Y 4/1), 60% silt; 30% clay, low plasticity; 10% fine grained sand, subangular to subrounded, very fine grains.	345		
	CLAY (CL): dark grayish brown (2.5Y 4/2), 90% clay, medium to high plasticity; 5% fine grained sand, very fine grains; 5% silt.			
350		350		

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WELL NUMBER **MPWSP MW-5D**

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am
PROJECT NUMBER 14077-15
LOCATION **Marina, CA**

(continued)

True Vertical Depth (feet)	Graphic Log	Lithologic Log NOTE: Grain size distribution percentages are approximate. Material code (e.g. SP) reference Unified Soil Classification visual method. Color code (e.g. 10YR 5/2) reference Munsell Soil Color Charts.	Depth bgs (feet)	Sieve Sample Number	Drill Rate (ft/hr)
355		SANDY CLAY (CL): dark greenish gray (10Y 4/1), 50% clay, low to medium plasticity; 35% fine grained sand, subangular to subrounded, very fine to fine grains; 15% silt.	355		
360			360		6
365		SANDY CLAY (CL): dark yellowish brown (10YR 4/4), 50% clay, low plasticity; 45% fine grained sand, subangular to subrounded; 5% silt.	365		
370		CLAY (CL): dark yellowish brown (10YR 4/4), 85% clay, medium to high plasticity; 15% silt; gray spots to 3mm.	370		
375			375		
380		CLAY WITH SAND (CL): dark yellowish brown (10YR 4/6), 60% clay, medium plasticity; 25% fine grained sand, very fine grains; 15% silt.	380		
385		SILT WITH SAND (ML): dark yellowish brown (10YR 3/6), 50% silt; 25% fine grained sand, very fine grains; 25% clay, medium to high plasticity.	385		6.6
390		CLAY (CL): light olive brown (2.5Y 5/3), 100% clay, medium to high plasticity.	390		

CEMEX Monterey Lapis Lustre #60 fine sand seal (382 - 385 ft bgs)

CEMEX Monterey Lapis Lustre #3 filter pack (385 - 440 ft bgs)

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WELL NUMBER **MPWSP MW-5D**

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am
PROJECT NUMBER 14077-15
LOCATION **Marina, CA**

True Vertical Depth (feet)	(continued)	Graphic Log	Lithologic Log NOTE: Grain size distribution percentages are approximate. Material code (e.g. SP) reference Unified Soil Classification visual method. Color code (e.g. 10YR 5/2) reference Munsell Soil Color Charts.	Depth bgs (feet)	Sieve Sample Number	Drill Rate (ft/hr)
			SANDY SILT (ML): dark grayish brown (2.5Y 4/2), 50% silt; 40% fine grained sand, very fine grains; 10% clay.			
			FAT CLAY WITH SAND (CH): dark olive brown (2.5Y 3/3), 75% clay, high plasticity; 25% fine to medium grained sand, subangular to subrounded; contains quartz, feldspar, mica, and amphibole.			
395			SAND WITH GRAVEL (SP): dark greenish gray (10Y 4/1) and dark brown (10YR 3/3), 80% medium to coarse grained sand, subangular to subrounded; 20% fine to coarse gravel subangular to subrounded; contains quartz, feldspar, mica, and amphibole; chert; shell fragments to 4.8mm; larger grains from 397.5-407.5 ft bgs.	395		
	4 in. ID x Sch 80 wall PVC well screen with 0.040 in. slots (395 - 435 ft bgs)					
400				400	24	
405				405		
			SAND (SP): dark yellowish brown (10YR 3/6), 100% fine to medium grained sand, subangular to subrounded; contains quartz, feldspar, mica, and amphibole; trace shell fragments to 4.8mm.			
410				410	25	6.6
415				415		
420				420		
			SAND WITH GRAVEL (SP): grayish brown (2.5Y 5/2), 85% fine to coarse grained sand, subangular to subrounded; 15% fine to coarse gravel subrounded to rounded; contains quartz, feldspar, mica, and amphibole; trace cobbles.			
425			SAND (SP): grayish brown (2.5Y 5/2), 95% medium to coarse grained sand, subangular to subrounded; 5% fine to coarse gravel rounded; contains quartz, feldspar, mica, and amphibole.	425	26	
			SAND (SP): light olive brown (2.5Y 5/4), 95% medium grained sand, subangular to subrounded; 5% fine gravel rounded; contains quartz, feldspar, mica, and amphibole.			
			CLAYEY SAND WITH GRAVEL (SC): light olive brown (2.5Y 5/4), 45% fine to medium grained sand, subangular to subrounded; 25% clay, medium to high plasticity; 20% fine to coarse gravel subangular			
430				430		

WELL CONSTRUCTION LOG MPWSP MW TM LITH ALL WELLS.GPJ GEOSCIENCE.GDT 7/7/16

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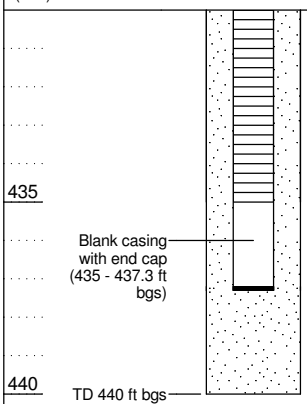
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WELL NUMBER **MPWSP MW-5D**

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am
PROJECT NUMBER 14077-15
LOCATION **Marina, CA**

(continued)



True Vertical Depth (feet)	Graphic Log	Lithologic Log NOTE: Grain size distribution percentages are approximate. Material code (e.g. SP) reference Unified Soil Classification visual method. Color code (e.g. 10YR 5/2) reference Munsell Soil Color Charts.	Depth bgs (feet)	Sieve Sample Number	Drill Rate (ft/hr)
		to rounded; 10% cobbles; contains quartz, feldspar, mica, and amphibole.			
		SAND (SP): greenish black (5GY 2.5/1), 90% medium to coarse grained sand, subangular to subrounded; 10% fine to coarse gravel subrounded; contains quartz, feldspar, mica, and amphibole.			
		SAND (SP): very dark greenish gray (10Y 3/1), 100% fine to medium grained sand, subangular to subrounded; contains quartz, feldspar, mica, and amphibole.			
435			435		
		SAND WITH GRAVEL (SP): dark grayish brown (2.5Y 4/2), 80% fine to coarse grained sand, subangular to subrounded; 10% fine to coarse gravel subangular to rounded; 10% cobbles; contains quartz, feldspar, mica, and amphibole; trace cobbles.		27	
440		Bottom of borehole at 440 feet.	440		

APPENDIX C

PACIFIC SURVEYS

TEMPERATURE
DELTA TEMPERATURE
FLUID RESISTIVITY
DELTA FLUID RESISTIVITY

Job No. 19106

File No.

Company CASCADE DRILLING

Well MW-5 DEEP

Field SALINAS

County MONTEREY State CA

Location

OFF OF NEPONSET RD.
GPS: N 36o 43.075' W 121o 46.472'

Other Services:

DUAL INDUCTION
GAMMA-RAY

			Elevation
Permanent Datum	G.L.	Elevation above perm. datum	K.B.
Log Measured From	G.L.	0'	D.F.
Drilling Measured From	G.L.		G.L.

Date	01-08-2015		
Run Number	ONE		
Depth Driller	432'		
Depth Logger	430'		
Bottom Logged Interval	430'		
Top Log Interval	0'		
Open Hole Size	12" (0'-20')	10.75" (20"-100')	9.875" (100'-300')
Type Fluid	WATER		8" (300'-432')
Density / Viscosity	N/A		
Fluid Level	73'		
Bentonite Seal	N/A		
Time Well Ready	1500		
Time Logger on Bottom	1515		
Equipment Number	PS-7		
Location	LA		
Recorded By	SCHUMACHER		
Witnessed By	N. REYNOLDS		

Borehole Record				Tubing Record			
Run Number	Bit	From	To	Size	Weight	From	To
ONE	12"	0'	20'				
TWO	10.75"	20'	100'				
THREE	9.875"	100'	300'				
FOUR	8"	300'	432'				

Casing Record	Size	Wgt/Ft	Top	Bottom
Surface String				
Prot. String				
Production String	4" PVC	SCH 80	0'	432'
Liner				

<<< Fold Here >>>

All interpretations are opinions based on inferences from electrical or other measurements and Pacific Surveys cannot and do not guarantee the accuracy or correctness of any interpretation, and we shall not, except in the case of gross or willful negligence on our part, be liable or responsible for any loss, costs, damages, or expenses incurred or sustained by anyone resulting from any interpretation made by any of our officers, agents or employees. These interpretations are also subject to Pacific Surveys' general terms and conditions set out in our current Price Schedule.

Comments

Calibration Report

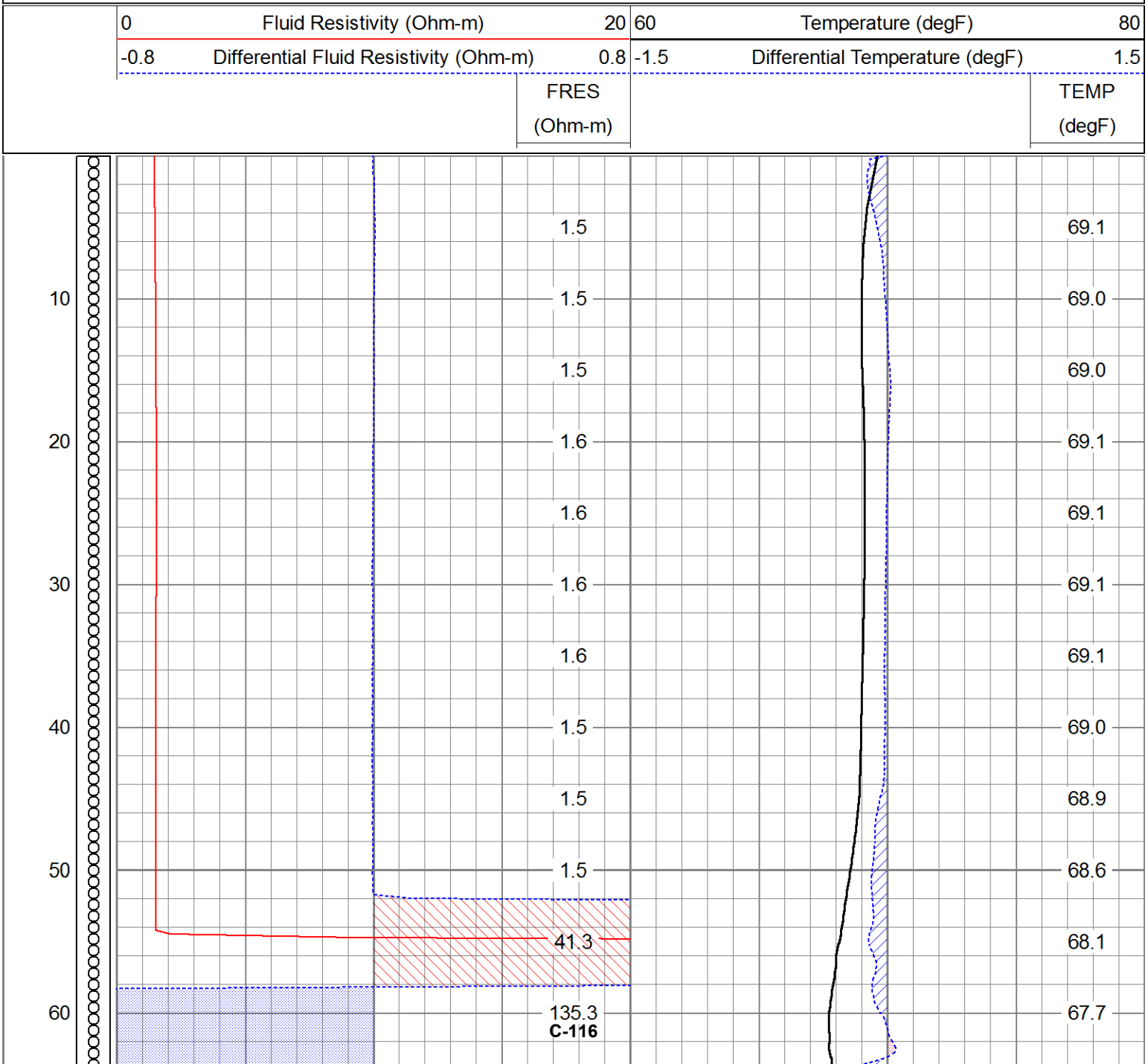
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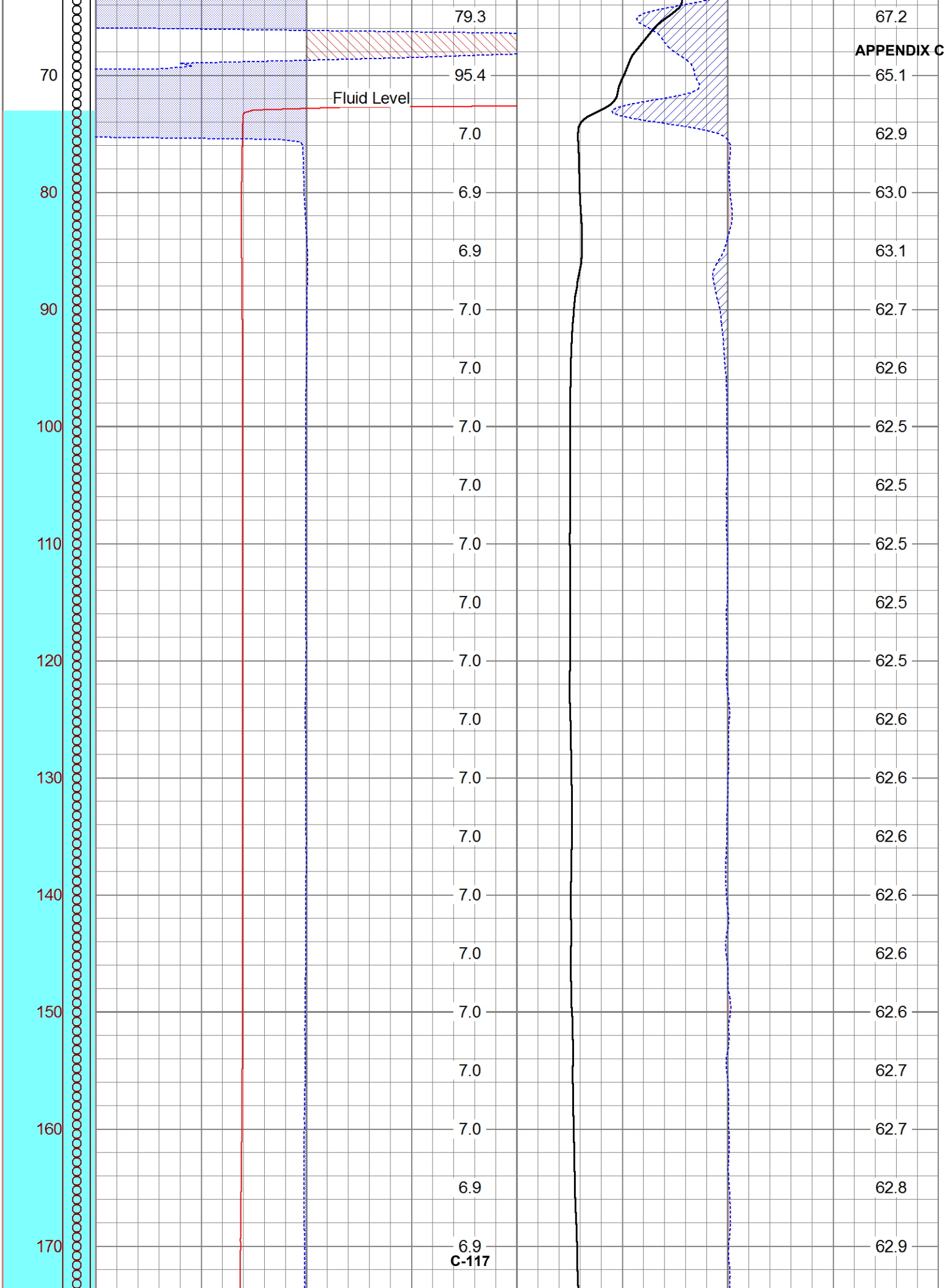
Temperature Calibration Report

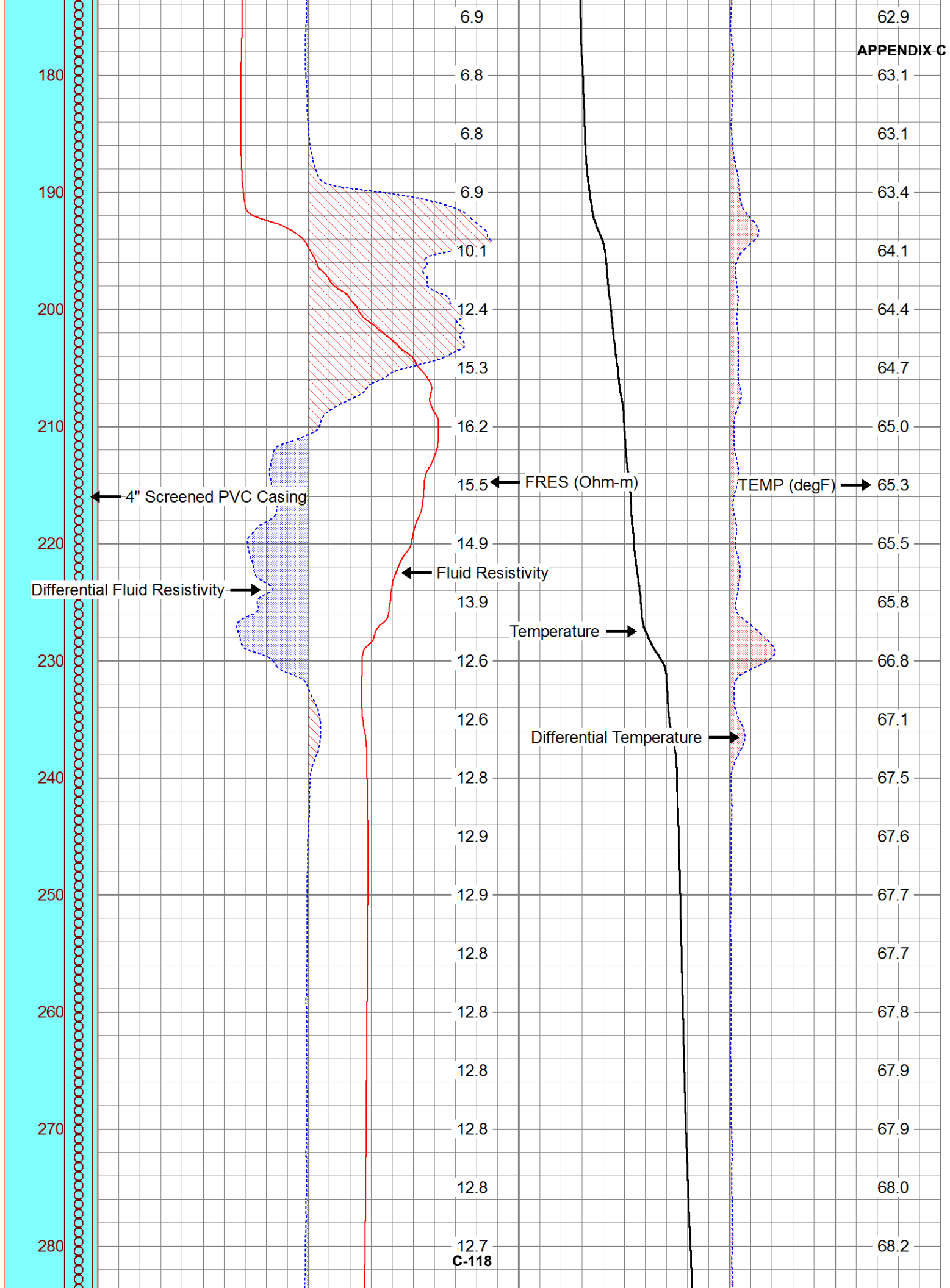
APPENDIX C

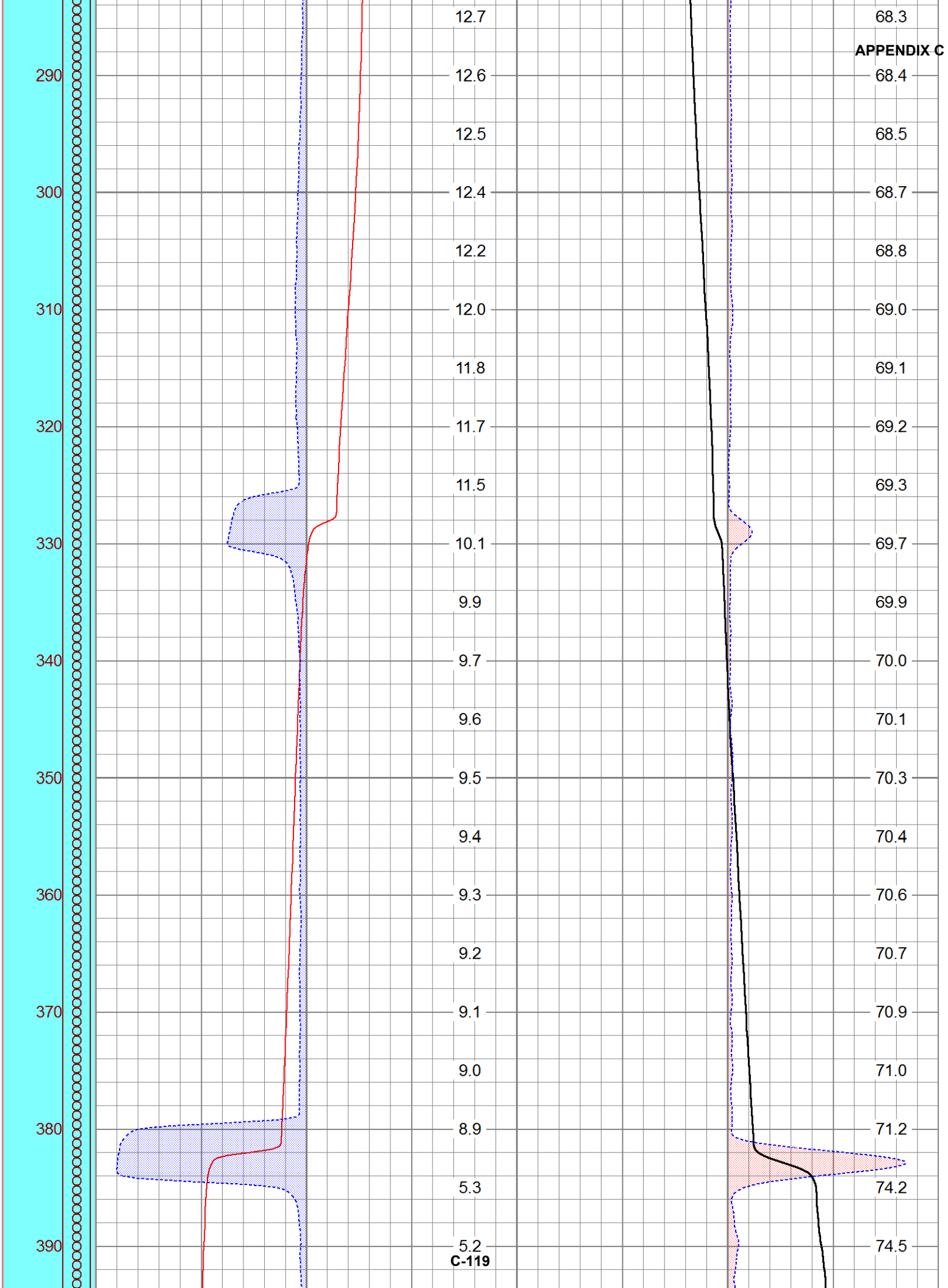
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Tool Model:	MLS	
Performed:	Wed Aug 29 07:13:35 2012	
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High Reference:	149.00 degF	4545.00cps
Gain:	0.03	
Offset:	-5.71	
Delta Spacing	2	

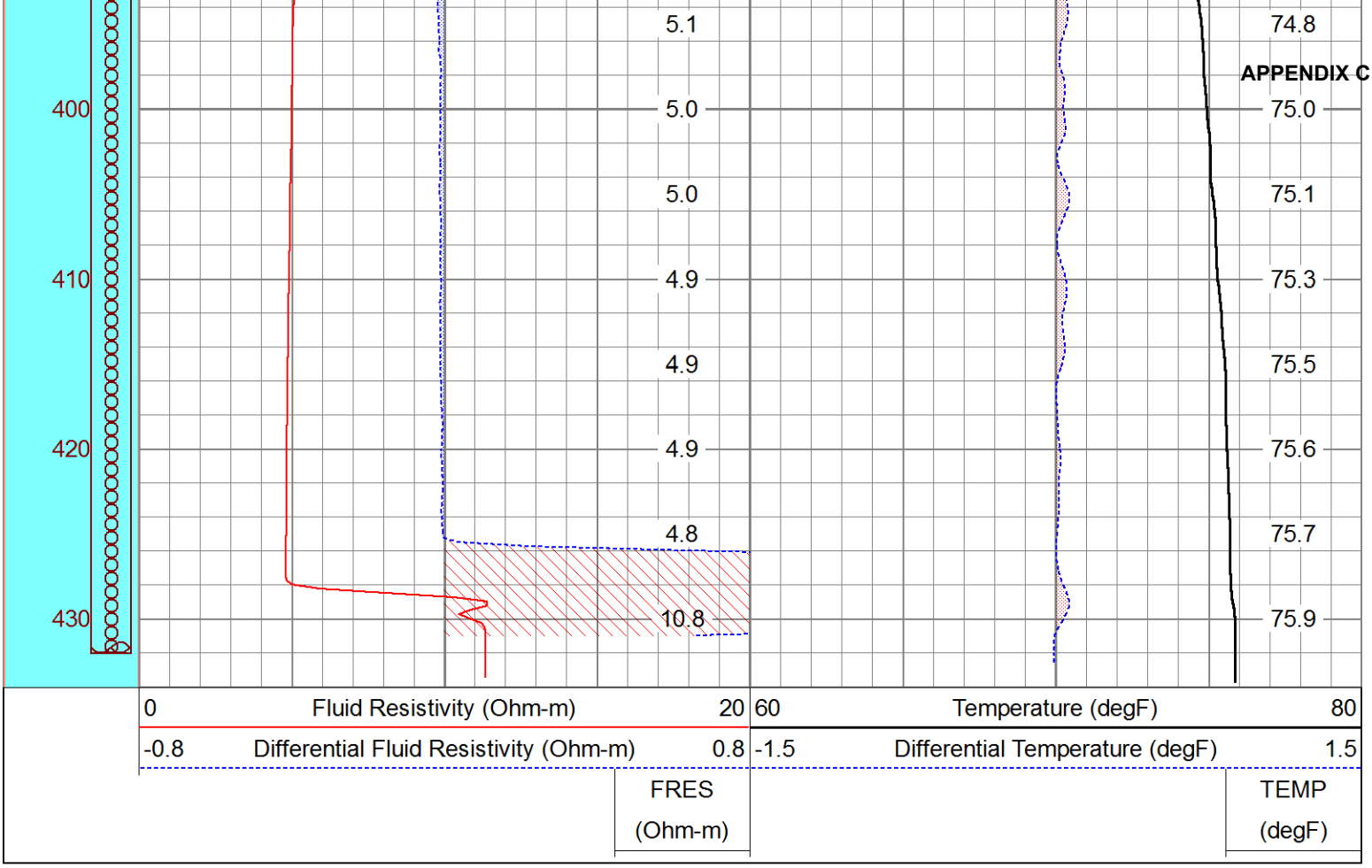
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Dataset Pathname	tmp
Presentation Format	frttemp2
Dataset Creation	Thu Jan 08 15:02:34 2015
Charted by	Depth in Feet scaled 1:120




Fluid Level
70
80
90
100
110
120
130
140
150
160
170
79.3
95.4
7.0
6.9
6.9
7.0
7.0
7.0
7.0
7.0
7.0
7.0
7.0
7.0
7.0
7.0
7.0
7.0
7.0
6.9
6.9
67.2
65.1
62.9
63.0
63.1
62.7
62.6
62.5
62.5
62.5
62.5
62.6
62.6
62.6
62.6
62.6
62.6
62.7
62.7
62.8
62.9


180
190
200
210
220
230
240
250
260
270
280
6.9
6.8
6.8
6.9
10.1
12.4
15.3
16.2
15.5
14.9
13.9
12.6
12.6
12.8
12.9
12.9
12.8
12.8
12.8
12.8
12.7
62.9
63.1
63.1
63.4
64.1
64.4
64.7
65.0
65.3
65.5
65.8
66.8
67.1
67.5
67.6
67.7
67.7
67.8
67.9
67.9
68.0
68.2
4" Screened PVC Casing
Differential Fluid Resistivity
Fluid Resistivity
FRES (Ohm-m)
Temperature
Differential Temperature
TEMP (degF)


290
300
310
320
330
340
350
360
370
380
390
12.7
12.6
12.5
12.4
12.2
12.0
11.8
11.7
11.5
10.1
9.9
9.7
9.6
9.5
9.4
9.3
9.2
9.1
9.0
8.9
5.3
5.2
68.3
68.4
68.5
68.7
68.8
69.0
69.1
69.2
69.3
69.7
69.9
70.0
70.1
70.3
70.4
70.6
70.7
70.9
71.0
71.2
74.2
74.5


400
410
420
430
5.1
5.0
5.0
4.9
4.9
4.9
4.8
10.8
74.8
75.0
75.1
75.3
75.5
75.6
75.7
75.9
0
Fluid Resistivity (Ohm-m)
20
-0.8
Differential Fluid Resistivity (Ohm-m)
0.8
FRES
(Ohm-m)
60
Temperature (degF)
80
-1.5
Differential Temperature (degF)
1.5
TEMP
(degF)

APPENDIX C

PACIFIC SURVEYS

DUAL INDUCTION GAMMA-RAY

Job No. 19106

File No.

Company CASCADE DRILLING

Well MW-5 DEEP

Field SALINAS

County MONTEREY State CA

Location

OFF OF NEPONSET RD.
GPS: N 36o 43.075' W 121o 46.472'

Other Services:

TEMPERATURE
FLUID RESISTIVITY

Permanent Datum	G.L.	Elevation above perm. datum	Elevation K.B. D.F. G.L.
Log Measured From	G.L.	0'	
Drilling Measured From	G.L.		

Date	01-08-2015		
Run Number	ONE		
Depth Driller	432'		
Depth Logger	430'		
Bottom Logged Interval	430'		
Top Log Interval	0'		
Open Hole Size	12" (0'-20')	10.75" (20"-100')	9.875" (100'-300')
Type Fluid	WATER		8" (300'-432')
Density / Viscosity	N/A		
Fluid Level	26'		
Bentonite Seal	N/A		
Time Well Ready	1500		
Time Logger on Bottom	1515		
Equipment Number	PS-7		
Location	LA		
Recorded By	SCHUMACHER		
Witnessed By	N. REYNOLDS		

Borehole Record				Tubing Record			
Run Number	Bit	From	To	Size	Weight	From	To
ONE	12"	0'	20'				
TWO	10.75"	20'	100'				
THREE	9.875"	100'	300'				
FOUR	8"	300'	432'				

Casing Record	Size	Wgt/Ft	Top	Bottom
Surface String				
Prot. String				
Production String	4" PVC	SCH 80	0'	432'
Liner				

<<< Fold Here >>>

All interpretations are opinions based on inferences from electrical or other measurements and Pacific Surveys cannot and do not guarantee the accuracy or correctness of any interpretation, and we shall not, except in the case of gross or willful negligence on our part, be liable or responsible for any loss, costs, damages, or expenses incurred or sustained by anyone resulting from any interpretation made by any of our officers, agents or employees. These interpretations are also subject to Pacific Surveys' general terms and conditions set out in our current Price Schedule.

Comments

Calibration Report

Database File 19106.db
Dataset Pathname DIL.1
Dataset Creation Thu Jan 08 17:02:19 2015

Dual Induction Calibration Report

Serial-Model: 0001-ALT
Surface Cal Performed:

APPENDIX C

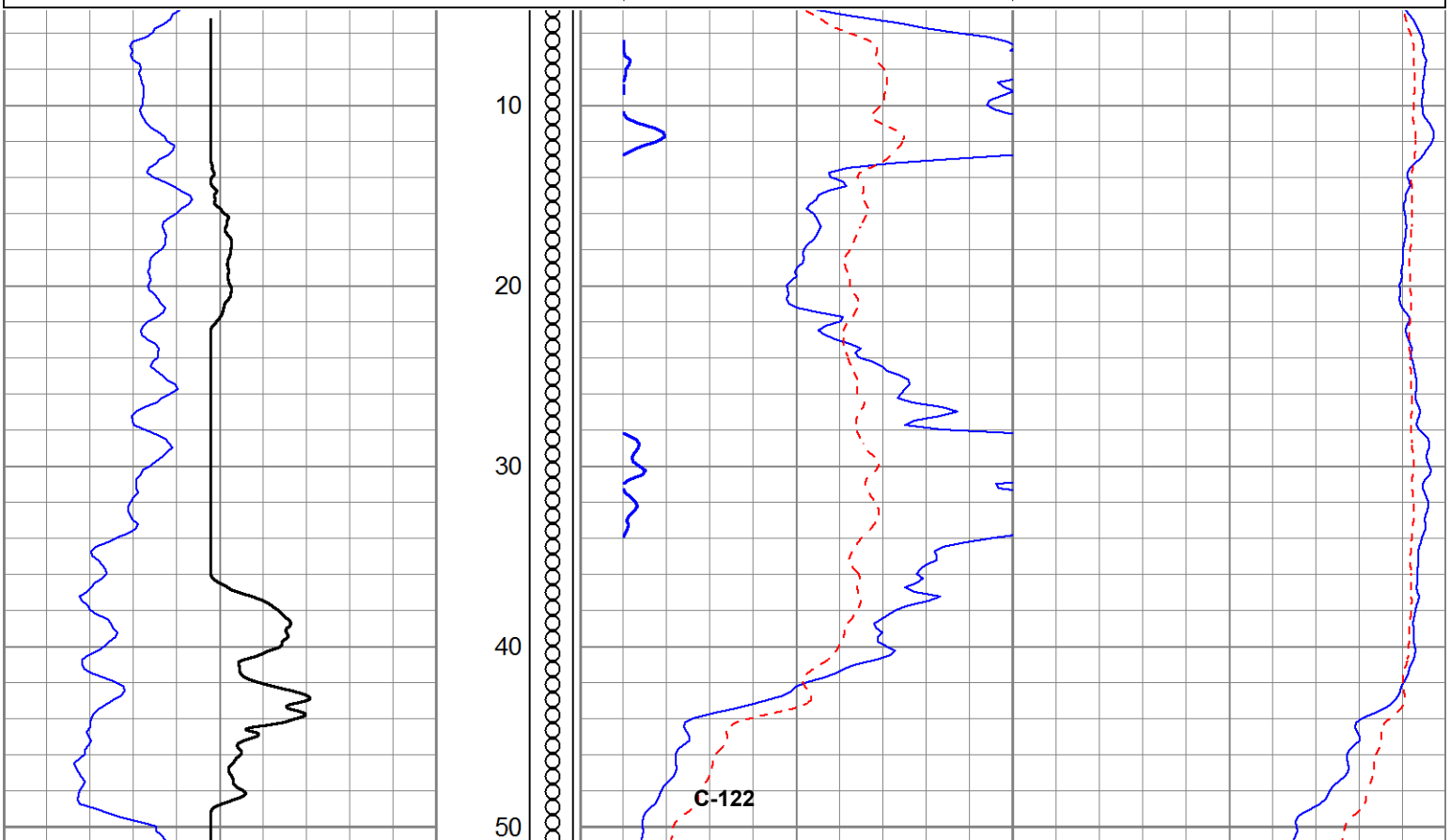
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Medium	2052.170	14102.500	cps	0.000	1960.000	mmho/m	0.163	-333.788

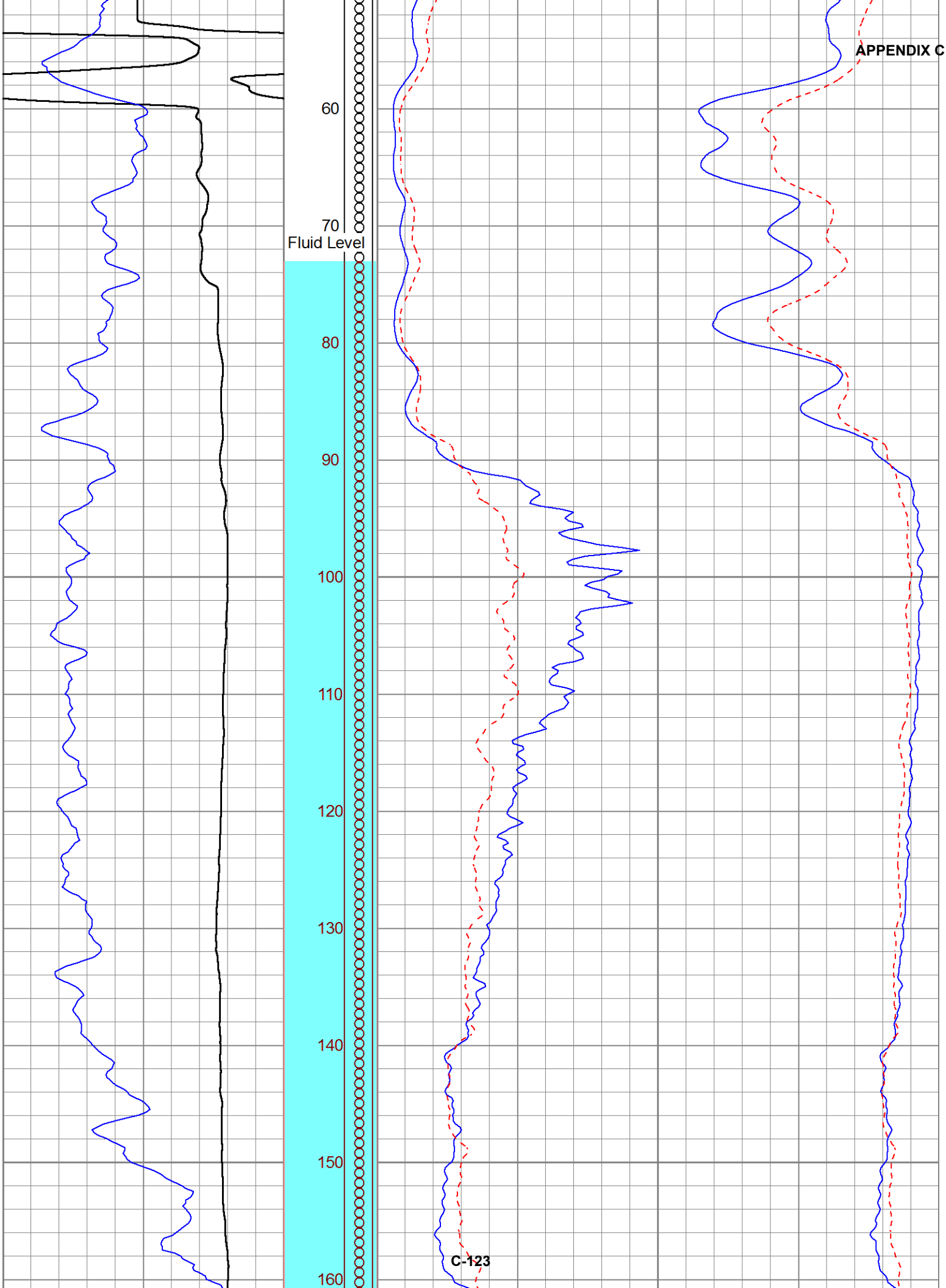
Gamma Ray Calibration Report

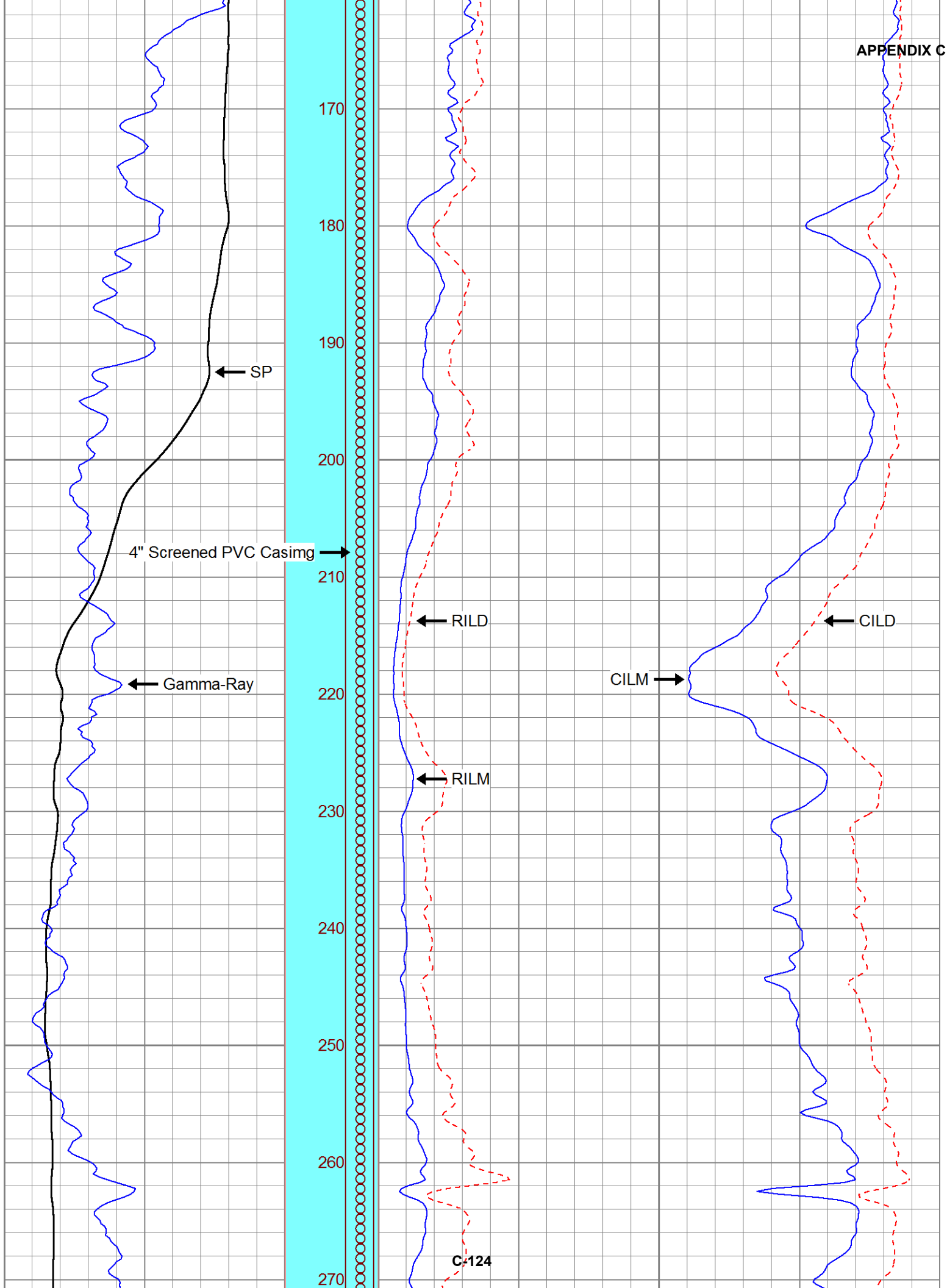
Serial Number:	PS_1	
Tool Model:	01	
Performed:	Sat Dec 13 17:32:47 2014	
Calibrator Value:	162.0	GAPI
Background Reading:	46.1	cps
Calibrator Reading:	180.8	cps
Sensitivity:	1.2020	GAPI/cps

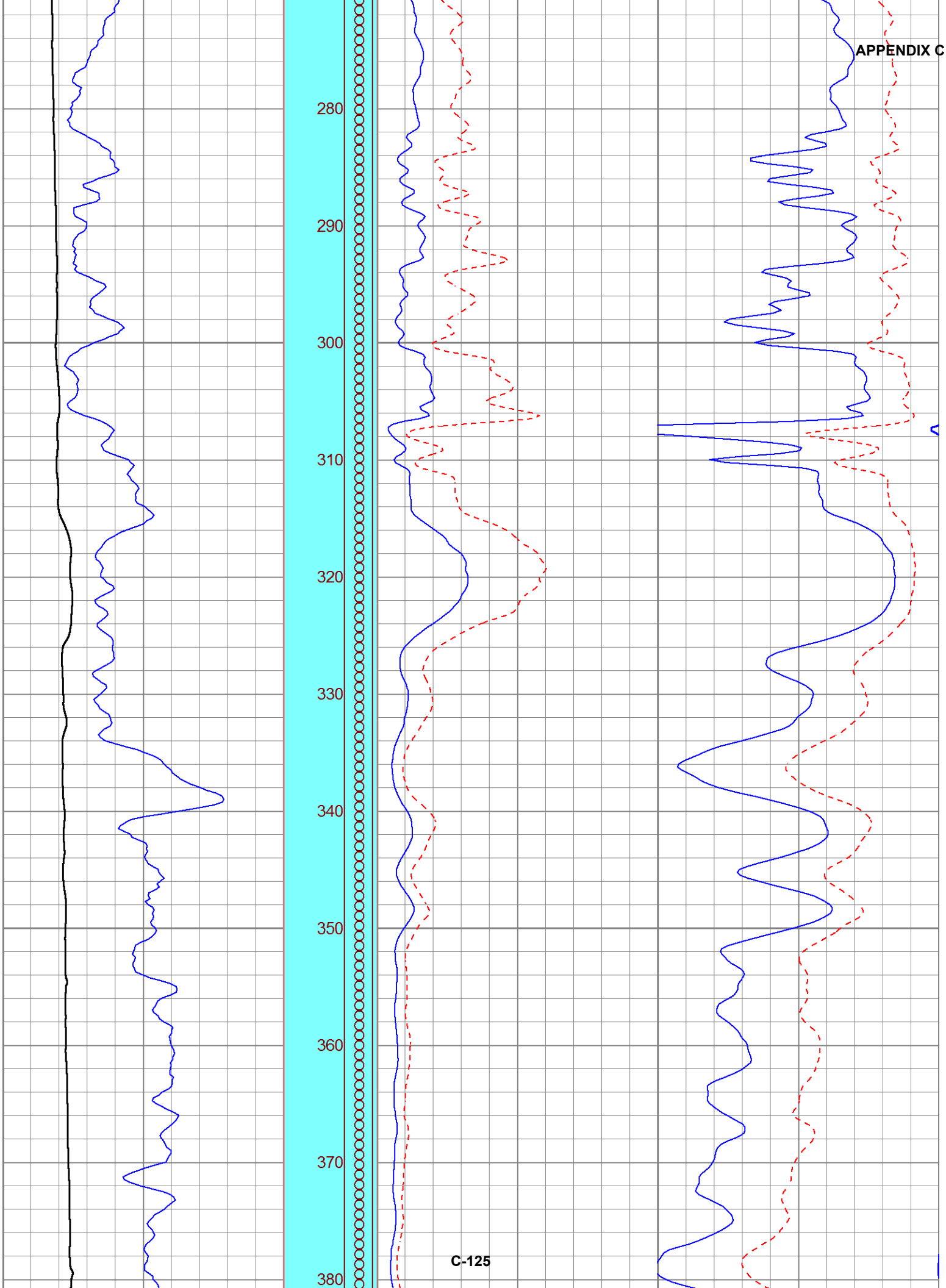
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Charted by	Depth in Feet scaled 1:120

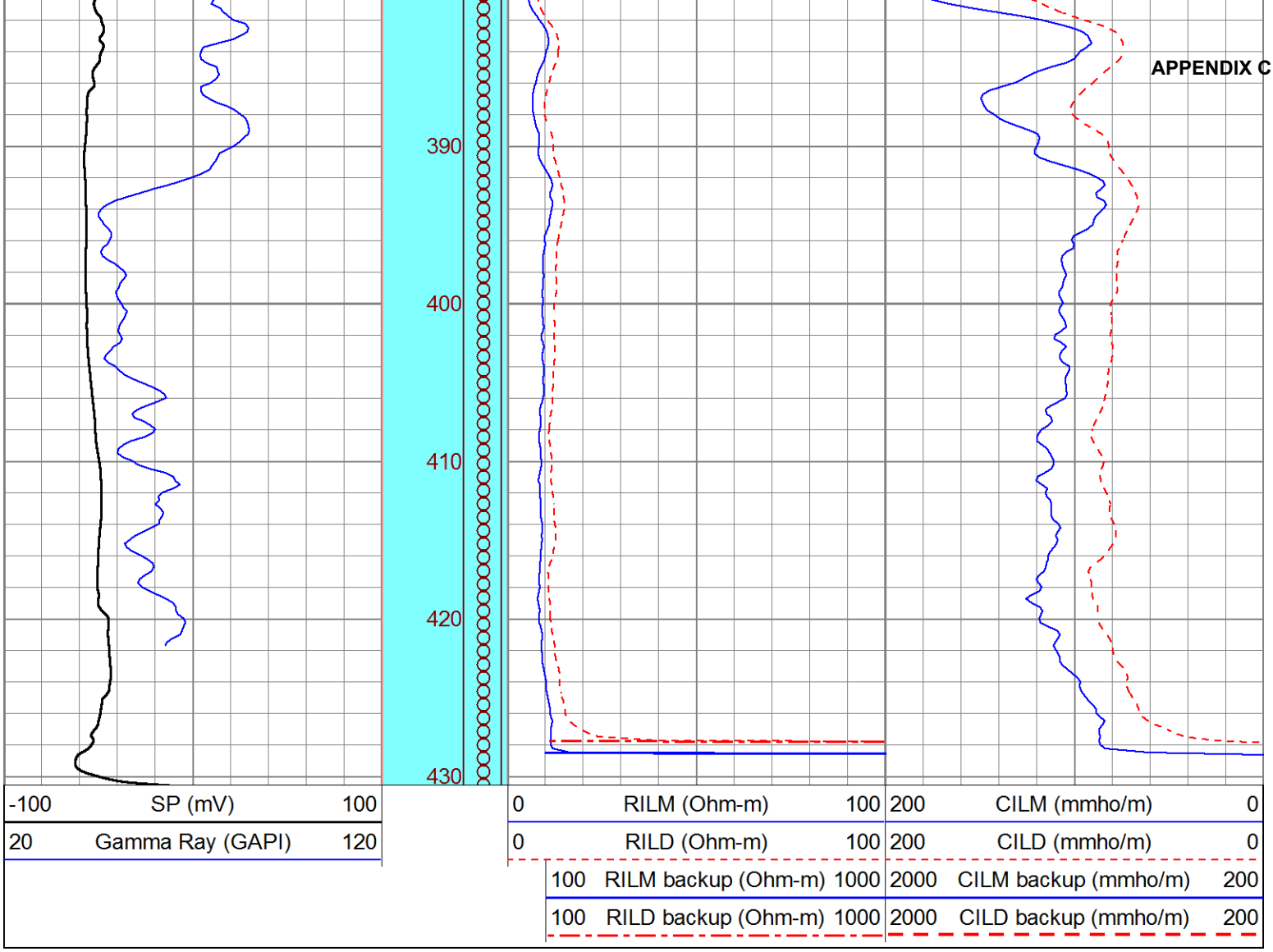
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20	Gamma Ray (GAPI)	120	0	RILD (Ohm-m)	100	200	CILD (mmho/m)	0
			100	RILM backup (Ohm-m)	1000	2000	CILM backup (mmho/m)	200
			100	RILD backup (Ohm-m)	1000	2000	CILD backup (mmho/m)	200

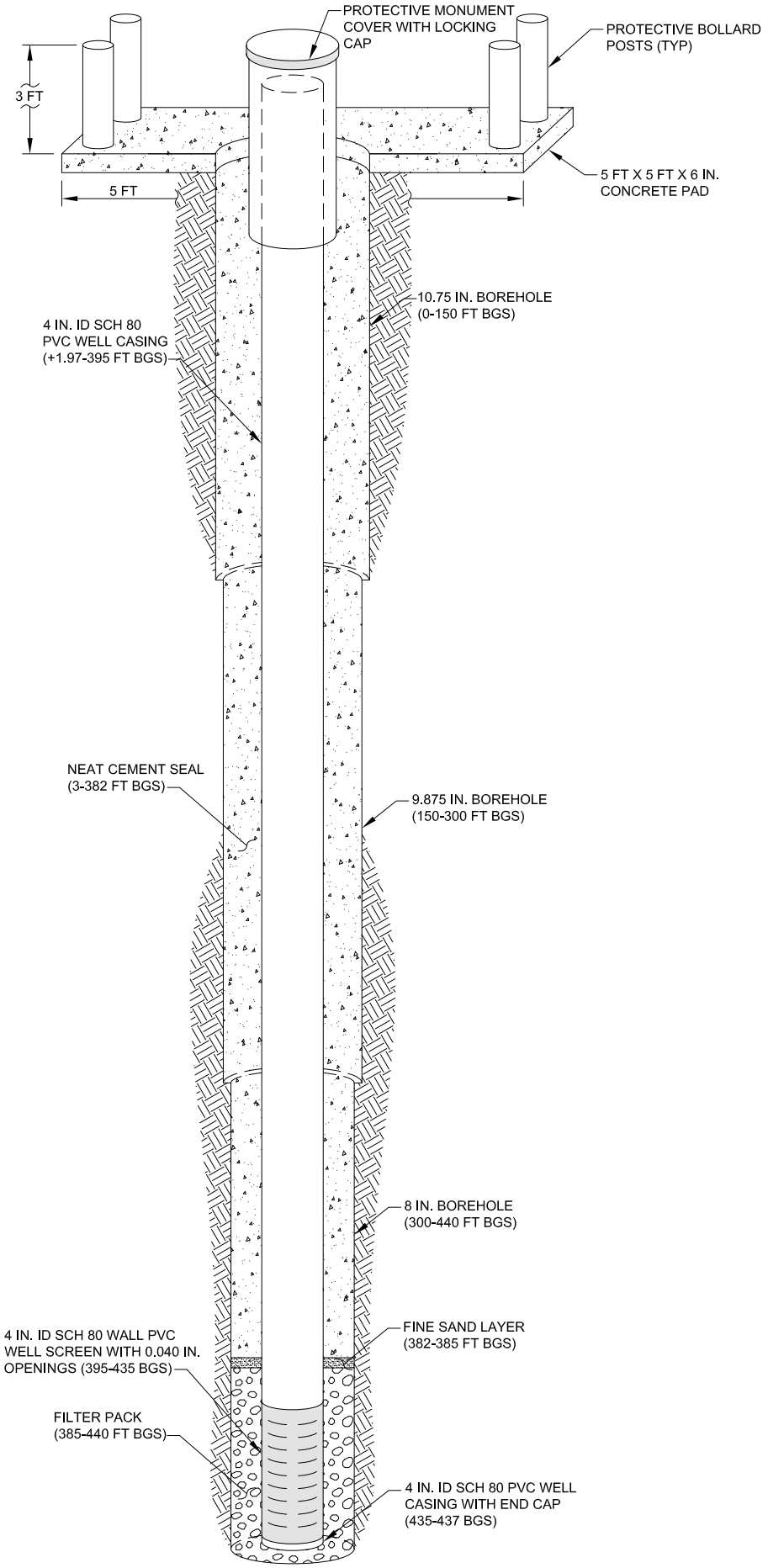



APPENDIX C
60
70
Fluid Level
80
90
100
110
120
130
140
150
160
C-123


170
180
190
200
210
220
230
240
250
260
270
SP
4" Screened PVC Casimg
Gamma-Ray
RILD
RILM
CILD
CILM


280
290
300
310
320
330
340
350
360
370
380


390
400
410
420
430
-100 SP (mV) 100
20 Gamma Ray (GAPI) 120
0 RILM (Ohm-m) 100
0 RILD (Ohm-m) 100
100 RILM backup (Ohm-m) 1000
100 RILD backup (Ohm-m) 1000
200 CILM (mmho/m) 0
200 CILD (mmho/m) 0
2000 CILM backup (mmho/m) 200
2000 CILD backup (mmho/m) 200



WELL PROFILE

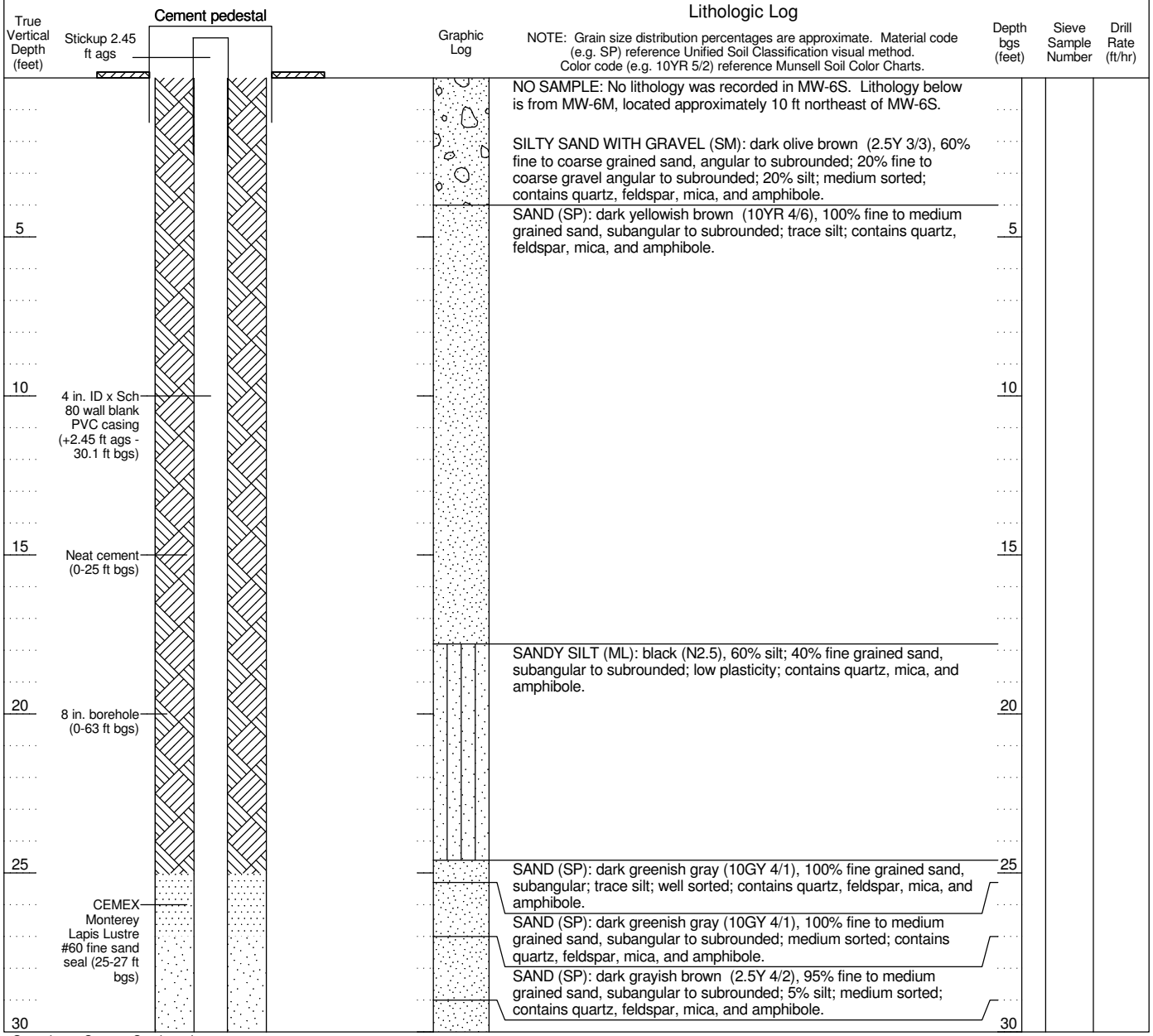
NOT TO SCALE

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BOREHOLE LITHOLOGIC LOG

WELL NUMBER **MPWSP MW-6S**	
CLIENT: Cal Am	LOCATION: **Marina, CA**
PROJECT NUMBER: 14077-15	**Blanco Rd**
REPORT DATE:	
DRILLING CONTRACTOR: Cascade Drilling	LOGGED BY: **NOT LOGGED**
DRILLER: D. King	

		SCREEN / BLANK	TOP DEPTH (ft bgs)	BOTTOM DEPTH (ft bgs)	LENGTH (ft)	MATERIAL	WALL THICKNESS (in.)	DIAMETER (in.)	SCREEN TYPE	PERF. SIZE (in.)
DRILLING RIG TYPE	ProSonic 600T									
DRILLING METHOD	Sonic	**Blank**	**-2.45**	**30.1**	**32.55**	**PVC**	**Sch 80**	**4 / ID**		
SAMPLING METHOD	Core	**Screen**	**30.1**	**60.1**	**30**	**PVC**	**Sch 80**	**4 / ID**	**Slotted**	**0.04**
BOREHOLE DIAMETER	8 in	**Blank**	**60.1**	**62.5**	**2.4**	**PVC**	**Sch 80**	**4 / ID**		
SURFACE ELEVATION	33.44 ft NAVD88									
TOC ELEVATION	35.89 ft NAVD88 (RP)									
START DATE	3/20/15									
FINISH DATE	3/21/15									



WELL CONSTRUCTION LOG MPWSP MW TM LITH ALL WELLS.GPJ GEOSCIENCE.GDT 7/7/16

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WELL NUMBER **MPWSP MW-6S**

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am
PROJECT NUMBER 14077-15
LOCATION **Marina, CA**

(continued)

True Vertical Depth (feet)	Graphic Log	Lithologic Log NOTE: Grain size distribution percentages are approximate. Material code (e.g. SP) reference Unified Soil Classification visual method. Color code (e.g. 10YR 5/2) reference Munsell Soil Color Charts.	Depth bgs (feet)	Sieve Sample Number	Drill Rate (ft/hr)
		SAND (SP): grayish brown (2.5Y 5/2), 100% fine to coarse grained sand, subangular to subrounded; contains quartz, feldspar, mica, and amphibole.			
35		SAND (SP): dark gray (2.5Y 4/1), 100% fine to medium grained sand, subangular to subrounded; medium sorted; contains quartz, feldspar, mica, and amphibole.	35		
		CLAYEY SAND (SC): black (N2.5), 50% medium grained sand, subangular to subrounded; 20% silt; 20% clay, low plasticity; 10% fine gravel subangular to subrounded.			
40		SAND (SP): dark greenish gray (10GY 4/1), 100% fine to medium grained sand, subangular to subrounded; medium sorted; contains quartz, feldspar, mica, and amphibole.	40		
		SAND (SP): very dark greenish gray (10G 3/1), 95% fine to coarse grained sand, angular to subrounded; 5% clay; trace fine gravel angular to subrounded; trace silt; poorly sorted; contains quartz, feldspar, mica, and amphibole.			
45			45		
50		FAT CLAY WITH SAND (CH): very dark greenish gray (5GY 3/1), 50% clay, medium to high plasticity; 30% silt; 20% fine grained sand, subangular to subrounded.	50		
55			55		
		SAND (SP): greenish black (5G 2.5/1), 100% fine to medium grained sand, subangular to subrounded; contains quartz, feldspar, mica, and amphibole.			
60			60		
		CLAY (CL): very dark greenish gray (5GY 3/1), 80% clay, low plasticity; 20% silt.			
		Bottom of borehole at 63 feet.			

CEMEX Monterey Lapis Lustre #3 filter pack (27-63 ft bgs)

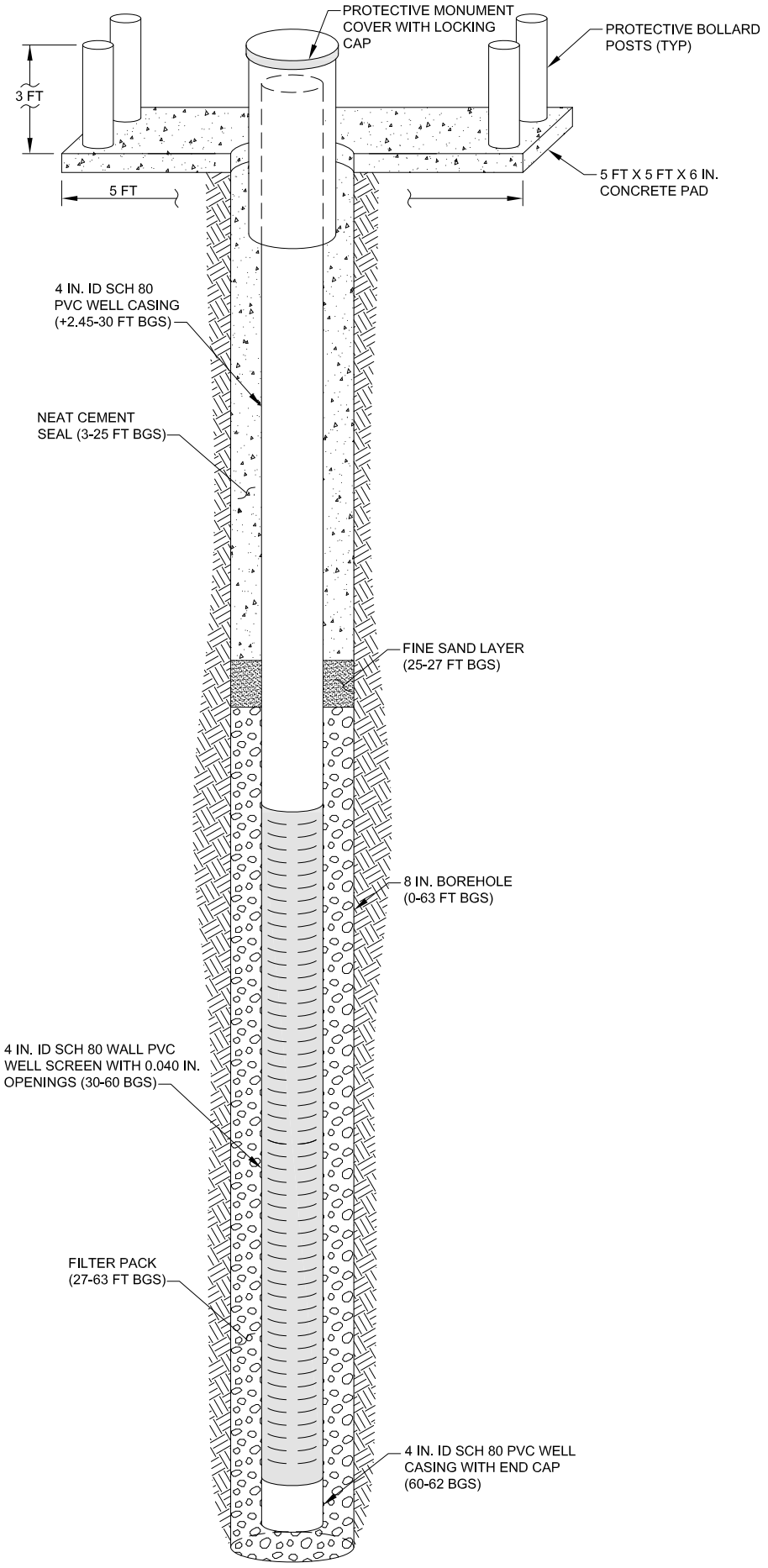
4 in. ID x Sch 80 wall PVC well screen with 0.040 in. slots (30.1-60.1 ft bgs)

Blank casing with end cap (60.1-62.5 ft bgs)

TD 63 ft bgs

WELL CONSTRUCTION LOG MPWSP MW TM LITH ALL WELLS.GPJ GEOSCIENCE.GDT 7/7/16

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WELL PROFILE

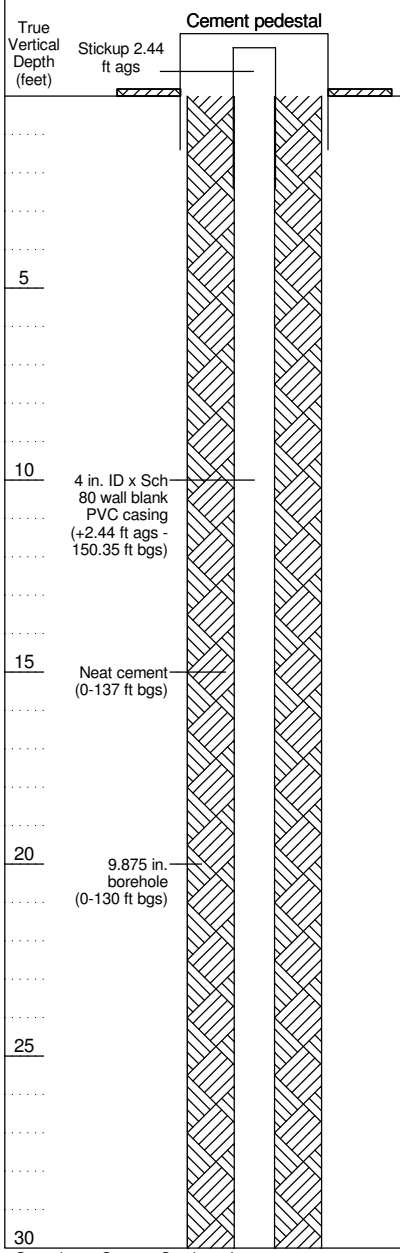
NOT TO SCALE

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BOREHOLE LITHOLOGIC LOG

WELL NUMBER **MPWSP MW-6M**	
CLIENT: Cal Am	LOCATION: **Marina, CA**
PROJECT NUMBER: 14077-15	**Blanco Rd**
REPORT DATE:	
DRILLING CONTRACTOR: Cascade Drilling	LOGGED BY: **J. Sobolew and A. Khalighi**
DRILLER: D. King	

		SCREEN / BLANK	TOP DEPTH (ft bgs)	BOTTOM DEPTH (ft bgs)	LENGTH (ft)	MATERIAL	WALL THICKNESS (in.)	DIAMETER (in.)	SCREEN TYPE	PERF. SIZE (in.)
DRILLING RIG TYPE	ProSonic 600T									
DRILLING METHOD	Sonic	**Blank**	**-2.44**	**150.35**	**152.79**	**PVC**	**Sch 80**	**4 / ID**		
SAMPLING METHOD	Core	**Screen**	**150.35**	**210.35**	**60**	**PVC**	**Sch 80**	**4 / ID**	**Slotted**	**0.04**
BOREHOLE DIAMETER	9.875, 8 in	**Blank**	**210.35**	**212.7**	**2.35**	**PVC**	**Sch 80**	**4 / ID**		
SURFACE ELEVATION	33.24 ft NAVD88									
TOC ELEVATION	35.68 ft NAVD88 (RP)									
START DATE	3/10/15									
FINISH DATE	3/20/15									



Lithologic Log

Graphic Log

NOTE: Grain size distribution percentages are approximate. Material code (e.g. SP) reference Unified Soil Classification visual method. Color code (e.g. 10YR 5/2) reference Munsell Soil Color Charts.

Depth bgs (feet) | Sieve Sample Number | Drill Rate (ft/hr)

SILTY SAND WITH GRAVEL (SM): dark olive brown (2.5Y 3/3), 60% fine to coarse grained sand, angular to subrounded; 20% fine to coarse gravel angular to subrounded; 20% silt; medium sorted; contains quartz, feldspar, mica, and amphibole.

SAND (SP): dark yellowish brown (10YR 4/6), 100% fine to medium grained sand, subangular to subrounded; trace silt; contains quartz, feldspar, mica, and amphibole.

SANDY SILT (ML): black (N2.5), 60% silt; 40% fine grained sand, subangular to subrounded; low plasticity; contains quartz, mica, and amphibole.

18

SAND (SP): dark greenish gray (10GY 4/1), 100% fine grained sand, subangular; trace silt; well sorted; contains quartz, feldspar, mica, and amphibole.

SAND (SP): dark greenish gray (10GY 4/1), 100% fine to medium grained sand, subangular to subrounded; medium sorted; contains quartz, feldspar, mica, and amphibole.

SAND (SP): dark grayish brown (2.5Y 4/2), 95% fine to medium grained sand, subangular to subrounded; 5% silt; medium sorted; contains quartz, feldspar, mica, and amphibole.

WELL CONSTRUCTION LOG MPWSP MW TM LITH ALL WELLS.GPJ GEOSCIENCE.GDT 7/7/16

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WELL NUMBER **MPWSP MW-6M**

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am
PROJECT NUMBER 14077-15
LOCATION **Marina, CA**

True Vertical Depth (feet)	(continued)	Graphic Log	Lithologic Log NOTE: Grain size distribution percentages are approximate. Material code (e.g. SP) reference Unified Soil Classification visual method. Color code (e.g. 10YR 5/2) reference Munsell Soil Color Charts.	Depth bgs (feet)	Sieve Sample Number	Drill Rate (ft/hr)
35			SAND (SP): grayish brown (2.5Y 5/2), 100% fine to coarse grained sand, subangular to subrounded; contains quartz, feldspar, mica, and amphibole.	35		
			SAND (SP): dark gray (2.5Y 4/1), 100% fine to medium grained sand, subangular to subrounded; medium sorted; contains quartz, feldspar, mica, and amphibole.			
			CLAYEY SAND (SC): black (N2.5), 50% medium grained sand, subangular to subrounded; 20% silt; 20% clay, low plasticity; 10% fine gravel subangular to subrounded.			
40			SAND (SP): dark greenish gray (10GY 4/1), 100% fine to medium grained sand, subangular to subrounded; medium sorted; contains quartz, feldspar, mica, and amphibole.	40		
			SAND (SP): very dark greenish gray (10G 3/1), 95% fine to coarse grained sand, angular to subrounded; 5% clay; trace fine gravel angular to subrounded; trace silt; poorly sorted; contains quartz, feldspar, mica, and amphibole.			18
45				45		
			FAT CLAY WITH SAND (CH): very dark greenish gray (5GY 3/1), 50% clay, medium to high plasticity; 30% silt; 20% fine grained sand, subangular to subrounded.			
50				50		
55				55		
			SAND (SP): greenish black (5G 2.5/1), 100% fine to medium grained sand, subangular to subrounded; contains quartz, feldspar, mica, and amphibole.			
60				60		
			CLAY (CL): very dark greenish gray (5GY 3/1), 80% clay, low plasticity; 20% silt.			
65				65		
70				70		

WELL CONSTRUCTION LOG MPWSP MW TM LITH ALL WELLS.GPJ GEOSCIENCE.GDT 7/7/16

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WELL NUMBER **MPWSP MW-6M**

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am
PROJECT NUMBER 14077-15
LOCATION **Marina, CA**

(continued)

Lithologic Log

NOTE: Grain size distribution percentages are approximate. Material code (e.g. SP) reference Unified Soil Classification visual method. Color code (e.g. 10YR 5/2) reference Munsell Soil Color Charts.

True Vertical Depth (feet)	Graphic Log	Lithologic Log	Depth bgs (feet)	Sieve Sample Number	Drill Rate (ft/hr)
75		SILT WITH SAND (MH): black (N2.5), 60% silt; 20% fine grained sand, subangular to subrounded; 15% clay, high plasticity; 5% fine gravel subangular to subrounded.	75		
		FAT CLAY (CH): greenish black (10GY 2.5/1), 80% clay, high plasticity; 20% silt.			
80			80		
85			85		
		FAT CLAY (CH): greenish black (10GY 2.5/1), 100% clay, high plasticity.			
90			90		
95			95		21
100			100		
105			105		
110			110		

WELL CONSTRUCTION LOG MPWSP MW TM LITH ALL WELLS.GPJ GEOSCIENCE.GDT 7/7/16

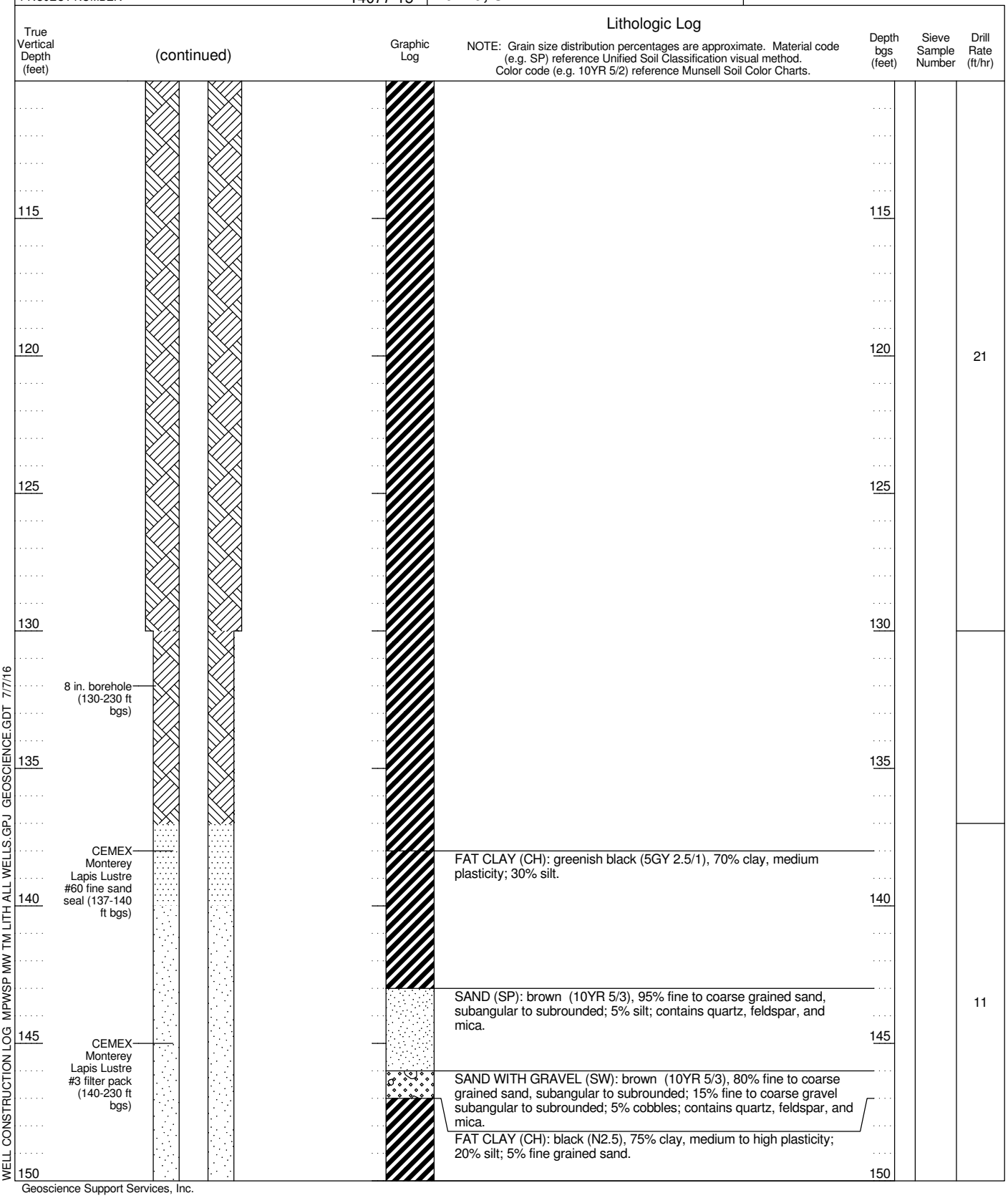
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WELL NUMBER **MPWSP MW-6M**

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am
PROJECT NUMBER 14077-15
LOCATION **Marina, CA**



WELL CONSTRUCTION LOG MPWSP MW TM LITH ALL WELLS.GPJ GEOSCIENCE.GDT 7/7/16

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WELL NUMBER **MPWSP MW-6M**

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am
PROJECT NUMBER 14077-15
LOCATION **Marina, CA**

(continued)

True Vertical Depth (feet)	Graphic Log	Lithologic Log NOTE: Grain size distribution percentages are approximate. Material code (e.g. SP) reference Unified Soil Classification visual method. Color code (e.g. 10YR 5/2) reference Munsell Soil Color Charts.	Depth bgs (feet)	Sieve Sample Number	Drill Rate (ft/hr)
155		4 in. ID x Sch 80 wall PVC well screen with 0.040 in. slots (150.35-210.35 ft bgs) SAND WITH GRAVEL (SP): light olive brown (2.5Y 5/3), 70% medium to coarse grained sand, subangular to subrounded; 30% fine gravel subangular to subrounded; contains quartz, feldspar, and amphibole.	155		
		SAND (SP): olive brown (2.5Y 4/3), 100% fine to medium grained sand, subangular to subrounded; contains quartz, feldspar, mica, and amphibole.			
		FAT CLAY (CH): black (N2.5), 80% clay; 10% silt; 5% fine to coarse gravel; 5% fine to coarse grained sand; contains quartz, feldspar, mica, and amphibole.			
160		SAND WITH GRAVEL (SP): olive gray (5Y 4/2), 60% fine to coarse grained sand, subangular to subrounded; 30% fine gravel subangular to subrounded; 10% cobbles; contains quartz, feldspar, and amphibole.	160		
165			165		
170			170		11
		SAND (SP): gray (2.5Y 5/1), 95% fine to coarse grained sand, angular to subrounded; 5% fine gravel angular to subrounded; contains quartz, feldspar, and amphibole.			
175			175		
180		SAND (SP): gray (2.5Y 5/1), 100% fine to medium grained sand, subangular to subrounded; contains quartz, feldspar, mica, and amphibole.	180		
		GRAVEL (GP): dark grayish brown (2.5Y 4/2), 80% fine gravel subangular to subrounded; 10% fine to coarse grained sand, subangular to subrounded; 5% silt; 5% cobbles; contains quartz, feldspar, mica, and amphibole.			
185			185		
		CLAY (CL): light olive brown (2.5Y 5/4), 85% clay, medium to high plasticity; 10% silt; 5% fine grained sand.			
190		SILTY SAND (SM): light olive brown (2.5Y 5/4), 60% fine grained sand; 25% silt; 15% clay, low plasticity; contains quartz, feldspar, and mica.	190		

WELL CONSTRUCTION LOG MPWSP MW TM LITH ALL WELLS.GPJ GEOSCIENCE.GDT 7/7/16

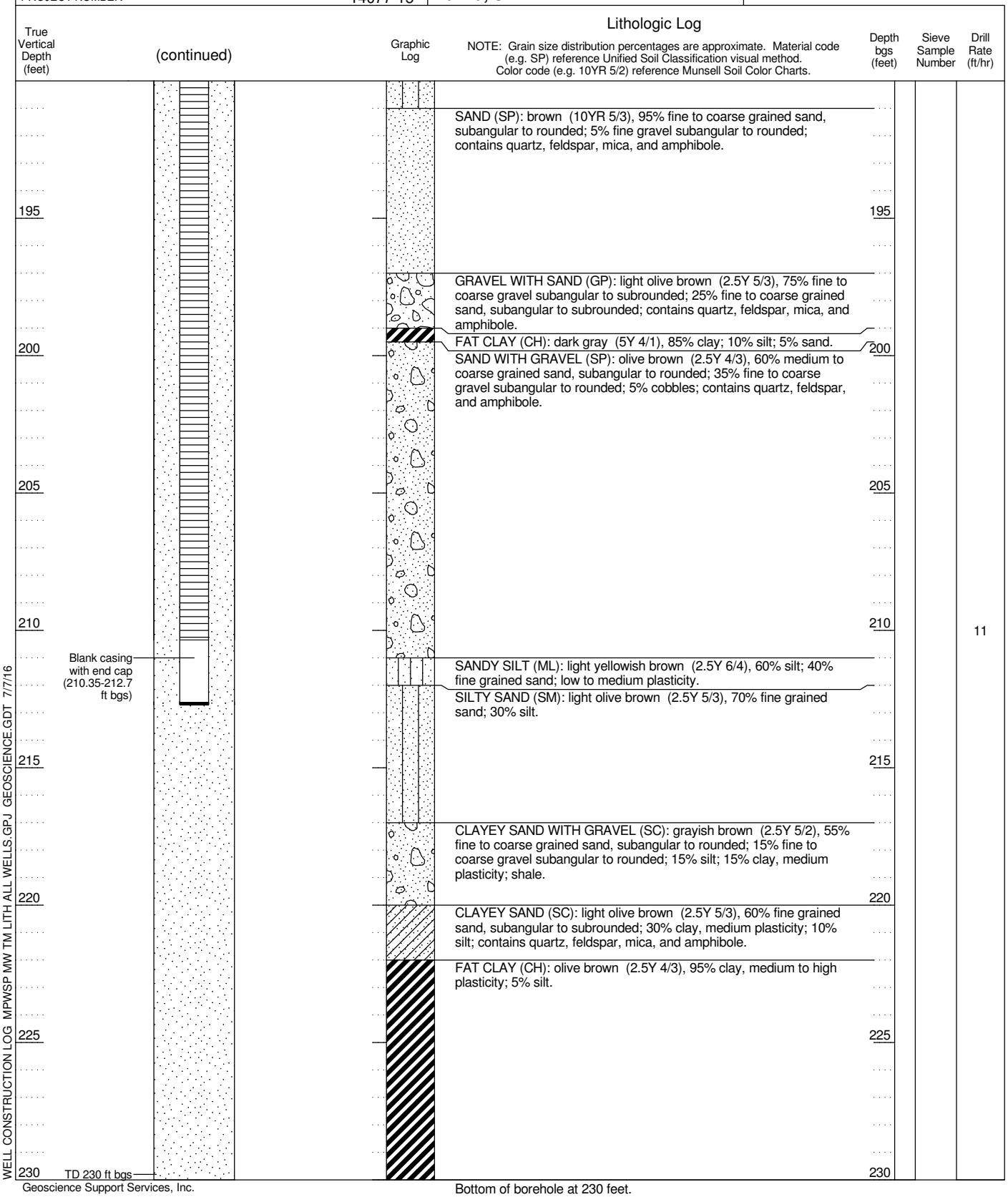
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WELL NUMBER **MPWSP MW-6M**

BOREHOLE LITHOLOGIC LOG (continued)

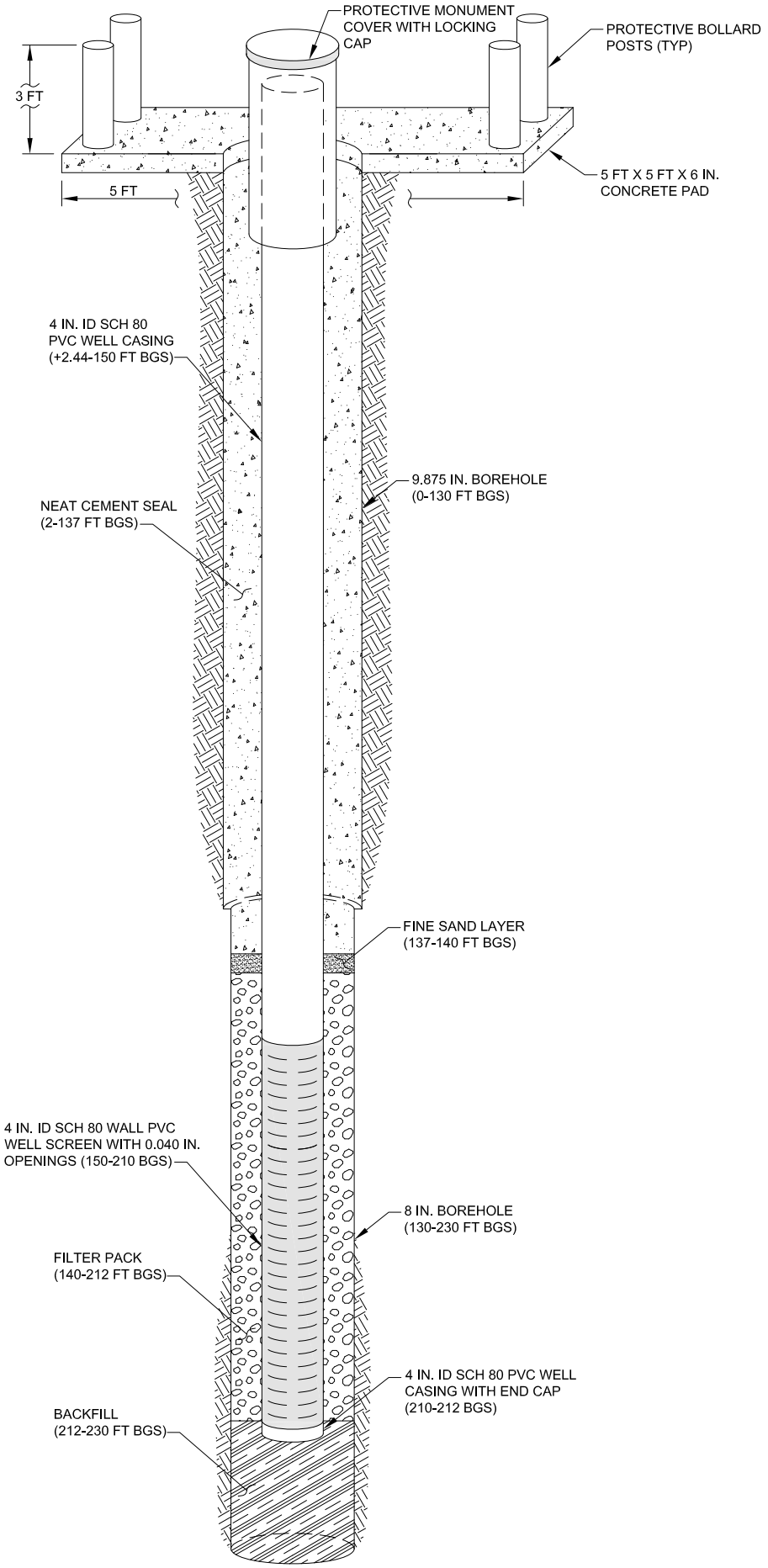
CLIENT Cal Am | LOCATION **Marina, CA**
PROJECT NUMBER 14077-15



WELL CONSTRUCTION LOG MPWSP MW TM LITH ALL WELLS.GPJ GEOSCIENCE.GDT 7/7/16

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Bottom of borehole at 230 feet.



WELL PROFILE

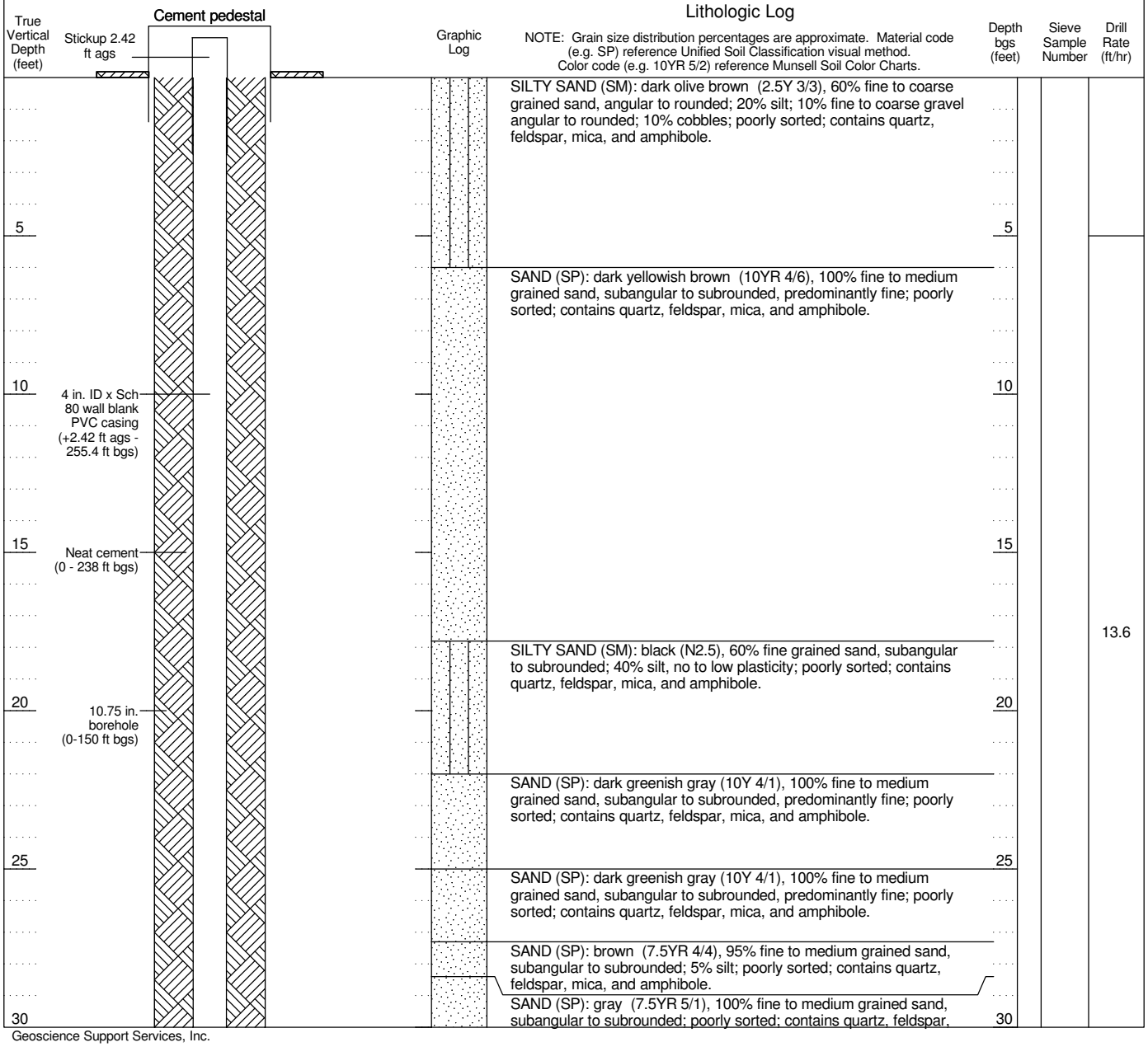
NOT TO SCALE

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BOREHOLE LITHOLOGIC LOG

WELL NUMBER **MPWSP MW-6D**	
CLIENT: Cal Am	LOCATION: **Marina, CA**
PROJECT NUMBER: 14077-15	**Blanco Rd**
REPORT DATE:	
DRILLING CONTRACTOR: Cascade Drilling	LOGGED BY: **A. Khalighi**
DRILLER: D. King	

		SCREEN / BLANK	TOP DEPTH (ft bgs)	BOTTOM DEPTH (ft bgs)	LENGTH (ft)	MATERIAL	WALL THICKNESS (in.)	DIAMETER (in.)	SCREEN TYPE	PERF. SIZE (in.)
DRILLING RIG TYPE	ProSonic 600T									
DRILLING METHOD	Sonic	**Blank**	**-2.42**	**255.4**	**257.82**	**PVC**	**Sch 80**	**4 / ID**		
SAMPLING METHOD	Core	**Screen**	**255.4**	**325.4**	**70**	**PVC**	**Sch 80**	**4 / ID**	**Slotted**	**0.04**
BOREHOLE DIAMETER	10.75, 9.875, 8 in	**Blank**	**325.4**	**327.75**	**2.35**	**PVC**	**Sch 80**	**4 / ID**		
SURFACE ELEVATION	33.40 ft NAVD88									
TOC ELEVATION	35.82 ft NAVD88 (RP)									
START DATE	2/19/15									
FINISH DATE	3/10/15									



WELL CONSTRUCTION LOG MPWSP MW TM LITH ALL WELLS.GPJ GEOSCIENCE.GDT 7/7/16

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WELL NUMBER **MPWSP MW-6D**

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am | LOCATION **Marina, CA**
PROJECT NUMBER 14077-15

True Vertical Depth (feet)	(continued)	Graphic Log	Lithologic Log NOTE: Grain size distribution percentages are approximate. Material code (e.g. SP) reference Unified Soil Classification visual method. Color code (e.g. 10YR 5/2) reference Munsell Soil Color Charts.	Depth bgs (feet)	Sieve Sample Number	Drill Rate (ft/hr)
			mica, and amphibole.			
35				35		
40			CLAYEY SAND (SC): black (N2.5), 50% medium grained sand, subangular to subrounded; 20% silt; 20% clay, medium to high plasticity; 10% fine gravel subangular to subrounded; poorly sorted; contains quartz, feldspar, mica, and amphibole.	40		
			SAND (SP): very dark greenish gray (5GY 3/1), 100% fine to medium grained sand, subangular to subrounded; trace fine gravel subangular to subrounded; trace silt; poorly sorted; contains quartz, feldspar, mica, and amphibole.			
45				45		
50				50		13.6
			FAT CLAY WITH SAND (CH): very dark greenish gray (5GY 3/1), 50% clay, high plasticity; 30% silt; 20% fine grained sand, subangular to subrounded; contains quartz, feldspar, mica, and amphibole.			
55				55		
			SAND (SP): greenish black (5GY 2.5/1), 100% fine to medium grained sand, subangular to subrounded; poorly sorted; contains quartz, feldspar, mica, and amphibole.			
60				60		
			FAT CLAY (CH): very dark greenish gray (5GY 3/1), 80% clay, high plasticity; 20% silt.			
65				65		
70				70		

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WELL NUMBER **MPWSP MW-6D**

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am
PROJECT NUMBER 14077-15
LOCATION **Marina, CA**

(continued)

Lithologic Log

NOTE: Grain size distribution percentages are approximate. Material code (e.g. SP) reference Unified Soil Classification visual method. Color code (e.g. 10YR 5/2) reference Munsell Soil Color Charts.

True Vertical Depth (feet)	Graphic Log	Lithologic Log	Depth bgs (feet)	Sieve Sample Number	Drill Rate (ft/hr)
75		SILT WITH SAND (MH): black (N2.5), 60% silt, high plasticity; 20% fine grained sand, subangular to subrounded; 15% clay; 5% fine gravel subangular to subrounded.	75		
		FAT CLAY (CH): greenish black (10GY 2.5/1), 80% clay, high plasticity; 20% silt.			
80			80		
85			85		13.6
		FAT CLAY (CH): greenish black (10GY 2.5/1), 100% clay, high plasticity.			
90			90		
95			95		
100			100		
105			105		9
110			110		

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WELL NUMBER **MPWSP MW-6D**

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am
PROJECT NUMBER 14077-15
LOCATION **Marina, CA**

True Vertical Depth (feet)	(continued)	Graphic Log	Lithologic Log NOTE: Grain size distribution percentages are approximate. Material code (e.g. SP) reference Unified Soil Classification visual method. Color code (e.g. 10YR 5/2) reference Munsell Soil Color Charts.	Depth bgs (feet)	Sieve Sample Number	Drill Rate (ft/hr)
115				115		
120				120		
125				125		
130				130		9
135				135		
140			FAT CLAY (CH): greenish black (5GY 2.5/1), 70% clay, medium plasticity; 30% silt.	140		
145			SAND (SP): brown (10YR 5/3), 95% fine to coarse grained sand, subangular to subrounded; 5% silt; poorly sorted; contains quartz, feldspar, and mica.	145		
150			SAND WITH GRAVEL (SW): brown (10YR 5/3), 70% fine to coarse grained sand, subangular to subrounded; 30% fine to coarse gravel subangular to subrounded; poorly sorted; contains quartz, feldspar, mica, and amphibole. FAT CLAY (CH): black (N2.5), 75% clay, medium to high plasticity; 20% silt; 5% fine grained sand.	150		

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WELL NUMBER **MPWSP MW-6D**

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am
PROJECT NUMBER 14077-15
LOCATION **Marina, CA**

(continued)

True Vertical Depth (feet)	Lithologic Log	Depth bgs (feet)	Sieve Sample Number	Drill Rate (ft/hr)
	NOTE: Grain size distribution percentages are approximate. Material code (e.g. SP) reference Unified Soil Classification visual method. Color code (e.g. 10YR 5/2) reference Munsell Soil Color Charts.			
155	SAND WITH GRAVEL (SP): light olive brown (2.5Y 5/3), 70% medium to coarse grained sand, subangular to rounded; 30% fine gravel subangular to rounded; poorly sorted; contains quartz, feldspar, amphibole, and other.	155		
	SAND (SP): olive brown (2.5Y 4/3), 100% fine to medium grained sand, subangular to subrounded; poorly sorted; contains quartz, feldspar, mica, and amphibole.			
	FAT CLAY (CH): black (N2.5), 80% clay, high plasticity; 10% silt; 5% fine gravel subangular to subrounded; 5% fine to medium grained sand, subangular to subrounded.			
160	GRAVEL WITH SAND (GP): olive gray (5Y 4/2), 50% fine to coarse gravel subangular to rounded, predominantly coarse; 40% fine to coarse grained sand, subangular to rounded; 10% cobbles; poorly sorted; contains quartz, feldspar, amphibole, and other.	160		
	SAND (SP): olive gray (5Y 4/2), 95% fine to coarse grained sand, subangular to subrounded; 5% fine to coarse gravel subangular to subrounded; poorly sorted; contains quartz, feldspar, mica, and amphibole.			
165	SAND WITH GRAVEL (SP): olive gray (5Y 4/2), 60% fine to coarse grained sand, subangular to subrounded; 30% fine to coarse gravel subangular to subrounded; 10% cobbles; poorly sorted; contains quartz, feldspar, amphibole, and evaporites; shale.	165		
170	GRAVEL WITH SAND (GP): dark yellowish brown (10YR 4/4), 50% fine to coarse gravel subangular to rounded; 35% fine to coarse grained sand, subangular to rounded; 5% silt; 10% cobbles; poorly sorted; contains quartz, feldspar, and amphibole.	170		9
175	SAND (SP): gray (2.5Y 5/1), 95% fine to coarse grained sand, subangular to subrounded; 5% fine gravel subangular to subrounded; poorly sorted; contains quartz, feldspar, mica, and amphibole.	175		
180	GRAVEL WITH SAND (GP): dark grayish brown (2.5Y 4/2), 80% fine gravel subangular to subrounded; 15% fine to coarse grained sand, subangular to subrounded; 5% silt; poorly sorted; contains quartz, feldspar, amphibole, and other.	180		
185	GRAVEL (GP): dark gray (2.5Y 4/1), 85% fine to coarse gravel subangular to rounded; 5% fine to coarse grained sand, subangular to rounded; 5% silt; 5% cobbles; poorly sorted; contains quartz, feldspar, amphibole, and other.	185		
	GRAVEL WITH SAND (GP): brown (10YR 5/3), 65% fine to coarse gravel subangular to rounded; 30% fine to coarse grained sand, subangular to rounded; 5% cobbles; poorly sorted; contains quartz, feldspar, amphibole, and other.			7
190	CLAY (CL): light olive brown (2.5Y 5/4), 85% clay, low to medium plasticity; 10% silt; 5% fine grained sand; red iron-oxide staining at	190		

9.88 in. borehole (150-300 ft bgs)

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WELL NUMBER **MPWSP MW-6D**

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am
PROJECT NUMBER 14077-15
LOCATION **Marina, CA**

True Vertical Depth (feet)	(continued)	Graphic Log	Lithologic Log NOTE: Grain size distribution percentages are approximate. Material code (e.g. SP) reference Unified Soil Classification visual method. Color code (e.g. 10YR 5/2) reference Munsell Soil Color Charts.	Depth bgs (feet)	Sieve Sample Number	Drill Rate (ft/hr)
			188.7 ft contact.			
			SILTY SAND (SM): light olive brown (2.5Y 5/4), 60% fine grained sand, subangular to subrounded; 25% silt; 15% clay, low plasticity; poorly sorted; contains quartz, feldspar, and mica.			
			SAND (SP): olive brown (2.5Y 4/4), 95% fine to medium grained sand, subangular to subrounded; 5% silt; poorly sorted; contains quartz, feldspar, mica, and amphibole.			
195			SAND (SP): brown (10YR 5/3), 95% fine to coarse grained sand, subangular to rounded; 5% fine gravel subangular to rounded; poorly sorted; contains quartz, feldspar, mica, and amphibole; shale.	195		
			SILTY SAND WITH GRAVEL (SM): light olive brown (2.5Y 5/3), 40% fine to coarse gravel subangular to rounded; 40% fine to coarse grained sand, subangular to rounded; 15% silt; 5% clay, low plasticity; poorly sorted; contains quartz, feldspar, and amphibole.			
200			FAT CLAY (CH): dark gray (5Y 4/1), 85% clay, high plasticity; 10% silt; 5% medium grained sand, subangular to subrounded.	200		
			SAND (SW): dark grayish brown (2.5Y 4/2), 90% fine to coarse grained sand, subangular to subrounded; 10% fine gravel subangular to subrounded; well sorted; contains quartz, feldspar, amphibole, and other; trace shale.			
205			SAND WITH GRAVEL (SP): olive brown (2.5Y 4/3), 60% medium to coarse grained sand, subangular to rounded; 35% fine to coarse gravel subangular to rounded; 5% cobbles; poorly sorted; contains quartz, feldspar, and amphibole; trace shale.	205		
210				210		7
			SANDY SILT (ML): light yellowish brown (2.5Y 6/4), 60% silt, low to medium plasticity; 40% fine grained sand.			
			SILTY SAND (SM): light olive brown (2.5Y 5/3), 70% fine grained sand; 30% silt; poorly sorted.			
215				215		
			CLAYEY SAND WITH GRAVEL (SC): grayish brown (2.5Y 5/2), 55% fine to coarse grained sand, subangular to rounded; 15% fine to coarse gravel subangular to rounded; 15% silt; 15% clay, medium plasticity; poorly sorted; trace shale.			
220				220		
			CLAYEY SAND (SC): grayish brown (2.5Y 5/2), 60% fine grained sand, subangular to subrounded; 30% clay, medium plasticity; 10% silt; poorly sorted; contains quartz, feldspar, mica, and amphibole.			
			FAT CLAY (CH): light olive brown (2.5Y 5/3), 70% clay, medium plasticity; 20% silt; 10% fine grained sand.			
			FAT CLAY (CH): olive brown (2.5Y 4/3), 95% clay, medium to high plasticity; 5% silt.			
225				225		
230				230		

WELL CONSTRUCTION LOG MPWSP MW TM LITH ALL WELLS.GPJ GEOSCIENCE.GDT 7/7/16

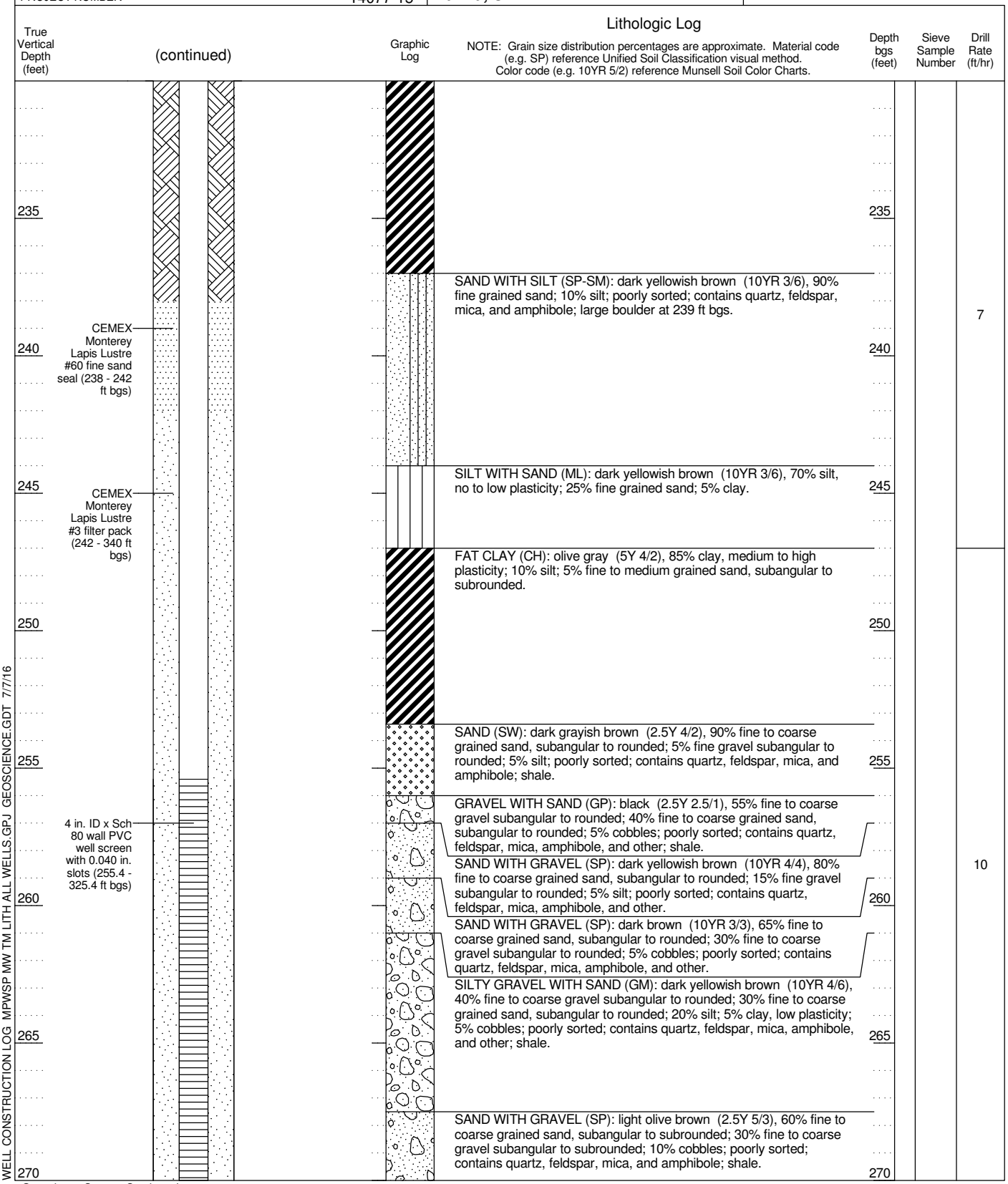
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WELL NUMBER **MPWSP MW-6D**

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am
PROJECT NUMBER 14077-15
LOCATION **Marina, CA**



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WELL NUMBER **MPWSP MW-6D**

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am
PROJECT NUMBER 14077-15
LOCATION **Marina, CA**

True Vertical Depth (feet)	(continued)	Graphic Log	Lithologic Log NOTE: Grain size distribution percentages are approximate. Material code (e.g. SP) reference Unified Soil Classification visual method. Color code (e.g. 10YR 5/2) reference Munsell Soil Color Charts.	Depth bgs (feet)	Sieve Sample Number	Drill Rate (ft/hr)
275			CLAY WITH GRAVEL (CL): light olive brown (2.5Y 5/3), 65% clay, medium to high plasticity; 20% fine to coarse gravel rounded; 5% medium grained sand, rounded; 5% silt; 5% cobbles; contains quartz, feldspar, mica, amphibole, evaporites, and other; shale.	275		
			SAND WITH GRAVEL (SW): dark yellowish brown (10YR 3/4), 80% fine to coarse grained sand, subangular to rounded; 15% fine to coarse gravel subangular to rounded; 5% cobbles; poorly sorted; contains quartz, feldspar, amphibole, and other.			
280				280		
			GRAVELLY FAT CLAY (CH): olive (5Y 4/4), 45% clay; 35% fine to coarse gravel subangular to rounded; 10% coarse grained sand, subangular to rounded; 5% silt; 5% cobbles; contains quartz, feldspar, amphibole, and other; trace shale.			
285			SAND WITH SILT AND GRAVEL (SP-SM): dark olive gray (5Y 3/2), 65% fine to coarse grained sand, subangular to rounded; 20% fine to coarse gravel subangular to rounded; 10% silt; 5% cobbles; poorly sorted; contains quartz, feldspar, mica, and other; shale.	285		
			SAND WITH SILT AND GRAVEL (SP-SM): olive gray (5Y 4/2), 60% fine to coarse grained sand, subangular to rounded, predominantly coarse; 20% fine to coarse gravel subangular to rounded, predominantly fine; 10% silt; 10% cobbles; poorly sorted; shale.			
290				290		10
295				295		
			SILTY SAND (SM): light olive brown (2.5Y 5/4), 60% fine grained sand; 40% silt; poorly sorted.			
300			SILT WITH SAND (ML): light olive brown (2.5Y 5/6), 75% silt, low plasticity; 15% fine grained sand; 10% clay.	300		
	8 in. borehole (300-340 ft bgs)		FAT CLAY (CH): olive (5Y 5/3), 90% clay, medium to high; 10% silt.			
305				305		
			SAND (SP): olive brown (2.5Y 4/3), 90% fine to medium grained sand, subangular to rounded; 5% fine gravel subangular to rounded; 5% cobbles; poorly sorted; contains quartz, feldspar, amphibole, and other.			
			SAND WITH GRAVEL (SP): pale brown (10YR 6/3), 75% fine to coarse grained sand, subangular to rounded, grades coarser towards 312 ft bgs; 20% fine to coarse gravel subangular to rounded; 5%			
310				310		

WELL CONSTRUCTION LOG MPWSP MW TM LITH ALL WELLS.GPJ GEOSCIENCE.GDT 7/7/16

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WELL NUMBER
MPWSP MW-6D

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am
PROJECT NUMBER 14077-15
LOCATION **Marina, CA**

True Vertical Depth (feet)	(continued)	Graphic Log	Lithologic Log NOTE: Grain size distribution percentages are approximate. Material code (e.g. SP) reference Unified Soil Classification visual method. Color code (e.g. 10YR 5/2) reference Munsell Soil Color Charts.	Depth bgs (feet)	Sieve Sample Number	Drill Rate (ft/hr)
			cobbles; poorly sorted; contains quartz, feldspar, amphibole, and other; shale.			
315				315		
320				320		
			SAND (SW): dark yellowish brown (10YR 4/6), 100% fine to coarse grained sand, subangular to subrounded; poorly sorted; contains quartz, feldspar, and amphibole.			
325	Blank casing with end cap (325.4-327.75 ft bgs)			325		10
			SAND WITH SILT AND GRAVEL (SP-SM): dark grayish brown (2.5Y 4/2), 45% fine to coarse grained sand, subangular to rounded; 35% fine to coarse gravel subangular to rounded; 10% silt; 10% cobbles; poorly sorted; contains quartz, feldspar, amphibole, and other.			
330				330		
335				335		
			GRAVELLY FAT CLAY (CH): olive gray (5Y 4/2), 45% clay, medium to high plasticity; 35% fine to coarse gravel subangular to rounded; 10% fine to coarse grained sand, subangular to rounded; 5% silt; 5% cobbles; contains quartz, feldspar, amphibole, and other; shale.			
340	TD 340 ft bgs		Bottom of borehole at 340 feet.	340		

WELL CONSTRUCTION LOG MPWSP MW TM LITH ALL WELLS.GPJ GEOSCIENCE.GDT 7/7/16

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PACIFIC SURVEYS

TEMPERATURE
DELTA TEMPERATURE
FLUID RESISTIVITY
DELTA FLUID RESISTIVITY

Job No. 19184

Company CASCADE DRILLING

Well MW-6D

Field SALINAS

County MONTEREY State CA

File No.

Location

799 W. BLANCO RD.
GPS: N 36o 40' 37" W 121o 44' 49"

Other Services:

DUAL INDUCTION
GAMMA-RAY

		Elevation		Elevation
Permanent Datum	G.L.			
Log Measured From	G.L.	0' above perm. datum	K.B.	
Drilling Measured From	G.L.		D.F.	
			G.L.	

Date	02-24-2015										
Run Number	ONE										
Depth Driller	340'										
Depth Logger	335'										
Bottom Logged Interval	324'										
Top Log Interval	0'										
Open Hole Size	10.75" (0'-100')						9.875" (100'-250')			8" (250'-340')	
Type Fluid	WATER										
Density / Viscosity	N/A										
Fluid Level	38'										
Bentonite Seal	N/A										
Time Well Ready	1000										
Time Logger on Bottom	1100										
Equipment Number	PS-8										
Location	LA										
Recorded By	SCHUMACHER										
Witnessed By	A. KHALIGHI										

Borehole Record				Tubing Record			
Run Number	Bit	From	To	Size	Weight	From	To
ONE	10.75"	0'	100'				
TWO	9.875"	100'	250'				
THREE	8"	250'	340'				

Casing Record	Size	Wgt/Ft	Top	Bottom
Surface String				
Prot. String				
Production String	4" PVC	SCH 80	0'	340'
Liner				

<<< Fold Here >>>

All interpretations are opinions based on inferences from electrical or other measurements and Pacific Surveys cannot and do not guarantee the accuracy or correctness of any interpretation, and we shall not, except in the case of gross or willful negligence on our part, be liable or responsible for any loss, costs, damages, or expenses incurred or sustained by anyone resulting from any interpretation made by any of our officers, agents or employees. These interpretations are also subject to Pacific Surveys' general terms and conditions set out in our current Price Schedule.

Comments

Calibration Report

Database File	19184.db
Dataset Pathname	tmp3
Dataset Creation	Tue Feb 24 12:10:17 2015

Temperature Calibration Report

Serial Number:	3553	
Tool Model:	MLS	
Performed:	Mon Feb 23 16:47:18 2015	
	Reference	Reading
Low Reference:	43.34 degF	1441.00cps
High Reference:	149.00 degF	4545.00cps
Gain:	0.03	
Offset:	-9.71	
Delta Spacing	2	

FRT Calibration Report

Serial Number:	3553
Tool Model:	MLS
Performed:	Mon Feb 23 16:47:15 2015

Resistivity Calibration:

System Reading	Calibration Reference
32145.000 cps	1.800 Ohm-m
11466.000 cps	86.960 Ohm-m

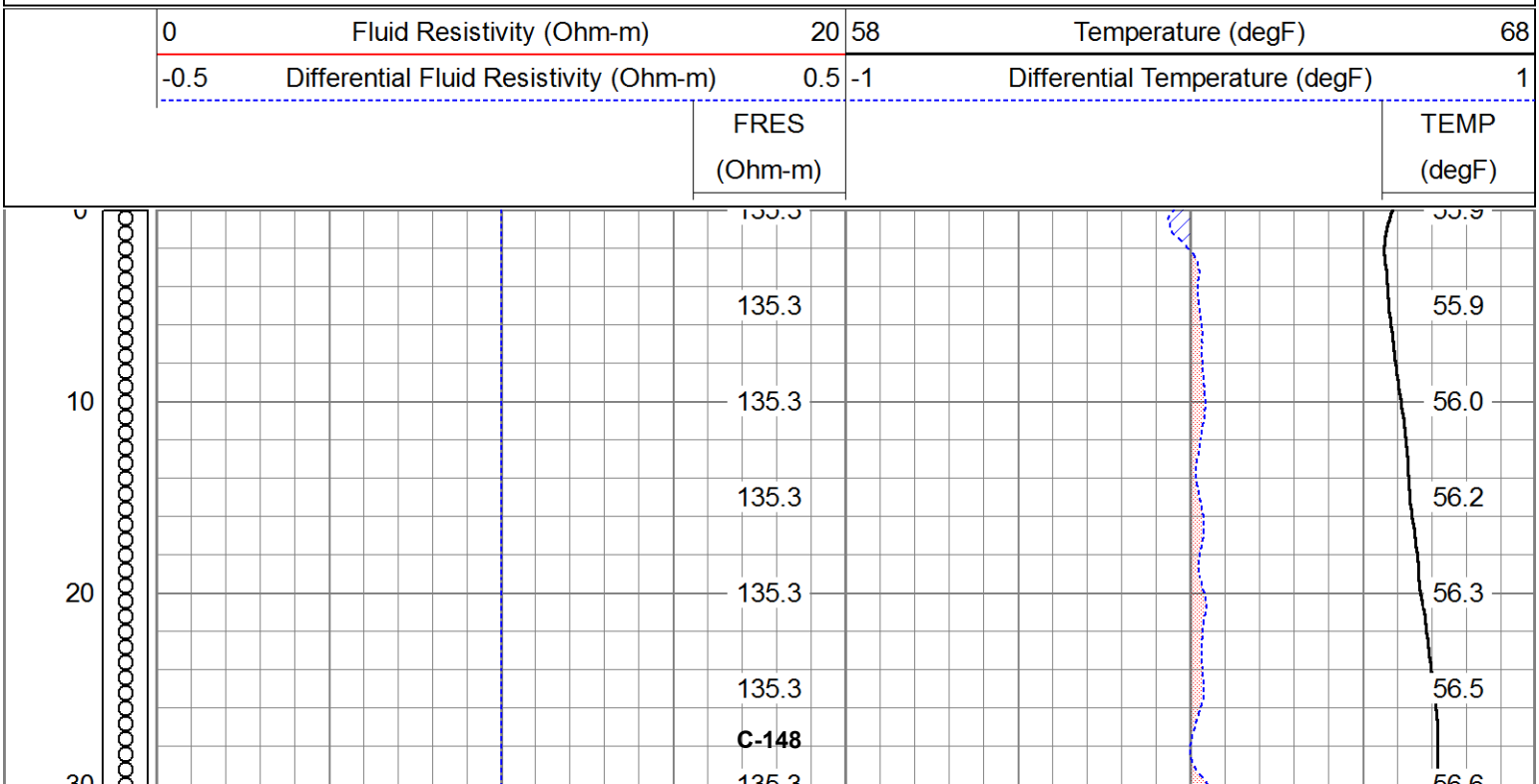
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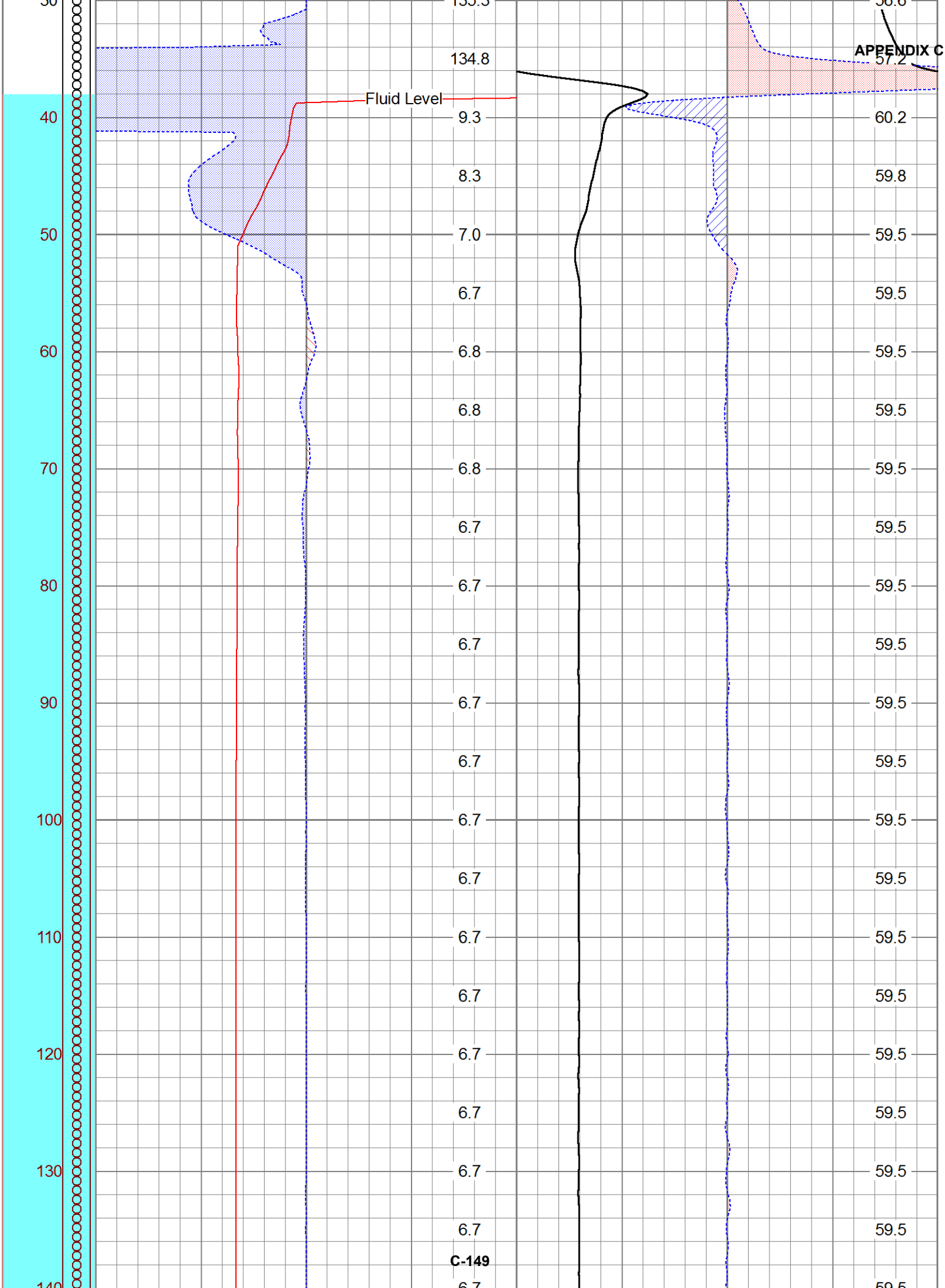
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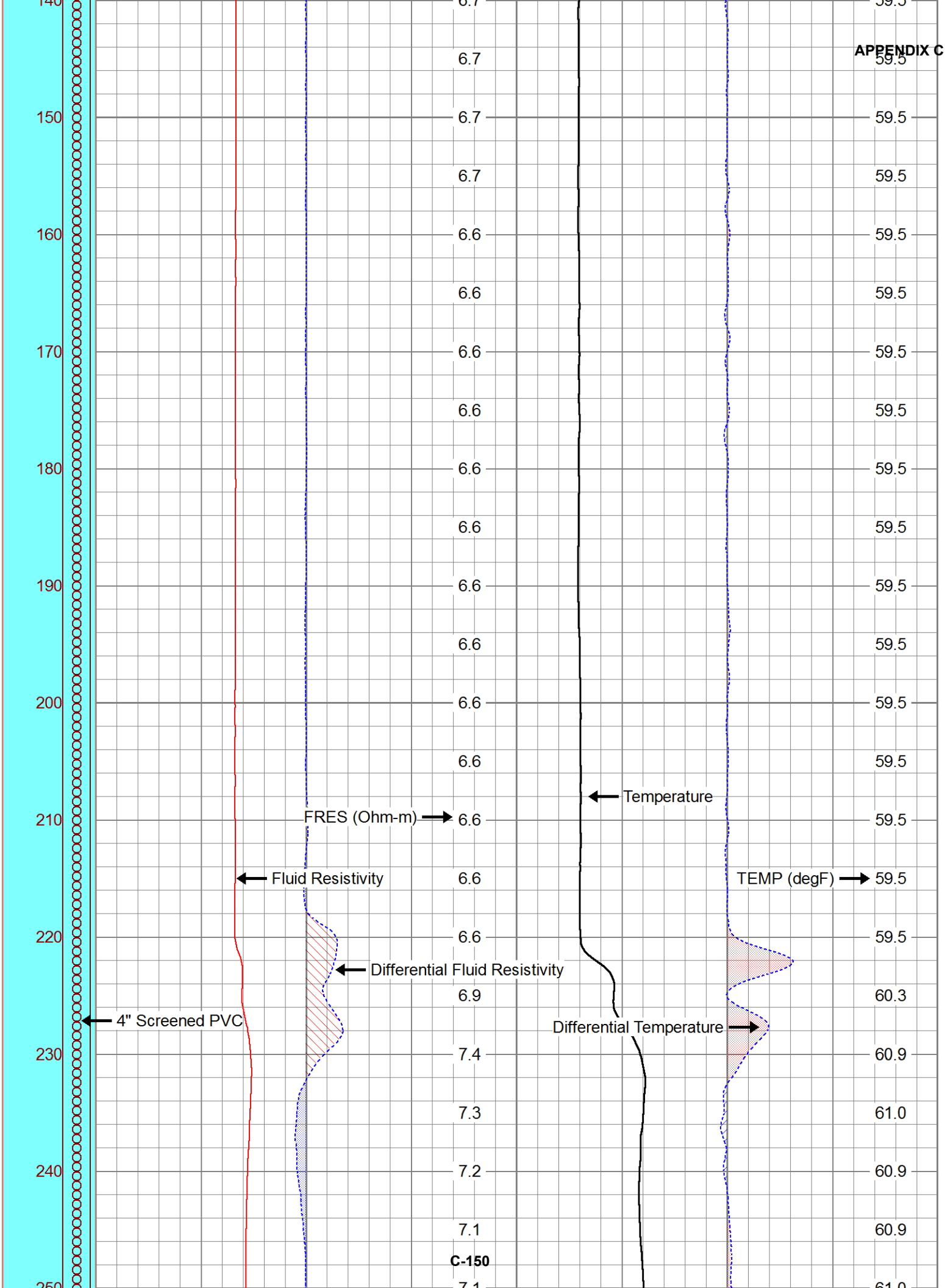
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1.000 cps	1.000

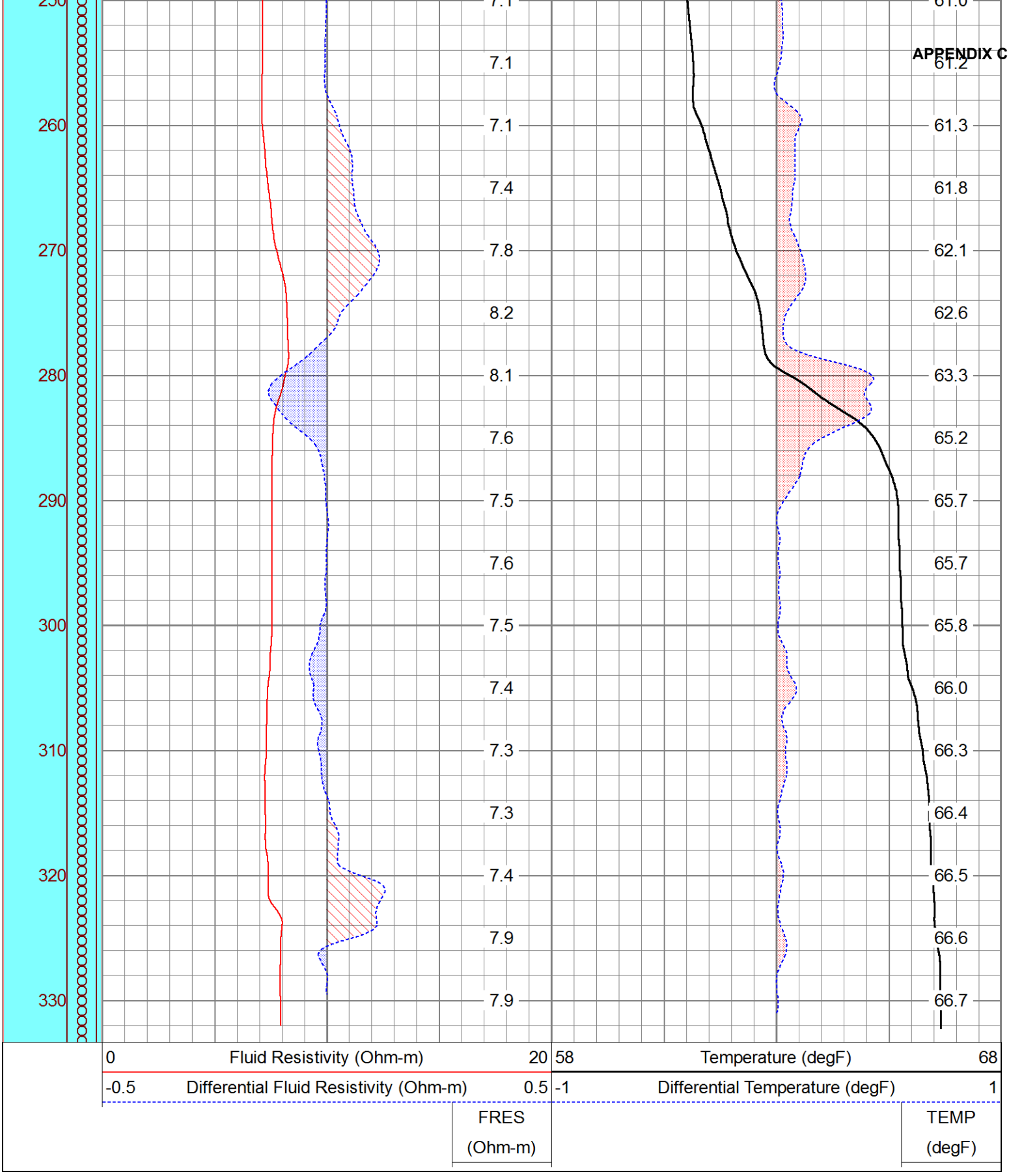
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Database File	19184.db
Dataset Pathname	tmp3
Presentation Format	frttemp2
Dataset Creation	Tue Feb 24 12:10:17 2015
Charted by	Depth in Feet scaled 1:120




APPENDIX C
Fluid Level
134.8
9.3
8.3
7.0
6.7
6.8
6.8
6.8
6.7
6.7
6.7


140
150
160
170
180
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200
210
220
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240
250
6.7
6.7
6.7
6.6
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6.6
6.6
6.6
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6.6
6.6
6.6
6.6
6.6
6.9
7.4
7.3
7.2
7.1
59.5
59.5
59.5
59.5
59.5
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59.5
59.5
59.5
59.5
59.5
59.5
60.3
60.9
61.0
60.9
60.9
61.0
Temperature
FRES (Ohm-m)
Fluid Resistivity
TEMP (degF)
Differential Fluid Resistivity
4" Screened PVC
Differential Temperature


250
260
270
280
290
300
310
320
330
7.1
7.1
7.4
7.8
8.2
8.1
7.6
7.5
7.6
7.5
7.4
7.3
7.3
7.4
7.9
7.9
61.2
61.3
61.8
62.1
62.6
63.3
65.2
65.7
65.7
65.8
66.0
66.3
66.4
66.5
66.6
66.7
0
Fluid Resistivity (Ohm-m)
20
-0.5
Differential Fluid Resistivity (Ohm-m)
0.5
FRES
(Ohm-m)
58
Temperature (degF)
68
-1
Differential Temperature (degF)
1
TEMP
(degF)

APPENDIX C

PACIFIC SURVEYS

DUAL INDUCTION GAMMA-RAY

Job No. 19184

File No.

Company CASCADE DRILLING

Well MW-6D

Field SALINAS

County MONTEREY State CA

Location

799 W. BLANCO RD.
GPS: N 36o 40' 37" W 121o 44' 49"

Other Services:

TEMPERATURE
FLUID RESISTIVITY

Permanent Datum	G.L.	Elevation above perm. datum	Elevation K.B. / D.F. / G.L.
Log Measured From	G.L.	0'	
Drilling Measured From	G.L.		

Date	02-24-2015		
Run Number	ONE		
Depth Driller	340'		
Depth Logger	335'		
Bottom Logged Interval	335'		
Top Log Interval	0'		
Open Hole Size	10.75" (0'-100')	9.875" (100'-250')	8" (250'-340')
Type Fluid	WATER		
Density / Viscosity	N/A		
Fluid Level	38'		
Bentonite Seal	N/A		
Time Well Ready	1000		
Time Logger on Bottom	1100		
Equipment Number	PS-8		
Location	LA		
Recorded By	SCHUMACHER		
Witnessed By	A. KHALIGHI		

Borehole Record				Tubing Record			
Run Number	Bit	From	To	Size	Weight	From	To
ONE	10.75"	0'	100'				
TWO	9.875"	100'	250'				
THREE	8"	250'	340'				

Casing Record	Size	Wgt/Ft	Top	Bottom
Surface String				
Prot. String				
Production String	4" PVC	SCH 80	0'	340'
Liner				

<<< Fold Here >>>

All interpretations are opinions based on inferences from electrical or other measurements and Pacific Surveys cannot and do not guarantee the accuracy or correctness of any interpretation, and we shall not, except in the case of gross or willful negligence on our part, be liable or responsible for any loss, costs, damages, or expenses incurred or sustained by anyone resulting from any interpretation made by any of our officers, agents or employees. These interpretations are also subject to Pacific Surveys' general terms and conditions set out in our current Price Schedule.

Comments

Calibration Report

Database File 19184.db
Dataset Pathname DIL2
Dataset Creation Tue Feb 24 14:05:16 2015

C-152

Dual Induction Calibration Report

Serial-Model: 0001-ALT
Surface Cal Performed:

APPENDIX C

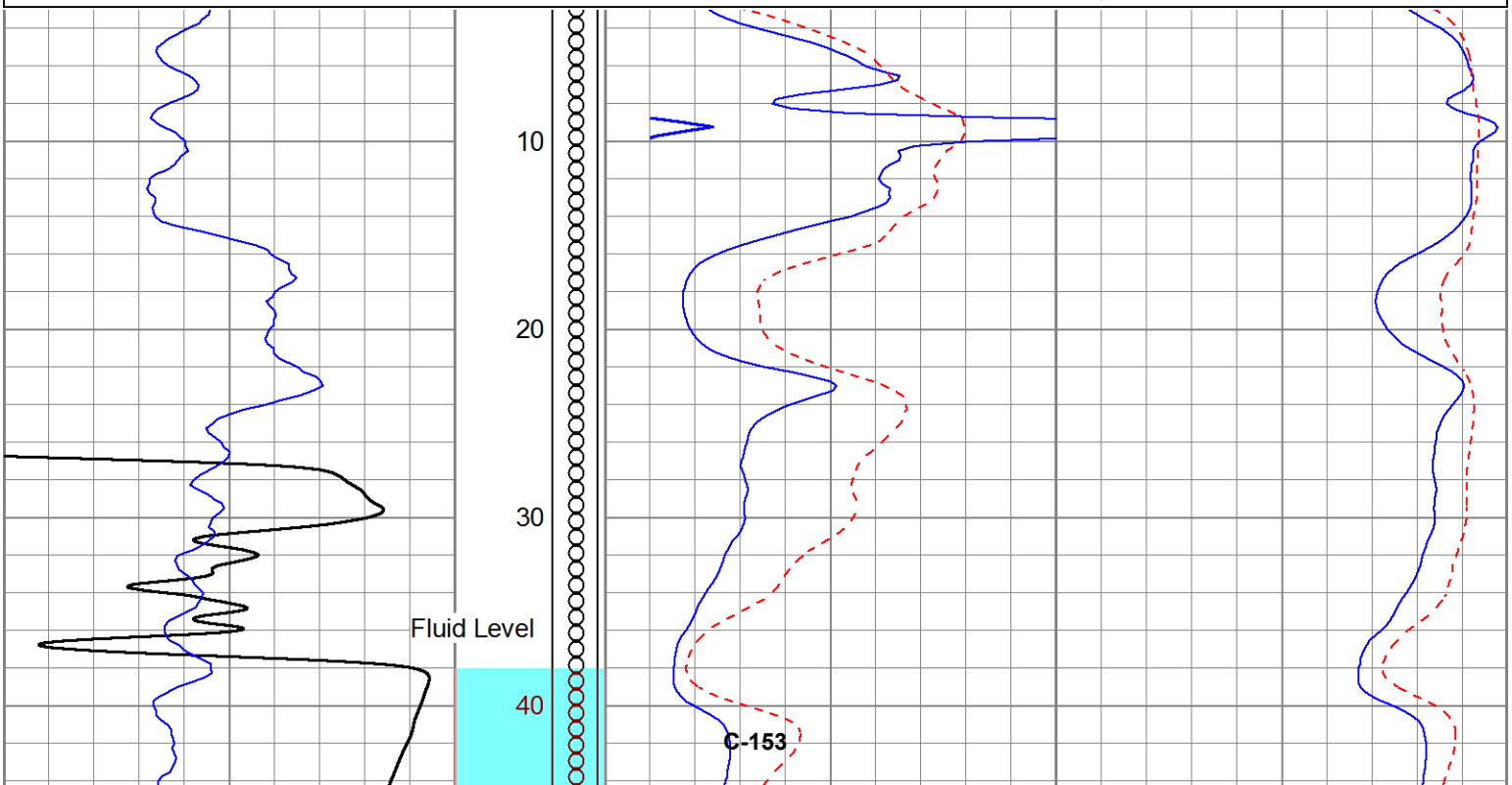
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Medium	2156.841	14524.973	cps	0.000	1960.000	mmho/m	0.158	-341.798

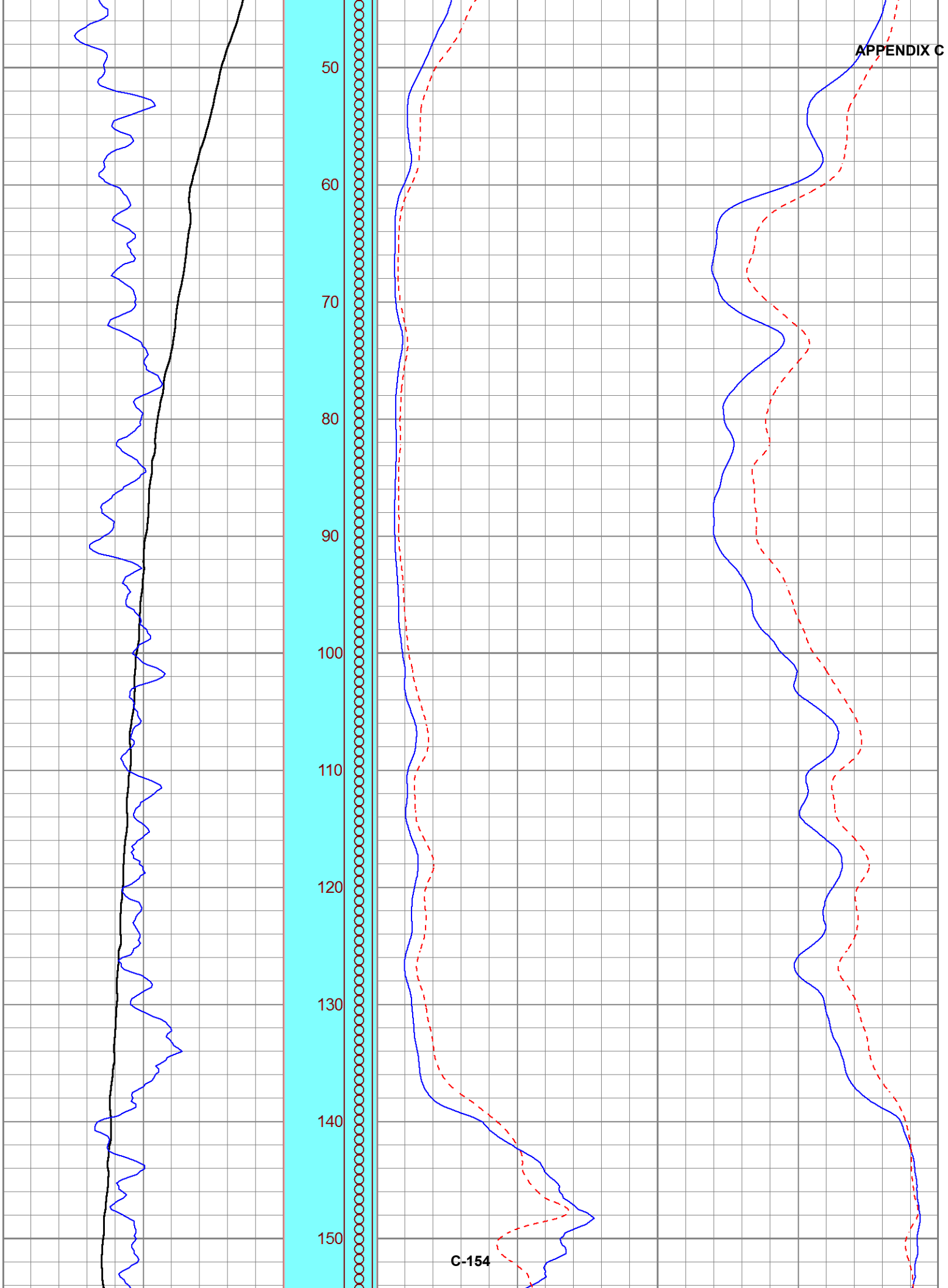
Gamma Ray Calibration Report

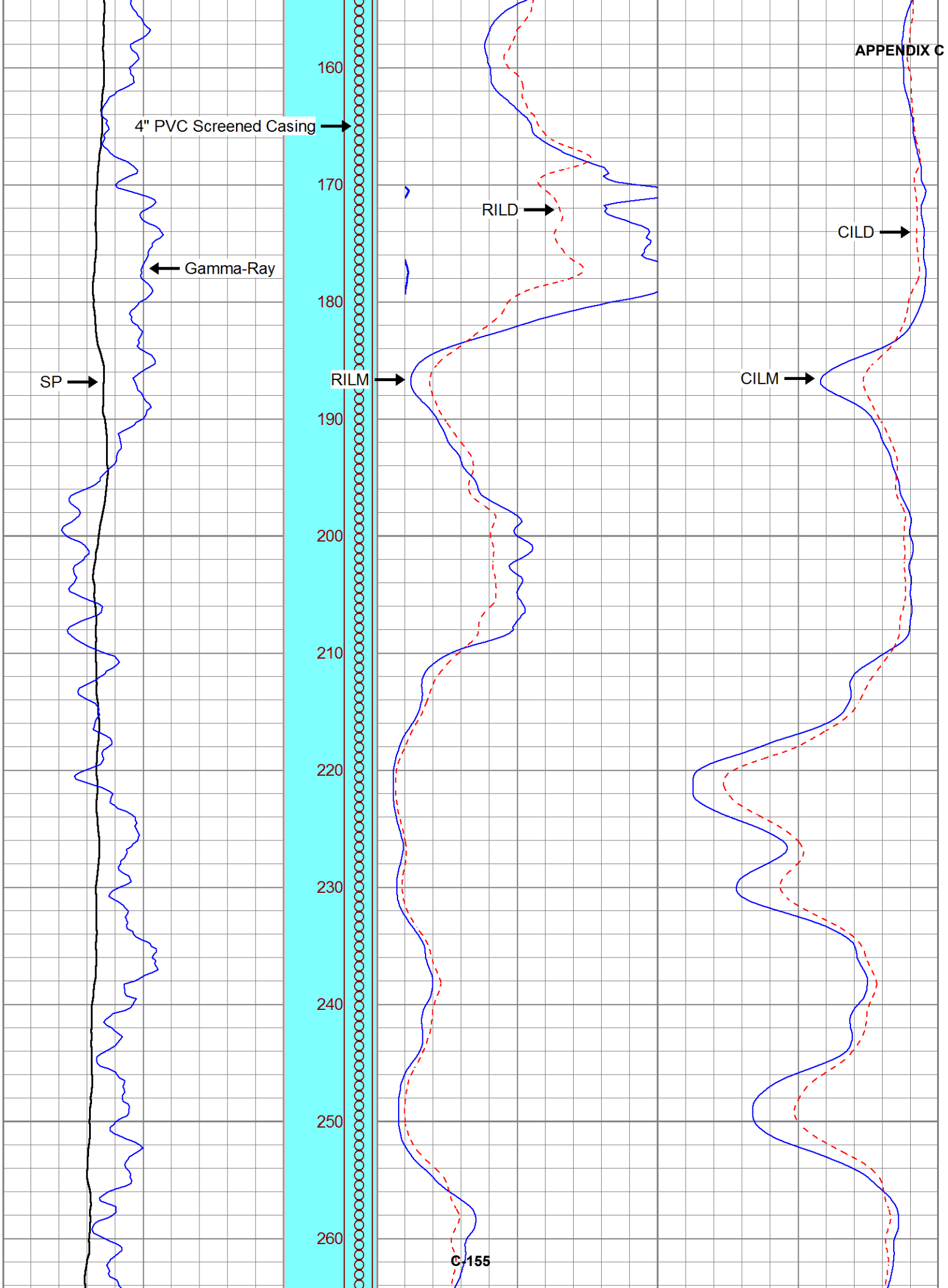
Serial Number:	PS_1	
Tool Model:	01	
Performed:	Sat Jan 10 13:10:57 2015	
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Background Reading:	46.1	cps
Calibrator Reading:	180.8	cps
Sensitivity:	1.2020	GAPI/cps

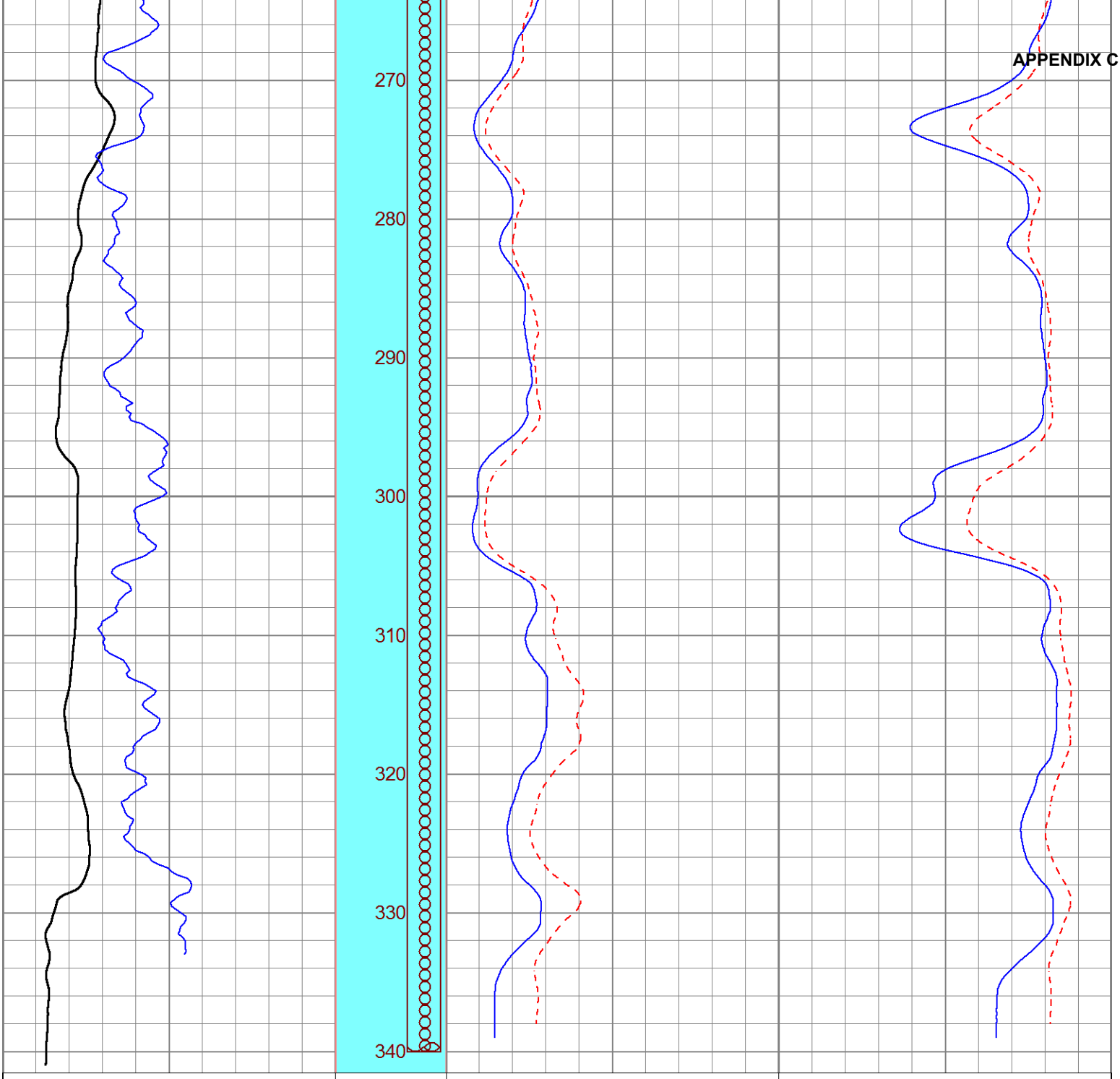
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Presentation Format	dil
Dataset Creation	Tue Feb 24 14:05:16 2015
Charted by	Depth in Feet scaled 1:120

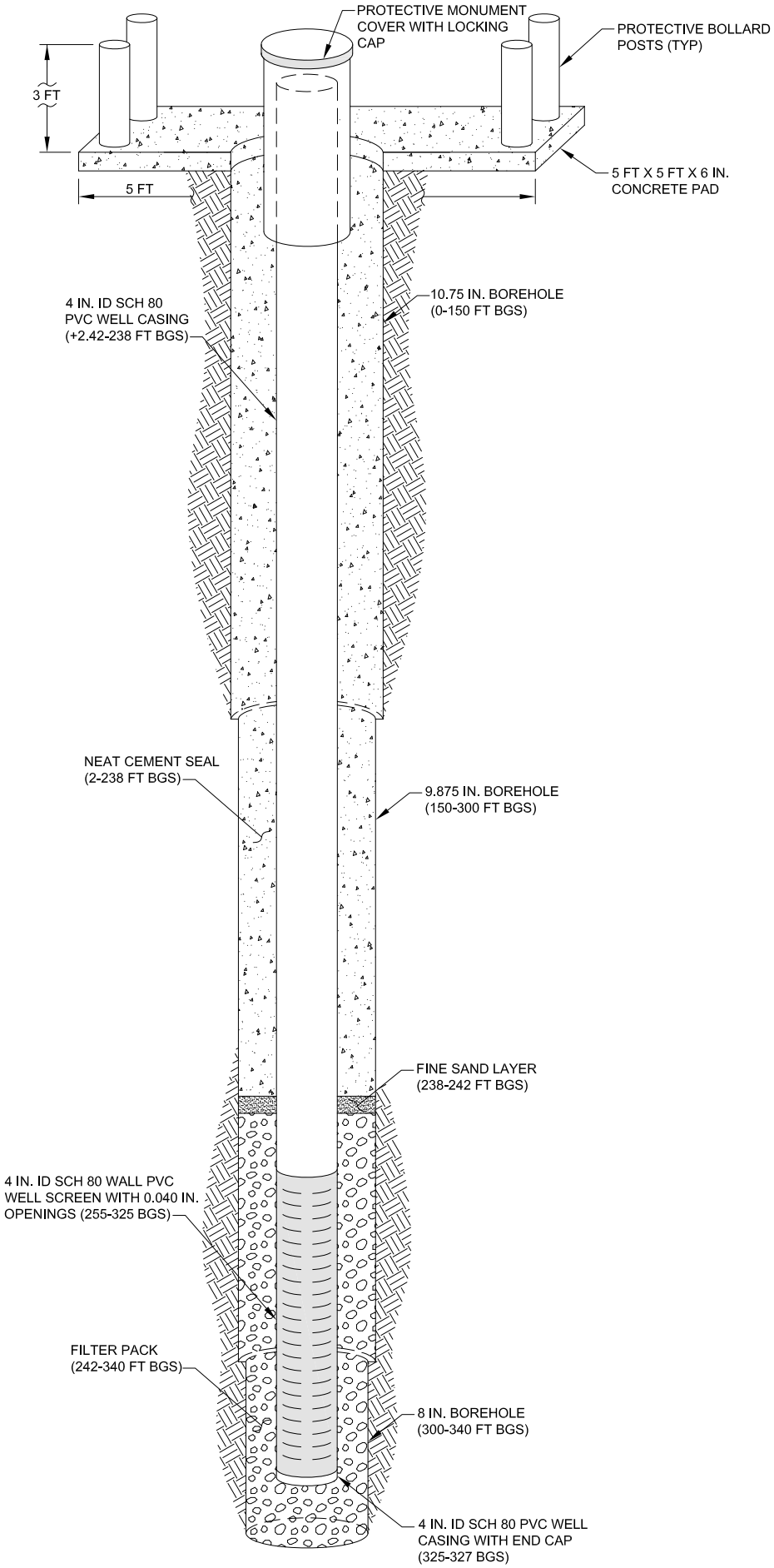
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20 Gamma-Ray (GAPI) 120	0 RILD (Ohm-m) 100	200 CILD (mmho/m) 0
	100 RILM backup (Ohm-m) 1000	2000 CILD backup (mmho/m) 200
	100 RILD backup (Ohm-m) 1000	2000 CILM backup (mmho/m) 200




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210
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250
260
4" PVC Screened Casing
Gamma-Ray
SP
RILD
RILM
CILD
CILM


270
280
290
300
310
320
330
340
-30 SP (mV) 120
20 Gamma-Ray (GAPI) 120
0 RILM (Ohm-m) 100
0 RILD (Ohm-m) 100
100 RILM backup (Ohm-m) 1000
100 RILD backup (Ohm-m) 1000
200 CILM (mmho/m) 0
200 CILD (mmho/m) 0
CILD backup
2000 (mmho/m) 200
CILM backup
2000 (mmho/m) 200



WELL PROFILE

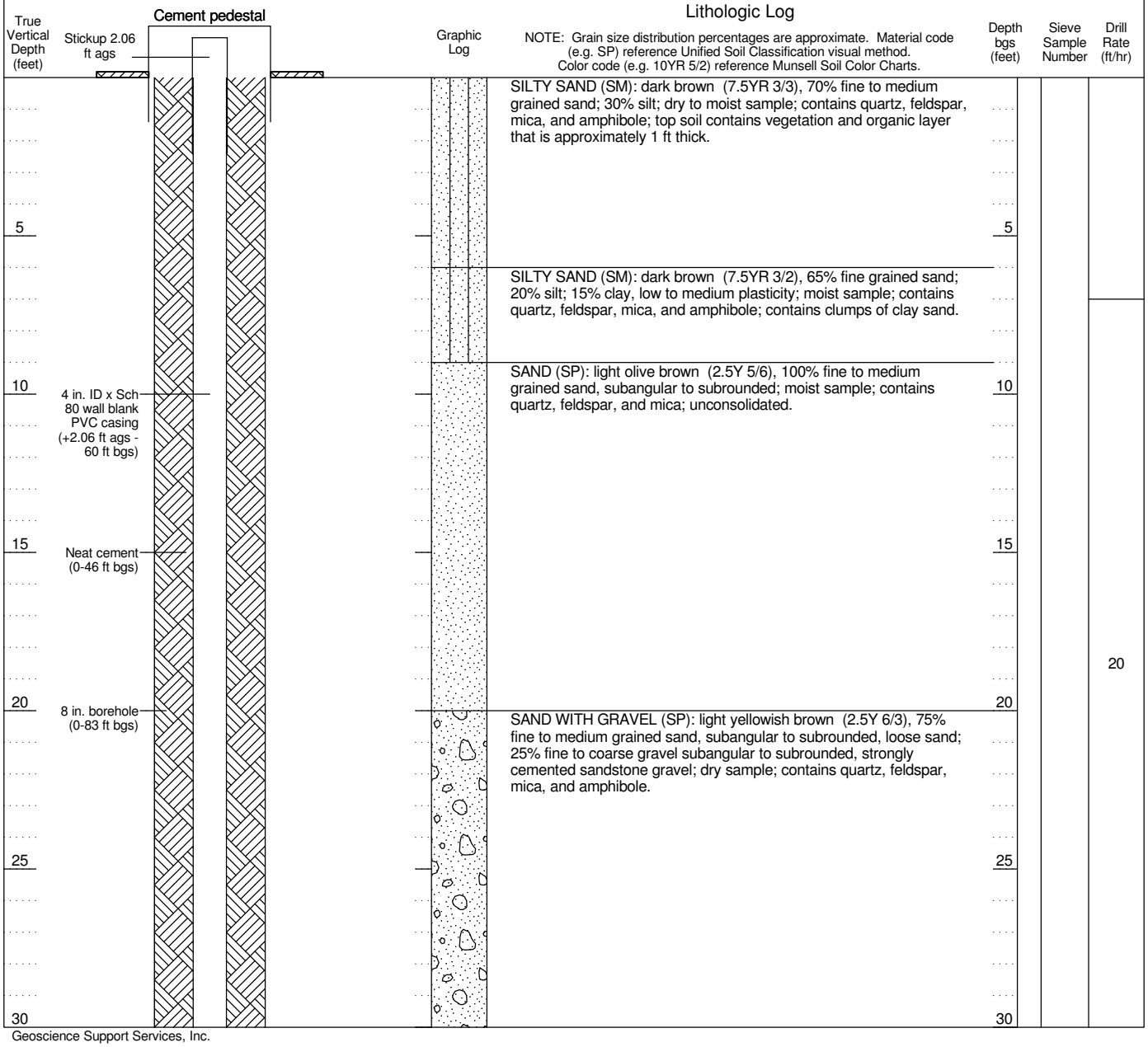
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BOREHOLE LITHOLOGIC LOG

WELL NUMBER **MPWSP MW-7S**	
CLIENT: Cal Am	LOCATION: **Marina, CA**
PROJECT NUMBER: 14077-15	**Lapis Rd**
REPORT DATE:	
DRILLING CONTRACTOR: Cascade Drilling	LOGGED BY: **J. Sobolew**
DRILLER: D. King	

		SCREEN / BLANK	TOP DEPTH (ft bgs)	BOTTOM DEPTH (ft bgs)	LENGTH (ft)	MATERIAL	WALL THICKNESS (in.)	DIAMETER (in.)	SCREEN TYPE	PERF. SIZE (in.)
DRILLING RIG TYPE	ProSonic 600T									
DRILLING METHOD	Sonic	**Blank**	**-2.06**	**60**	**62.06**	**PVC**	**Sch 80**	**4 / ID**		
SAMPLING METHOD	Core	**Screen**	**60**	**80**	**20**	**PVC**	**Sch 80**	**4 / ID**	**Slotted**	**0.04**
BOREHOLE DIAMETER	8 in	**Blank**	**80**	**82.4**	**2.4**	**PVC**	**Sch 80**	**4 / ID**		
SURFACE ELEVATION	48.58 ft NAVD88									
TOC ELEVATION	50.64 ft NAVD88 (RP)									
START DATE	7/22/15									
FINISH DATE	7/23/15									



WELL CONSTRUCTION LOG MPWSP MW TM LITH ALL WELLS.GPJ GEOSCIENCE.GDT 7/7/16

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WELL NUMBER **MPWSP MW-7S**

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am
PROJECT NUMBER 14077-15
LOCATION **Marina, CA**

True Vertical Depth (feet)	(continued)	Graphic Log	Lithologic Log NOTE: Grain size distribution percentages are approximate. Material code (e.g. SP) reference Unified Soil Classification visual method. Color code (e.g. 10YR 5/2) reference Munsell Soil Color Charts.	Depth bgs (feet)	Sieve Sample Number	Drill Rate (ft/hr)
35			SILTY SAND (SM): brown (10YR 4/3), 85% sand; 15% silt, none to low plasticity; moist sample; contains quartz, feldspar, mica, and amphibole; unconsolidated.	35		
40			SAND (SP): yellowish brown (10YR 5/4), 100% fine grained sand; moist to wet sample; contains quartz, feldspar, mica, and amphibole; unconsolidated.	40		
45			NO SAMPLE: No recovery; lost core within borehole.	45		
50	CEMEX Monterey Lapis Lustre #60 fine sand seal (46 - 49.5 ft bgs)		SAND (SP): pale brown (10YR 6/3), 90% medium to coarse grained sand, subangular to subrounded; 10% fine gravel subangular to subrounded; wet sample; contains quartz, feldspar, mica, and amphibole; unconsolidated.	50		20
			SAND (SP): light brownish gray (10YR 6/2), 100% fine to medium grained sand, subangular to subrounded; wet sample; contains quartz, feldspar, mica, and amphibole; unconsolidated.			
	CEMEX Monterey Lapis Lustre #3 filter pack (49.5 - 83 ft bgs)		SAND (SP): light brownish gray (10YR 6/2), 100% medium to coarse grained sand, subangular to subrounded; wet sample; contains quartz, feldspar, mica, and amphibole.			
55			SAND WITH GRAVEL (SP): dark yellowish brown (10YR 3/6), 80% fine to coarse grained sand, subangular to subrounded; 20% fine gravel subangular to subrounded; wet sample; contains quartz, feldspar, mica, and amphibole; unconsolidated.	55		
60			SAND (SP): dark yellowish brown (10YR 4/4), 90% fine to coarse grained sand, subangular to subrounded; 10% fine gravel subangular to subrounded; wet sample; contains quartz, feldspar, mica, and amphibole; unconsolidated.	60		
	4 in. ID x Sch 80 wall PVC well screen with 0.040 in. slots (60 - 80 ft bgs)					
65			SAND (SP): strong brown (7.5YR 4/6), 95% fine to coarse grained sand, subangular to subrounded; 5% fine gravel rounded; wet sample; contains quartz, feldspar, mica, and amphibole; unconsolidated.	65		
70				70		

WELL CONSTRUCTION LOG MPWSP MW TM LITH ALL WELLS.GPJ GEOSCIENCE.GDT 7/7/16

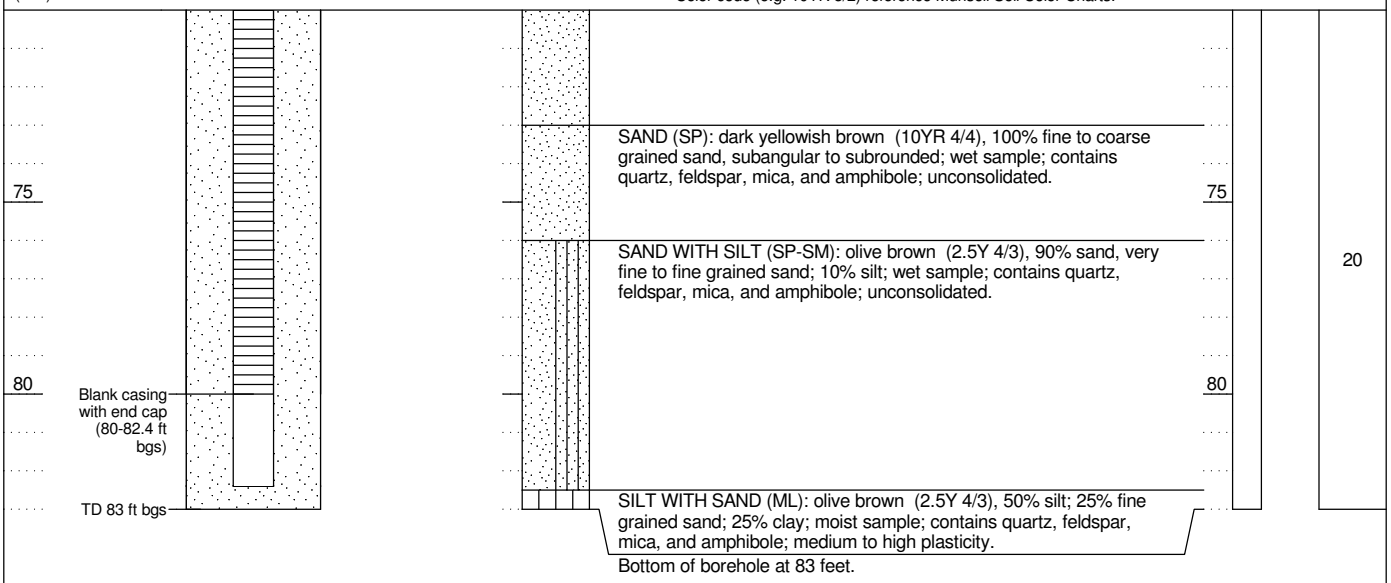
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WELL NUMBER **MPWSP MW-7S**

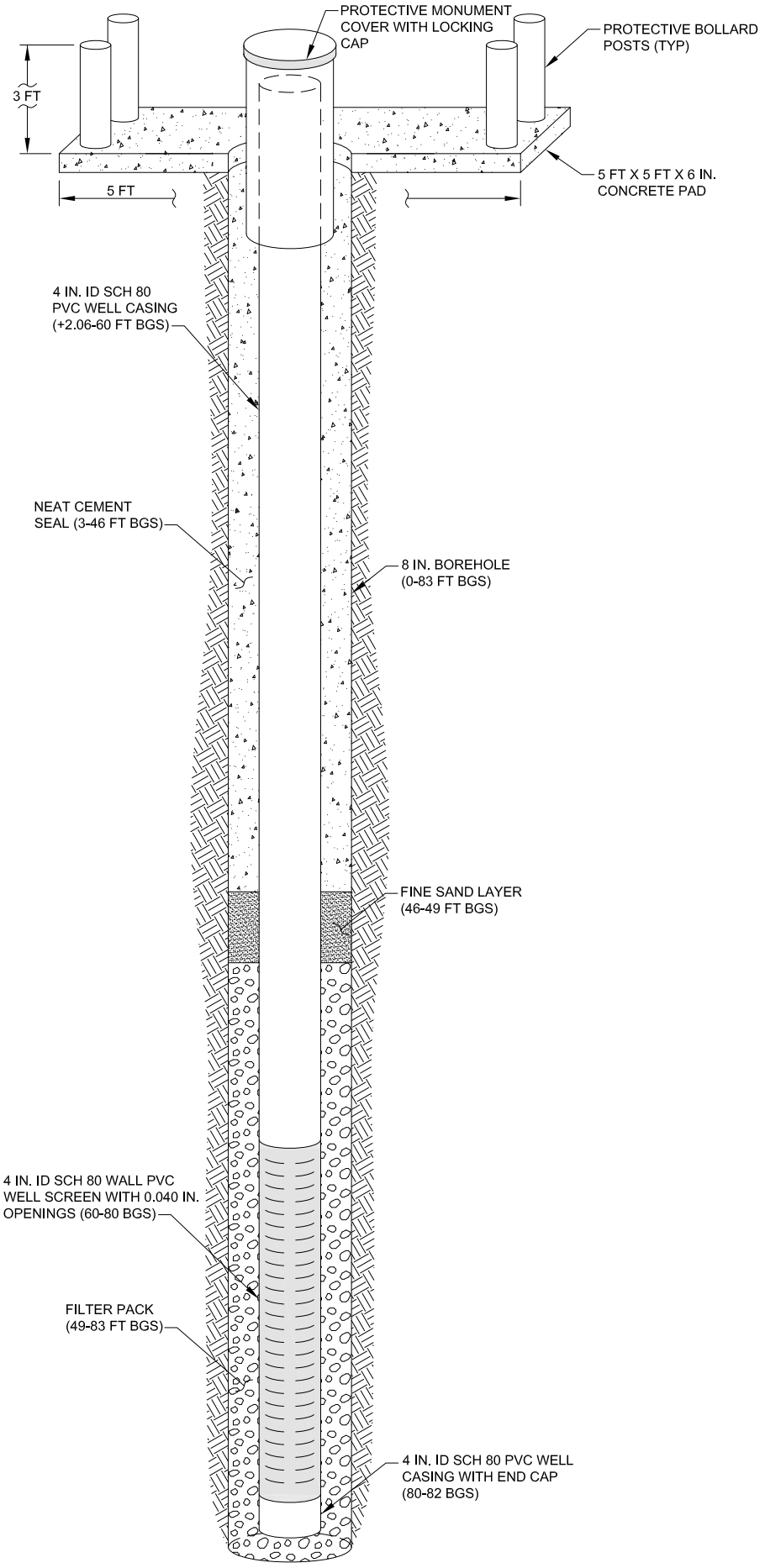
BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am | LOCATION **Marina, CA**
PROJECT NUMBER 14077-15



WELL CONSTRUCTION LOG MPWSP MW TM LITH ALL WELLS.GPJ GEOSCIENCE.GDT 7/7/16

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CALIFORNIA AMERICAN WATER

Date: 09-AUG-16

Drawn: AS

Checked: LW

Approved: PK

CLIENT: CALIFORNIA AMERICAN WATER

PROJECT: MONTEREY PENINSULA WATER SUPPLY PROJECT

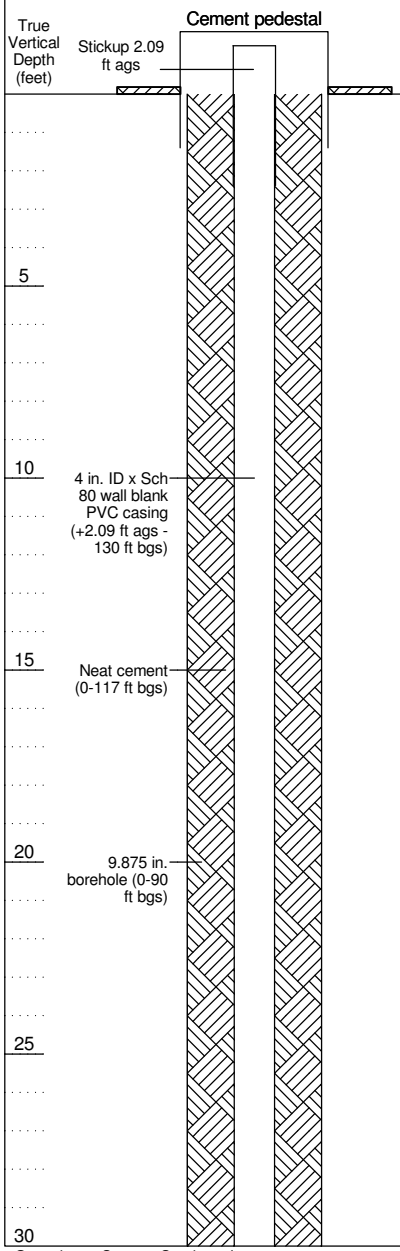
MW-7S AS-BUILT

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BOREHOLE LITHOLOGIC LOG

WELL NUMBER **MPWSP MW-7M**	
CLIENT: Cal Am	LOCATION: **Marina, CA**
PROJECT NUMBER: 14077-15	**Lapis Rd**
REPORT DATE:	
DRILLING CONTRACTOR: Cascade Drilling	LOGGED BY: **A. Khalighi**
DRILLER: D. King	

		SCREEN / BLANK	TOP DEPTH (ft bgs)	BOTTOM DEPTH (ft bgs)	LENGTH (ft)	MATERIAL	WALL THICKNESS (in.)	DIAMETER (in.)	SCREEN TYPE	PERF. SIZE (in.)
DRILLING RIG TYPE	ProSonic 600T									
DRILLING METHOD	Sonic	**Blank**	**-2.09**	**130**	**132.09**	**PVC**	**Sch 80**	**4 / ID**		
SAMPLING METHOD	Core	**Screen**	**130**	**220**	**90**	**PVC**	**Sch 80**	**4 / ID**	**Slotted**	**0.04**
BOREHOLE DIAMETER	9.875, 8 in	**Blank**	**220**	**222.375**	**2.375**	**PVC**	**Sch 80**	**4 / ID**		
SURFACE ELEVATION	48.20 ft NAVD88									
TOC ELEVATION	50.29 ft NAVD88 (RP)									
START DATE	7/13/15									
FINISH DATE	7/22/15									



Lithologic Log

Graphic Log

NOTE: Grain size distribution percentages are approximate. Material code (e.g. SP) reference Unified Soil Classification visual method. Color code (e.g. 10YR 5/2) reference Munsell Soil Color Charts.

Depth bgs (feet)	Lithologic Description	Sieve Sample Number	Drill Rate (ft/hr)
	SILTY SAND (SM): dark brown (7.5YR 3/3), 70% fine to medium grained sand; 30% silt; dry to moist sample; contains quartz, feldspar, mica, and amphibole; contains top soil.		
5	SILTY SAND (SM): dark brown (7.5YR 3/2), 65% fine grained sand; 20% silt; 15% clay, low to medium plasticity; contains quartz, feldspar, mica, and amphibole; contains clumps of clayey sand.		
10	SAND (SP): light olive brown (2.5Y 5/6), 100% fine to medium grained sand, subangular to subrounded; moist sample; contains quartz, feldspar, and mica; unconsolidated.		
15			
20	SAND WITH GRAVEL (SP): light yellowish brown (2.5Y 6/3), 75% fine to medium grained sand, subangular to subrounded; 25% fine to coarse gravel subangular to subrounded; dry sample; contains quartz, feldspar, mica, and amphibole; contains strongly cemented sand with gravel matrix; loose sand.		
25			
30			

WELL CONSTRUCTION LOG MPWSP MW TM LITH ALL WELLS.GPJ GEOSCIENCE.GDT 7/7/16

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WELL NUMBER **MPWSP MW-7M**

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am
PROJECT NUMBER 14077-15
LOCATION **Marina, CA**

True Vertical Depth (feet)	(continued)	Graphic Log	Lithologic Log NOTE: Grain size distribution percentages are approximate. Material code (e.g. SP) reference Unified Soil Classification visual method. Color code (e.g. 10YR 5/2) reference Munsell Soil Color Charts.	Depth bgs (feet)	Sieve Sample Number	Drill Rate (ft/hr)
			SILTY SAND (SM): brown (10YR 4/3), 85% sand, very fine to fine grained; 15% silt, none to low plasticity; moist sample; contains quartz, feldspar, mica, and amphibole; unconsolidated.			
35				35		
			SAND (SP): pale brown (10YR 6/3), 100% fine to coarse grained sand, subangular to subrounded; wet sample; contains quartz, feldspar, mica, and amphibole; unconsolidated.			
40				40		
45				45		
50				50		
			SAND (SP): pale brown (10YR 6/3), 90% medium to coarse grained sand, subangular to subrounded; 10% fine gravel subangular to subrounded; contains quartz, feldspar, mica, and amphibole; unconsolidated.		
			SAND (SP): light brownish gray (10YR 6/2), 100% fine to coarse grained sand, subangular to subrounded; wet sample; contains quartz, feldspar, mica, and amphibole; unconsolidated.			
55				55		
60				60		
			SAND (SP): yellowish brown (10YR 5/4), 100% fine grained sand; wet sample; contains quartz, feldspar, mica, and amphibole; unconsolidated.			
			SAND (SP): strong brown (7.5YR 4/6), 95% fine to coarse grained sand, subangular to subrounded; 5% fine gravel rounded; wet sample; contains quartz, feldspar, mica, and amphibole; unconsolidated.			
65				65		
70				70		

WELL CONSTRUCTION LOG MPWSP MW TM LITH ALL WELLS.GPJ GEOSCIENCE.GDT 7/7/16

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WELL NUMBER **MPWSP MW-7M**

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am
PROJECT NUMBER 14077-15
LOCATION **Marina, CA**

True Vertical Depth (feet)	(continued)	Graphic Log	Lithologic Log NOTE: Grain size distribution percentages are approximate. Material code (e.g. SP) reference Unified Soil Classification visual method. Color code (e.g. 10YR 5/2) reference Munsell Soil Color Charts.	Depth bgs (feet)	Sieve Sample Number	Drill Rate (ft/hr)
75			SAND WITH SILT (SP-SM): olive brown (2.5Y 4/3), 90% sand, very fine to fine grained; 10% silt; wet sample; contains quartz, feldspar, mica, and amphibole; unconsolidated.	75		
80				80		
85				85		
90			SILT WITH SAND (ML): light olive brown (2.5Y 5/3), 80% silt; 20% sand, very fine to fine grained; low to medium plasticity; moist sample; contains quartz, feldspar, mica, and amphibole; unconsolidated.	90		
	8 in. borehole (90-223 ft bgs)		CLAY (CL): greenish black (10GY 2.5/1), 100% clay, high plasticity; moist sample.			
95			SAND (SP): dark yellowish brown (10YR 4/4), 100% medium grained sand, subangular to subrounded; wet sample; contains quartz, feldspar, mica, and amphibole; unconsolidated.	95		
100				100		5
105				105		
110			CLAY (CL): greenish black (10GY 2.5/1), 100% clay, high plasticity; moist sample.	110		

WELL CONSTRUCTION LOG MPWSP MW TM LITH ALL WELLS.GPJ GEOSCIENCE.GDT 7/7/16

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WELL NUMBER
MPWSP MW-7M

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am
PROJECT NUMBER 14077-15
LOCATION **Marina, CA**

True Vertical Depth (feet)	(continued)	Graphic Log	Lithologic Log NOTE: Grain size distribution percentages are approximate. Material code (e.g. SP) reference Unified Soil Classification visual method. Color code (e.g. 10YR 5/2) reference Munsell Soil Color Charts.	Depth bgs (feet)	Sieve Sample Number	Drill Rate (ft/hr)
115			SAND (SP): dark yellowish brown (10YR 3/6), 95% fine to coarse grained sand, subangular to subrounded; 5% fine gravel subangular to subrounded; wet sample; contains quartz, feldspar, mica, and amphibole; unconsolidated.	115		
120	CEMEX Monterey Lapis Lustre #60 fine sand seal (117 - 120 ft bgs)		SILTY SAND (SM): brown (10YR 5/3), 85% fine to medium grained sand, subangular to subrounded; 15% silt, none to low plasticity; moist to wet sample; contains quartz, feldspar, and mica; unconsolidated.	120		
125	CEMEX Monterey Lapis Lustre #3 filter pack (120 - 223.375 ft bgs)		SAND (SP): brown (10YR 5/3), 100% sand, very fine to fine grained; contains quartz, feldspar, mica, and amphibole; unconsolidated.	125		5
130				130		
135	4 in. ID x Sch 80 wall PVC well screen with 0.040 in. slots (130 - 220 ft bgs)			135		
140				140		
145			CLAY (CL): greenish gray (10GY 6/1), 100% clay, high plasticity; moist sample.	145		
150				150		

WELL CONSTRUCTION LOG MPWSP MW TM LITH ALL WELLS.GPJ GEOSCIENCE.GDT 7/7/16

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WELL NUMBER **MPWSP MW-7M**

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am
PROJECT NUMBER 14077-15
LOCATION **Marina, CA**

True Vertical Depth (feet)	(continued)	Graphic Log	Lithologic Log NOTE: Grain size distribution percentages are approximate. Material code (e.g. SP) reference Unified Soil Classification visual method. Color code (e.g. 10YR 5/2) reference Munsell Soil Color Charts.	Depth bgs (feet)	Sieve Sample Number	Drill Rate (ft/hr)
			SILT (ML): dark greenish gray (10Y 4/1), 90% silt; 10% sand, very fine to fine grained; low plasticity; moist sample.			
			CLAY (CL): dark greenish gray (10Y 4/1), 85% clay, low plasticity; 10% sand, very fine grained; 5% silt; moist sample.			
155			SILTY SAND (SM): dark greenish gray (10Y 4/1), 75% sand, very fine grained; 20% silt; 5% clay; moist to wet sample; contains quartz, feldspar, mica, and amphibole; unconsolidated.	155		
160			SAND WITH CLAY (SP-SC): dark greenish gray (10Y 4/1), 90% fine to coarse grained sand, subangular to subrounded; 10% clay; wet sample; contains quartz, feldspar, mica, and amphibole; contains clumps of clay.	160		
			CLAYEY SAND WITH GRAVEL (SC): grayish brown (2.5Y 5/2), 65% sand, subangular to subrounded; 20% clay, low plasticity; 15% gravel subangular to subrounded; trace cobbles; moist sample; contains quartz, feldspar, mica, and amphibole.			
165				165		
			SAND (SP): dark yellowish brown (10YR 4/6), 100% fine grained sand; wet sample; contains quartz, feldspar, mica, and amphibole; unconsolidated.			
170				170		
175				175		
180				180		
185				185		
			GRAVEL WITH SAND (GP): dark brown (7.5YR 3/2), 60% fine to coarse gravel rounded; 35% fine to coarse grained sand, subangular to subrounded; 5% cobbles; wet sample; contains quartz, feldspar, mica, and amphibole; contains trace round cobbles; unconsolidated.			
190				190		

WELL CONSTRUCTION LOG MPWSP MW TM LITH ALL WELLS.GPJ GEOSCIENCE.GDT 7/7/16

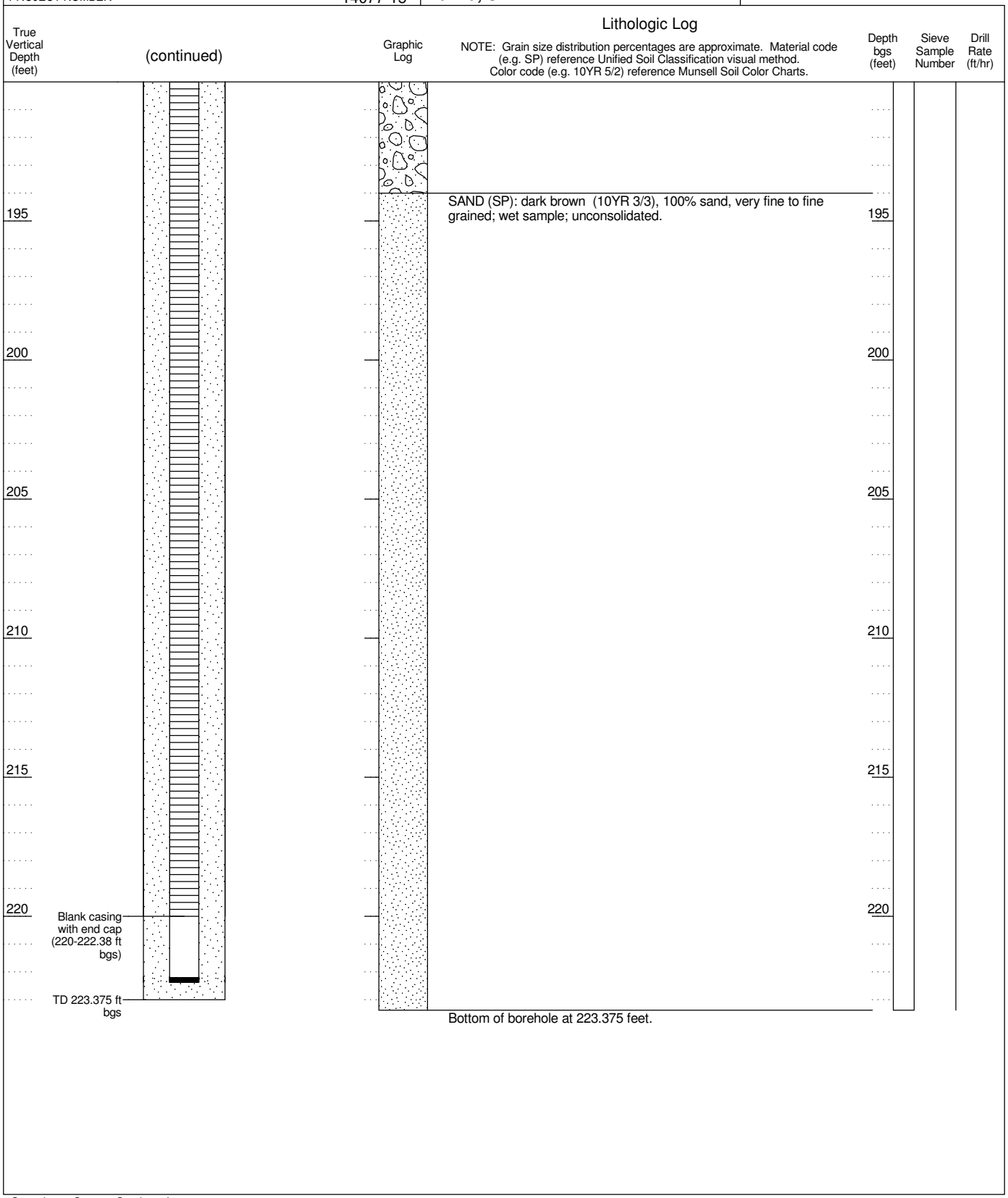
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WELL NUMBER
MPWSP MW-7M

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am
PROJECT NUMBER 14077-15
LOCATION **Marina, CA**



WELL CONSTRUCTION LOG MPWSP MW TM LITH ALL WELLS.GPJ GEOSCIENCE.GDT 7/7/16

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PACIFIC SURVEYS

TEMPERATURE
DELTA TEMPERATURE
FLUID RESISTIVITY
DELTA FLUID RESISTIVITY

Job No.	19868
Company	CASCADE DRILLING
Well	MW-7M
Field	MARINA
File No.	
County	MONTEREY
State	CA

Location

LAPIS RD. NEAR SOUTHERN INT. WITH DEL MONTE BLVD.
GPS: N 36o 42' 23" W 121o 47' 20"

Other Services:
DUAL INDUCTION
GAMMA-RAY

		Elevation		
Permanent Datum	G.L.		K.B.:	
Log Measured From	G.L.	0' above perm. datum	D.F.:	
Drilling Measured From	G.L.		G.L.:	

Date	07-13-2015
Run Number	ONE
Depth Driller	87'
Depth Logger	86'
Bottom Logged Interval	86'
Top Log Interval	0'
Open Hole Size	8" (0'-87')
Type Fluid	WATER
Density / Viscosity	N/A
Fluid Level	45'
Bentonite Seal	N/A
Time Well Ready	1330
Time Logger on Bottom	1345
Equipment Number	PS-8
Location	LA
Recorded By	SCHUMACHER
Witnessed By	A. KHALIGHI

Borehole Record

Run Number	Bit	From	To
ONE	8"	0'	87'

Tubing Record

Size	Weight	From	To
4" PVC	SCH 80	0'	87'

	Size	Wgt/Ft	Top	Bottom
Casing Record				
Surface String				
Prot. String				
Production String				
Liner				

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All interpretations are opinions based on inferences from electrical or other measurements and Pacific Surveys cannot and do not guarantee the accuracy or correctness of any interpretation, and we shall not, except in the case of gross or willful negligence on our part, be liable or responsible for any loss, costs, damages, or expenses incurred or sustained by anyone resulting from any interpretation made by any of our officers, agents or employees. These interpretations are also subject to Pacific Surveys' general terms and conditions set out in our current Price Schedule.

Comments

Calibration Report

Database File	19868.db
Dataset Pathname	tmpFR
Dataset Creation	Mon Jul 13 13:54:24 2015

Temperature Calibration Report

Serial Number:	3553	
Tool Model:	MLS	
Performed:	Mon Feb 23 16:47:18 2015	
	Reference	Reading
Low Reference:	43.34 degF	1441.00cps
High Reference:	149.00 degF	4545.00cps
Gain:	0.03	
Offset:	-9.71	
Delta Spacing	2	

FRT Calibration Report

Serial Number:	3553
Tool Model:	MLS
Performed:	Mon Feb 23 16:47:15 2015

Resistivity Calibration:

System Reading	Calibration Reference
32145.000 cps	1.800 Ohm-m
11466.000 cps	86.960 Ohm-m

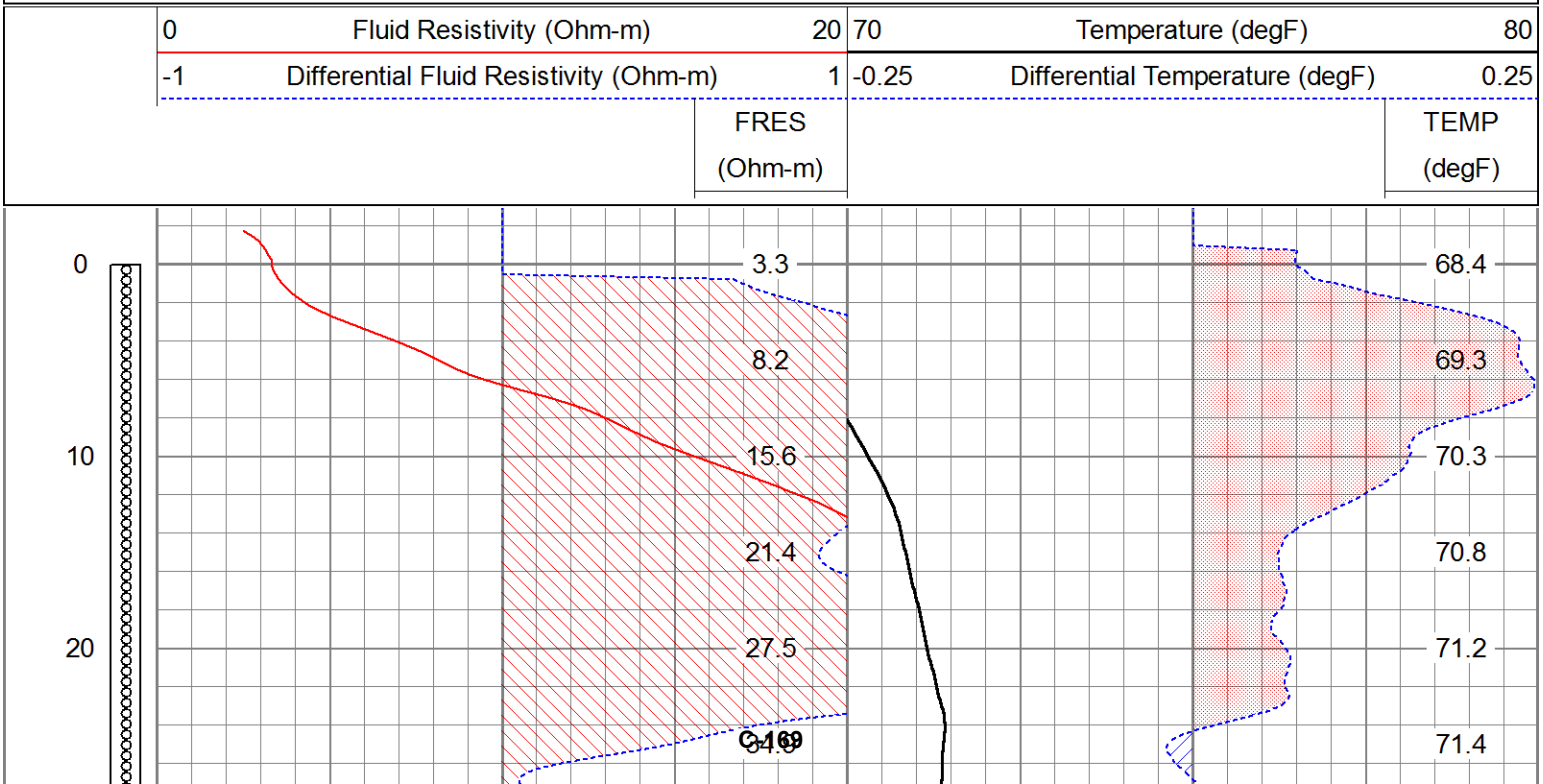
Gain: -0.004
Offset: 135.338

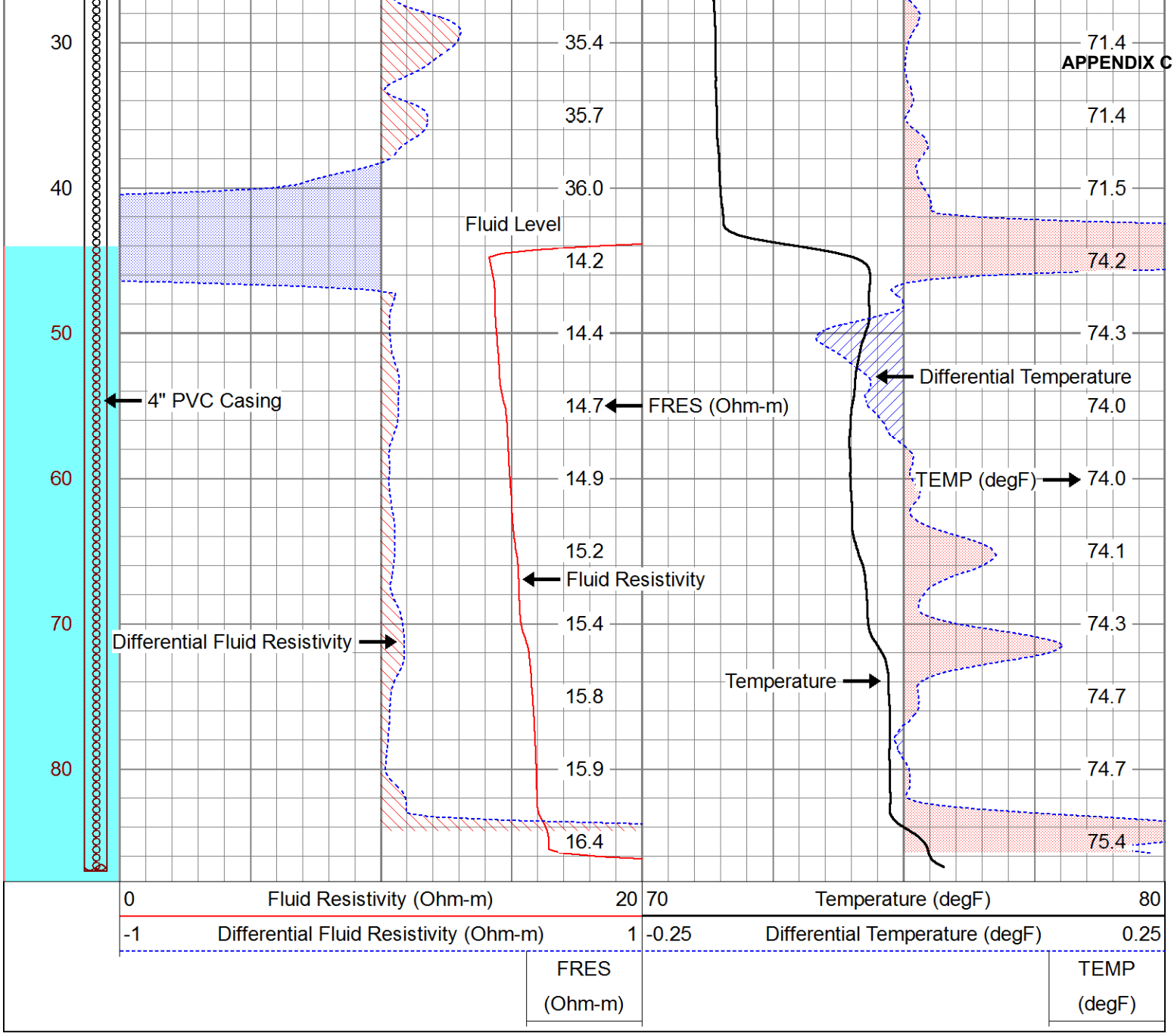
Conductivity Calibration:

System Reading	Calibration Reference
0.000 cps	0.000
1.000 cps	1.000

Gain: 1.000
Offset: 0.000

Database File	19868.db
Dataset Pathname	tmpFR
Presentation Format	frttemp2
Dataset Creation	Mon Jul 13 13:54:24 2015
Charted by	Depth in Feet scaled 1:120




APPENDIX C
30
40
50
60
70
80
35.4
35.7
36.0
14.2
14.4
14.7
14.9
15.2
15.4
15.8
15.9
16.4
71.4
71.4
71.5
74.2
74.3
74.0
74.0
74.1
74.3
74.7
74.7
75.4
Fluid Level
4" PVC Casing
FRES (Ohm-m)
Differential Temperature
TEMP (degF)
Fluid Resistivity
Differential Fluid Resistivity
Temperature
0
Fluid Resistivity (Ohm-m)
20
70
Temperature (degF)
80
-1
Differential Fluid Resistivity (Ohm-m)
1
-0.25
Differential Temperature (degF)
0.25
FRES
(Ohm-m)
TEMP
(degF)

PACIFIC SURVEYS

DUAL INDUCTION GAMMA-RAY

Job No. 19868

File No.

Company CASCADE DRILLING

Well MW-7M

Field MARINA

County MONTEREY State CA

Location

LAPIS RD. NEAR SOUTHERN INT. WITH DEL MONTE BLVD.
GPS: N 36o 42' 23" W 121o 47' 20"

Other Services:

TEMPERATURE
FLUID RESISTIVITY

				Elevation	
Permanent Datum	G.L.	Elevation		K.B.:	
Log Measured From	G.L.	0'	above perm. datum	D.F.:	
Drilling Measured From	G.L.			G.L.:	

Date	07-13-2015							
Run Number	ONE							
Depth Driller	87'							
Depth Logger	86'							
Bottom Logged Interval	86'							
Top Log Interval	0'							
Open Hole Size	8" (0'-87')							
Type Fluid	WATER							
Density / Viscosity	N/A							
Fluid Level	45'							
Bentonite Seal	N/A							
Time Well Ready	1330							
Time Logger on Bottom	1345							
Equipment Number	PS-8							
Location	LA							
Recorded By	SCHUMACHER							
Witnessed By	A. KHALIGHI							

Borehole Record				Tubing Record			
Run Number	Bit	From	To	Size	Weight	From	To
ONE	8"	0'	87'				

Casing Record	Size	Wgt/Ft	Top	Bottom
Surface String				
Prot. String				
Production String	4" PVC	SCH 80	0'	87'
Liner				

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Comments

Calibration Report

Database File	19868.db
Dataset Pathname	dil2
Dataset Creation	Mon Jul 13 15:22:33 2015

Serial-Model: 0001-ALT
Surface Cal Performed:

APPENDIX C

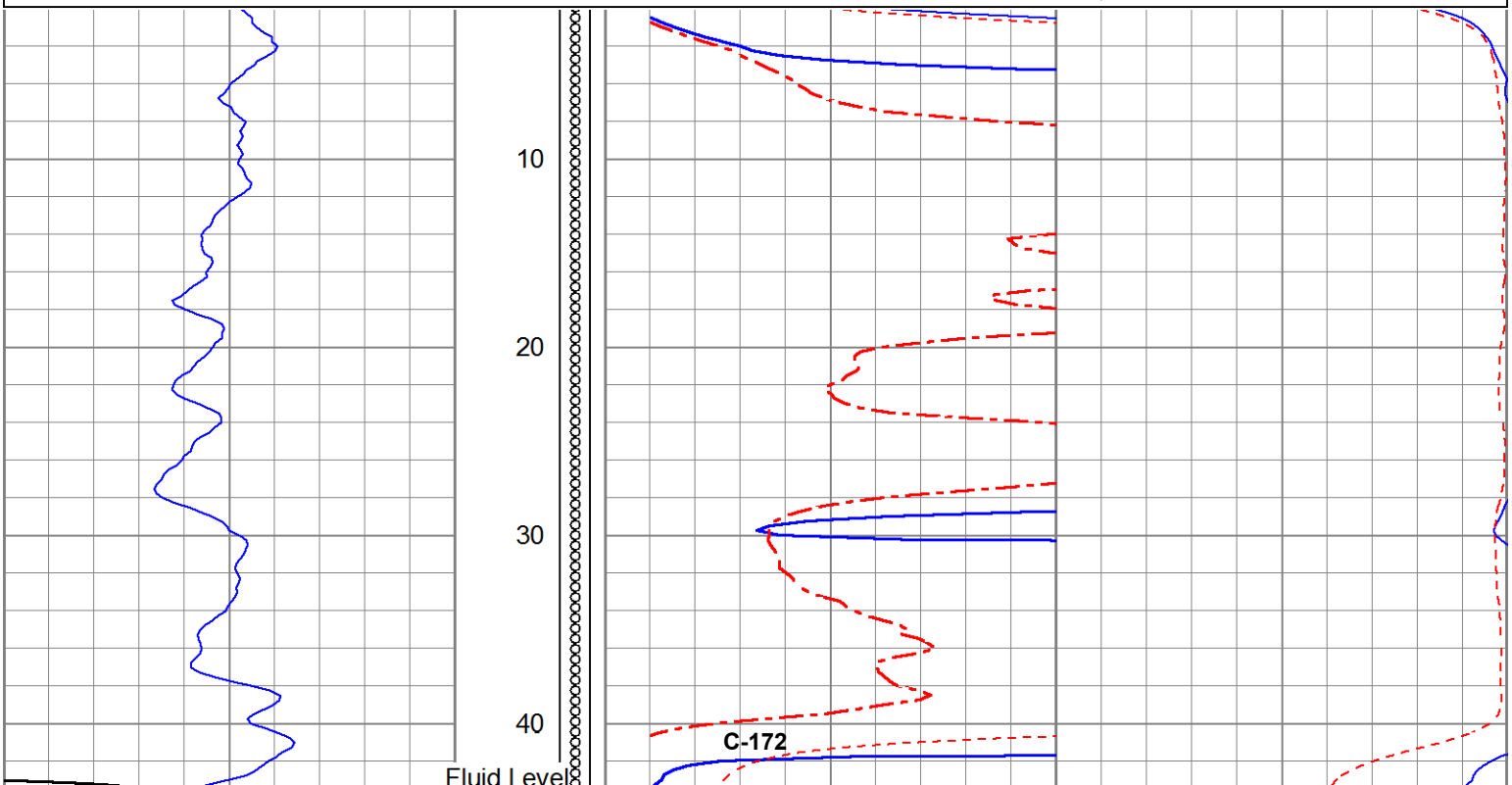
Loop:	Readings Air	Readings Loop		References Air	References Loop		Results m	Results b
Deep	1408.289	3426.231	cps	0.000	612.000	mmho/m	0.303	-427.105
Medium	2130.555	14599.017	cps	0.000	1960.000	mmho/m	0.157	-334.916

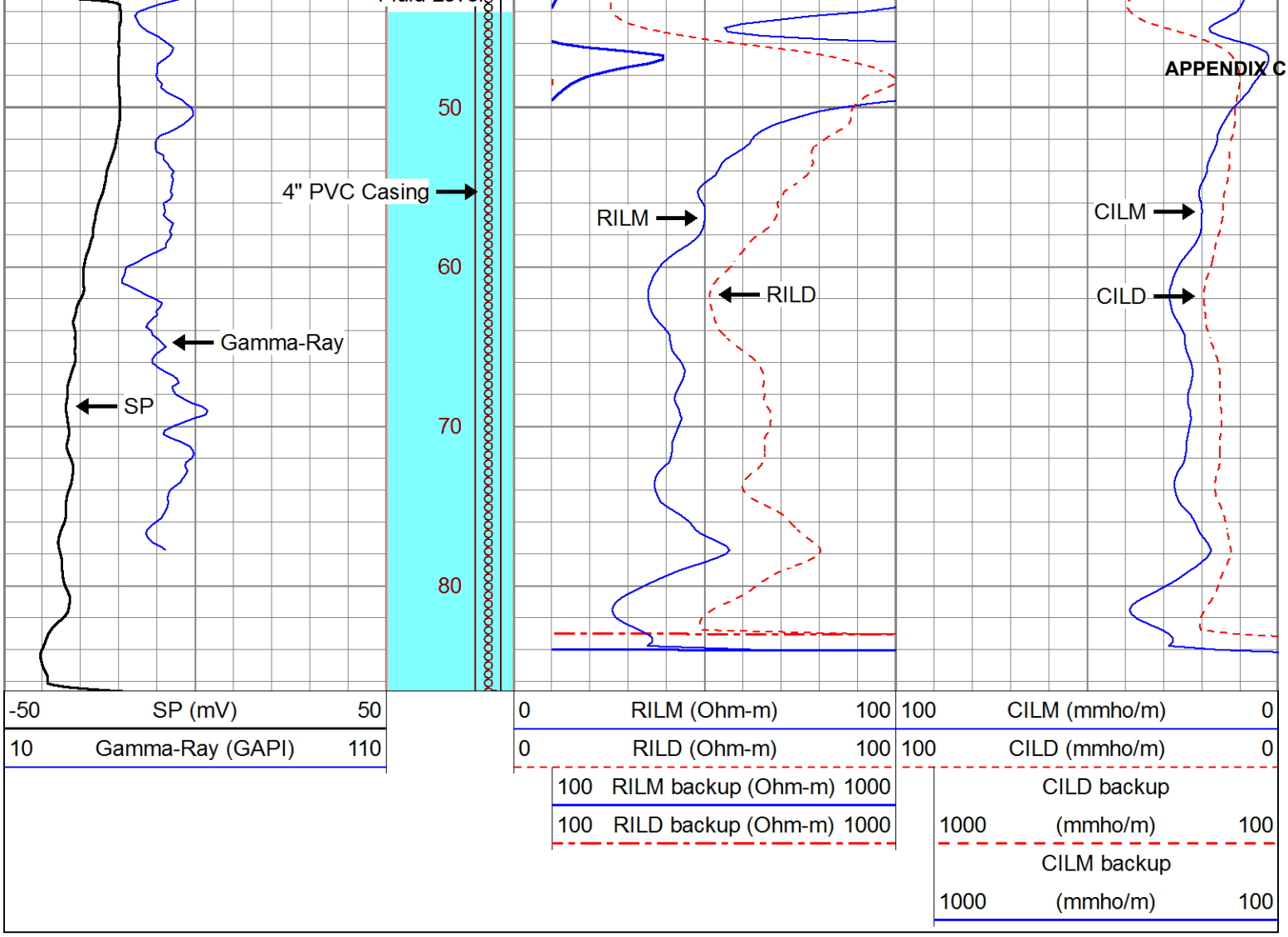
Gamma Ray Calibration Report

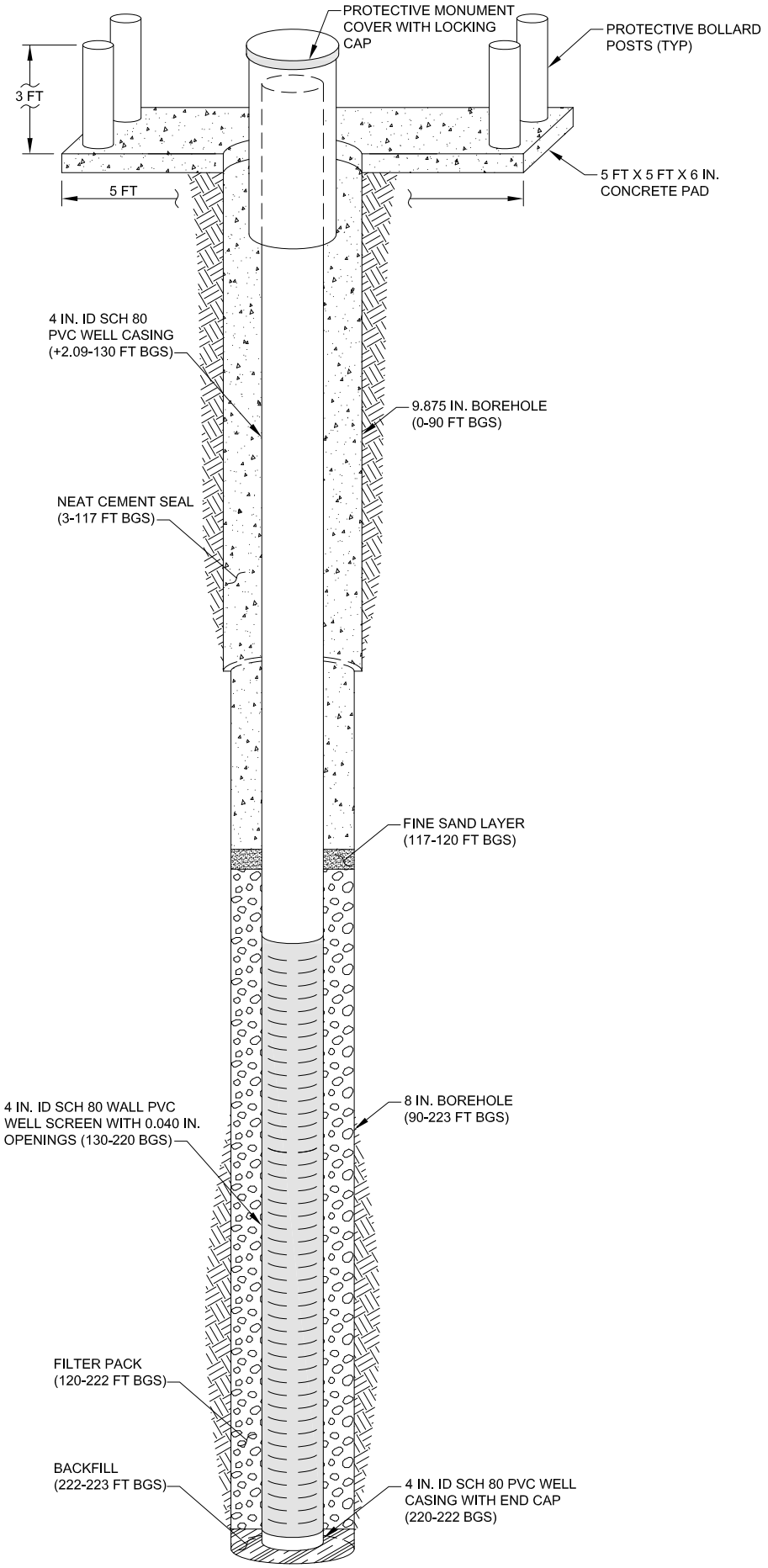
Serial Number:	PS_1	
Tool Model:	01	
Performed:	Sat Jan 10 13:10:57 2015	
Calibrator Value:	162.0	GAPI
Background Reading:	46.1	cps
Calibrator Reading:	180.8	cps
Sensitivity:	1.2020	GAPI/cps

Database File	19868.db
Dataset Pathname	dil2
Presentation Format	dil
Dataset Creation	Mon Jul 13 15:22:33 2015
Charted by	Depth in Feet scaled 1:120

-50 SP (mV) 50	0 RILM (Ohm-m) 100	100 CILM (mmho/m) 0
10 Gamma-Ray (GAPI) 110	0 RILD (Ohm-m) 100	100 CILD (mmho/m) 0
	100 RILM backup (Ohm-m) 1000	CILD backup 1000 (mmho/m) 100
	100 RILD backup (Ohm-m) 1000	CILM backup 1000 (mmho/m) 100




50
60
70
80
4" PVC Casing
Gamma-Ray
SP
RILM
RILD
CILM
CILD
-50 SP (mV) 50
10 Gamma-Ray (GAPI) 110
0 RILM (Ohm-m) 100
0 RILD (Ohm-m) 100
100 RILM backup (Ohm-m) 1000
100 RILD backup (Ohm-m) 1000
100 CILM (mmho/m) 0
100 CILD (mmho/m) 0
CILD backup
1000 (mmho/m) 100
CILM backup
1000 (mmho/m) 100



WELL PROFILE

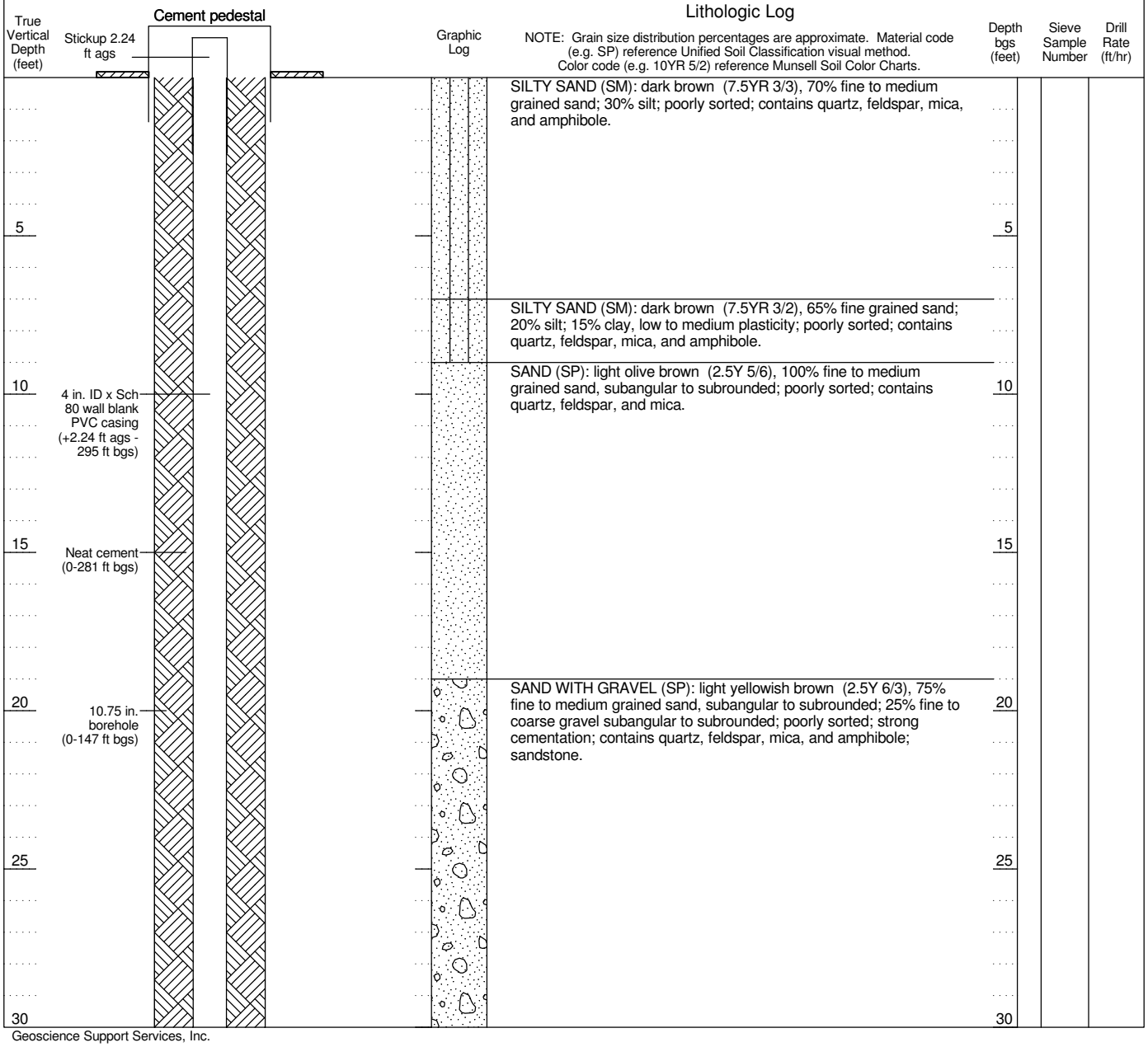
NOT TO SCALE

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BOREHOLE LITHOLOGIC LOG

WELL NUMBER **MPWSP MW-7D**	
CLIENT: Cal Am	LOCATION: **Marina, CA**
PROJECT NUMBER: 14077-15	**Lapis Rd**
REPORT DATE:	
DRILLING CONTRACTOR: Cascade Drilling	LOGGED BY: **A. Khalighi**
DRILLER: D. King	

		SCREEN / BLANK	TOP DEPTH (ft bgs)	BOTTOM DEPTH (ft bgs)	LENGTH (ft)	MATERIAL	WALL THICKNESS (in.)	DIAMETER (in.)	SCREEN TYPE	PERF. SIZE (in.)
DRILLING RIG TYPE	ProSonic 600T									
DRILLING METHOD	Sonic	**Blank**	**-2.24**	**295**	**297.24**	**PVC**	**Sch 80**	**4 / ID**		
SAMPLING METHOD	Core	**Screen**	**295**	**345**	**50**	**PVC**	**Sch 80**	**4 / ID**	**Slotted**	**0.04**
BOREHOLE DIAMETER	10.75, 9.875, 8 in	**Blank**	**345**	**347.77**	**2.77**	**PVC**	**Sch 80**	**4 / ID**		
SURFACE ELEVATION	48.05 ft NAVD88									
TOC ELEVATION	50.24 ft NAVD88 (RP)									
START DATE	6/27/15									
FINISH DATE	7/13/15									



WELL CONSTRUCTION LOG MPWSP MW TM LITH ALL WELLS.GPJ GEOSCIENCE.GDT 7/7/16

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WELL NUMBER **MPWSP MW-7D**

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am
PROJECT NUMBER 14077-15
LOCATION **Marina, CA**

True Vertical Depth (feet)	(continued)	Graphic Log	Lithologic Log NOTE: Grain size distribution percentages are approximate. Material code (e.g. SP) reference Unified Soil Classification visual method. Color code (e.g. 10YR 5/2) reference Munsell Soil Color Charts.	Depth bgs (feet)	Sieve Sample Number	Drill Rate (ft/hr)
			SILTY SAND (SM): brown (10YR 4/3), 85% fine grained sand; 15% silt, no to low plasticity; poorly sorted; contains quartz, feldspar, mica, and amphibole.			
35				35		
			SAND (SP): yellowish brown (10YR 5/4), 100% fine grained sand; poorly sorted; contains quartz, feldspar, mica, and amphibole.			
40				40		
			SAND (SP): pale brown (10YR 6/3), 100% fine to coarse grained sand, subangular to subrounded; poorly sorted; contains quartz, feldspar, mica, and amphibole.			
45				45		
50				50		
			SAND (SP): pale brown (10YR 6/3), 90% medium to coarse grained sand, subangular to subrounded; 10% fine gravel subangular to subrounded; poorly sorted; contains quartz, feldspar, mica, and amphibole.		
			SAND (SP): light brownish gray (10YR 6/2), 100% fine to medium grained sand, subangular to subrounded; poorly sorted; contains quartz, feldspar, mica, and amphibole.			
55			SAND (SP): dark yellowish brown (10YR 3/6), 100% fine to coarse grained sand, subangular to subrounded; poorly sorted; contains quartz, feldspar, mica, and amphibole.	55		
			SAND (SP): dark yellowish brown (10YR 4/4), 100% fine to coarse grained sand, subangular to subrounded; poorly sorted; contains quartz, feldspar, mica, and amphibole.			
60				60		
			SAND (SP): yellowish brown (10YR 5/4), 100% fine grained sand; poorly sorted; contains quartz, feldspar, mica, and amphibole.		1	
65			SAND (SP): strong brown (7.5YR 4/6), 95% fine to coarse grained sand, subangular to rounded; 5% fine gravel subangular to rounded; poorly sorted; contains quartz, feldspar, mica, and amphibole.	65		
70				70		

WELL CONSTRUCTION LOG MPWSP MW TM LITH ALL WELLS.GPJ GEOSCIENCE.GDT 7/7/16

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WELL NUMBER **MPWSP MW-7D**

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am
PROJECT NUMBER 14077-15
LOCATION **Marina, CA**

(continued)

True Vertical Depth (feet)	Lithologic Log	Depth bgs (feet)	Sieve Sample Number	Drill Rate (ft/hr)
	NOTE: Grain size distribution percentages are approximate. Material code (e.g. SP) reference Unified Soil Classification visual method. Color code (e.g. 10YR 5/2) reference Munsell Soil Color Charts.			
	SAND (SP): dark yellowish brown (10YR 4/4), 100% fine to coarse grained sand, subangular to subrounded; poorly sorted; contains quartz, feldspar, mica, and amphibole.			
	SAND WITH SILT (SP-SM): olive brown (2.5Y 4/3), 90% fine grained sand; 10% silt; poorly sorted; contains quartz, feldspar, mica, and amphibole.			
75		75	2	
80		80		
	ELASTIC SILT WITH SAND (MH): olive brown (2.5Y 4/3), 50% silt, medium to high plasticity; 25% fine grained sand; 25% clay; contains quartz, feldspar, mica, and amphibole.			
85	SAND (SP): dark yellowish brown (10YR 4/4), 100% fine to medium grained sand, subangular to subrounded; poorly sorted; contains quartz, feldspar, mica, and amphibole.	85		
	SILT WITH SAND (ML): light olive brown (2.5Y 5/3), 80% silt, low to medium plasticity; 20% fine grained sand; contains quartz, feldspar, mica, and amphibole.			
90		90		
	SAND (SP): dark yellowish brown (10YR 4/6), 100% fine to medium grained sand, subangular to subrounded; poorly sorted; contains quartz, feldspar, and mica.		3	
	CLAY (CL): greenish black (10GY 2.5/1), 100% clay, high plasticity.			
95		95		
	SAND (SP): dark yellowish brown (10YR 4/4), 100% medium grained sand, subangular to subrounded; poorly sorted; contains quartz, feldspar, mica, and amphibole. NO SAMPLE.			
100		100		10
105		105		
	SAND (SP): dark yellowish brown (10YR 4/4), 100% medium grained sand, subangular to subrounded; poorly sorted; contains quartz, feldspar, mica, and amphibole.			
110	FAT CLAY (CH): black (N2.5), 100% clay, high plasticity.	110		

WELL CONSTRUCTION LOG MPWSP MW TM LITH ALL WELLS.GPJ GEOSCIENCE.GDT 7/7/16

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WELL NUMBER **MPWSP MW-7D**

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am
PROJECT NUMBER 14077-15
LOCATION **Marina, CA**

(continued)

Lithologic Log

NOTE: Grain size distribution percentages are approximate. Material code (e.g. SP) reference Unified Soil Classification visual method. Color code (e.g. 10YR 5/2) reference Munsell Soil Color Charts.

True Vertical Depth (feet)	Graphic Log	Lithologic Log	Depth bgs (feet)	Sieve Sample Number	Drill Rate (ft/hr)
115		SAND WITH SILT (SP-SM): yellowish brown (10YR 5/4), 90% fine to medium grained sand, subangular to subrounded; 10% silt; poorly sorted; contains quartz, feldspar, mica, and amphibole.	115		
		SAND (SP): dark yellowish brown (10YR 3/6), 100% fine to coarse grained sand, subangular to subrounded; trace fine gravel subangular to subrounded; poorly sorted; contains quartz, feldspar, mica, and amphibole.			
		SAND (SP): brown (10YR 5/3), 90% fine to coarse grained sand, subangular to rounded; 5% fine to coarse gravel subangular to rounded; poorly sorted; contains quartz, feldspar, mica, and amphibole; 5% cobbles.		4	
120		SILTY SAND (SM): yellowish brown (10YR 5/4), 70% fine grained sand; 30% silt, no to low plasticity; poorly sorted; contains quartz, feldspar, and mica.	120		
		SILTY SAND (SM): brown (10YR 5/3), 85% fine to medium grained sand, subangular to subrounded; 15% silt, no to low plasticity; poorly sorted; contains quartz, feldspar, and mica.			
125			125		
		SAND (SP): brown (10YR 5/3), 100% fine grained sand; poorly sorted; contains quartz, feldspar, mica, and amphibole.			
130			130		
				5	
135			135		
140			140		
		SAND (SP): brown (10YR 4/3), 100% fine grained sand; poorly sorted.			
		SAND (SP): brownish yellow (10YR 6/8), 100% fine to medium grained sand, subangular to subrounded; poorly sorted; contains quartz, feldspar, and mica.			
145			145		
				6	
		FAT CLAY (CH): greenish gray (10GY 6/1), 100% clay, high plasticity.			
150			150		

9.875 in. borehole (147-297 ft bgs)

WELL CONSTRUCTION LOG MPWSP MW TM LITH ALL WELLS.GPJ GEOSCIENCE.GDT 7/7/16

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WELL NUMBER **MPWSP MW-7D**

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am
PROJECT NUMBER 14077-15
LOCATION **Marina, CA**

True Vertical Depth (feet)	(continued)	Graphic Log	Lithologic Log NOTE: Grain size distribution percentages are approximate. Material code (e.g. SP) reference Unified Soil Classification visual method. Color code (e.g. 10YR 5/2) reference Munsell Soil Color Charts.	Depth bgs (feet)	Sieve Sample Number	Drill Rate (ft/hr)
			SILT (ML): greenish gray (10Y 6/1), 90% silt, low plasticity; 10% fine grained sand.			
			CLAY (CL): greenish gray (10GY 6/1), 85% clay, low plasticity; 10% fine grained sand; 5% silt.			
155			SILTY SAND (SM): dark greenish gray (10GY 4/1), 75% fine grained sand; 20% silt; 5% clay; poorly sorted; contains quartz, feldspar, mica, and amphibole.	155		
			SILTY SAND (SM): dark greenish gray (10GY 4/1), 70% fine to coarse grained sand, subangular to subrounded; 20% silt; 5% fine to coarse gravel subangular to subrounded; 5% clay; poorly sorted; contains quartz, feldspar, mica, and amphibole.			
160			SAND (SP): dark greenish gray (10GY 4/1), 90% fine to coarse grained sand, subangular to rounded; 5% fine gravel subangular to rounded; 5% clay; poorly sorted; contains quartz, feldspar, mica, and amphibole.	160		
			CLAYEY SAND (SC): light yellowish brown (2.5Y 6/3), 75% fine to coarse grained sand, subangular to subrounded; 20% clay, high plasticity; 5% silt; poorly sorted; contains quartz, feldspar, mica, and amphibole.			
165			CLAYEY SAND WITH GRAVEL (SC): grayish brown (2.5Y 5/2), 65% fine to coarse grained sand, subangular to subrounded; 20% clay, low plasticity; 15% fine to coarse gravel subangular to subrounded; poorly sorted; contains quartz, feldspar, mica, and amphibole.	165		
			SAND (SP): dark yellowish brown (10YR 3/4), 100% fine grained sand; poorly sorted; contains quartz, feldspar, mica, and amphibole.			
170				170	7	
			SANDY CLAY (CL): greenish gray (10GY 6/1), 60% clay, high plasticity; 40% fine to coarse grained sand, subangular to subrounded; contains quartz, feldspar, mica, and amphibole.			
175			SAND (SP): dark yellowish brown (10YR 4/6), 100% fine to coarse grained sand, subangular to subrounded; poorly sorted; contains quartz, feldspar, mica, and amphibole.	175		11
180				180	8	
			SAND (SP): light yellowish brown (2.5Y 6/4) and strong brown (7.5YR 4/6), 100% medium grained sand, subangular to subrounded; poorly sorted; contains quartz, feldspar, mica, and amphibole.			
185				185		
			GRAVEL WITH SAND (GP): dark brown (7.5YR 3/2), 60% fine to coarse gravel subangular to rounded; 40% fine to coarse grained sand, subangular to rounded; trace cobbles; poorly sorted; contains quartz, feldspar, mica, and amphibole; trace cobbles.			
190				190		

WELL CONSTRUCTION LOG MPWSP MW TM LITH ALL WELLS.GPJ GEOSCIENCE.GDT 7/7/16

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Claremont, CA 91711
Telephone: (909) 451-6650
Fax: (909) 451-6638
www.gssiwater.com

WELL NUMBER
MPWSP MW-7D

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am
PROJECT NUMBER 14077-15
LOCATION **Marina, CA**

True Vertical Depth (feet)	(continued)	Graphic Log	Lithologic Log NOTE: Grain size distribution percentages are approximate. Material code (e.g. SP) reference Unified Soil Classification visual method. Color code (e.g. 10YR 5/2) reference Munsell Soil Color Charts.	Depth bgs (feet)	Sieve Sample Number	Drill Rate (ft/hr)
			SAND WITH GRAVEL (SP): brown (10YR 5/3), 75% fine to coarse grained sand, subangular to rounded; 20% fine to coarse gravel subangular to rounded; 5% cobbles; poorly sorted; contains quartz, feldspar, mica, and amphibole; 5% cobbles.		9	
195			SAND (SP): dark brown (10YR 3/3), 100% fine grained sand; trace cobbles; trace fine to coarse gravel; trace silt; poorly sorted; contains quartz, feldspar, mica, and amphibole; sandstone.	195		
200				200	10	
205				205		
210				210		11
215				215		
220				220	11	
225			FAT CLAY (CH): dark greenish gray (10Y 4/1), 100% clay, high plasticity.	225		
			CLAYEY SAND (SC): brown (10YR 4/3), 70% fine grained sand; 20% clay, low plasticity; 10% silt; poorly sorted; contains quartz, feldspar, mica, and amphibole.			
230				230		

WELL CONSTRUCTION LOG MPWSP MW TM LITH ALL WELLS.GPJ GEOSCIENCE.GDT 7/7/16

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WELL NUMBER **MPWSP MW-7D**

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am
PROJECT NUMBER 14077-15
LOCATION **Marina, CA**

True Vertical Depth (feet)	(continued)	Graphic Log	Lithologic Log NOTE: Grain size distribution percentages are approximate. Material code (e.g. SP) reference Unified Soil Classification visual method. Color code (e.g. 10YR 5/2) reference Munsell Soil Color Charts.	Depth bgs (feet)	Sieve Sample Number	Drill Rate (ft/hr)
235			SAND WITH CLAY (SP-SC): olive brown (2.5Y 4/4), 90% fine grained sand; 5% silt; 5% clay; poorly sorted; contains quartz, feldspar, mica, and amphibole.	235		
			SAND WITH SILT (SP-SM): olive brown (2.5Y 4/4), 80% fine to coarse grained sand, subangular to rounded; 10% silt; 5% fine to coarse gravel subangular to rounded; 5% cobbles; poorly sorted; contains quartz, feldspar, mica, and amphibole.			
			SANDY CLAY WITH GRAVEL (CL): olive brown (2.5Y 4/4), 50% clay, high plasticity; 20% fine to coarse gravel subangular to rounded; 20% fine to coarse grained sand, subangular to rounded; 5% silt; 5% cobbles; contains quartz, feldspar, mica, and amphibole.			
240			SAND (SP): olive brown (2.5Y 4/4), 95% fine to medium grained sand, subangular to subrounded; 5% fine gravel subangular to subrounded; poorly sorted; contains quartz, feldspar, mica, and amphibole.	240		
			CLAYEY GRAVEL WITH SAND (GC): olive brown (2.5Y 4/4), 50% fine to coarse gravel subangular to rounded; 25% fine to coarse grained sand, subangular to rounded; 10% silt; 10% clay; 5% cobbles; poorly sorted; contains quartz, feldspar, mica, and amphibole.			
245			SAND WITH CLAY (SP-SC): olive brown (2.5Y 4/4), 90% fine to coarse grained sand, subangular to subrounded; 5% silt; 5% clay; poorly sorted; contains quartz, feldspar, and amphibole.	245		
			CLAY WITH SAND (CL): olive gray (5Y 4/2), 75% clay, low to medium plasticity; 15% fine to coarse grained sand, subangular to rounded; 5% fine to coarse gravel subangular to rounded; 5% cobbles; contains quartz, feldspar, mica, and amphibole.			11
250			CLAYEY SAND (SC): brown (7.5YR 4/4), 80% fine to coarse grained sand, subangular to subrounded; 10% silt; 10% clay, low plasticity; poorly sorted; contains quartz, feldspar, mica, and amphibole.	250		
255				255		
			CLAYEY SAND (SC): grayish brown (2.5Y 5/2), 65% fine to medium grained sand, subangular to subrounded; 20% clay, medium to high plasticity; 15% silt; poorly sorted; contains quartz, feldspar, mica, and amphibole.			
260			SAND (SP): grayish brown (2.5Y 5/2), 100% fine to medium grained sand, subangular to subrounded; poorly sorted; contains quartz, feldspar, mica, and amphibole.	260	12	
265			FAT CLAY (CH): light yellowish brown (2.5Y 6/3), 70% clay, medium to high plasticity; 30% silt.	265		
			SAND (SP): dark grayish brown (2.5Y 4/2), 95% fine grained sand; 5% silt; trace fine gravel; trace clay; poorly sorted; contains quartz, feldspar, mica, and amphibole.			8
270				270		

WELL CONSTRUCTION LOG MPWSP MW TM LITH ALL WELLS.GPJ GEOSCIENCE.GDT 7/7/16

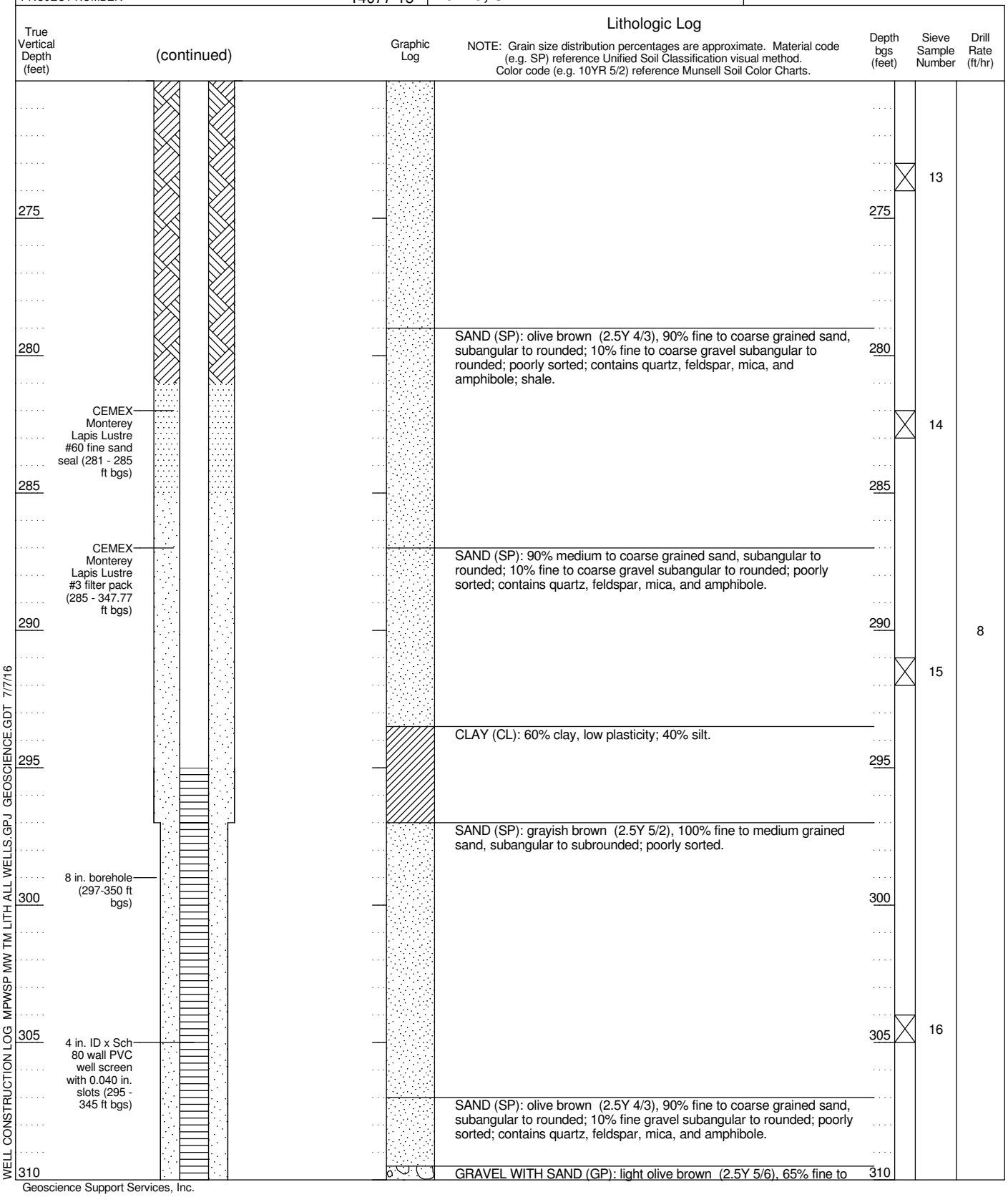
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WELL NUMBER **MPWSP MW-7D**

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am
PROJECT NUMBER 14077-15
LOCATION **Marina, CA**



WELL CONSTRUCTION LOG MPWSP MW TM LITH ALL WELLS.GPJ GEOSCIENCE.GDT 7/7/16

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WELL NUMBER **MPWSP MW-7D**

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am
PROJECT NUMBER 14077-15
LOCATION **Marina, CA**

True Vertical Depth (feet)	(continued)	Graphic Log	Lithologic Log NOTE: Grain size distribution percentages are approximate. Material code (e.g. SP) reference Unified Soil Classification visual method. Color code (e.g. 10YR 5/2) reference Munsell Soil Color Charts.	Depth bgs (feet)	Sieve Sample Number	Drill Rate (ft/hr)
			coarse gravel subangular to subrounded; 20% fine to coarse grained sand, subangular to subrounded; 5% cobbles; poorly sorted; contains quartz, feldspar, mica, and amphibole.			
			SAND WITH CLAY AND GRAVEL (SP-SC): light olive brown (2.5Y 5/3), 65% fine to coarse grained sand, subangular to subrounded; 20% fine to coarse gravel subangular to subrounded; 5% silt; 5% clay; 5% cobbles; poorly sorted; contains quartz, feldspar, mica, and amphibole.			
315				315		
			SAND WITH GRAVEL (SP): grayish brown (2.5Y 5/2), 75% coarse grained sand, subangular to subrounded; 15% fine to coarse gravel subangular to subrounded; 5% silt; 5% cobbles; poorly sorted; contains quartz, feldspar, mica, and amphibole.			
			FAT CLAY WITH GRAVEL (CH): olive gray (5Y 5/2), 55% clay, medium to high plasticity; 15% fine to coarse gravel subangular to subrounded; 10% fine to coarse grained sand, subangular to subrounded; 5% silt; 15% cobbles; contains quartz, feldspar, mica, and amphibole.			
320				320		
			FAT CLAY (CH): olive gray (5Y 5/2), 100% clay, high plasticity.			
325			SAND (SP): olive gray (5Y 4/2), 100% fine to medium grained sand, subangular to subrounded; poorly sorted; contains quartz, feldspar, mica, and amphibole.	325	17	
330				330		8
			GRAVEL WITH SAND (GP): olive brown (2.5Y 4/3), 50% fine to coarse gravel subangular to subrounded; 35% fine to coarse grained sand, subangular to subrounded; 5% silt; 10% cobbles; poorly sorted; contains quartz, feldspar, mica, and amphibole; shale.			
335				335		
			SAND WITH GRAVEL (SP): olive brown (2.5Y 4/3), 50% fine to coarse grained sand, subangular to subrounded; 35% fine to coarse gravel subangular to subrounded; 5% silt; 10% cobbles; poorly sorted; contains quartz, feldspar, mica, and amphibole.			
340				340	18	
			GRAVELLY FAT CLAY (CH): olive brown (2.5Y 4/3), 50% clay, high plasticity; 35% fine to coarse gravel subrounded to rounded; 10% fine to coarse grained sand, subrounded to rounded; 5% cobbles; contains quartz, feldspar, mica, and amphibole.			
345			SAND WITH SILT (SP-SM): olive brown (2.5Y 4/3), 80% fine to coarse grained sand; 10% fine gravel; 10% silt; poorly sorted; contains quartz, feldspar, mica, and amphibole.	345		
	Blank casing with end cap (345 - 347.77 ft bgs)		SAND WITH GRAVEL (SP): light olive brown (2.5Y 5/3), 50% fine to coarse grained sand, subangular to subrounded; 35% fine to coarse gravel subangular to subrounded; 5% silt; 10% cobbles; poorly sorted; contains quartz, feldspar, mica, and amphibole.			
	Backfill with native material (347.77-350 ft bgs)		GRAVELLY FAT CLAY (CH): light yellowish brown (2.5Y 6/3), 50% clay, high plasticity; 35% fine to coarse gravel subrounded to rounded; 10% fine to coarse grained sand, subrounded to rounded; 5% cobbles; contains quartz, feldspar, mica, and amphibole.			
350	TD 350 ft bgs			350	19	

WELL CONSTRUCTION LOG MPWSP MW TM LITH ALL WELLS.GPJ GEOSCIENCE.GDT 7/7/16

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WELL NUMBER **MPWSP MW-7D**

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am
PROJECT NUMBER 14077-15
LOCATION **Marina, CA**

True Vertical Depth (feet)	(continued)	Graphic Log	Lithologic Log NOTE: Grain size distribution percentages are approximate. Material code (e.g. SP) reference Unified Soil Classification visual method. Color code (e.g. 10YR 5/2) reference Munsell Soil Color Charts.	Depth bgs (feet)	Sieve Sample Number	Drill Rate (ft/hr)
			SAND WITH GRAVEL (SP): olive brown (2.5Y 4/3), 50% fine to coarse grained sand, subangular to subrounded; 35% fine to coarse gravel subangular to subrounded; 5% silt; 10% cobbles; poorly sorted; contains quartz, feldspar, mica, and amphibole.			
			Bottom of borehole at 350 feet.			

WELL CONSTRUCTION LOG MPWSP MW TM LITH ALL WELLS.GPJ GEOSCIENCE.GDT 7/7/16

PACIFIC SURVEYS

TEMPERATURE
DELTA TEMPERATURE
FLUID RESISTIVITY
DELTA FLUID RESISTIVITY

Job No. 19744

File No.

Company CASCADE DRILLING

Well MW-7D

Field MARINA

County MONTEREY State CA

Location

LAPIS RD. NEAR SOUTHERN INT. WITH DEL MONTE BLVD.
GPS: N 36o 42' 23" W 121o 47' 20"

Other Services:

DUAL INDUCTION
GAMMA-RAY

		Elevation	Elevation
Permanent Datum	G.L.		
Log Measured From	G.L.	0' above perm. datum	K.B.:
Drilling Measured From	G.L.		D.F.:
			G.L.:

Date	07-07-2015										
Run Number	ONE										
Depth Driller	351'										
Depth Logger	350'										
Bottom Logged Interval	350'										
Top Log Interval	40'										
Open Hole Size	10.75" (0'-97')						9.875" (97'-257')		8" (257'-351')		
Type Fluid	WATER										
Density / Viscosity	N/A										
Fluid Level	45'										
Bentonite Seal	N/A										
Time Well Ready	1230										
Time Logger on Bottom	1245										
Equipment Number	PS-8										
Location	LA										
Recorded By	SCHUMACHER										
Witnessed By	J. SOBOLEW										

Borehole Record				Tubing Record			
Run Number	Bit	From	To	Size	Weight	From	To
ONE	10.75"	0'	97'				
TWO	9.875"	97'	257'				
THREE	8"	257'	351'				

	Size	Wgt/Ft	Top	Bottom
Casing Record				
Surface String				
Prot. String				
Production String	4" PVC	SCH 80	0'	351'
Liner				

<<< Fold Here >>>

All interpretations are opinions based on inferences from electrical or other measurements and Pacific Surveys cannot and do not guarantee the accuracy or correctness of any interpretation, and we shall not, except in the case of gross or willful negligence on our part, be liable or responsible for any loss, costs, damages, or expenses incurred or sustained by anyone resulting from any interpretation made by any of our officers, agents or employees. These interpretations are also subject to Pacific Surveys' general terms and conditions set out in our current Price Schedule.

Comments

Calibration Report

Database File	19744.db
Dataset Pathname	tmp
Dataset Creation	Tue Jul 07 12:51:37 2015

Temperature Calibration Report

Serial Number:	3553	
Tool Model:	MLS	
Performed:	Mon Feb 23 16:47:18 2015	
	Reference	Reading
Low Reference:	43.34 degF	1441.00cps
High Reference:	149.00 degF	4545.00cps
Gain:	0.03	
Offset:	-9.71	
Delta Spacing	2	

FRT Calibration Report

Serial Number:	3553
Tool Model:	MLS
Performed:	Mon Feb 23 16:47:15 2015

Resistivity Calibration:

System Reading	Calibration Reference
32145.000 cps	1.800 Ohm-m
11466.000 cps	86.960 Ohm-m

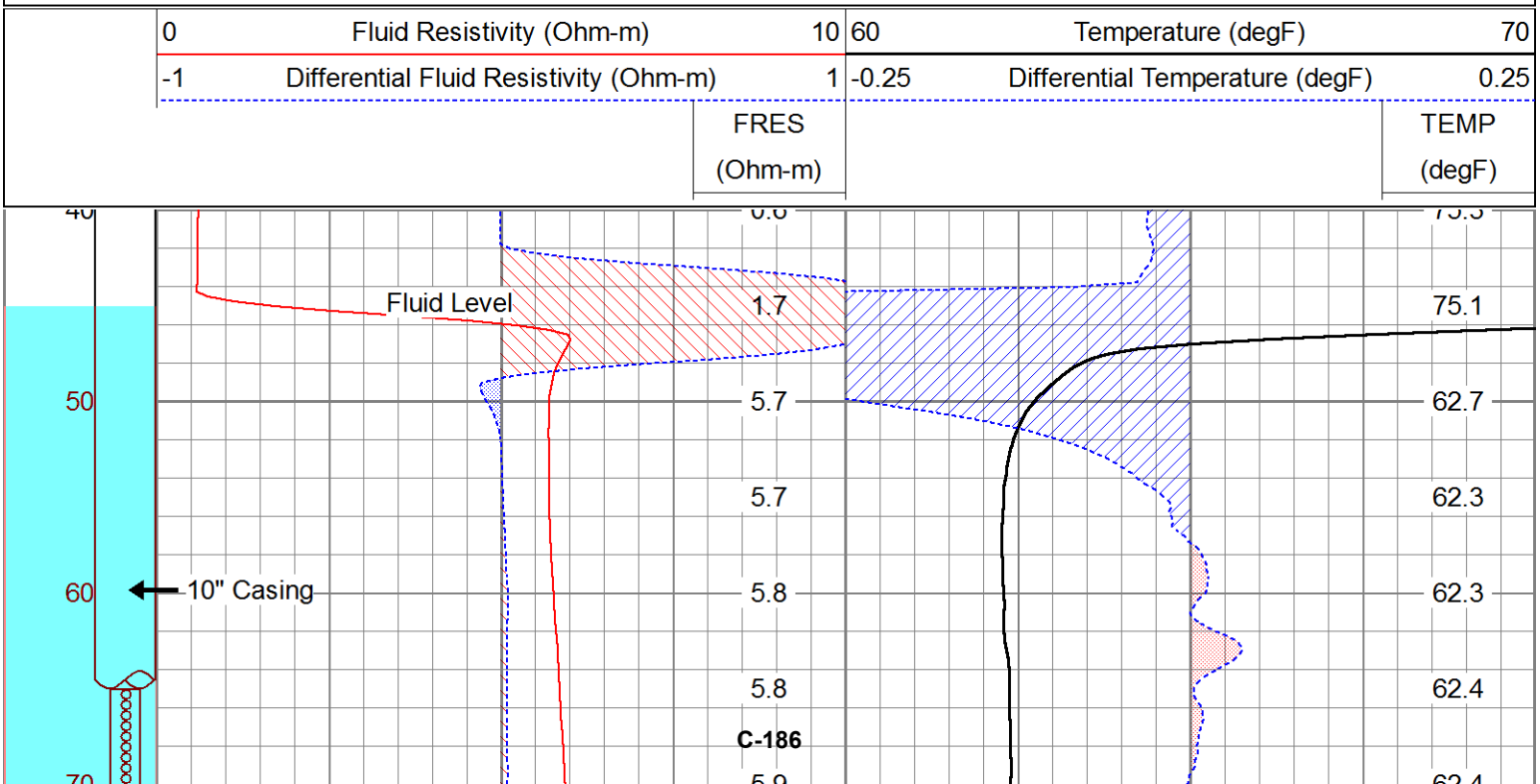
Gain: -0.004
Offset: 135.338

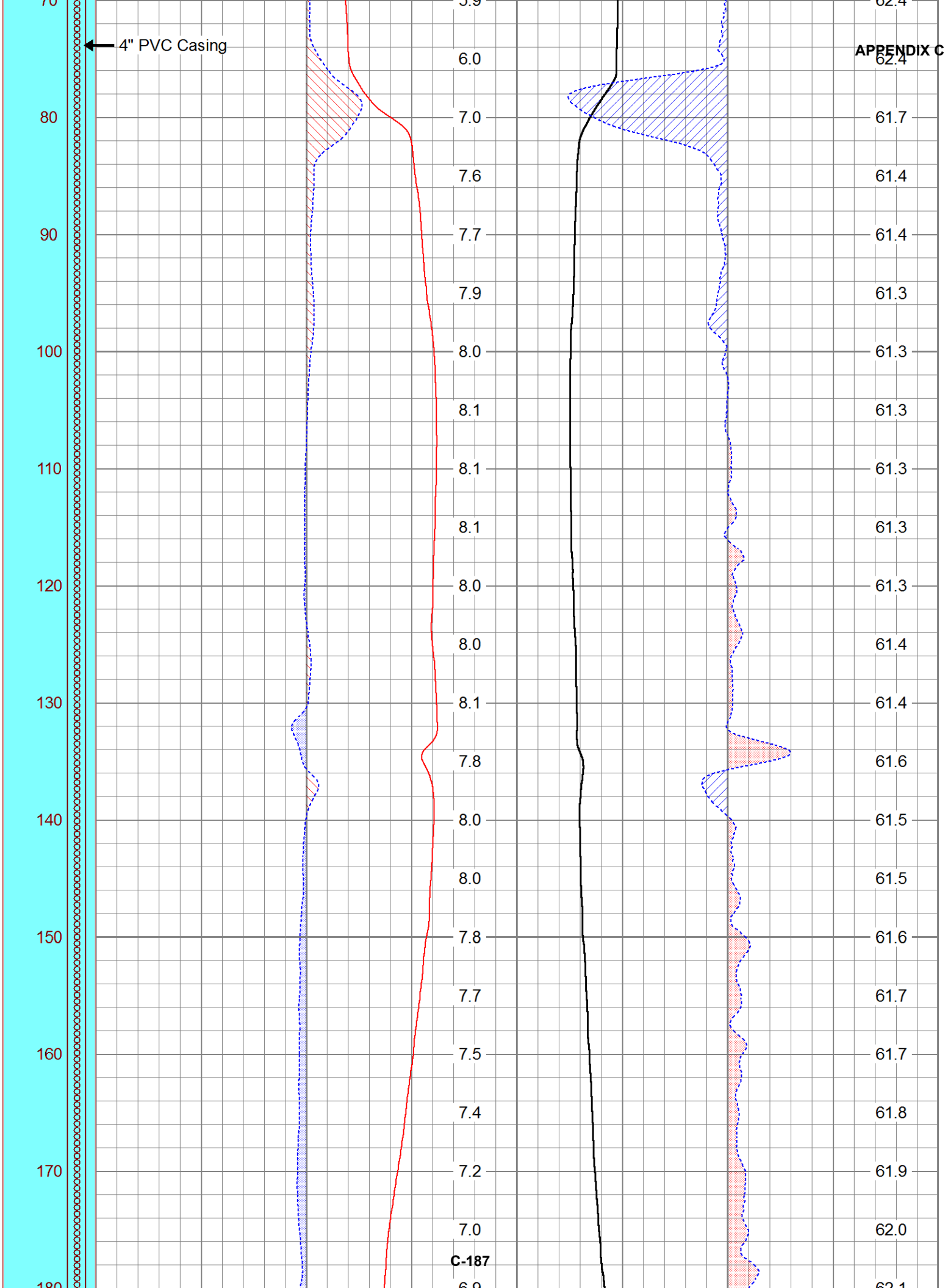
Conductivity Calibration:

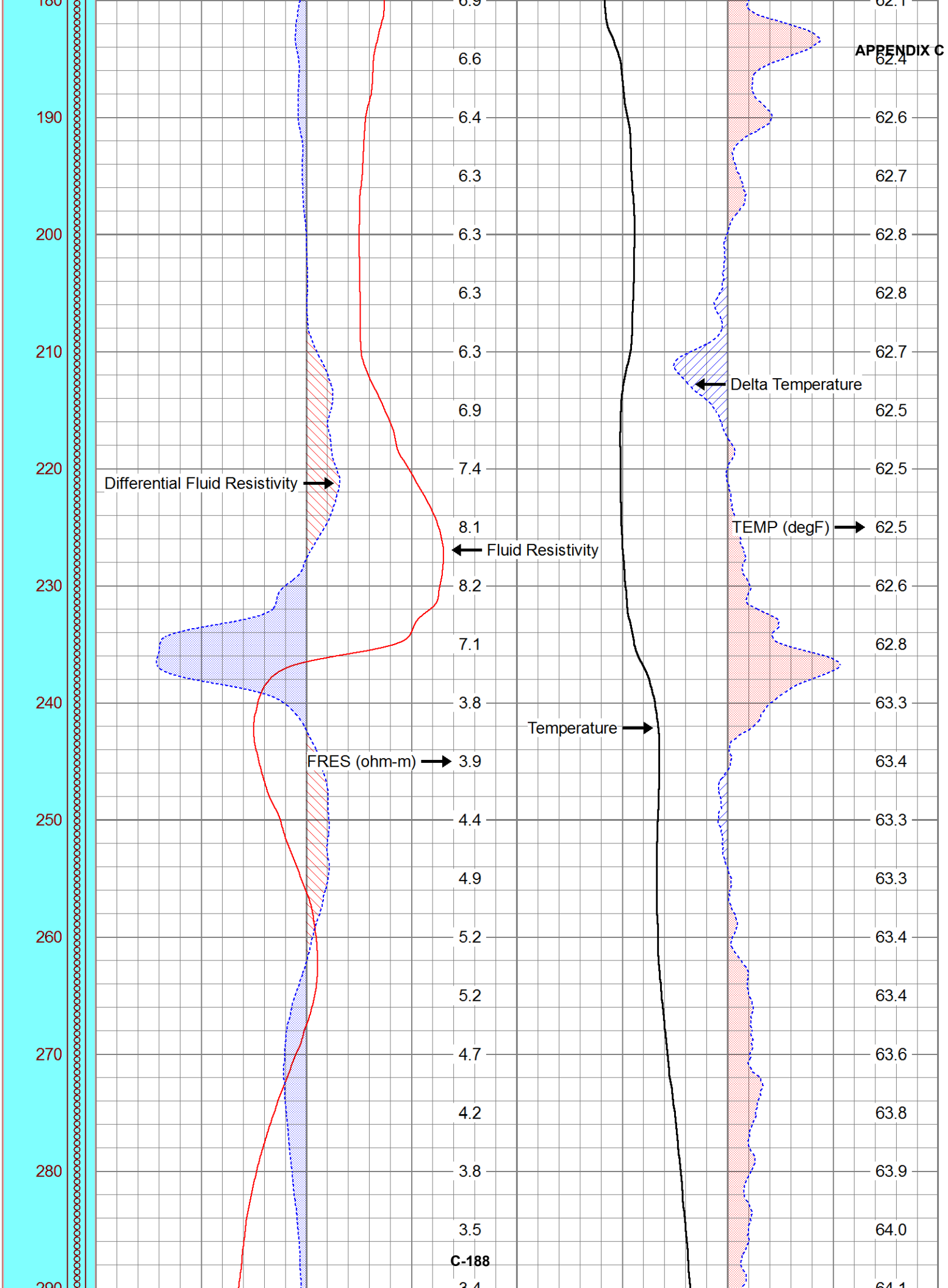
System Reading	Calibration Reference
0.000 cps	0.000
1.000 cps	1.000

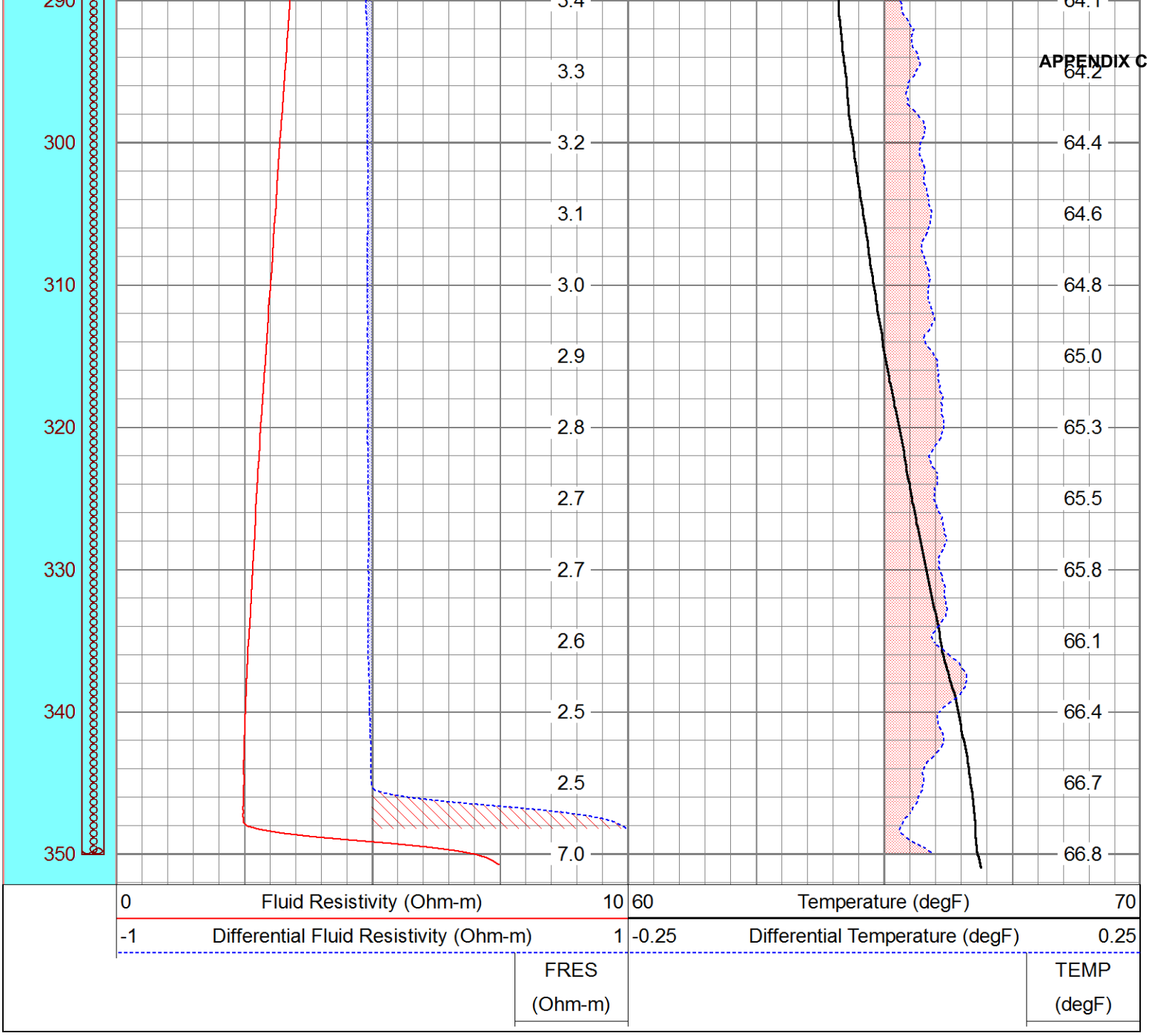
Gain: 1.000
Offset: 0.000

Database File	19744.db
Dataset Pathname	tmp
Presentation Format	frttemp2
Dataset Creation	Tue Jul 07 12:51:37 2015
Charted by	Depth in Feet scaled 1:120




4" PVC Casing
APPENDIX C
70
80
90
100
110
120
130
140
150
160
170
180
6.0
7.0
7.6
7.7
7.9
8.0
8.1
8.1
8.1
8.0
8.0
8.1
7.8
8.0
8.0
7.8
7.7
7.5
7.4
7.2
7.0
62.4
62.4
61.7
61.4
61.4
61.3
61.3
61.3
61.3
61.3
61.4
61.4
61.6
61.5
61.5
61.6
61.7
61.7
61.8
61.9
62.0
C-187


Differential Fluid Resistivity
Fluid Resistivity
FRES (ohm-m)
Temperature
Delta Temperature
TEMP (degF)


290
300
310
320
330
340
350
3.4
3.3
3.2
3.1
3.0
2.9
2.8
2.7
2.7
2.6
2.5
2.5
7.0
64.1
64.2
64.4
64.6
64.8
65.0
65.3
65.5
65.8
66.1
66.4
66.7
66.8
0
Fluid Resistivity (Ohm-m)
10
-1
Differential Fluid Resistivity (Ohm-m)
1
FRES
(Ohm-m)
60
Temperature (degF)
70
-0.25
Differential Temperature (degF)
0.25
TEMP
(degF)

PACIFIC SURVEYS

DUAL INDUCTION GAMMA-RAY

Job No. 19744

File No.

Company CASCADE DRILLING

Well MW-7D

Field MARINA

County MONTEREY State CA

Location

LAPIS RD. NEAR SOUTHERN INT. WITH DEL MONTE BLVD.
GPS: N 36o 42' 23" W 121o 47' 20"

Other Services:

TEMPERATURE
FLUID RESISTIVITY

Permanent Datum	G.L.	Elevation 0'	above perm. datum	Elevation K.B.:	
Log Measured From	G.L.			D.F.:	
Drilling Measured From	G.L.			G.L.	

Date	07-07-2015								
Run Number	ONE								
Depth Driller	351'								
Depth Logger	350'								
Bottom Logged Interval	350'								
Top Log Interval	40'								
Open Hole Size	10.75" (0'-97')			9.875" (97'-257')			8" (257'-351')		
Type Fluid	WATER								
Density / Viscosity	N/A								
Fluid Level	45'								
Bentonite Seal	N/A								
Time Well Ready	1230								
Time Logger on Bottom	1245								
Equipment Number	PS-8								
Location	LA								
Recorded By	SCHUMACHER								
Witnessed By	J. SOBOLEW								

Borehole Record				Tubing Record			
Run Number	Bit	From	To	Size	Weight	From	To
ONE	10.75"	0'	97'				
TWO	9.875"	97'	257'				
THREE	8"	257'	351'				

Casing Record	Size	Wgt/Ft	Top	Bottom
Surface String				
Prot. String				
Production String	4" PVC	SCH 80	0'	351'
Liner				

<<< Fold Here >>>

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Comments

Calibration Report

Database File	19744.db
Dataset Pathname	dil
Dataset Creation	Tue Jul 07 13:52:31 2015

Serial-Model: 0001-ALT
Surface Cal Performed:

APPENDIX C

Loop:	Readings Air	Readings Loop		References Air	References Loop		Results m	Results b
Deep	1432.080	3651.560	cps	0.000	612.000	mmho/m	0.276	-394.883
Medium	2032.000	14281.200	cps	0.000	1960.000	mmho/m	0.160	-325.140

Gamma Ray Calibration Report

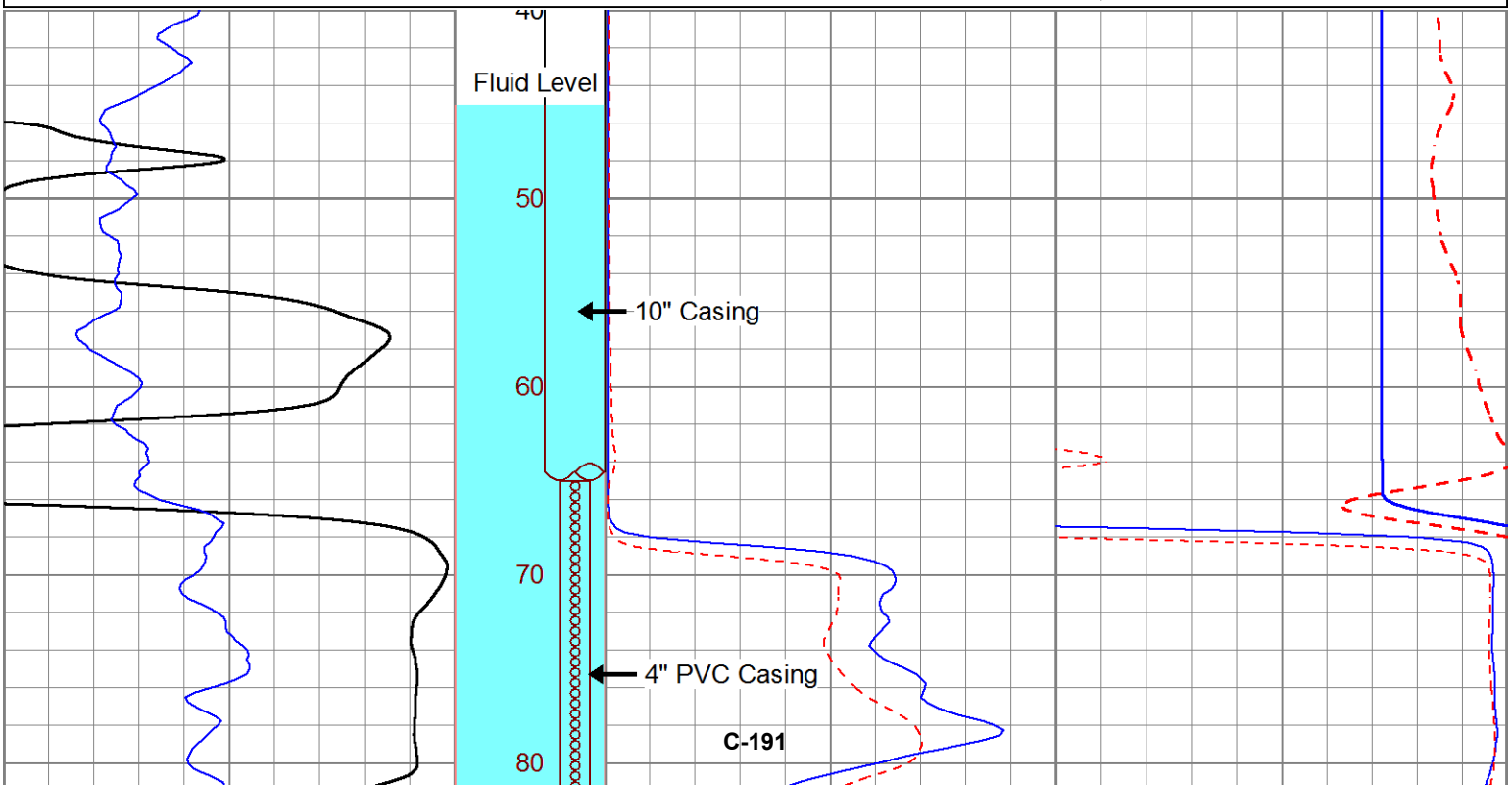
Serial Number:	PS_1	
Tool Model:	01	
Performed:	Sat Jan 10 13:10:57 2015	
Calibrator Value:	162.0	GAPI
Background Reading:	46.1	cps
Calibrator Reading:	180.8	cps
Sensitivity:	1.2020	GAPI/cps

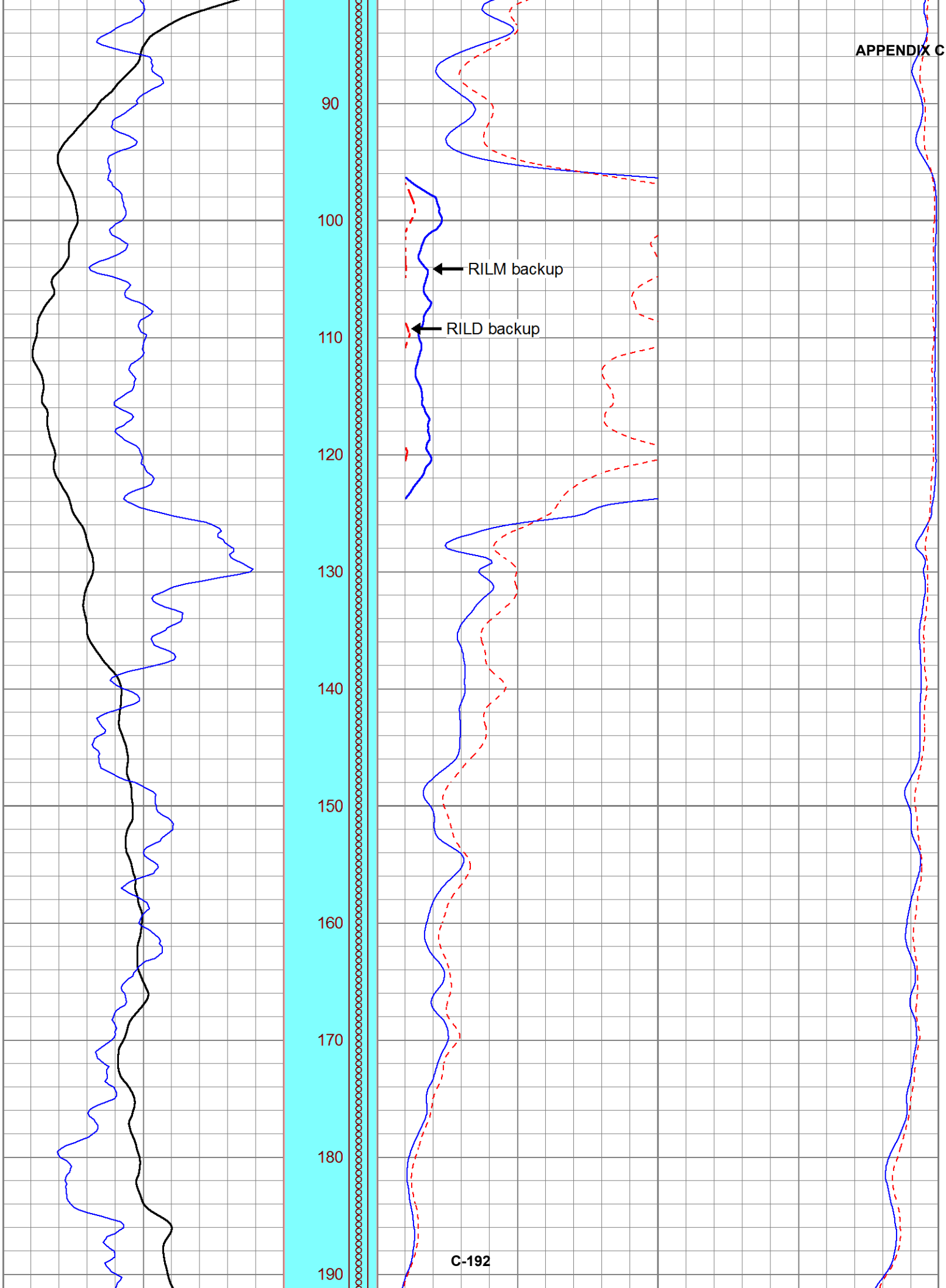
Database File	19744.db
Dataset Pathname	dil
Presentation Format	dil
Dataset Creation	Tue Jul 07 13:52:31 2015
Charted by	Depth in Feet scaled 1:120

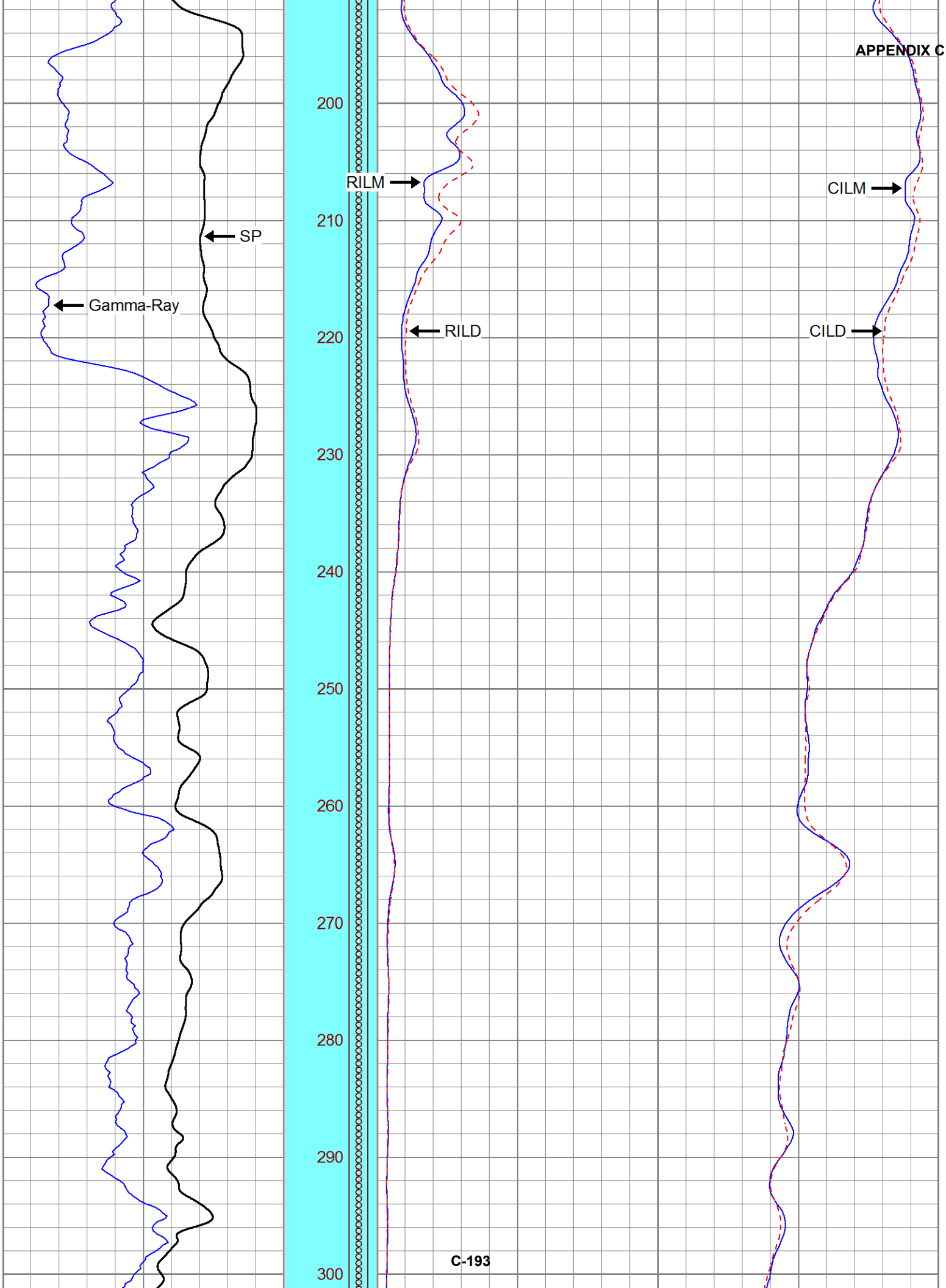
-10	SP (mV)	90
10	Gamma-Ray (GAPI)	110

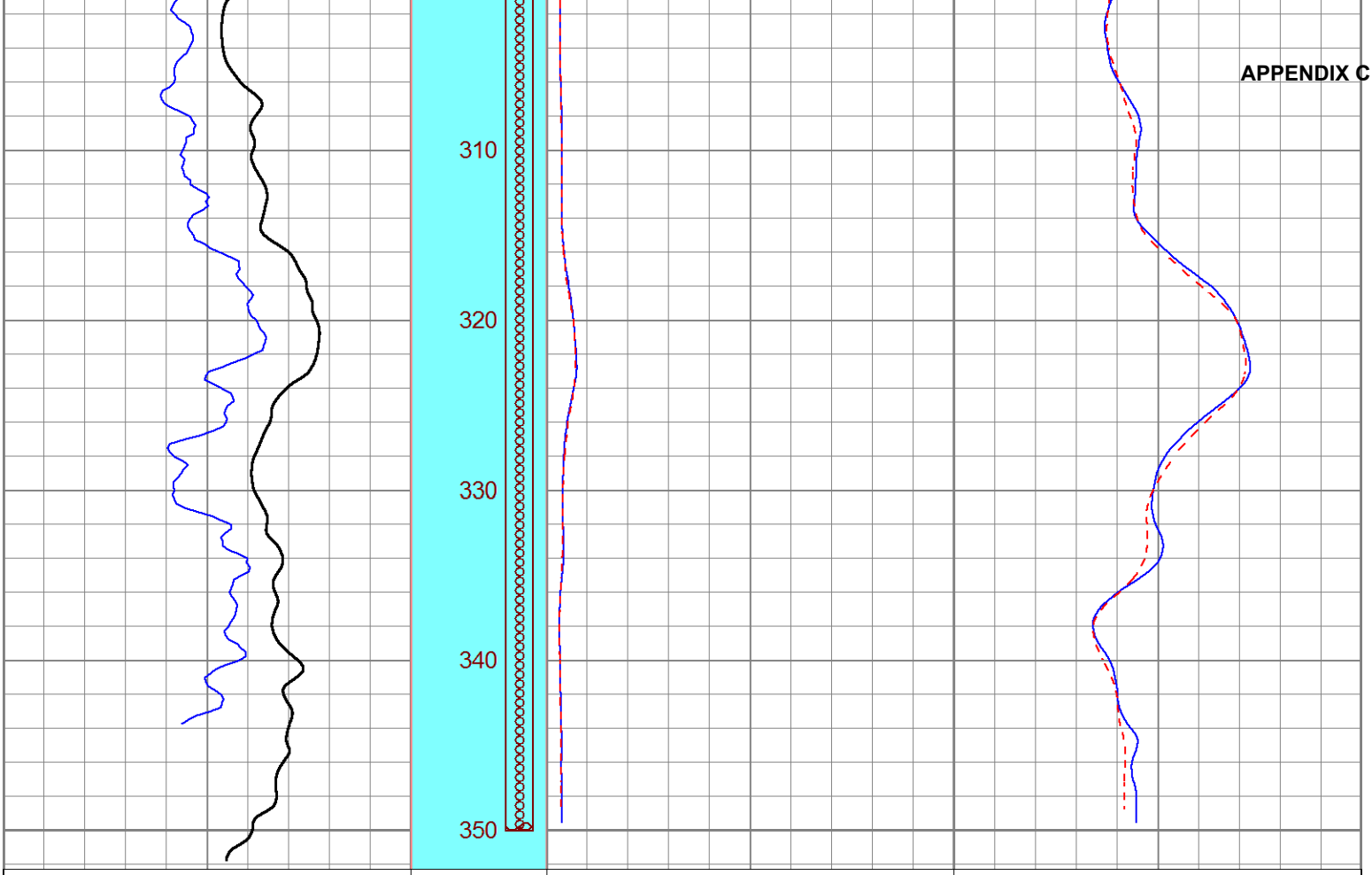
0	RILM (Ohm-m)	50
0	RILD (Ohm-m)	50
50	RILM backup (Ohm-m)	500
50	RILD backup (Ohm-m)	500

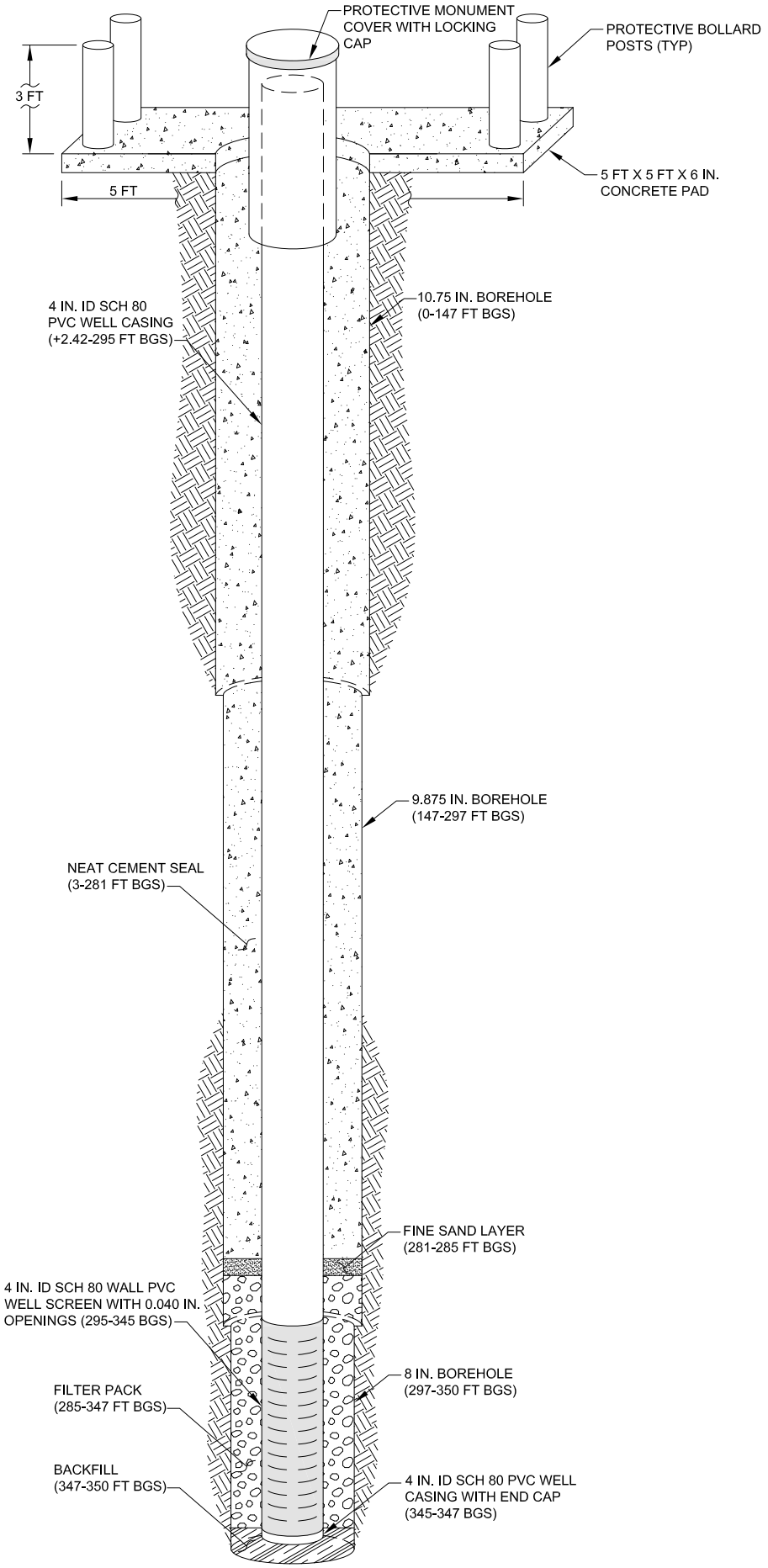
1000	CILM (mmho/m)	0
1000	CILD (mmho/m)	0
	CILD backup	
10000	(mmho/m)	1000
	CILM backup	
10000	(mmho/m)	1000




90
100
110
120
130
140
150
160
170
180
190
RILM backup
RILD backup


200
210
220
230
240
250
260
270
280
290
300
SP
Gamma-Ray
RILM
RILD
CILM
CILD


310
320
330
340
350
-10 SP (mV) 90
10 Gamma-Ray (GAPI) 110
0 RILM (Ohm-m) 50
0 RILD (Ohm-m) 50
50 RILM backup (Ohm-m) 500
50 RILD backup (Ohm-m) 500
1000 CILM (mmho/m) 0
1000 CILD (mmho/m) 0
CILD backup
10000 (mmho/m) 1000
CILM backup
10000 (mmho/m) 1000



WELL PROFILE

NOT TO SCALE

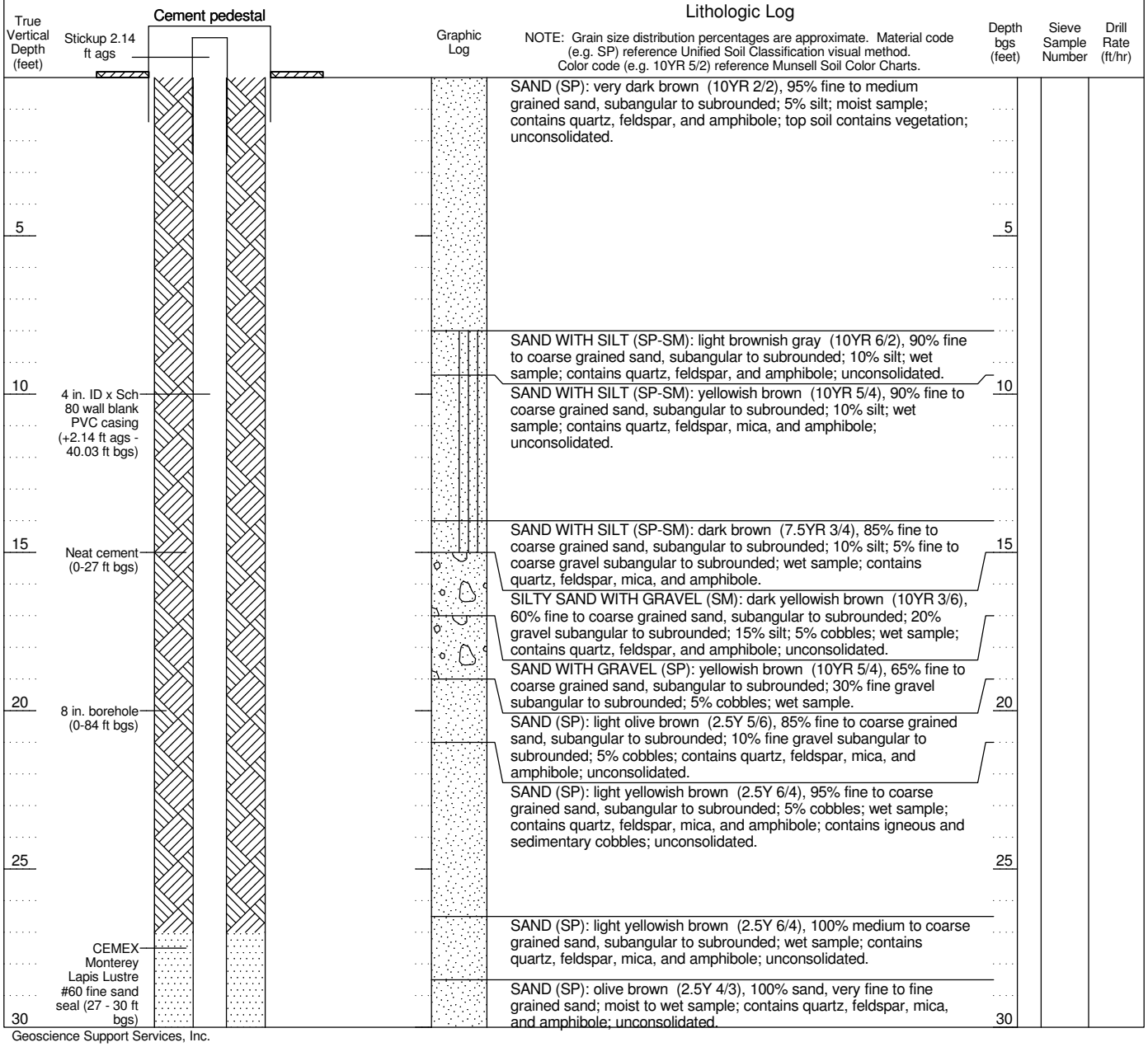
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Claremont, CA 91711
Telephone: (909) 451-6650
Fax: (909) 451-6638
www.gssiwater.com

WELL NUMBER
MPWSP MW-8S

BOREHOLE LITHOLOGIC LOG

CLIENT	Cal Am	LOCATION	**Marina, CA**
PROJECT NUMBER	14077-15		**Monte Rd**
REPORT DATE			
DRILLING CONTRACTOR	Cascade Drilling	LOGGED BY	**A. Khalighi**
DRILLER	D. King		

		SCREEN / BLANK	TOP DEPTH (ft bgs)	BOTTOM DEPTH (ft bgs)	LENGTH (ft)	MATERIAL	WALL THICKNESS (in.)	DIAMETER (in.)	SCREEN TYPE	PERF. SIZE (in.)
DRILLING RIG TYPE	ProSonic 600T									
DRILLING METHOD	Sonic	**Blank**	**-2.14**	**40.03**	**42.17**	**PVC**	**Sch 80**	**4 / ID**		
SAMPLING METHOD	Core	**Screen**	**40.03**	**80.03**	**40**	**PVC**	**Sch 80**	**4 / ID**	**Slotted**	**0.04**
BOREHOLE DIAMETER	8 in	**Blank**	**80.03**	**82.54**	**2.51**	**PVC**	**Sch 80**	**4 / ID**		
SURFACE ELEVATION	17.82 ft NAVD88									
TOC ELEVATION	19.96 ft NAVD88 (RP)									
START DATE	5/12/15									
FINISH DATE	5/13/15									



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WELL NUMBER **MPWSP MW-8S**

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am | LOCATION **Marina, CA**
PROJECT NUMBER 14077-15

True Vertical Depth (feet)	(continued)	Graphic Log	Lithologic Log NOTE: Grain size distribution percentages are approximate. Material code (e.g. SP) reference Unified Soil Classification visual method. Color code (e.g. 10YR 5/2) reference Munsell Soil Color Charts.	Depth bgs (feet)	Sieve Sample Number	Drill Rate (ft/hr)
35	CEMEX Monterey Lapis Lustre #3 filter pack (30 - 82.54 ft bgs)			35		
40			CLAY (CL): olive gray (5Y 4/2), 90% clay, high plasticity; 10% silt; moist sample.	40		
45	4 in. ID x Sch 80 wall PVC well screen with 0.040 in. slots (40.03-80.03 ft bgs)		SAND (SP): dark yellowish brown (10YR 4/6), 100% fine to medium grained sand, subangular to subrounded; wet sample; contains quartz, feldspar, and amphibole; unconsolidated.	45		
50			SAND (SP): dark yellowish brown (10YR 4/4), 100% fine to coarse grained sand, subangular to subrounded; wet sample; contains quartz, feldspar, and amphibole; unconsolidated.	50		
55			SAND (SP): brown (10YR 4/3), 90% fine to coarse grained sand, subangular to subrounded; 10% fine gravel subangular to subrounded; wet sample; contains quartz, feldspar, and amphibole; contains igneous and sedimentary gravel; unconsolidated.	55		
60			SAND (SP): grayish brown (10YR 5/2), 100% medium to coarse grained sand, subangular to rounded, predominately coarse grained sand; wet sample; contains quartz, feldspar, and amphibole; unconsolidated.	60		
65			SAND (SP): dark brown (10YR 3/3), 95% sand, very fine to fine grained sand; 5% silt; trace cobbles; moist to wet sample; contains rounded igneous and sedimentary cobbles (less than 5%); unconsolidated.	65		4
70				70		

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WELL NUMBER
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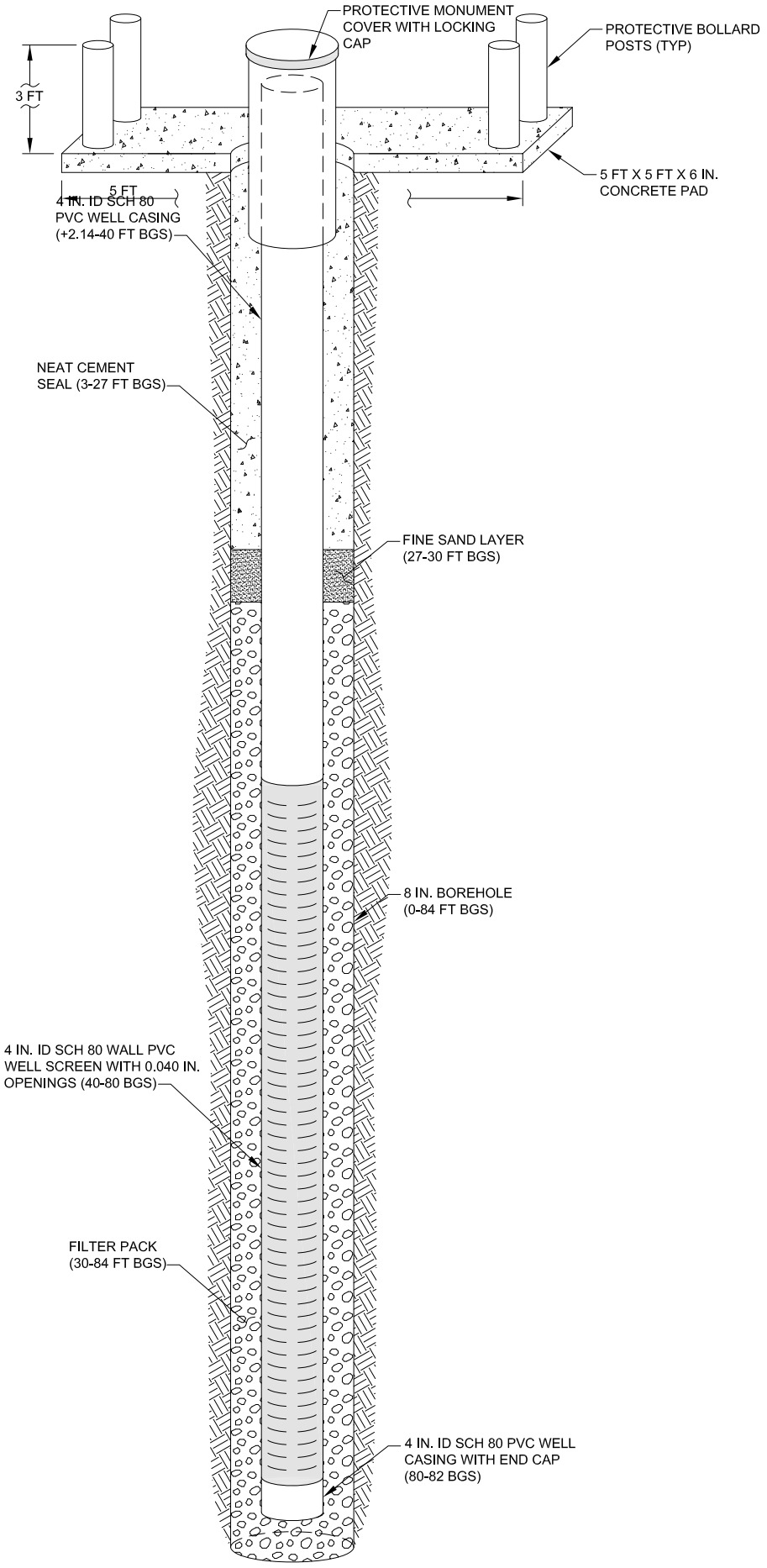
BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am
PROJECT NUMBER 14077-15
LOCATION **Marina, CA**

True Vertical Depth (feet)	(continued)	Graphic Log	Lithologic Log NOTE: Grain size distribution percentages are approximate. Material code (e.g. SP) reference Unified Soil Classification visual method. Color code (e.g. 10YR 5/2) reference Munsell Soil Color Charts.	Depth bgs (feet)	Sieve Sample Number	Drill Rate (ft/hr)
			SAND WITH GRAVEL (SP): grayish brown (10YR 5/2), 80% fine to coarse grained sand, subangular to subrounded; 15% gravel subangular to subrounded; 5% cobbles; contains quartz, feldspar, and amphibole; contains igneous and sedimentary cobbles; unconsolidated.			
75			SAND (SP): dark yellowish brown (10YR 3/4), 100% sand, very fine to fine grained sand; moist to wet sample; contains quartz, feldspar, mica, and amphibole; contains lens of coarse gravel; unconsolidated.	75		4
80	Blank casing with end cap (80.03-82.54 ft bgs)			80		
	TD 84 ft bgs		Bottom of borehole at 84 feet.			

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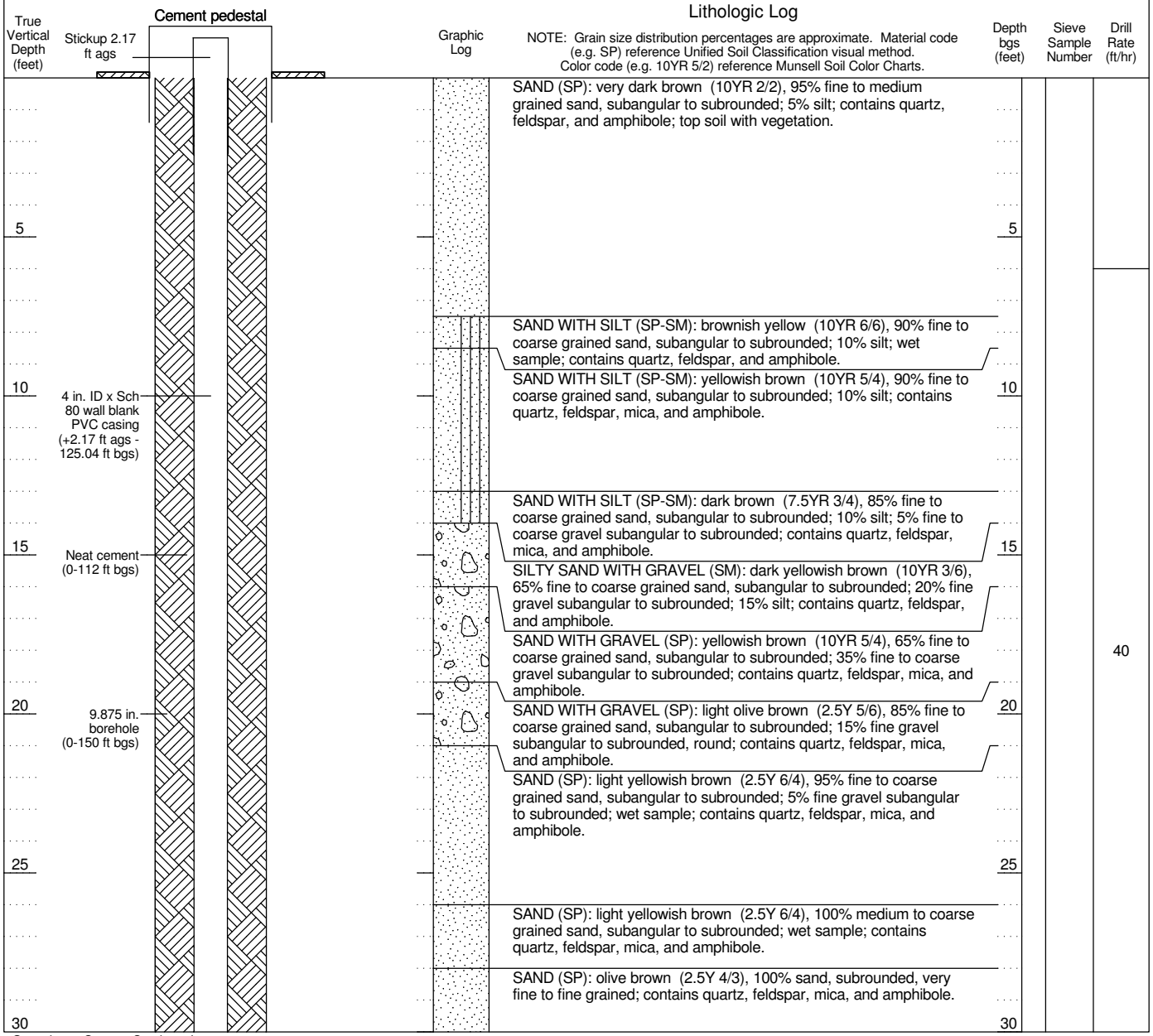
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BOREHOLE LITHOLOGIC LOG

WELL NUMBER **MPWSP MW-8M**	
CLIENT: Cal Am	LOCATION: **Marina, CA**
PROJECT NUMBER: 14077-15	**Monte Rd**
REPORT DATE:	
DRILLING CONTRACTOR: Cascade Drilling	LOGGED BY: **J. Sobolew**
DRILLER: D. King	

		SCREEN / BLANK	TOP DEPTH (ft bgs)	BOTTOM DEPTH (ft bgs)	LENGTH (ft)	MATERIAL	WALL THICKNESS (in.)	DIAMETER (in.)	SCREEN TYPE	PERF. SIZE (in.)
DRILLING RIG TYPE	ProSonic 600T									
DRILLING METHOD	Sonic	**Blank**	**-2.17**	**125.04**	**127.21**	**PVC**	**Sch 80**	**4 / ID**		
SAMPLING METHOD	Core	**Screen**	**125.04**	**215.04**	**90**	**PVC**	**Sch 80**	**4 / ID**	**Slotted**	**0.04**
BOREHOLE DIAMETER	9.875, 8 in	**Blank**	**215.04**	**217.54**	**2.5**	**PVC**	**Sch 80**	**4 / ID**		
SURFACE ELEVATION	17.82 ft NAVD88									
TOC ELEVATION	19.99 ft NAVD88 (RP)									
START DATE	5/04/15									
FINISH DATE	5/12/15									



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WELL NUMBER **MPWSP MW-8M**

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am
PROJECT NUMBER 14077-15
LOCATION **Marina, CA**

True Vertical Depth (feet)	(continued)	Graphic Log	Lithologic Log NOTE: Grain size distribution percentages are approximate. Material code (e.g. SP) reference Unified Soil Classification visual method. Color code (e.g. 10YR 5/2) reference Munsell Soil Color Charts.	Depth bgs (feet)	Sieve Sample Number	Drill Rate (ft/hr)
35				35		40
40			SAND (SP): dark yellowish brown (10YR 4/6), 100% fine to medium grained sand, subangular to subrounded; wet sample; contains quartz, feldspar, and amphibole.	40		
45				45		
50			SAND (SP): dark yellowish brown (10YR 4/4), 100% fine to coarse grained sand, subangular to subrounded; wet sample; contains quartz, feldspar, and amphibole.	50		26
55				55		
60			SAND (SP): brown (10YR 4/3), 90% fine to coarse grained sand, subangular to subrounded; 10% gravel subangular to subrounded; contains quartz, feldspar, and amphibole. SAND (SP): grayish brown (10YR 5/2), 100% medium to coarse grained sand, subangular to rounded, predominantly coarse grained; wet sample; contains quartz, feldspar, and amphibole.	60		
65			SAND (SP): dark brown (10YR 3/3), 95% sand, very fine to fine grained; 5% silt; trace cobbles; moist sample; contains trace cobbles.	65		
70				70		

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WELL NUMBER **MPWSP MW-8M**

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am
PROJECT NUMBER 14077-15
LOCATION **Marina, CA**

True Vertical Depth (feet)	(continued)	Graphic Log	Lithologic Log NOTE: Grain size distribution percentages are approximate. Material code (e.g. SP) reference Unified Soil Classification visual method. Color code (e.g. 10YR 5/2) reference Munsell Soil Color Charts.	Depth bgs (feet)	Sieve Sample Number	Drill Rate (ft/hr)
75			SAND WITH GRAVEL (SP): grayish brown (10YR 5/2), 80% fine to coarse grained sand, subangular to subrounded; 20% fine to coarse gravel subrounded to rounded; contains quartz, feldspar, and amphibole.	75		26
80			SAND (SP): dark yellowish brown (10YR 3/4), 100% sand, very fine to fine grained; moist sample; contains quartz, feldspar, mica, and amphibole.	80		
85			SANDY SILT (ML): dark yellowish brown (10YR 4/6), 60% silt; 40% sand, very fine to fine grained; contains quartz, feldspar, mica, and amphibole.	85		
90			FAT CLAY (CH): grayish brown (2.5Y 5/2) and grayish green (5G 4/2), 100% clay, high plasticity.	90		
95				95		
100				100		
105				105		
110			SILT (ML): light olive brown (2.5Y 5/4), 75% silt; 15% clay, medium plasticity; 10% fine grained sand; moist sample.	110		

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WELL NUMBER
MPWSP MW-8M

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am
PROJECT NUMBER 14077-15
LOCATION **Marina, CA**

True Vertical Depth (feet)	(continued)	Graphic Log	Lithologic Log NOTE: Grain size distribution percentages are approximate. Material code (e.g. SP) reference Unified Soil Classification visual method. Color code (e.g. 10YR 5/2) reference Munsell Soil Color Charts.	Depth bgs (feet)	Sieve Sample Number	Drill Rate (ft/hr)
115	CEMEX Monterey Lapis Lustre #60 fine sand seal (112 - 115 ft bgs)		SAND (SP): light olive brown (2.5Y 5/3), 100% fine to medium grained sand, subangular to subrounded, predominantly medium grained; moist sample; contains quartz, feldspar, mica, and amphibole.	115		
120	CEMEX Monterey Lapis Lustre #3 filter pack (115 - 220 ft bgs)		SAND WITH GRAVEL (SP): brown (10YR 5/3), 85% fine to coarse grained sand, subangular to subrounded; 15% fine to coarse gravel subangular to subrounded; contains quartz, feldspar, and amphibole; contains slight clay matrix.	120		
125				125		
130	4 in. ID x Sch 80 wall PVC well screen with 0.040 in. slots (125.04-215.04 ft bgs)			130		8
135			FAT CLAY (CH): light yellowish brown (2.5Y 6/3), 100% clay, medium plasticity.	135		
140			SAND WITH GRAVEL (SP): dark grayish brown (10YR 4/2), 70% fine to coarse grained sand, subangular to subrounded; 30% fine to coarse gravel subangular to subrounded; trace silt; contains quartz, feldspar, mica, and amphibole.	140		
			SILT (ML): olive (5Y 5/3), 100% silt; low to medium plasticity.			
145			SAND WITH GRAVEL (SP): pale brown (10YR 6/3), 75% fine to coarse grained sand; 25% fine to coarse gravel; medium sorted; contains quartz, feldspar, mica, and amphibole.	145		
150			SILT (ML): olive (5Y 5/3), 100% silt.	150		

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WELL NUMBER **MPWSP MW-8M**

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am
PROJECT NUMBER 14077-15
LOCATION **Marina, CA**

(continued)

True Vertical Depth (feet)	Graphic Log	Lithologic Log NOTE: Grain size distribution percentages are approximate. Material code (e.g. SP) reference Unified Soil Classification visual method. Color code (e.g. 10YR 5/2) reference Munsell Soil Color Charts.	Depth bgs (feet)	Sieve Sample Number	Drill Rate (ft/hr)
8 in. borehole (150-220 ft bgs)		SAND WITH GRAVEL (SP): dark yellowish brown (10YR 4/6), 75% fine to coarse grained sand, subangular to subrounded, subangular to subrounded; 25% fine to coarse gravel subangular to subrounded, subrounded; contains quartz, feldspar, and amphibole.			
155			155		
160		CLAYEY GRAVEL (GC): dark olive gray (5Y 3/2), 50% fine to coarse gravel subrounded to rounded; 45% clay, medium plasticity; 5% fine to coarse grained sand, subrounded to rounded; contains quartz, feldspar, and amphibole.	160		
		SAND WITH GRAVEL (SP): very dark grayish brown (10YR 3/2), 75% fine to coarse grained sand, subangular to subrounded; 25% fine to coarse gravel subangular to subrounded; trace silt; wet sample; contains quartz, feldspar, and amphibole; contains Monterey Shale.			8
165			165		
		SAND WITH GRAVEL (SP): dark yellowish brown (10YR 3/6), 85% fine to coarse grained sand, subrounded to rounded; 15% fine to coarse gravel subrounded to rounded; wet sample; contains quartz, feldspar, and amphibole; contains Monterey Shale.			
170			170		
		SAND (SP): very dark grayish brown (10YR 3/2), 100% fine grained sand; wet sample; weak cementation; contains quartz, feldspar, mica, and amphibole; grain size becomes fine from 210 ft to 220 ft and contains high amphibole content and silt (5% to 10%).			
175			175		
180			180		30
185			185		
190			190		

WELL CONSTRUCTION LOG MPWSP MW TM LITH ALL WELLS.GPJ GEOSCIENCE.GDT 7/7/16

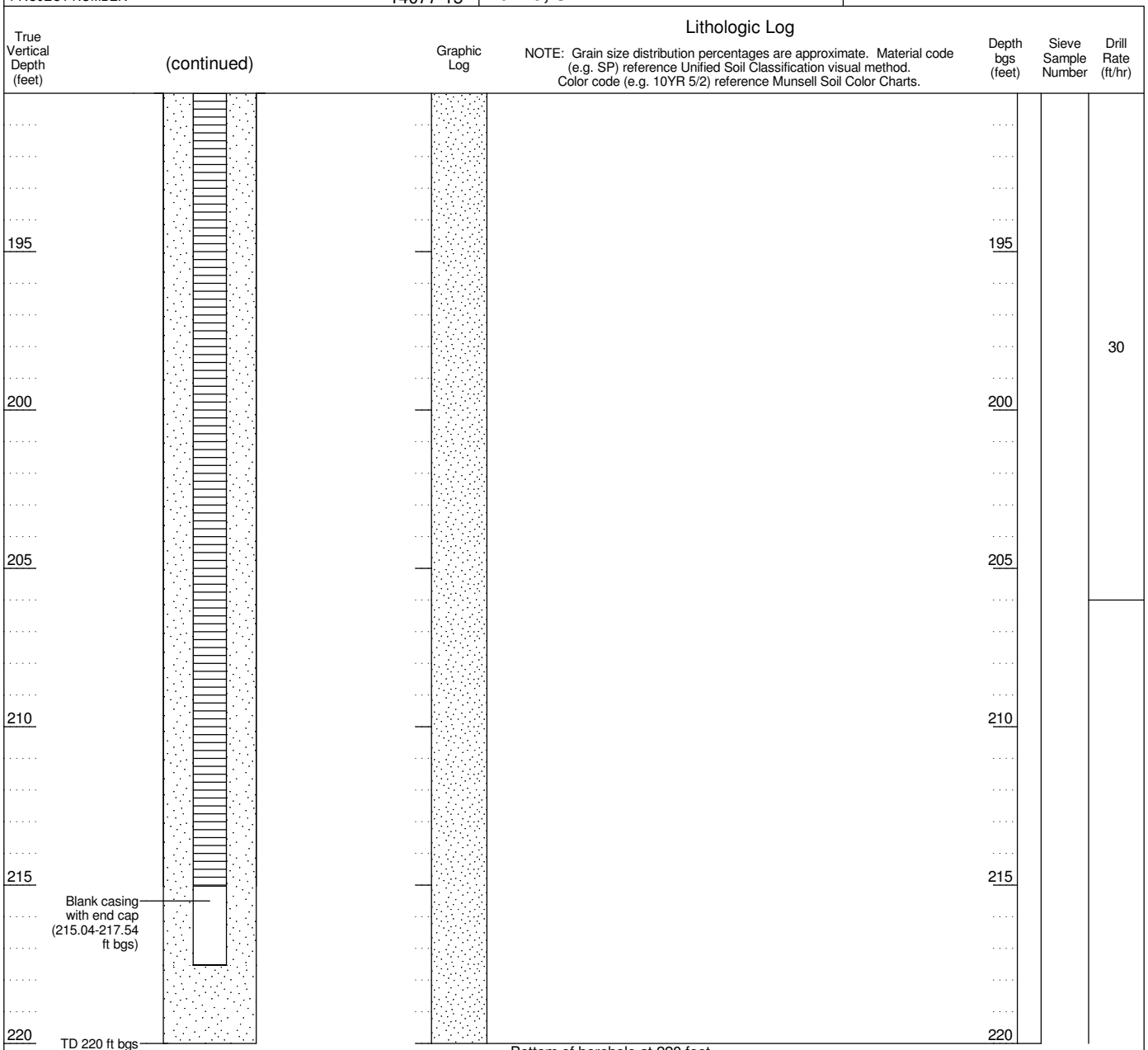
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WELL NUMBER **MPWSP MW-8M**

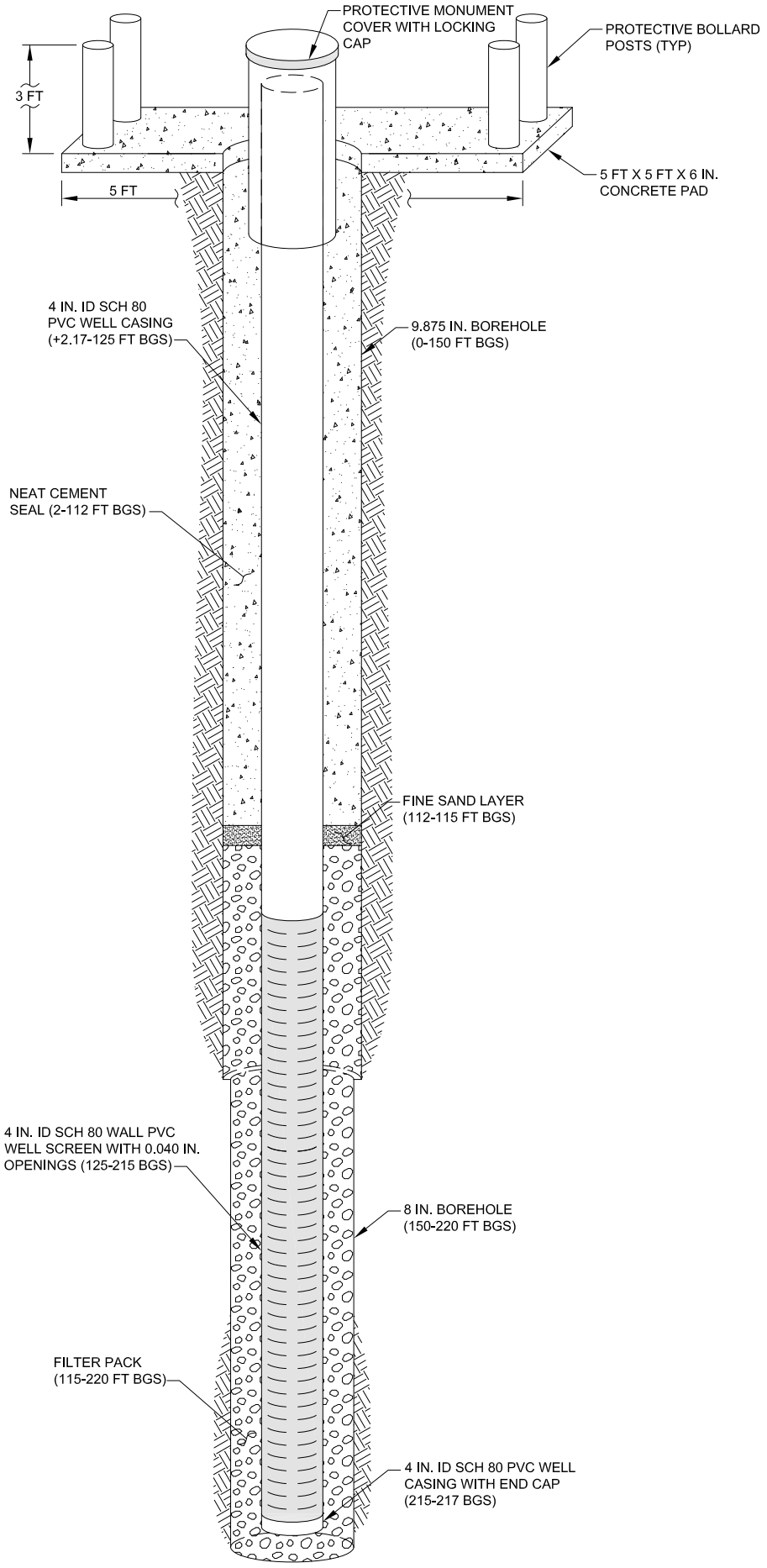
BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am
PROJECT NUMBER 14077-15
LOCATION **Marina, CA**



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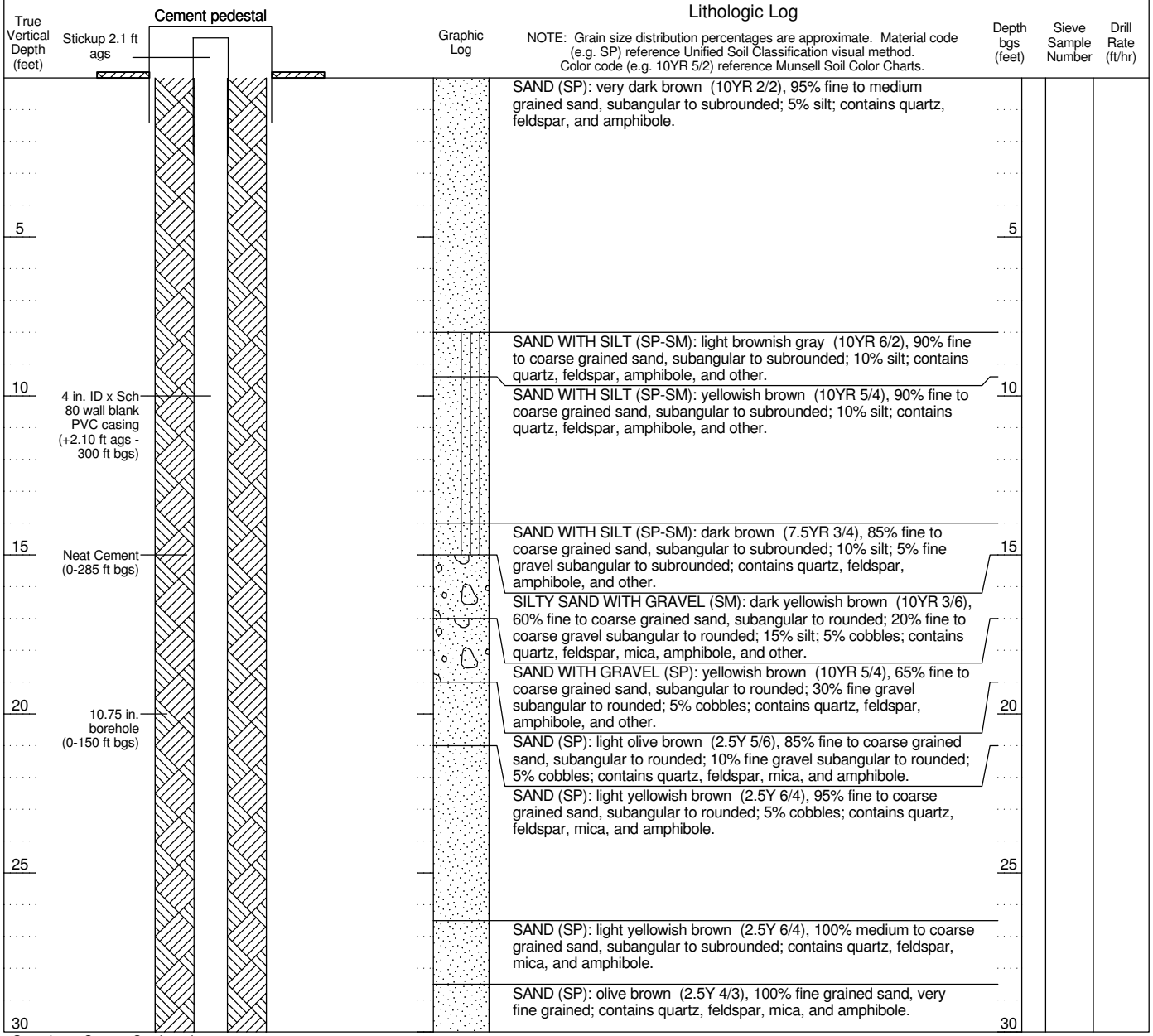
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BOREHOLE LITHOLOGIC LOG

WELL NUMBER **MPWSP MW-8D**	
CLIENT: Cal Am	LOCATION: **Marina, CA**
PROJECT NUMBER: 14077-15	**Monte Rd**
REPORT DATE:	
DRILLING CONTRACTOR: Cascade Drilling	LOGGED BY: **A. Khalighi**
DRILLER: D. King	

		SCREEN / BLANK	TOP DEPTH (ft bgs)	BOTTOM DEPTH (ft bgs)	LENGTH (ft)	MATERIAL	WALL THICKNESS (in.)	DIAMETER (in.)	SCREEN TYPE	PERF. SIZE (in.)
DRILLING RIG TYPE	ProSonic 600T									
DRILLING METHOD	Sonic	**Blank**	**-2.1**	**300**	**302.1**	**PVC**	**Sch 80**	**4 / ID**		
SAMPLING METHOD	Core	**Screen**	**300**	**350**	**50**	**PVC**	**Sch 80**	**4 / ID**	**Slotted**	**0.04**
BOREHOLE DIAMETER	10.75, 9.875, 8 in	**Blank**	**350**	**352.8**	**2.8**	**PVC**	**Sch 80**	**4 / ID**		
SURFACE ELEVATION	17.98 ft NAVD88									
TOC ELEVATION	20.08 ft NAVD88 (RP)									
START DATE	4/14/15									
FINISH DATE	5/03/15									



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WELL NUMBER **MPWSP MW-8D**

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am
PROJECT NUMBER 14077-15
LOCATION **Marina, CA**

True Vertical Depth (feet)	(continued)	Graphic Log	Lithologic Log NOTE: Grain size distribution percentages are approximate. Material code (e.g. SP) reference Unified Soil Classification visual method. Color code (e.g. 10YR 5/2) reference Munsell Soil Color Charts.	Depth bgs (feet)	Sieve Sample Number	Drill Rate (ft/hr)
35				35		
40				40		
			CLAY (CL): olive gray (5Y 4/2), 90% clay, high plasticity; 10% silt.			
			SAND (SP): dark yellowish brown (10YR 4/6), 100% fine to medium grained sand, subangular to subrounded; contains quartz, feldspar, amphibole, and other.			
45				45		
			SAND (SP): dark yellowish brown (10YR 4/4), 100% fine to coarse grained sand, subangular to subrounded; contains quartz, feldspar, and amphibole.			
50				50		
			SAND (SP): brown (10YR 4/3), 90% fine to coarse grained sand, subangular to subrounded; 10% fine gravel subangular to subrounded; contains quartz, feldspar, and amphibole.		1	
55			SAND (SP): grayish brown (10YR 5/2), 100% medium to coarse grained sand, subangular to rounded; contains quartz, feldspar, and amphibole.	55		
60				60	2	
			SAND (SP): dark brown (10YR 3/3), 95% fine grained sand, subangular to subrounded; 5% silt; trace cobbles; contains quartz, feldspar, mica, and amphibole.			
65				65		
						9
70				70		

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WELL NUMBER **MPWSP MW-8D**

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am
PROJECT NUMBER 14077-15
LOCATION **Marina, CA**

True Vertical Depth (feet)	(continued)	Graphic Log	Lithologic Log NOTE: Grain size distribution percentages are approximate. Material code (e.g. SP) reference Unified Soil Classification visual method. Color code (e.g. 10YR 5/2) reference Munsell Soil Color Charts.	Depth bgs (feet)	Sieve Sample Number	Drill Rate (ft/hr)
			SAND WITH GRAVEL (SP): grayish brown (10YR 5/2), 80% fine to coarse grained sand, subangular to rounded; 15% fine to coarse gravel subangular to rounded; 5% cobbles; contains quartz, feldspar, and amphibole.		3	
75			SAND (SP): dark yellowish brown (10YR 3/4), 100% fine grained sand, some very fine; contains quartz, feldspar, mica, and amphibole.	75		
80				80	4	
85			SAND WITH GRAVEL (SP): grayish brown (2.5Y 5/2), 85% fine to coarse grained sand, subangular to rounded; 15% fine to coarse gravel subangular to rounded; contains quartz, feldspar, and amphibole.	85		
			SAND (SP): black (N2.5), 100% fine grained sand; contains quartz, feldspar, mica, and amphibole.			
			FAT CLAY (CH): grayish brown (2.5Y 5/2), 100% clay, medium to high plasticity.			
90				90		9
			FAT CLAY (CH): grayish green (5G 4/2), 100% clay, medium to high plasticity.			
95				95		
100				100		
105				105		
			SILT (ML): light olive brown (2.5Y 5/4), 60% silt; 30% clay, low to medium plasticity; 10% fine grained sand.			
110				110		

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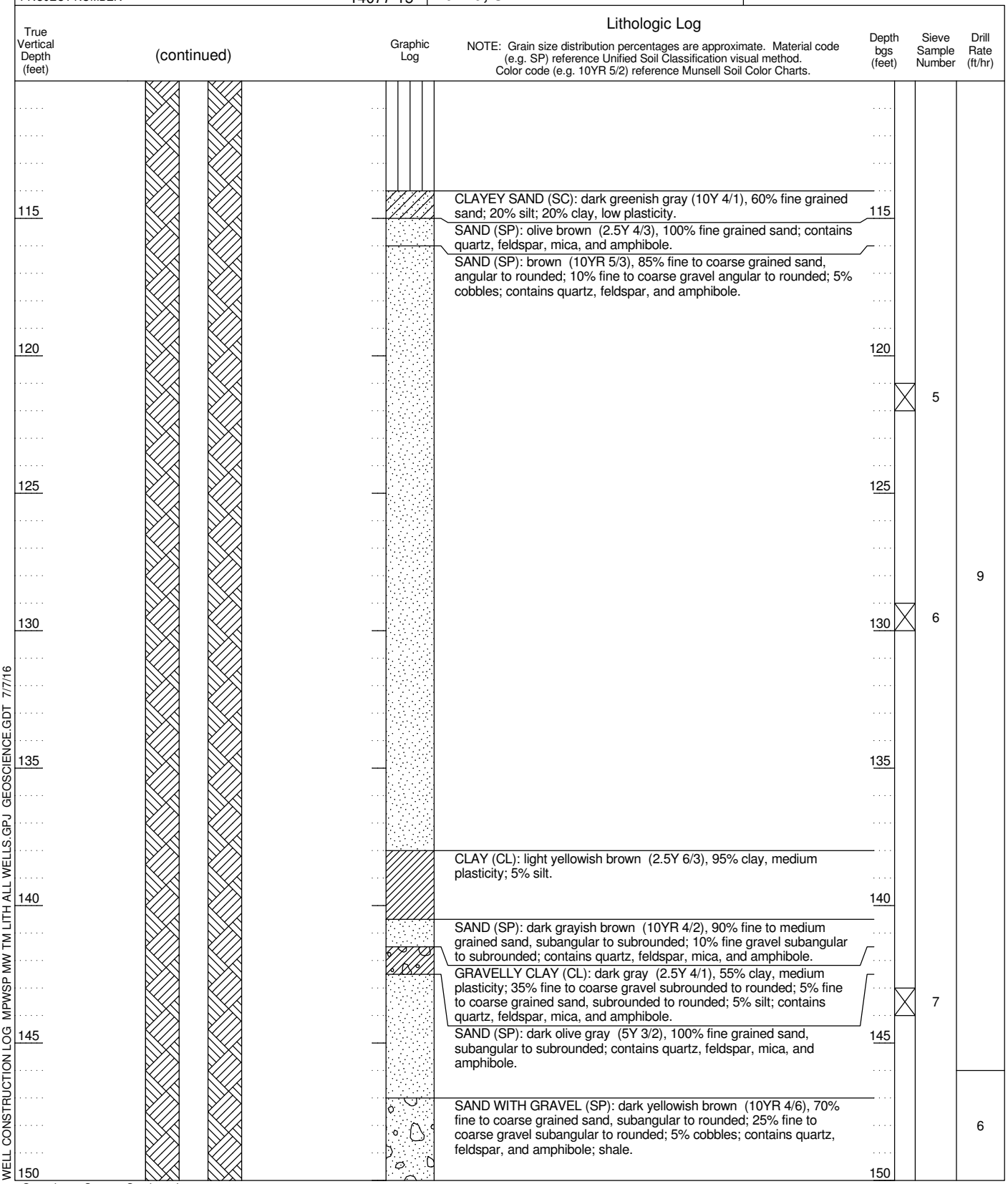
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WELL NUMBER **MPWSP MW-8D**

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am
PROJECT NUMBER 14077-15
LOCATION **Marina, CA**



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WELL NUMBER **MPWSP MW-8D**

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am | LOCATION **Marina, CA**
PROJECT NUMBER 14077-15

True Vertical Depth (feet)	(continued)	Graphic Log	Lithologic Log NOTE: Grain size distribution percentages are approximate. Material code (e.g. SP) reference Unified Soil Classification visual method. Color code (e.g. 10YR 5/2) reference Munsell Soil Color Charts.	Depth bgs (feet)	Sieve Sample Number	Drill Rate (ft/hr)
	9.875 in. borehole (150-280 ft bgs)				8	
155			CLAYEY GRAVEL (GC): dark olive gray (5Y 3/2), 50% fine to coarse gravel subangular to rounded; 30% clay, medium to high plasticity; 5% fine to coarse grained sand, subangular to rounded; 5% silt; 10% cobbles; contains quartz, feldspar, and amphibole; shale.	155		
			SAND WITH GRAVEL (SP): dark yellowish brown (10YR 4/6), 70% fine to coarse grained sand, subangular to rounded; 25% fine to coarse gravel subangular to rounded; 5% cobbles; contains quartz, feldspar, and amphibole; shale.			
160				160		
			SAND (SP): yellowish brown (10YR 5/4), 90% fine grained sand, subrounded to rounded; 5% fine to coarse gravel subrounded to rounded; 5% cobbles; contains quartz, feldspar, and amphibole; shale.		9	
165			SAND WITH GRAVEL (SP): very dark grayish brown (10YR 3/2), 70% fine to coarse grained sand, subangular to subrounded; 20% fine to coarse gravel subangular to subrounded; 5% silt; 5% cobbles; contains quartz, feldspar, and amphibole.	165		
			GRAVEL WITH SAND (GP): dark yellowish brown (10YR 3/6), 80% fine to coarse gravel subrounded to rounded; 15% fine to coarse grained sand, subrounded to rounded; 5% cobbles; contains quartz, feldspar, and amphibole.			
170				170		6
			SAND (SP): very dark grayish brown (10YR 3/2), 100% fine grained sand; contains quartz, feldspar, mica, and amphibole; friable sandstone.			
175				175	10	
180				180		
185				185		
					11	
190				190		

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WELL NUMBER **MPWSP MW-8D**

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am
PROJECT NUMBER 14077-15
LOCATION **Marina, CA**

True Vertical Depth (feet)	(continued)	Graphic Log	Lithologic Log NOTE: Grain size distribution percentages are approximate. Material code (e.g. SP) reference Unified Soil Classification visual method. Color code (e.g. 10YR 5/2) reference Munsell Soil Color Charts.	Depth bgs (feet)	Sieve Sample Number	Drill Rate (ft/hr)
195			SAND WITH SILT (SP-SM): very dark grayish brown (10YR 3/2), 90% fine grained sand; 10% silt; contains quartz, feldspar, mica, and amphibole; friable sandstone.	195	12	
200			SAND (SP): very dark grayish brown (10YR 3/2), 100% fine grained sand; contains quartz, feldspar, mica, and amphibole; friable sandstone.	200		6
205			SAND WITH CLAY (SP-SC): very dark grayish brown (10YR 3/2), 85% fine grained sand; 10% silt; 5% clay; contains quartz, feldspar, mica, and amphibole; friable sandstone.	205	13	
210				210		
215				215	14	
220				220		8
225				225	15	
230			CLAY WITH SAND (CL): light olive brown (2.5Y 5/3), 80% clay, low to medium plasticity; 20% fine grained sand.	230		

WELL CONSTRUCTION LOG MPWSP MW TM LITH ALL WELLS.GPJ GEOSCIENCE.GDT 7/7/16

Geoscience Support Services, Inc.

GEOSCIENCE
P.O. Box 220
Claremont, CA 91711
Telephone: (909) 451-6650
Fax: (909) 451-6638
www.gssiwater.com

WELL NUMBER **MPWSP MW-8D**

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am
PROJECT NUMBER 14077-15
LOCATION **Marina, CA**

True Vertical Depth (feet)	(continued)	Graphic Log	Lithologic Log NOTE: Grain size distribution percentages are approximate. Material code (e.g. SP) reference Unified Soil Classification visual method. Color code (e.g. 10YR 5/2) reference Munsell Soil Color Charts.	Depth bgs (feet)	Sieve Sample Number	Drill Rate (ft/hr)
			SILTY SAND (SM): light olive brown (2.5Y 5/4), 60% fine grained sand; 30% silt; 10% clay, no to low plasticity; contains quartz, feldspar, mica, and amphibole.			
			CLAY WITH SAND (CL): olive brown (2.5Y 4/3), 70% clay, low to medium plasticity; 20% fine to medium grained sand, subangular to subrounded; 5% fine gravel subangular to subrounded; 5% silt; shale.			
235			SILTY SAND WITH GRAVEL (SM): olive brown (2.5Y 4/3), 60% fine to coarse grained sand, subangular to subrounded; 15% coarse gravel subangular to subrounded; 15% silt; 10% clay, not to low plasticity; contains quartz, feldspar, and amphibole; shale.	235		
			SILTY SAND (SM): light olive brown (2.5Y 5/3), 75% fine grained sand; 20% silt; 5% clay; contains quartz, feldspar, and amphibole.			
			SANDY SILT (ML): light olive brown (2.5Y 5/3), 60% silt; 30% fine grained sand; 10% clay, no to low plasticity; contains quartz, feldspar, mica, and amphibole.			
240				240		
			CLAYEY SAND (SC): light olive brown (2.5Y 5/3), 70% fine to medium grained sand, subangular to subrounded; 20% clay; 10% silt; contains quartz, feldspar, mica, and amphibole.			
245				245		
			CLAY WITH SAND (CL): light olive brown (2.5Y 5/3), 70% clay, low to medium plasticity; 15% fine to medium grained sand, subrounded to rounded; 10% fine gravel subrounded to rounded; 5% silt; contains quartz, feldspar, mica, and amphibole.			
250			CLAYEY SAND (SC): light olive brown (2.5Y 5/3), 70% fine to coarse grained sand, subangular to rounded; 20% clay; 5% fine to coarse gravel subangular to rounded; 5% silt; trace cobbles; contains quartz, feldspar, mica, and amphibole.	250		8
			SAND WITH GRAVEL (SP): light olive brown (2.5Y 5/3), 80% fine to coarse grained sand, subangular to rounded; 15% fine to coarse gravel subangular to rounded; 5% silt; trace cobbles; contains quartz, feldspar, and amphibole.		16	
255				255		
			CLAY (CL): light brownish gray (2.5Y 6/2), 95% clay, low to medium plasticity; 5% silt.			
			CLAY WITH SAND (CL): light yellowish brown (2.5Y 6/4), 70% clay, low plasticity; 25% fine to coarse grained sand; 5% silt.			
260				260		
265				265		
			CLAY (CL): dark yellowish brown (10YR 4/4), 85% clay, low plasticity; 10% fine grained sand; 5% silt.			
270			CLAYEY SAND (SC): olive brown (2.5Y 4/3), 70% fine grained sand; 30% clay, low plasticity; contains quartz, feldspar, mica, and	270		

WELL CONSTRUCTION LOG MPWSP MW TM LITH ALL WELLS.GPJ GEOSCIENCE.GDT 7/7/16

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WELL NUMBER **MPWSP MW-8D**

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am | LOCATION **Marina, CA**
PROJECT NUMBER 14077-15

True Vertical Depth (feet)	(continued)	Graphic Log	Lithologic Log NOTE: Grain size distribution percentages are approximate. Material code (e.g. SP) reference Unified Soil Classification visual method. Color code (e.g. 10YR 5/2) reference Munsell Soil Color Charts.	Depth bgs (feet)	Sieve Sample Number	Drill Rate (ft/hr)
			amphibole.			
			CLAY (CL): dark grayish brown (2.5Y 4/2), 100% clay, medium plasticity.			8
275				275		
			CLAY (CL): dark yellowish brown (10YR 3/6), 100% clay, medium to high plasticity.			
280	8 in. borehole (280-360 ft bgs)			280		
285				285		
	CEMEX Monterey Lapis Lustre #60 fine sand seal (285 - 288 ft bgs)		SILTY SAND (SM): light olive brown (2.5Y 5/4), 80% fine grained sand; 15% silt; 5% clay, no to low plasticity.			
290				290		
	CEMEX Monterey Lapis Lustre #3 filter pack (288 - 360 ft bgs)					5
295			CLAY (CL): light olive brown (2.5Y 5/3), 80% clay, low plasticity; 15% silt; 5% fine grained sand.	295		
			SAND WITH GRAVEL (SP): gray (2.5Y 5/1), 85% fine to coarse grained sand, subangular to rounded; 15% fine to coarse gravel subangular to rounded; contains quartz, feldspar, and amphibole; shale.			
300				300	17	
	4 in. ID x Sch 80 wall PVC well screen with 0.040 in. slots (300 - 350 ft bgs)					
305				305		
310				310		

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WELL NUMBER
MPWSP MW-8D

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am
PROJECT NUMBER 14077-15
LOCATION **Marina, CA**

True Vertical Depth (feet)	(continued)	Graphic Log	Lithologic Log NOTE: Grain size distribution percentages are approximate. Material code (e.g. SP) reference Unified Soil Classification visual method. Color code (e.g. 10YR 5/2) reference Munsell Soil Color Charts.	Depth bgs (feet)	Sieve Sample Number	Drill Rate (ft/hr)
					18	
			SAND WITH GRAVEL (SP): gray (2.5Y 5/1), 65% fine to coarse grained sand, subangular to rounded; 35% fine to coarse gravel subangular to rounded; trace clay; contains quartz, feldspar, and amphibole; shale.			
315			FAT CLAY WITH SAND (CH): light olive brown (2.5Y 5/3), 70% clay, medium to high plasticity; 10% fine to coarse gravel subrounded to rounded; 10% fine to coarse grained sand, subrounded to rounded; 10% cobbles; contains quartz, feldspar, and amphibole.	315		5
			SAND WITH GRAVEL (SP): gray (2.5Y 5/1), 60% fine to coarse grained sand, subrounded to rounded; 20% fine to coarse gravel subrounded to rounded; 20% cobbles; contains quartz, feldspar, and amphibole; shale.			
320			SAND (SP): light olive brown (2.5Y 5/3), 90% fine to coarse grained sand, subangular to rounded; 5% fine to coarse gravel subangular to rounded; 5% cobbles; contains quartz, feldspar, and amphibole.	320		
					19	
325			FAT CLAY (CH): yellowish brown (10YR 5/8), 100% clay, high plasticity.	325		
330			SAND (SP): dark yellowish brown (10YR 4/4), 100% fine grained sand; contains quartz, feldspar, mica, and amphibole.	330		
			SAND (SP): light olive brown (2.5Y 5/3), 95% fine to coarse grained sand, subangular to subrounded; 5% fine gravel subangular to subrounded; contains quartz, feldspar, mica, and amphibole.			
335				335	20	
340				340		
			SAND (SP): olive brown (2.5Y 4/4), 100% fine to medium grained sand, subangular to subrounded; contains quartz, feldspar, mica, and amphibole.			
345				345		
350				350		

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WELL NUMBER
MPWSP MW-8D

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am
PROJECT NUMBER 14077-15
LOCATION **Marina, CA**

True Vertical Depth (feet)	(continued)	Graphic Log	Lithologic Log NOTE: Grain size distribution percentages are approximate. Material code (e.g. SP) reference Unified Soil Classification visual method. Color code (e.g. 10YR 5/2) reference Munsell Soil Color Charts.	Depth bgs (feet)	Sieve Sample Number	Drill Rate (ft/hr)
	Blank casing with end cap (350-352.8 ft bgs)		FAT CLAY WITH GRAVEL (CH): light olive brown (2.5Y 5/3), 70% clay, medium to high plasticity; 15% fine to coarse gravel subrounded to rounded; 10% fine to coarse grained sand, subrounded to rounded; 5% cobbles; contains quartz, feldspar, and amphibole; shale.			
			FAT CLAY (CH): light olive brown (2.5Y 5/3), 100% clay, medium to high plasticity.			
355				355		
			SILTY SAND (SM): dark gray (2.5Y 4/1), 70% fine to coarse grained sand, subrounded to rounded; 10% fine to coarse gravel subrounded to rounded; 10% silt; 5% clay; 5% cobbles; contains quartz, feldspar, and amphibole; shale.			
360	TD 360 ft bgs		FAT CLAY WITH GRAVEL (CH): light olive brown (2.5Y 5/3), 85% clay, medium to high plasticity; 15% fine to coarse gravel rounded; rounded; trace cobbles; shale.	360		
			Bottom of borehole at 360 feet.			

WELL CONSTRUCTION LOG MPWSP MW TM LITH ALL WELLS.GPJ GEOSCIENCE.GDT 7/7/16

PACIFIC SURVEYS

TEMPERATURE
DELTA TEMPERATURE
FLUID RESISTIVITY
DELTA FLUID RESISTIVITY

Job No. 19537

File No.

Company CASCADE DRILLING

Well MW-8D

Field SALINAS

County MONTEREY State CA

Location

325 MONTE RD.
GPS: N 36o 43' 36" W 121o 47' 15"

Other Services:

DUAL INDUCTION
GAMMA-RAY

		Elevation	Elevation
Permanent Datum	G.L.		
Log Measured From	G.L.	0' above perm. datum	K.B.:
Drilling Measured From	G.L.		D.F.:
			G.L.:

Date	04-20-2015										
Run Number	ONE										
Depth Driller	360'										
Depth Logger	355'										
Bottom Logged Interval	355'										
Top Log Interval	0'										
Open Hole Size	10.75" (0'-150')						9.875" (150'-276')			8" (250'-340')	
Type Fluid	WATER										
Density / Viscosity	N/A										
Fluid Level	14'										
Bentonite Seal	N/A										
Time Well Ready	1200										
Time Logger on Bottom	1230										
Equipment Number	PS-8										
Location	LA										
Recorded By	SCHUMACHER										
Witnessed By	A. KHALIGHI										

Borehole Record				Tubing Record			
Run Number	Bit	From	To	Size	Weight	From	To
ONE	10.75"	0'	150'				
TWO	9.875"	150'	276'				
THREE	8"	267'	360'				

Casing Record	Size	Wgt/Ft	Top	Bottom
Surface String				
Prot. String				
Production String	4" PVC	SCH 80	0'	360'
Liner				

<<< Fold Here >>>

All interpretations are opinions based on inferences from electrical or other measurements and Pacific Surveys cannot and do not guarantee the accuracy or correctness of any interpretation, and we shall not, except in the case of gross or willful negligence on our part, be liable or responsible for any loss, costs, damages, or expenses incurred or sustained by anyone resulting from any interpretation made by any of our officers, agents or employees. These interpretations are also subject to Pacific Surveys' general terms and conditions set out in our current Price Schedule.

Comments

Calibration Report

Database File	19537.db
Dataset Pathname	tmp
Dataset Creation	Mon Apr 20 12:35:45 2015

Temperature Calibration Report

Serial Number:	3553	
Tool Model:	MLS	
Performed:	Mon Feb 23 16:47:18 2015	
	Reference	Reading
Low Reference:	43.34 degF	1441.00cps
High Reference:	149.00 degF	4545.00cps
Gain:	0.03	
Offset:	-9.71	
Delta Spacing	2	

FRT Calibration Report

Serial Number:	3553
Tool Model:	MLS
Performed:	Mon Feb 23 16:47:15 2015

Resistivity Calibration:

System Reading	Calibration Reference
32145.000 cps	1.800 Ohm-m
11466.000 cps	86.960 Ohm-m

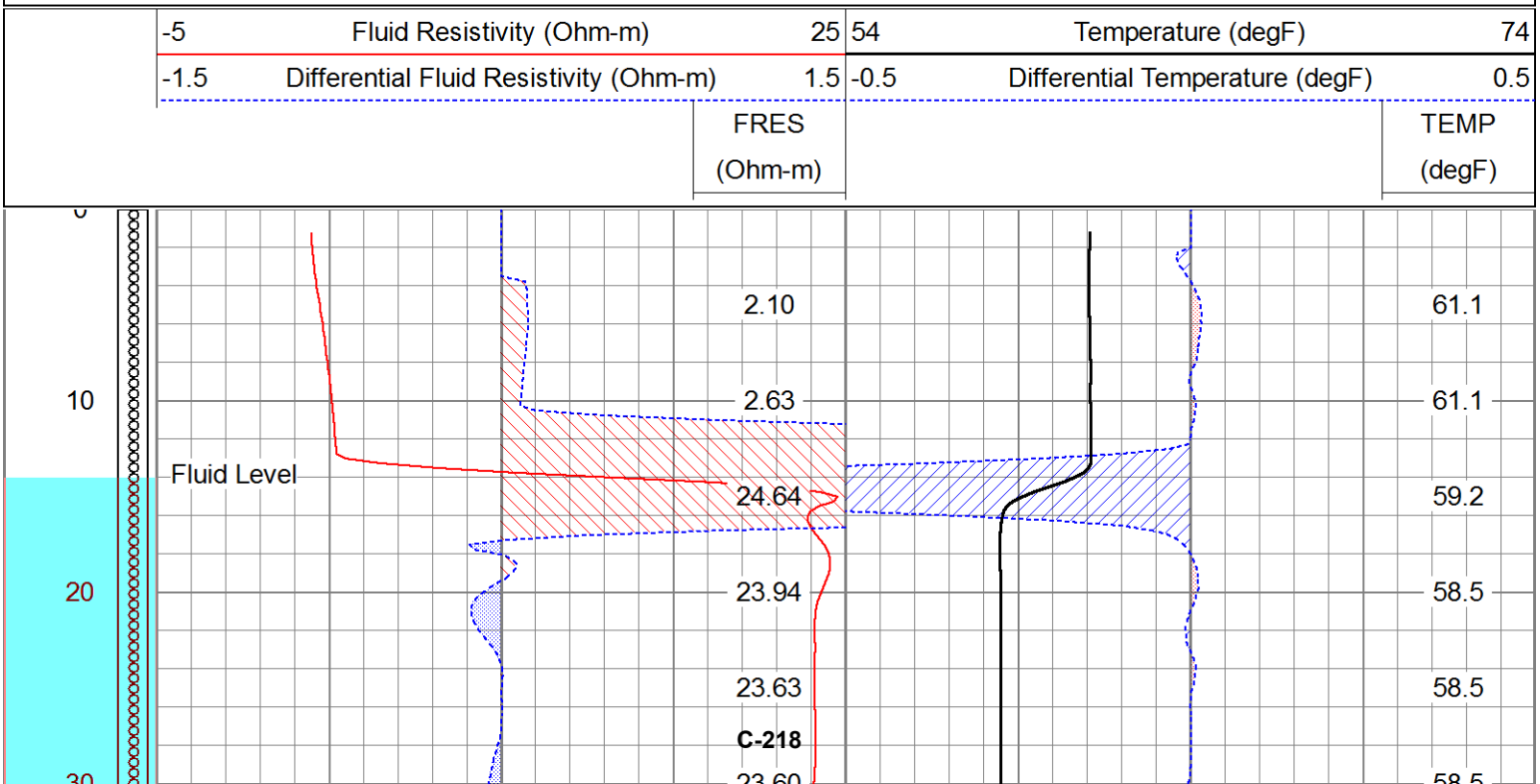
Gain: -0.004
Offset: 135.338

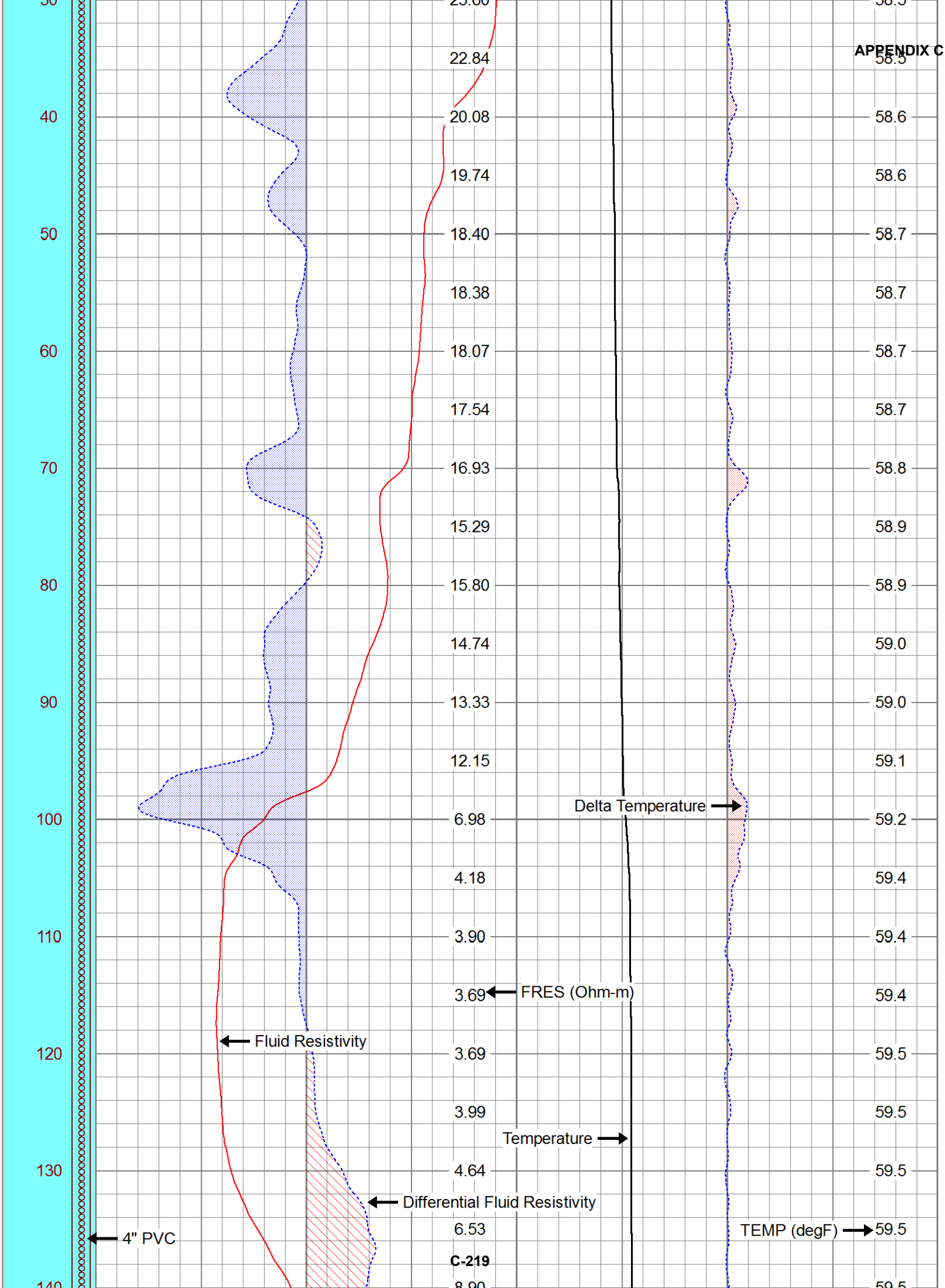
Conductivity Calibration:

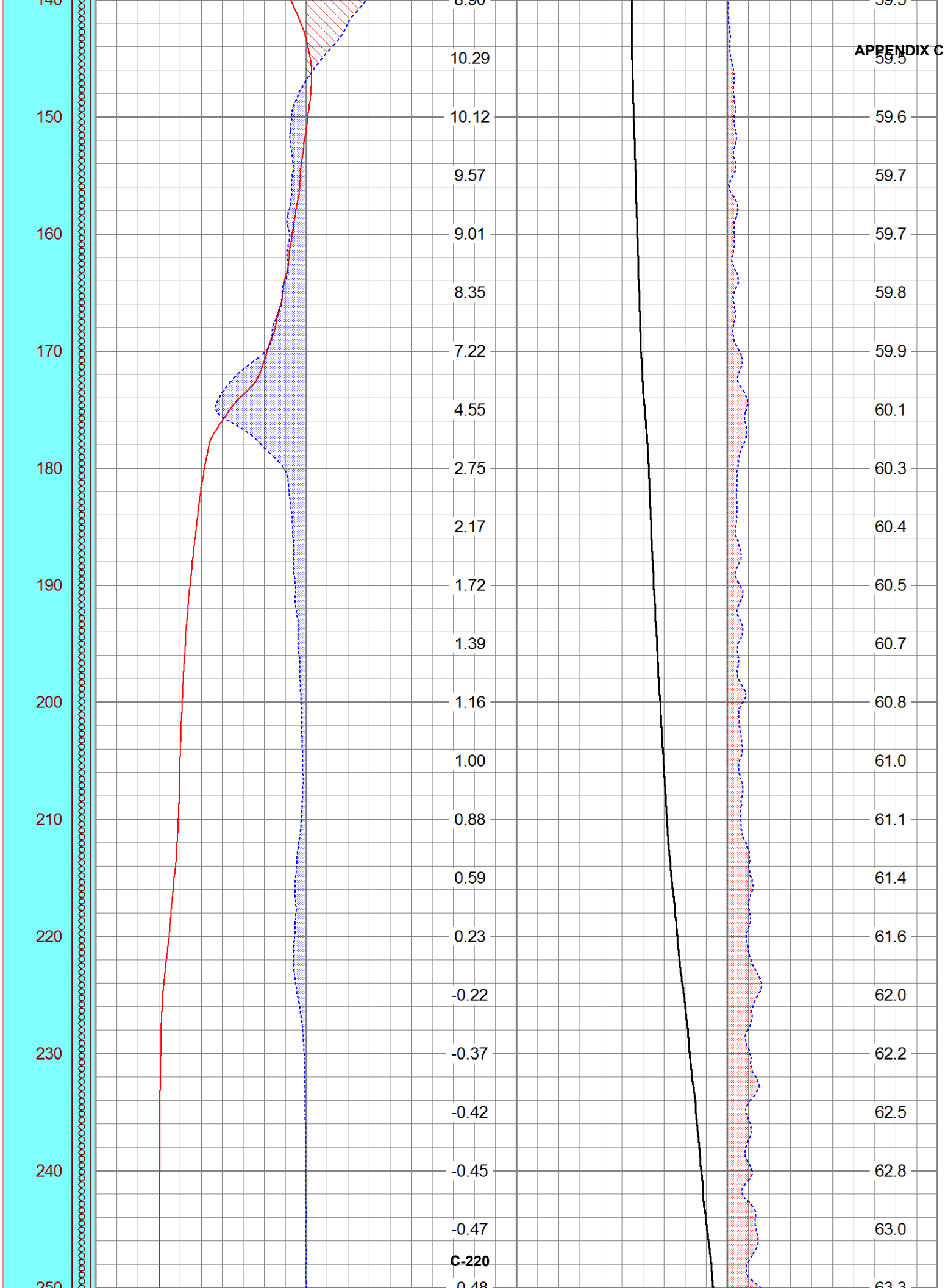
System Reading	Calibration Reference
0.000 cps	0.000
1.000 cps	1.000

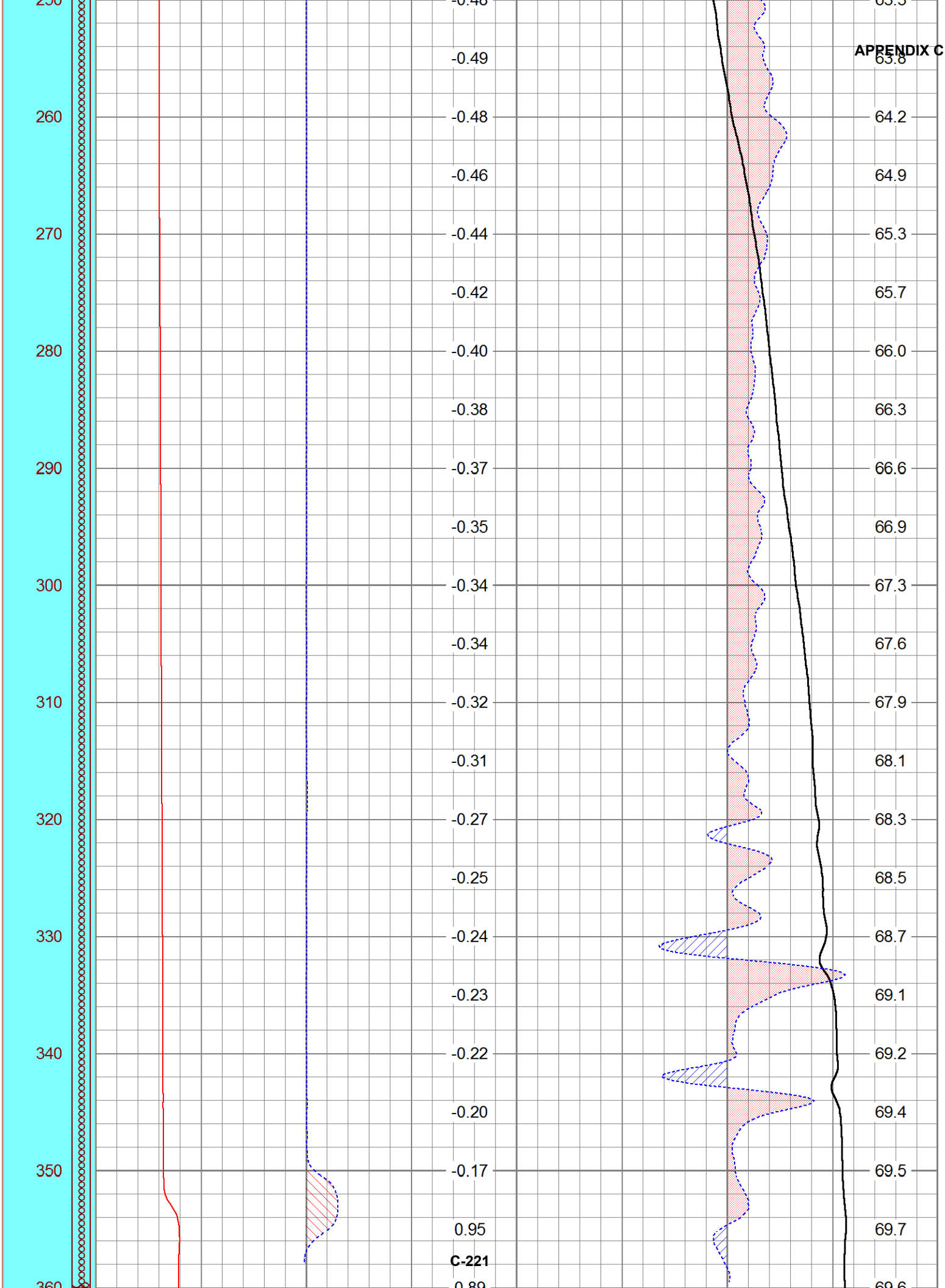
Gain: 1.000
Offset: 0.000

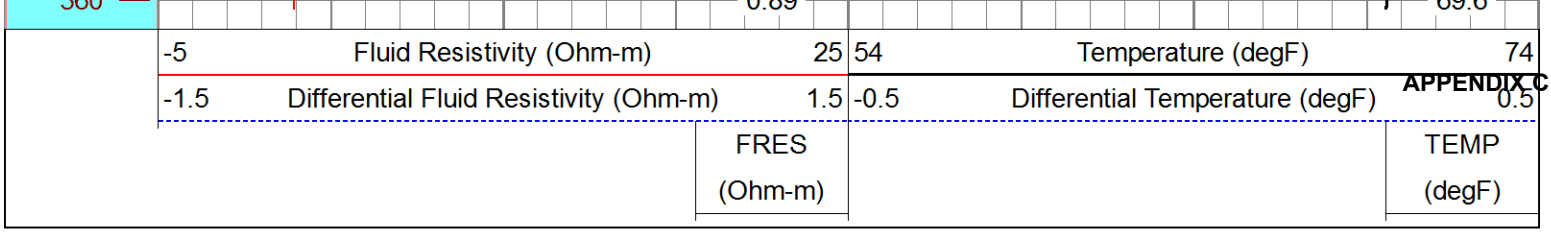
Database File	19537.db
Dataset Pathname	tmp
Presentation Format	frttemp2
Dataset Creation	Mon Apr 20 12:35:45 2015
Charted by	Depth in Feet scaled 1:120




40
50
60
70
80
90
100
110
120
130
140
22.84
20.08
19.74
18.40
18.38
18.07
17.54
16.93
15.29
15.80
14.74
13.33
12.15
6.98
4.18
3.90
3.69
3.69
3.99
4.64
6.53
8.90
58.6
58.6
58.7
58.7
58.7
58.8
58.9
58.9
59.0
59.0
59.1
59.2
59.4
59.4
59.4
59.5
59.5
59.5
59.5
Delta Temperature
FRES (Ohm-m)
Fluid Resistivity
Temperature
Differential Fluid Resistivity
4" PVC
TEMP (degF)


140
150
160
170
180
190
200
210
220
230
240
250
10.29
10.12
9.57
9.01
8.35
7.22
4.55
2.75
2.17
1.72
1.39
1.16
1.00
0.88
0.59
0.23
-0.22
-0.37
-0.42
-0.45
-0.47
-0.48
59.5
59.6
59.7
59.7
59.8
59.9
60.1
60.3
60.4
60.5
60.7
60.8
61.0
61.1
61.4
61.6
62.0
62.2
62.5
62.8
63.0
63.3


APPENDIX C
250
260
270
280
290
300
310
320
330
340
350
360
-0.49
-0.48
-0.46
-0.44
-0.42
-0.40
-0.38
-0.37
-0.35
-0.34
-0.34
-0.32
-0.31
-0.27
-0.25
-0.24
-0.23
-0.22
-0.20
-0.17
0.95
63.8
64.2
64.9
65.3
65.7
66.0
66.3
66.6
66.9
67.3
67.6
67.9
68.1
68.3
68.5
68.7
69.1
69.2
69.4
69.5
69.7
C-221


360
0.89
69.6
-5
Fluid Resistivity (Ohm-m)
25
54
Temperature (degF)
74
-1.5
Differential Fluid Resistivity (Ohm-m)
1.5
-0.5
Differential Temperature (degF)
0.5
FRES
(Ohm-m)
TEMP
(degF)

PACIFIC SURVEYS

DUAL INDUCTION GAMMA-RAY

Job No. 19537

File No.

Company CASCADE DRILLING

Well MW-8D

Field SALINAS

County MONTEREY State CA

Location

325 MONTE RD.
GPS: N 36o 43' 36" W 121o 47' 15"

Other Services:

TEMPERATURE
FLUID RESISTIVITY

				Elevation
Permanent Datum	G.L.			K.B.:
Log Measured From	G.L.	0'	above perm. datum	D.F.:
Drilling Measured From	G.L.			G.L.:

Date	04-20-2015							
Run Number	ONE							
Depth Driller	360'							
Depth Logger	355'							
Bottom Logged Interval	355'							
Top Log Interval	0'							
Open Hole Size	10.75" (0'-150')			9.875" (150'-276')			8" (250'-340')	
Type Fluid	WATER							
Density / Viscosity	N/A							
Fluid Level	14'							
Bentonite Seal	N/A							
Time Well Ready	1200							
Time Logger on Bottom	1230							
Equipment Number	PS-8							
Location	LA							
Recorded By	SCHUMACHER							
Witnessed By	A. KHALIGHI							

Borehole Record				Tubing Record			
Run Number	Bit	From	To	Size	Weight	From	To
ONE	10.75"	0'	150'				
TWO	9.875"	150'	276'				
THREE	8"	267'	360'				

Casing Record	Size	Wgt/Ft	Top	Bottom
Surface String				
Prot. String				
Production String	4" PVC	SCH 80	0'	360'
Liner				

<<< Fold Here >>>

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Comments

Calibration Report

Database File	19537.db
Dataset Pathname	dil1
Dataset Creation	Mon Apr 20 14:03:49 2015

Serial-Model: 0001-ALT
Surface Cal Performed:

APPENDIX C

Loop:	Readings Air	Readings Loop		References Air	References Loop		Results m	Results b
Deep	1432.079	3651.555	cps	0.000	612.000	mmho/m	0.276	-394.883
Medium	2031.999	14281.231	cps	0.000	1960.000	mmho/m	0.160	-325.140

Gamma Ray Calibration Report

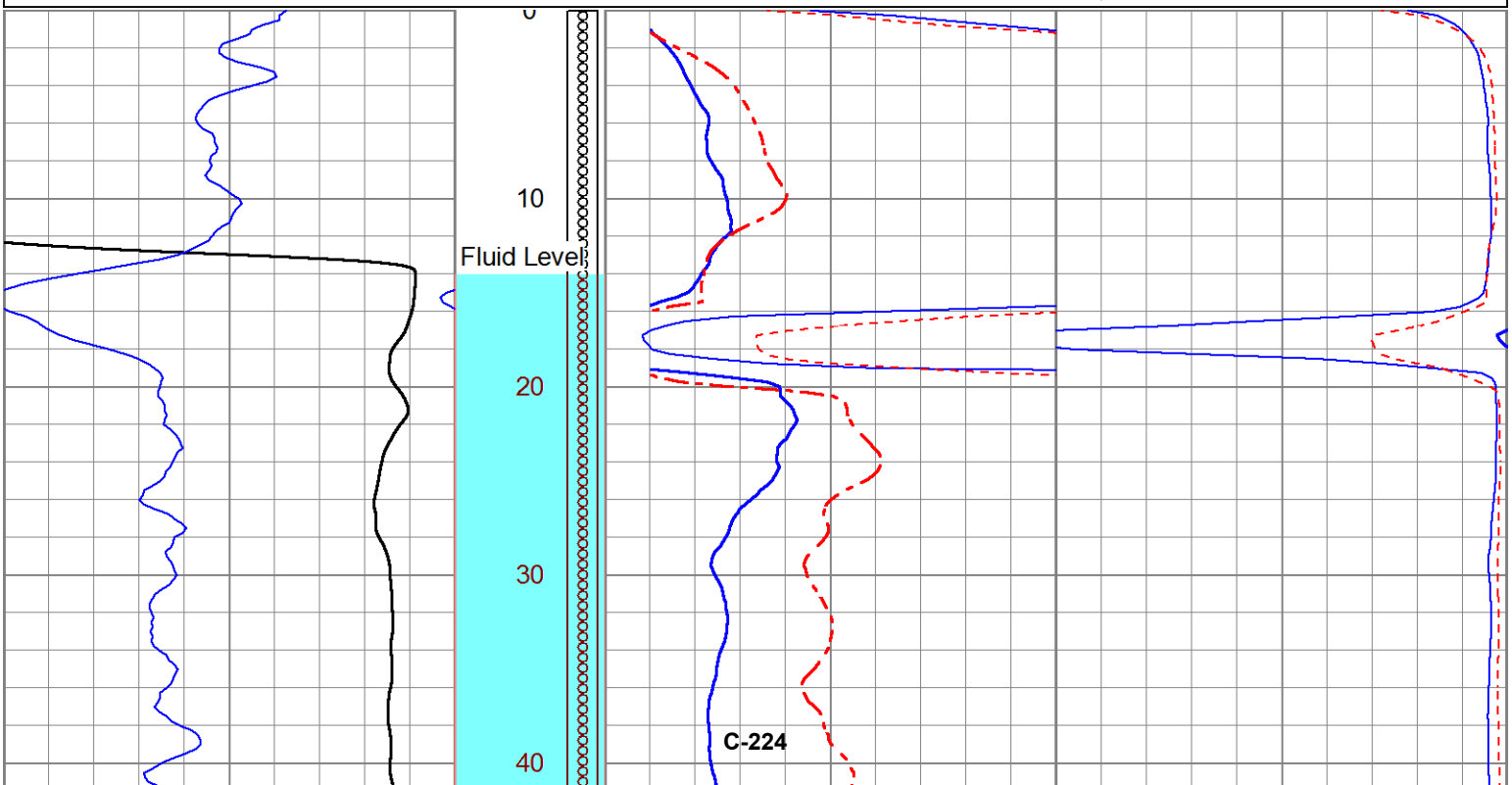
Serial Number:	PS_1	
Tool Model:	01	
Performed:	Sat Jan 10 13:10:57 2015	
Calibrator Value:	162.0	GAPI
Background Reading:	46.1	cps
Calibrator Reading:	180.8	cps
Sensitivity:	1.2020	GAPI/cps

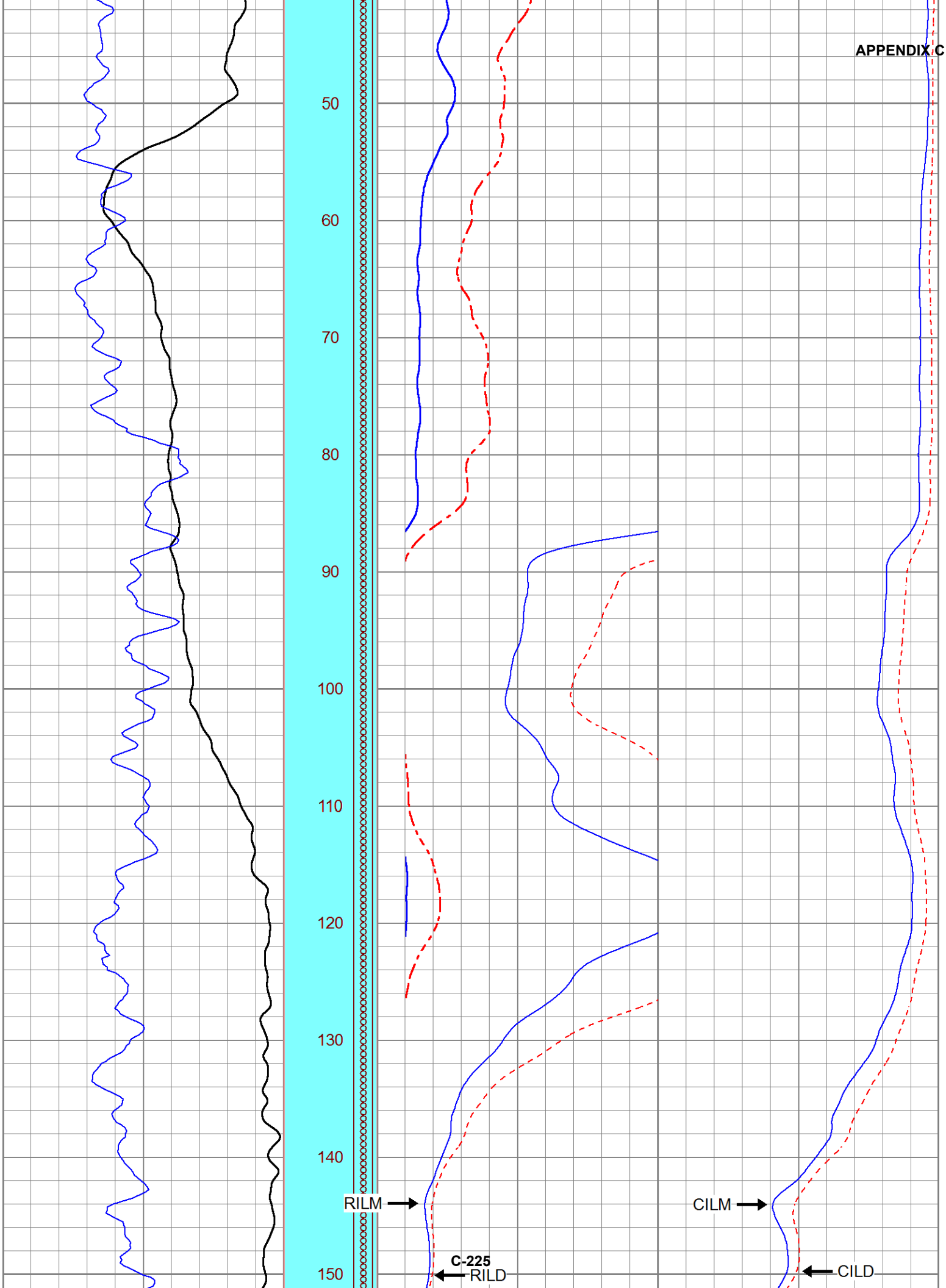
Database File	19537.db
Dataset Pathname	dil1
Presentation Format	dil
Dataset Creation	Mon Apr 20 14:03:49 2015
Charted by	Depth in Feet scaled 1:120

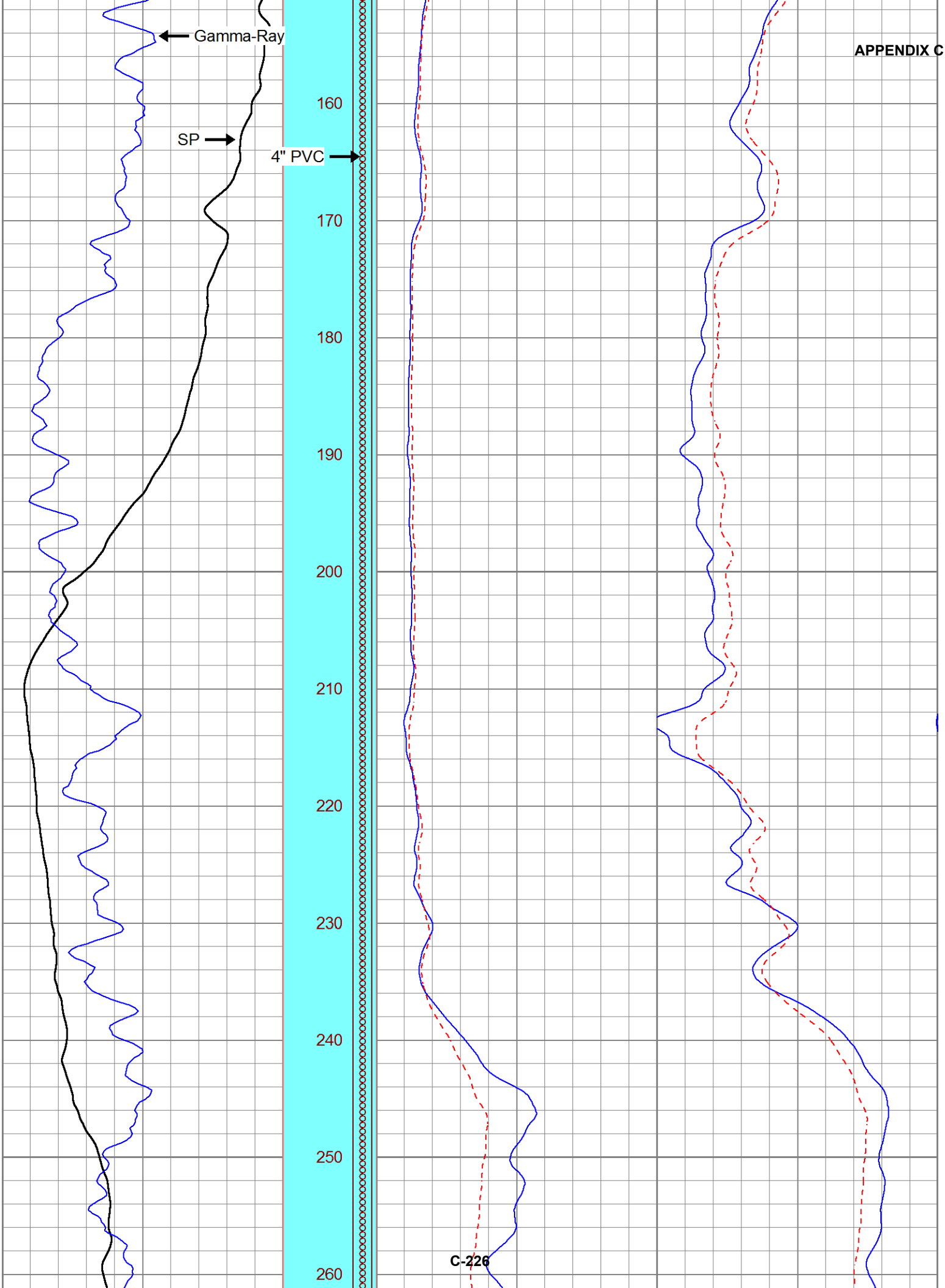
-140	SP (mV)	60
20	Gamma-Ray (GAPI)	120

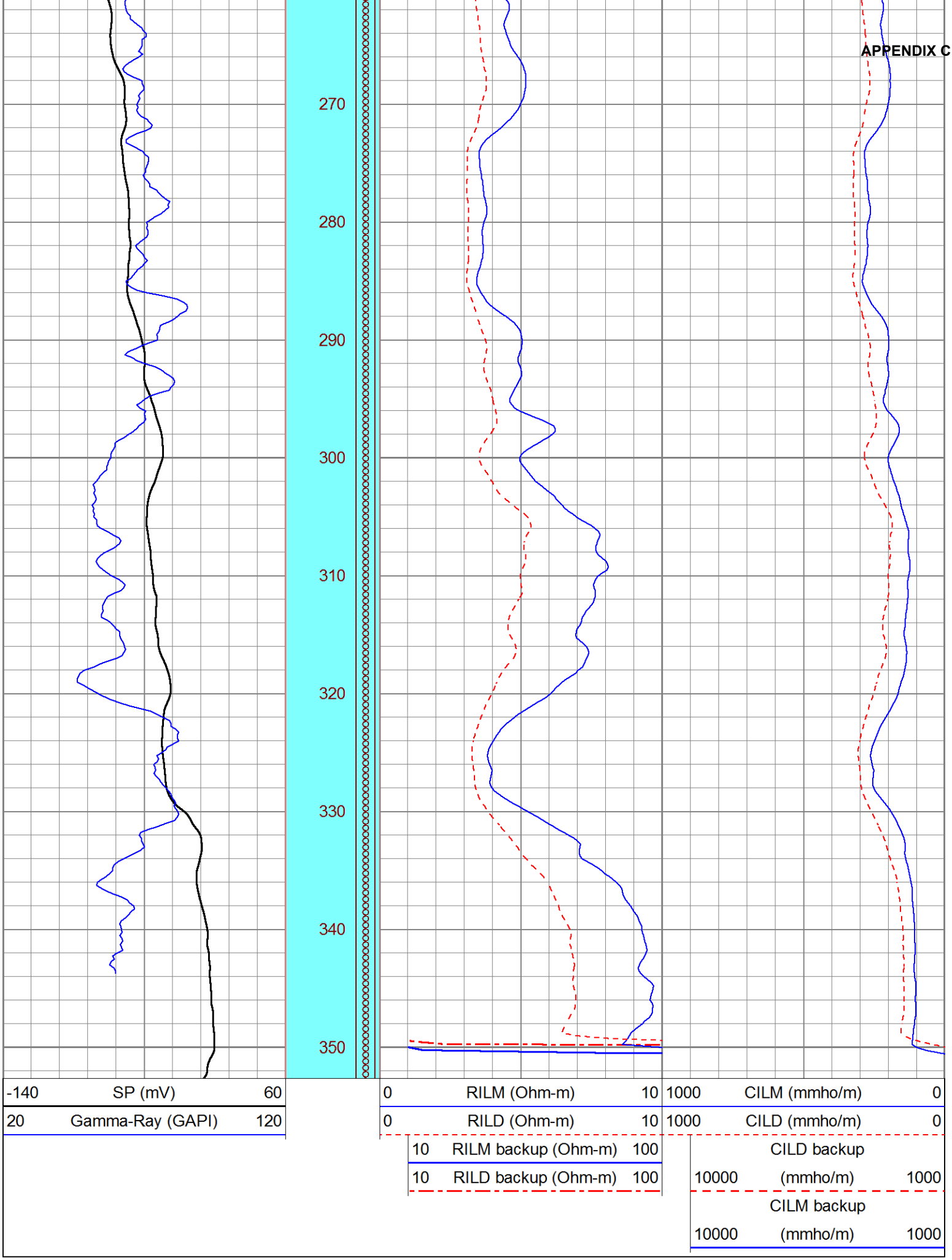
0	RILM (Ohm-m)	10
0	RILD (Ohm-m)	10
10	RILM backup (Ohm-m)	100
10	RILD backup (Ohm-m)	100

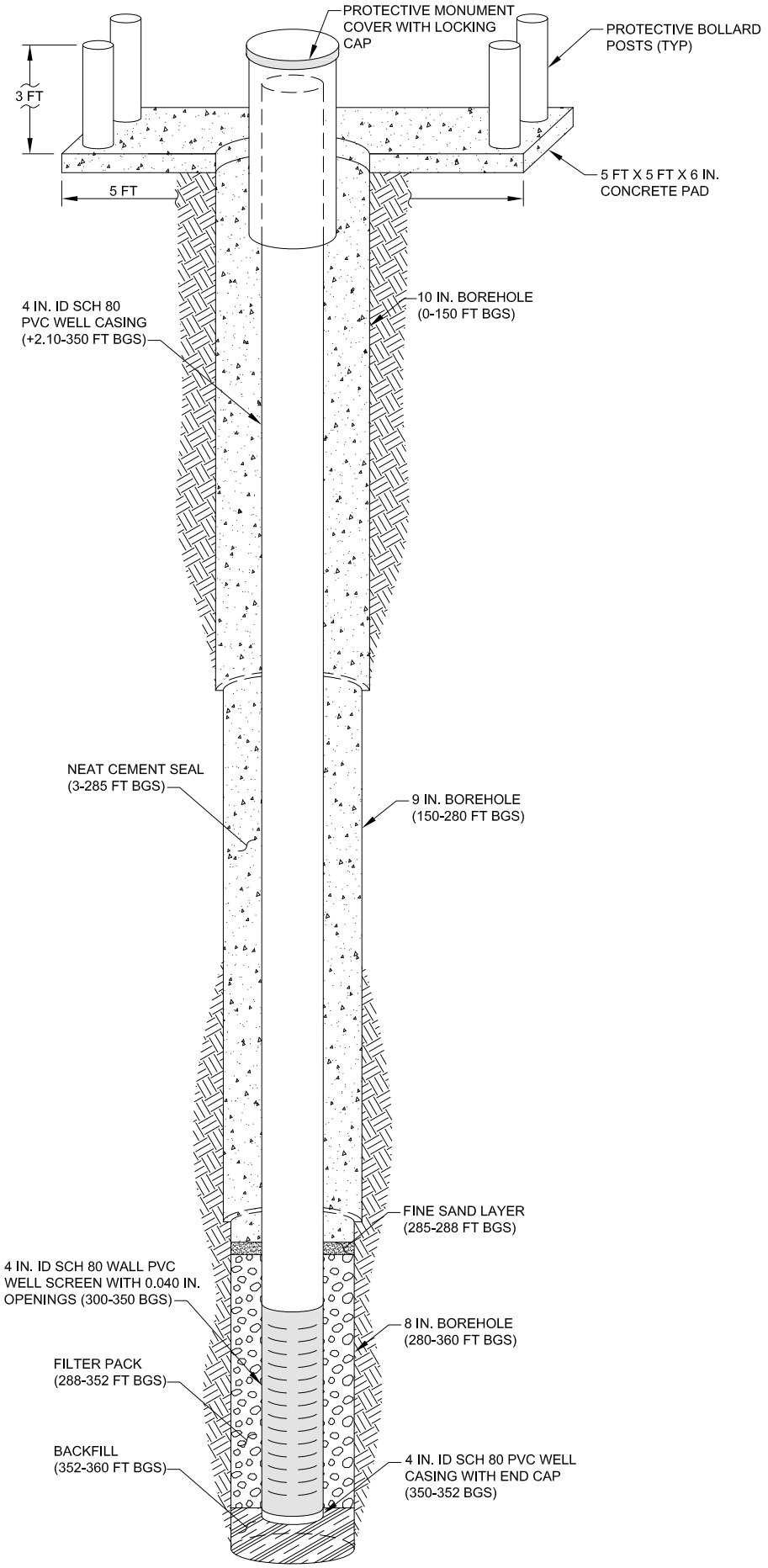
1000	CILM (mmho/m)	0
1000	CILD (mmho/m)	0
	CILD backup	
10000	(mmho/m)	1000
	CILM backup	
10000	(mmho/m)	1000




50
60
70
80
90
100
110
120
130
140
150
RILM
RILD
CILM
CILD
C-225


Gamma-Ray
SP
4" PVC
160
170
180
190
200
210
220
230
240
250
260


270
280
290
300
310
320
330
340
350
-140 SP (mV) 60
20 Gamma-Ray (GAPI) 120
0 RILM (Ohm-m) 10
0 RILD (Ohm-m) 10
10 RILM backup (Ohm-m) 100
10 RILD backup (Ohm-m) 100
1000 CILM (mmho/m) 0
1000 CILD (mmho/m) 0
CILD backup
10000 (mmho/m) 1000
CILM backup
10000 (mmho/m) 1000



WELL PROFILE

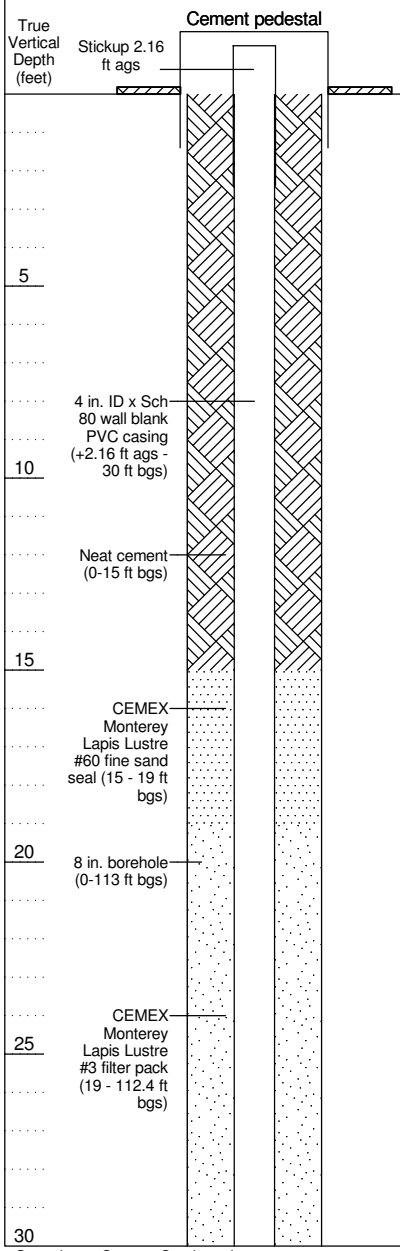
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BOREHOLE LITHOLOGIC LOG

WELL NUMBER **MPWSP MW-9S**	
CLIENT: Cal Am	LOCATION: **Marina, CA**
PROJECT NUMBER: 14077-15	**Monte Rd**
REPORT DATE:	
DRILLING CONTRACTOR: Cascade Drilling	LOGGED BY: **J. Sobolew**
DRILLER:	

		SCREEN / BLANK	TOP DEPTH (ft bgs)	BOTTOM DEPTH (ft bgs)	LENGTH (ft)	MATERIAL	WALL THICKNESS (in.)	DIAMETER (in.)	SCREEN TYPE	PERF. SIZE (in.)
DRILLING RIG TYPE	ProSonic 600T									
DRILLING METHOD	Sonic	**Blank**	**-2.16**	**30**	**32.16**	**PVC**	**Sch 80**	**4 / ID**		
SAMPLING METHOD	Core	**Screen**	**30**	**110**	**80**	**PVC**	**Sch 80**	**4 / ID**	**Slotted**	**0.04**
BOREHOLE DIAMETER	8 in	**Blank**	**110**	**112.4**	**2.4**	**PVC**	**Sch 80**	**4 / ID**		
SURFACE ELEVATION	16.26 ft NAVD88									
TOC ELEVATION	18.42 ft NAVD88 (RP)									
START DATE	6/13/15									
FINISH DATE	6/14/15									



Lithologic Log

NOTE: Grain size distribution percentages are approximate. Material code (e.g. SP) reference Unified Soil Classification visual method. Color code (e.g. 10YR 5/2) reference Munsell Soil Color Charts.

Graphic Log	Lithologic Log	Depth bgs (feet)	Sieve Sample Number	Drill Rate (ft/hr)
	SAND WITH SILT (SP-SM): dark yellowish brown (10YR 4/4), 90% sand, very fine to fine grained; 10% silt; moist sample; contains quartz, feldspar, mica, and amphibole; unconsolidated.	5		
	SILTY SAND (SM): dark olive brown (2.5Y 3/3), 75% sand, very fine to fine grained; 25% silt; low plasticity; wet sample; contains quartz, feldspar, mica, and amphibole; unconsolidated.			
	SILTY SAND (SM): greenish black (10Y 2.5/1), 70% sand, very fine to fine grained; 30% silt; low plasticity; wet sample; contains quartz, feldspar, mica, and amphibole; unconsolidated.	10		
	SAND (SP): very dark greenish gray (10Y 3/1), 100% fine grained sand; wet sample; contains quartz, feldspar, mica, and amphibole; unconsolidated.	15		35
	SAND WITH CLAY (SP-SC): (5BG 2.5/1), 90% fine grained sand; 5% silt; 5% clay, low plasticity; wet sample; contains quartz, feldspar, mica, and amphibole; unconsolidated.	20		
	SAND (SP): dark greenish gray (5GY 4/1), 100% fine to medium grained sand, subangular to subrounded; wet sample; contains quartz, feldspar, mica, and amphibole; grading becomes fine to coarse sand from 30 ft to 32 ft; unconsolidated.	25		
		30		

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WELL NUMBER **MPWSP MW-9S**

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am
PROJECT NUMBER 14077-15
LOCATION **Marina, CA**

True Vertical Depth (feet)	(continued)	Graphic Log	Lithologic Log NOTE: Grain size distribution percentages are approximate. Material code (e.g. SP) reference Unified Soil Classification visual method. Color code (e.g. 10YR 5/2) reference Munsell Soil Color Charts.	Depth bgs (feet)	Sieve Sample Number	Drill Rate (ft/hr)
	4 in. ID x Sch 80 wall PVC well screen with 0.040 in. slots (30-110 ft bgs)		SAND (SP): dark greenish gray (10GY 4/1), 100% sand, subangular to subrounded, very fine to fine grained; wet sample; contains quartz, feldspar, mica, and amphibole; unconsolidated.			
35			SAND (SP): dark greenish gray (5GY 4/1), 100% fine to medium grained sand, subangular to subrounded; wet sample; contains quartz, feldspar, mica, and amphibole; unconsolidated.	35		
			SANDY SILT (ML): very dark greenish gray (5GY 3/1), 40% silt; 30% sand, very fine grained; 30% clay, low to medium plasticity; moist sample; contains quartz, feldspar, mica, and amphibole.			
40				40		
45				45		
			SAND (SP): very dark greenish gray (5GY 3/1), 95% fine to coarse grained sand, subangular to subrounded; 5% silt; wet sample; contains quartz, feldspar, mica, and amphibole; unconsolidated.		
			CLAY (CL): very dark greenish gray (5GY 3/1), 80% clay, high plasticity; 15% silt; 5% sand, very fine to fine grained; moist sample; contains shells.			
50			SILT (ML): black (N2.5), 70% silt; 30% clay, medium plasticity; contains shells from 56 ft to 57 ft.	50		35
55				55		
60				60		
			SAND WITH SILT (SP-SM): very dark gray (N3), 90% sand, subangular to subrounded, very fine to fine grained; 10% silt; moist sample; contains quartz, feldspar, mica, and amphibole; unconsolidated.		
65			SILT (ML): very dark gray (N3), 70% silt; 30% clay, medium plasticity; fine grained sand; moist sample; contains shells from 67 ft to 69 ft.	65		
70			SILT WITH SAND (ML): very dark gray (N3), 80% silt; 15% sand, very fine sand; 5% clay, low to medium plasticity; moist sample.	70		

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WELL NUMBER **MPWSP MW-9S**

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am
PROJECT NUMBER 14077-15
LOCATION **Marina, CA**

True Vertical Depth (feet)	(continued)	Graphic Log	Lithologic Log NOTE: Grain size distribution percentages are approximate. Material code (e.g. SP) reference Unified Soil Classification visual method. Color code (e.g. 10YR 5/2) reference Munsell Soil Color Charts.	Depth bgs (feet)	Sieve Sample Number	Drill Rate (ft/hr)
75			SAND WITH SILT (SP-SM): very dark gray (N3), 90% sand, very fine to fine sand; 10% silt; moist to wet sample; contains quartz, mica, and amphibole; unconsolidated.	75		35
80				80		
85				85		
90				90		
95			SILTY SAND (SM): very dark gray (N3), 60% sand, very fine grained; 40% silt; wet sample; contains quartz, feldspar, mica, and amphibole; unconsolidated.	95		
100			SAND (SP): greenish black (5GY 2.5/1), 100% fine to coarse grained sand, subangular to subrounded; wet sample; contains quartz, feldspar, mica, and amphibole; unconsolidated.	100		25
105			SAND (SP): dark olive gray (5Y 3/2), 100% fine to coarse grained sand, subangular to subrounded; moist sample; contains quartz, feldspar, mica, and amphibole.	105		
110			CLAY (CL): greenish black (5GY 2.5/1), 85% clay, low plasticity; 15% silt. SAND (SP): grayish green (5G 5/2), 100% fine to medium grained sand, subangular to subrounded; wet sample; contains quartz, feldspar, and mica; unconsolidated.	110		

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WELL NUMBER **MPWSP MW-9S**

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am
PROJECT NUMBER 14077-15
LOCATION **Marina, CA**

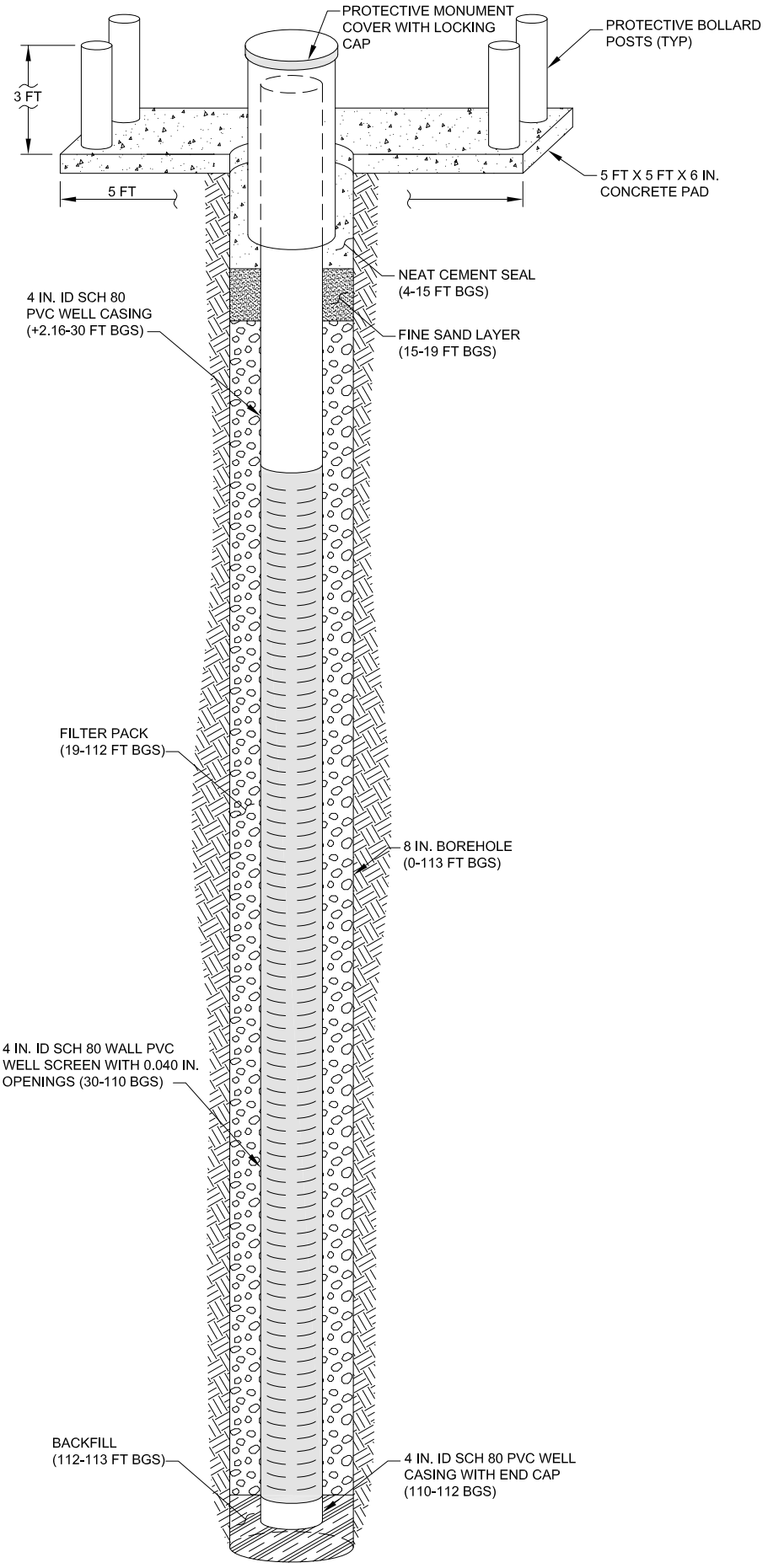
(continued)

Lithologic Log

NOTE: Grain size distribution percentages are approximate. Material code (e.g. SP) reference Unified Soil Classification visual method. Color code (e.g. 10YR 5/2) reference Munsell Soil Color Charts.

True Vertical Depth (feet)	Graphic Log	Depth bgs (feet)	Sieve Sample Number	Drill Rate (ft/hr)
Blank casing with end cap (110-112.4 ft bgs)				25
Backfill with native material (112.4-113 ft bgs) TD 113 ft bgs	CLAY (CL): greenish gray (5GY 6/1), 100% clay, high plasticity; moist sample.			
	Bottom of borehole at 113 feet.			

WELL CONSTRUCTION LOG MPWSP MW TM LITH ALL WELLS.GPJ GEOSCIENCE.GDT 7/7/16



WELL PROFILE

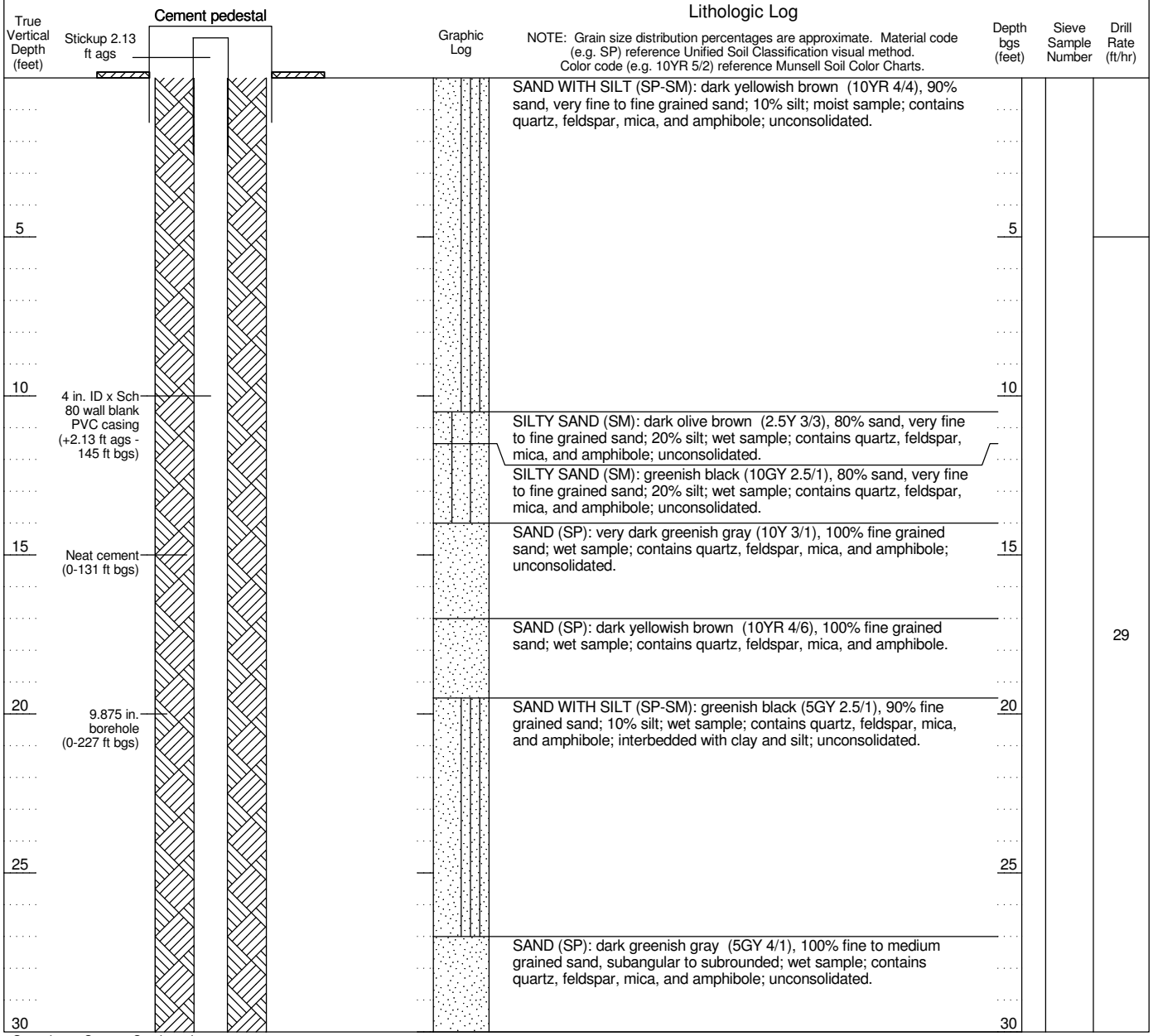
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BOREHOLE LITHOLOGIC LOG

WELL NUMBER **MPWSP MW-9M**	
CLIENT: Cal Am	LOCATION: **Marina, CA**
PROJECT NUMBER: 14077-15	**Monte Rd**
REPORT DATE:	
DRILLING CONTRACTOR: Cascade Drilling	LOGGED BY: **A. Khalighi**
DRILLER: D. King	

		SCREEN / BLANK	TOP DEPTH (ft bgs)	BOTTOM DEPTH (ft bgs)	LENGTH (ft)	MATERIAL	WALL THICKNESS (in.)	DIAMETER (in.)	SCREEN TYPE	PERF. SIZE (in.)
DRILLING RIG TYPE	ProSonic 600T									
DRILLING METHOD	Sonic	**Blank**	**-2.13**	**145**	**147.13**	**PVC**	**Sch 80**	**4 /**		
SAMPLING METHOD	Core	**Screen**	**145**	**225**	**80**	**PVC**	**Sch 80**	**4 / ID**	**Slotted**	**0.04**
BOREHOLE DIAMETER	9.875 in	**Blank**	**225**	**227**	**2**	**PVC**	**Sch 80**	**4 / ID**		
SURFACE ELEVATION	16.19 ft NAVD88									
TOC ELEVATION	18.32 ft NAVD88 (RP)									
START DATE	6/03/15									
FINISH DATE	6/13/15									



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WELL NUMBER **MPWSP MW-9M**

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am
PROJECT NUMBER 14077-15
LOCATION **Marina, CA**

True Vertical Depth (feet)	(continued)	Graphic Log	Lithologic Log NOTE: Grain size distribution percentages are approximate. Material code (e.g. SP) reference Unified Soil Classification visual method. Color code (e.g. 10YR 5/2) reference Munsell Soil Color Charts.	Depth bgs (feet)	Sieve Sample Number	Drill Rate (ft/hr)
			SILTY SAND (SM): dark greenish gray (5GY 4/1), 75% fine grained sand; 15% silt; 10% clay, low to medium plasticity; wet sample; contains quartz, feldspar, mica, and amphibole; unconsolidated.			
35			SAND (SP): dark greenish gray (5GY 4/1), 100% fine grained sand; wet sample; contains quartz, feldspar, mica, and amphibole; unconsolidated.	35		
			SAND (SP): gray (N5), 100% fine to medium grained sand, subangular to subrounded; wet sample; contains quartz, feldspar, mica, and amphibole; unconsolidated.			
40			SANDY SILT (ML): very dark greenish gray (5GY 3/1), 40% silt; 30% sand, very fine grained sand; 30% clay, low to medium plasticity; moist sample; contains quartz, feldspar, mica, and amphibole; unconsolidated.	40		
45			SAND (SP): very dark greenish gray (5GY 3/1), 95% fine to coarse grained sand, subangular to subrounded; 5% silt; wet sample; contains quartz, feldspar, mica, and amphibole; unconsolidated.	45		
			CLAY (CL): very dark greenish gray (5GY 3/1), 80% clay, high plasticity; 20% silt; trace sand; moist sample; unconsolidated.			
50			SAND (SP): greenish black (5G 2.5/1), 100% fine grained sand; wet sample; contains quartz, feldspar, mica, and amphibole; unconsolidated.	50		29
55			SILT (ML): black (N2.5), 70% silt; 30% clay, medium to high plasticity; moist sample.	55		
60				60		
65				65		
			SILT WITH SAND (ML): black (N2.5), 80% silt; 15% sand, very fine grained sand; 5% clay, low to medium plasticity; moist sample.			
70				70		

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WELL NUMBER **MPWSP MW-9M**

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am
PROJECT NUMBER 14077-15
LOCATION **Marina, CA**

True Vertical Depth (feet)	(continued)	Graphic Log	Lithologic Log NOTE: Grain size distribution percentages are approximate. Material code (e.g. SP) reference Unified Soil Classification visual method. Color code (e.g. 10YR 5/2) reference Munsell Soil Color Charts.	Depth bgs (feet)	Sieve Sample Number	Drill Rate (ft/hr)
						29
75			SAND WITH SILT (SP-SM): black (N2.5), 90% sand, very fine to fine grained sand; 10% silt; moist to wet sample; contains quartz, feldspar, mica, and amphibole; unconsolidated.	75		
80				80		
85				85		
90				90		
			SILTY SAND (SM): black (N2.5), 60% sand, very fine grained sand; 40% silt; wet sample; contains quartz, feldspar, mica, and amphibole; unconsolidated.			15
95			SAND (SP): greenish black (5GY 2.5/1), 100% fine to coarse grained sand, subangular to subrounded; wet sample; contains quartz, feldspar, mica, and amphibole; unconsolidated.	95		
100				100		
105			SAND (SP): dark olive gray (5Y 3/2), 100% fine to coarse grained sand, subangular to subrounded; moist sample; contains quartz, feldspar, mica, and amphibole.	105		
110			SAND (SP): greenish black (10Y 2.5/1), 95% fine to coarse grained sand; 5% fine gravel; moist sample; contains quartz, feldspar, mica,	110		

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WELL NUMBER **MPWSP MW-9M**

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am
PROJECT NUMBER 14077-15
LOCATION **Marina, CA**

(continued)

True Vertical Depth (feet)	Graphic Log	Lithologic Log NOTE: Grain size distribution percentages are approximate. Material code (e.g. SP) reference Unified Soil Classification visual method. Color code (e.g. 10YR 5/2) reference Munsell Soil Color Charts.	Depth bgs (feet)	Sieve Sample Number	Drill Rate (ft/hr)
		and amphibole.			
		CLAY (CL): greenish gray (5G 6/1), 100% clay, high plasticity; moist sample.			15
115			115		
120			120		
125			125		
		SILTY SAND (SM): very dark greenish gray (5GY 3/1), 70% fine grained sand; 30% silt; moist sample; contains quartz, feldspar, mica, and amphibole; unconsolidated.			
		CLAY (CL): dark greenish gray (5GY 4/1), 100% clay, high plasticity; moist sample.			
130			130		
		SAND (SP): dark greenish gray (5GY 4/1), 100% fine to medium grained sand; wet sample; contains quartz, feldspar, mica, and amphibole; unconsolidated.			13
135			135		
140			140		
		SAND WITH GRAVEL (SP): dark greenish gray (5GY 4/1), 70% fine to coarse grained sand, subrounded to rounded; 20% fine to coarse gravel subrounded to rounded fine gravel and rounded coarse gravel; 10% cobbles; wet sample; contains quartz, feldspar, mica, and amphibole; contains Monterey Shale and round cobbles; unconsolidated.			
145			145		
150			150		

CEMEX Monterey Lapis Lustre #60 fine sand seal (131 - 135 ft bgs)

CEMEX Monterey Lapis Lustre #3 filter pack (135 - 227 ft bgs)

4 in. ID x Sch 80 wall PVC well screen with 0.040 in. slots (145-225 ft bgs)

WELL CONSTRUCTION LOG MPWSP MW TM LITH ALL WELLS.GPJ GEOSCIENCE.GDT 7/7/16

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WELL NUMBER **MPWSP MW-9M**

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am
PROJECT NUMBER 14077-15
LOCATION **Marina, CA**

True Vertical Depth (feet)	(continued)	Graphic Log	Lithologic Log NOTE: Grain size distribution percentages are approximate. Material code (e.g. SP) reference Unified Soil Classification visual method. Color code (e.g. 10YR 5/2) reference Munsell Soil Color Charts.	Depth bgs (feet)	Sieve Sample Number	Drill Rate (ft/hr)
			SAND (SP): dark greenish gray (5GY 4/1), 95% fine to coarse grained sand, subangular to subrounded; 5% fine gravel subangular to subrounded; contains quartz, feldspar, and amphibole; unconsolidated.			13
155			SAND WITH GRAVEL (SP): dark greenish gray (5GY 4/1), 65% fine to coarse grained sand, subangular to subrounded; 25% fine to coarse gravel; 10% cobbles; contains quartz, feldspar, and amphibole; contains Monterey Shale, round gravel and igneous rocks as cobbles; unconsolidated.	155		
			GRAVEL WITH SAND (GP): grayish brown (2.5Y 5/2), 65% fine to coarse gravel subangular to subrounded; 20% fine to coarse grained sand, subangular to subrounded, predominately medium to coarse grained sand; 15% cobbles; wet sample; contains quartz, feldspar, and amphibole; contains inclusions of shales and various igneous rocks as gravel; unconsolidated.			
160				160		2.5
			SAND (SP): grayish brown (2.5Y 5/2), 90% fine to coarse grained sand, subangular to subrounded; 10% fine to coarse gravel rounded; wet sample; contains quartz, feldspar, mica, and amphibole; unconsolidated.			
165			GRAVEL WITH SAND (GP): olive brown (2.5Y 4/3), 70% fine to coarse gravel rounded; 20% fine to coarse grained sand, subangular to subrounded; 10% cobbles; moist sample; contains quartz, feldspar, mica, and amphibole; contains round cobbles; grading with depth: cobbles increase to 25%, sand to 20% and gravel to 55%.	165		
			SAND WITH GRAVEL (SP): very dark greenish gray (5GY 3/1), 70% fine to coarse grained sand, subangular to subrounded; 30% fine to coarse gravel rounded; wet sample; contains quartz, feldspar, mica, and amphibole; unconsolidated.			
170				170		
			SAND (SP): dark grayish brown (2.5Y 4/2), 100% fine to medium grained sand, subangular to subrounded; wet sample; contains quartz, feldspar, mica, and amphibole; unconsolidated.			
175			GRAVEL WITH SAND (GP): dark olive brown (2.5Y 3/3), 75% fine to coarse gravel rounded; 20% fine to coarse grained sand, subangular to subrounded; 5% cobbles; contains quartz, feldspar, mica, and amphibole; unconsolidated.	175		
			SAND (SP): gray (2.5Y 5/1), 100% fine to coarse grained sand, subangular to subrounded; wet sample; contains quartz, feldspar, mica, and amphibole; unconsolidated.			
180				180		
			GRAVEL WITH SAND (GP): gray (2.5Y 5/1), 70% fine to coarse gravel subrounded to rounded; 15% fine to coarse grained sand, subangular to subrounded; 15% cobbles; wet sample; contains quartz, feldspar, mica, and amphibole; includes Monterey Shale with various igneous and sedimentary rocks; unconsolidated.			20
185				185		
			SAND WITH GRAVEL (SP): dark grayish brown (2.5Y 4/2), 80% medium to coarse grained sand, subangular to subrounded; 20% fine to coarse gravel rounded; wet sample; contains quartz, feldspar, mica, and amphibole; Includes Monterey Shale and various igneous and sedimentary rocks as gravel; unconsolidated.			
190				190		

WELL CONSTRUCTION LOG MPWSP MW TM LITH ALL WELLS.GPJ GEOSCIENCE.GDT 7/7/16

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WELL NUMBER **MPWSP MW-9M**

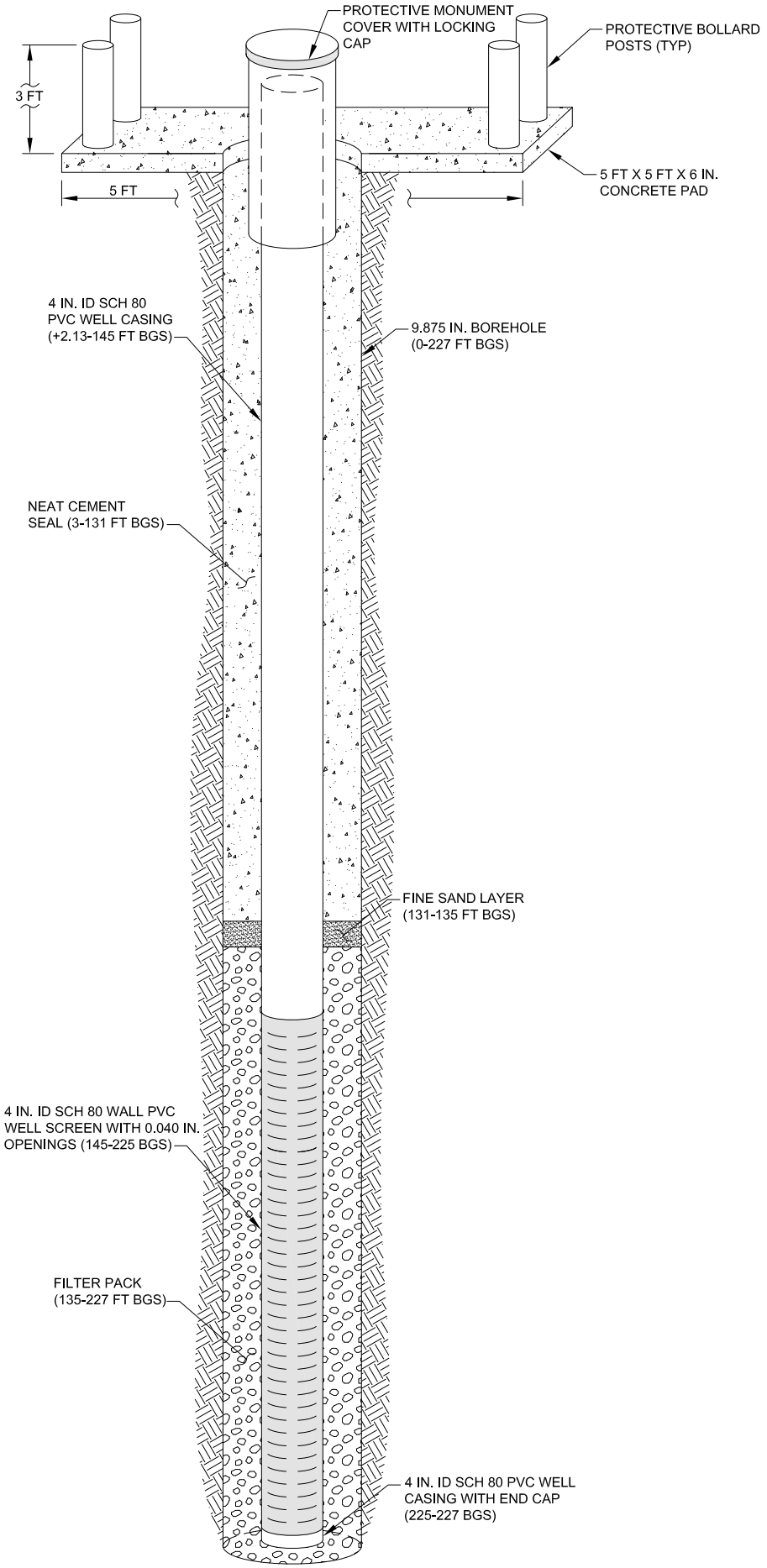
BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am
PROJECT NUMBER 14077-15
LOCATION **Marina, CA**

True Vertical Depth (feet)	(continued)	Graphic Log	Lithologic Log NOTE: Grain size distribution percentages are approximate. Material code (e.g. SP) reference Unified Soil Classification visual method. Color code (e.g. 10YR 5/2) reference Munsell Soil Color Charts.	Depth bgs (feet)	Sieve Sample Number	Drill Rate (ft/hr)
195			GRAVEL (GP): dark grayish brown (2.5Y 4/2), 70% fine to coarse gravel subrounded to rounded, subrounded to rounded; 30% cobbles; subrounded to rounded; wet sample; includes round cobbles and Monterey Shale with various igneous and sedimentary rocks; unconsolidated.	195		
			GRAVEL WITH SAND (GP): dark grayish brown (2.5Y 4/2), 50% fine to coarse gravel subrounded to rounded coarse gravel; 45% medium to coarse grained sand, subangular to subrounded; 5% cobbles; contains quartz, feldspar, mica, and amphibole; contains subrounded and rounded cobbles and Monterey Shale; unconsolidated.			20
200			SAND (SP): dark brown (7.5YR 3/4), 100% fine grained sand; trace fine gravel; wet sample; contains quartz, feldspar, mica, and amphibole; contains weakly cemented clasts; trace gravel at 207 ft; unconsolidated.	200		
205				205		
210			SAND (SP): dark brown (7.5YR 3/4), 100% fine to medium grained sand; contains quartz, feldspar, mica, and amphibole; contains weakly cemented clasts that increase in quantity; unconsolidated.	210		
215				215		16
220				220		
225	Blank casing with end cap (225-227 ft bgs) TD 227 ft bgs		Bottom of borehole at 227 feet.	225		

WELL CONSTRUCTION LOG MPWSP MW TM LITH ALL WELLS.GPJ GEOSCIENCE.GDT 7/7/16

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WELL PROFILE

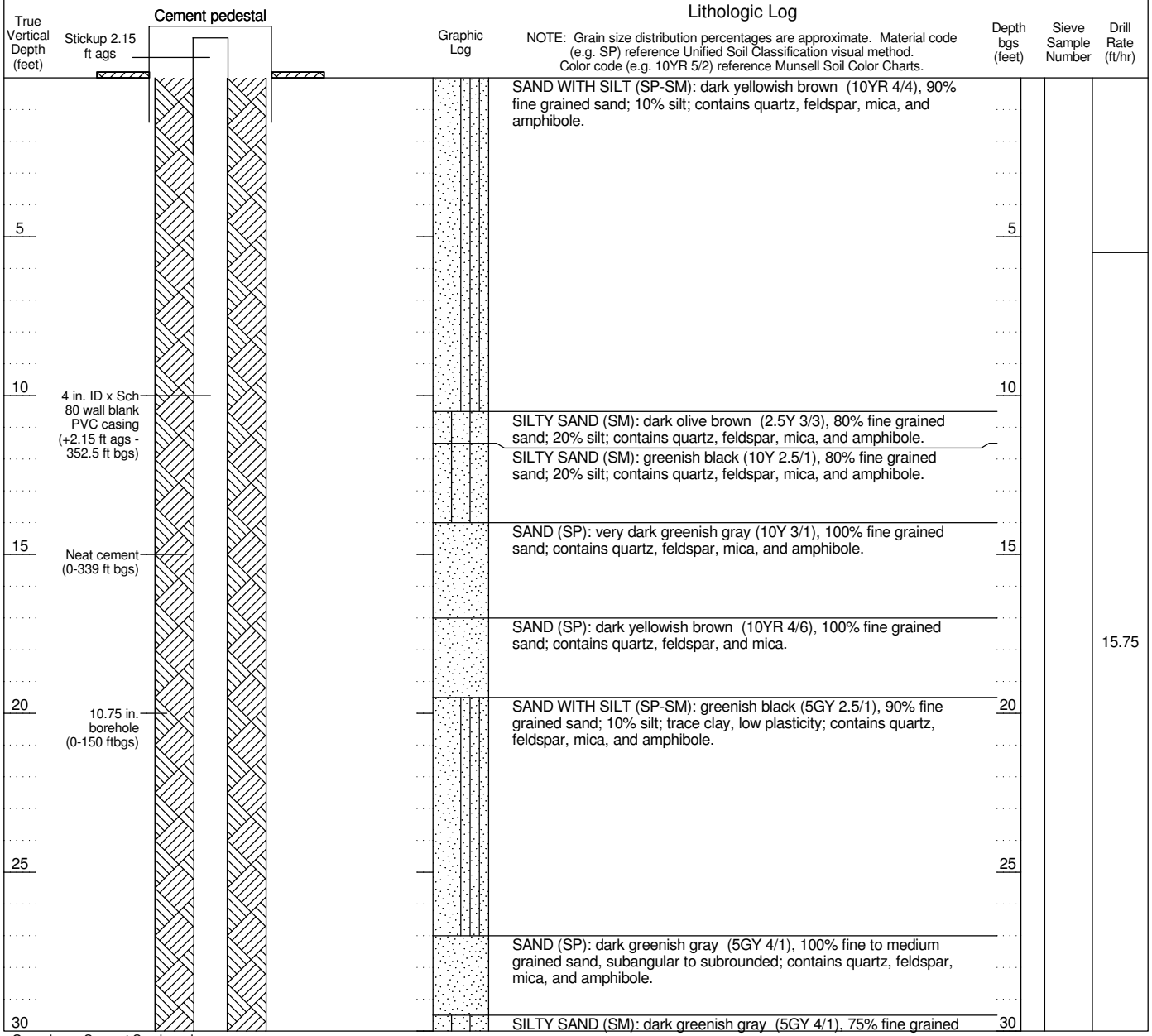
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BOREHOLE LITHOLOGIC LOG

WELL NUMBER **MPWSP MW-9D**	
CLIENT: Cal Am	LOCATION: **Marina, CA**
PROJECT NUMBER: 14077-15	**Monte Rd**
REPORT DATE:	
DRILLING CONTRACTOR: Cascade Drilling	LOGGED BY: **A. Khalighi and E. Crow-Willard**
DRILLER: D. King	

		SCREEN / BLANK	TOP DEPTH (ft bgs)	BOTTOM DEPTH (ft bgs)	LENGTH (ft)	MATERIAL	WALL THICKNESS (in.)	DIAMETER (in.)	SCREEN TYPE	PERF. SIZE (in.)
DRILLING RIG TYPE	ProSonic 600T									
DRILLING METHOD	Sonic	**Blank**	**-2.15**	**352.5**	**354.65**	**PVC**	**Sch 80**	**4 / ID**		
SAMPLING METHOD	Core	**Screen**	**352.5**	**392.5**	**40**	**PVC**	**Sch 80**	**4 / ID**	**Slotted**	**0.04**
BOREHOLE DIAMETER	10.75, 9.875, 8 in	**Blank**	**392.5**	**395**	**2.5**	**PVC**	**Sch 80**	**4 / ID**		
SURFACE ELEVATION	16.17 ft NAVD88									
TOC ELEVATION	18.32 ft NAVD88 (RP)									
START DATE	5/15/15									
FINISH DATE	6/03/15									



WELL CONSTRUCTION LOG MPWSP MW TM LITH ALL WELLS.GPJ GEOSCIENCE.GDT 7/7/16

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WELL NUMBER **MPWSP MW-9D**

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am
PROJECT NUMBER 14077-15
LOCATION **Marina, CA**

(continued)

True Vertical Depth (feet)	Lithologic Log	Depth bgs (feet)	Sieve Sample Number	Drill Rate (ft/hr)
	sand; 15% silt; 10% clay, low to medium plasticity; contains quartz, feldspar, mica, and amphibole.			
	SAND (SP): dark greenish gray (5GY 4/1), 100% fine grained sand; contains quartz, feldspar, mica, and amphibole.			15.75
35		35		
	SAND (SP): gray (N5), 100% fine to medium grained sand, subangular to subrounded; contains quartz, feldspar, mica, and amphibole.			
40	SANDY SILT (MH): very dark greenish gray (5G 3/1), 40% silt; 30% fine grained sand; 30% clay, medium to high plasticity; contains quartz, feldspar, mica, and amphibole.	40		
45		45		
	CLAYEY SAND (SC): very dark greenish gray (5G 3/1), 70% fine grained sand; 15% silt; 15% clay, no to low plasticity; contains quartz, feldspar, mica, and amphibole.			
	SAND (SP): very dark greenish gray (5G 3/1), 95% fine to coarse grained sand, subangular to subrounded; 5% silt; contains quartz, feldspar, mica, and amphibole; sea shells.			
50	FAT CLAY (CH): very dark greenish gray (5GY 3/1), 75% clay, high plasticity; 20% silt; 5% fine grained sand.	50		
	SAND (SP): greenish black (5GY 2.5/1), 100% fine grained sand; contains quartz, feldspar, mica, and amphibole.			
	SILT (MH): black (N2.5), 70% silt; 30% clay, medium to high plasticity; trace sand; black ash spots, more sand with depth.			
55		55		
60		60		
65		65		
	SILT WITH SAND (ML): black (N2.5), 80% silt; 15% fine grained sand; 5% clay, low to medium plasticity.			
70		70		

NOTE: Grain size distribution percentages are approximate. Material code (e.g. SP) reference Unified Soil Classification visual method. Color code (e.g. 10YR 5/2) reference Munsell Soil Color Charts.

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WELL NUMBER **MPWSP MW-9D**

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am
PROJECT NUMBER 14077-15
LOCATION **Marina, CA**

True Vertical Depth (feet)	(continued)	Graphic Log	Lithologic Log NOTE: Grain size distribution percentages are approximate. Material code (e.g. SP) reference Unified Soil Classification visual method. Color code (e.g. 10YR 5/2) reference Munsell Soil Color Charts.	Depth bgs (feet)	Sieve Sample Number	Drill Rate (ft/hr)
75			SAND WITH SILT (SP-SM): black (N2.5), 90% fine grained sand; 10% silt; contains quartz, feldspar, mica, and amphibole.	75	1	
80				80		
85				85		
90				90	2	
			SILTY SAND (SM): black (N2.5), 60% fine grained sand; 40% silt; contains quartz, feldspar, mica, and amphibole.			
95			SAND (SP): greenish black (5GY 2.5/1), 100% fine to coarse grained sand, subangular to subrounded; contains quartz, feldspar, mica, and amphibole.	95		
100				100		
105			SAND (SP): dark olive gray (5Y 3/2), 100% fine to coarse grained sand, subangular to subrounded; contains quartz, feldspar, and mica.	105	3	
110			SAND (SP): dark gray (5Y 4/1), 95% fine to coarse grained sand, subangular to subrounded; 5% fine gravel subangular to subrounded;	110		

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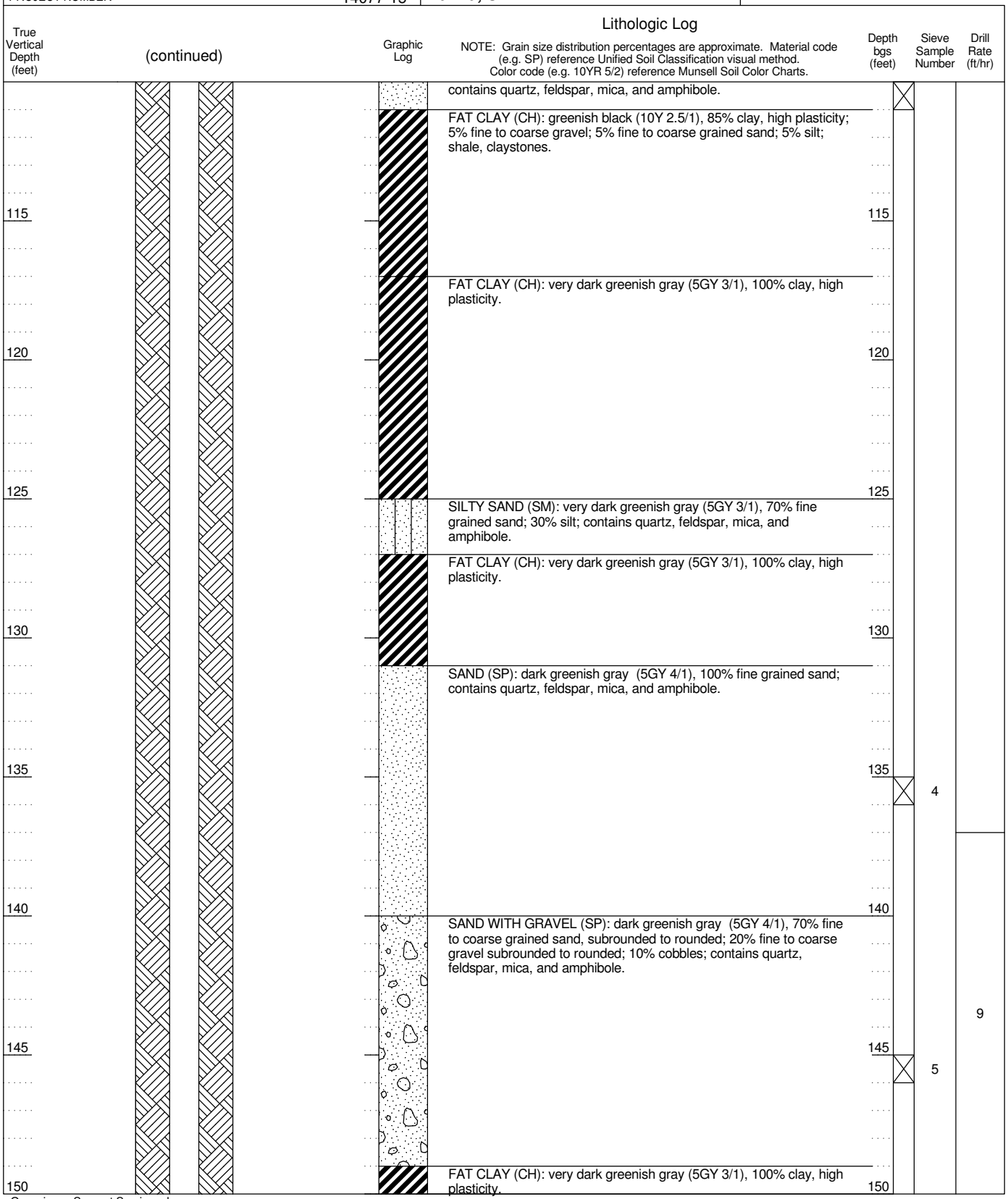
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WELL NUMBER **MPWSP MW-9D**

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am
PROJECT NUMBER 14077-15
LOCATION **Marina, CA**



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WELL NUMBER **MPWSP MW-9D**

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am
PROJECT NUMBER 14077-15
LOCATION **Marina, CA**

(continued)

True Vertical Depth (feet)	Graphic Log	Lithologic Log NOTE: Grain size distribution percentages are approximate. Material code (e.g. SP) reference Unified Soil Classification visual method. Color code (e.g. 10YR 5/2) reference Munsell Soil Color Charts.	Depth bgs (feet)	Sieve Sample Number	Drill Rate (ft/hr)
		SAND (SP): dark greenish gray (5GY 4/1), 95% fine to coarse grained sand, subangular to subrounded; 5% fine gravel subangular to subrounded; contains quartz, feldspar, and amphibole.			
155		SAND WITH GRAVEL (SP): dark greenish gray (5GY 4/1), 65% fine to coarse grained sand, subangular to rounded; 25% fine to coarse gravel subangular to rounded; 10% cobbles; contains quartz, feldspar, and amphibole; shale.	155	6	
160		GRAVEL WITH SAND (GP): dark greenish gray (5GY 4/1), 70% fine to coarse gravel subangular to subrounded; 15% fine to coarse grained sand, subangular to subrounded; 15% cobbles; contains quartz, feldspar, and amphibole; shale.	160		
		SAND (SP): grayish brown (2.5Y 5/2), 90% fine to coarse grained sand, subangular to rounded; 10% fine gravel subangular to rounded; contains quartz, feldspar, mica, and amphibole.			
165		GRAVEL WITH SAND (GP): olive brown (2.5Y 4/3), 70% fine to coarse gravel subangular to rounded; 20% fine to coarse grained sand, subangular to rounded; 10% cobbles; contains quartz, feldspar, mica, and amphibole.	165	7	
		SAND WITH GRAVEL (SP): very dark greenish gray (5GY 3/1), 70% fine to coarse grained sand, subangular to rounded; 30% fine to coarse gravel subangular to rounded; contains quartz, feldspar, mica, and amphibole; shale; more gravel with depth.			
170			170		9
		SAND (SP): dark grayish brown (2.5Y 4/2), 100% fine to medium grained sand, subangular to subrounded; contains quartz, feldspar, mica, and amphibole.			
175		GRAVEL WITH SAND (GP): dark olive brown (2.5Y 3/3), 75% fine to coarse gravel subangular to rounded; 20% fine to coarse grained sand, subangular to rounded; 5% cobbles; contains quartz, feldspar, mica, and amphibole.	175	8	
		SAND (SP): gray (2.5Y 5/1), 100% fine to coarse grained sand, subangular to subrounded; contains quartz, feldspar, mica, and amphibole.			
180			180		
		GRAVEL WITH SAND (GP): gray (2.5Y 5/1), 70% fine to coarse gravel subrounded to rounded; 15% fine to coarse grained sand, subrounded to rounded; 15% cobbles; contains quartz, feldspar, mica, and amphibole.			
185			185	9	
		SAND WITH GRAVEL (SP): dark grayish brown (2.5Y 4/2), 80% medium to coarse grained sand, subangular to rounded; 20% fine to coarse gravel subangular to rounded; contains quartz, feldspar, mica, and amphibole; shale.			
190			190		

9.875 in. borehole (150-300 ft bgs)

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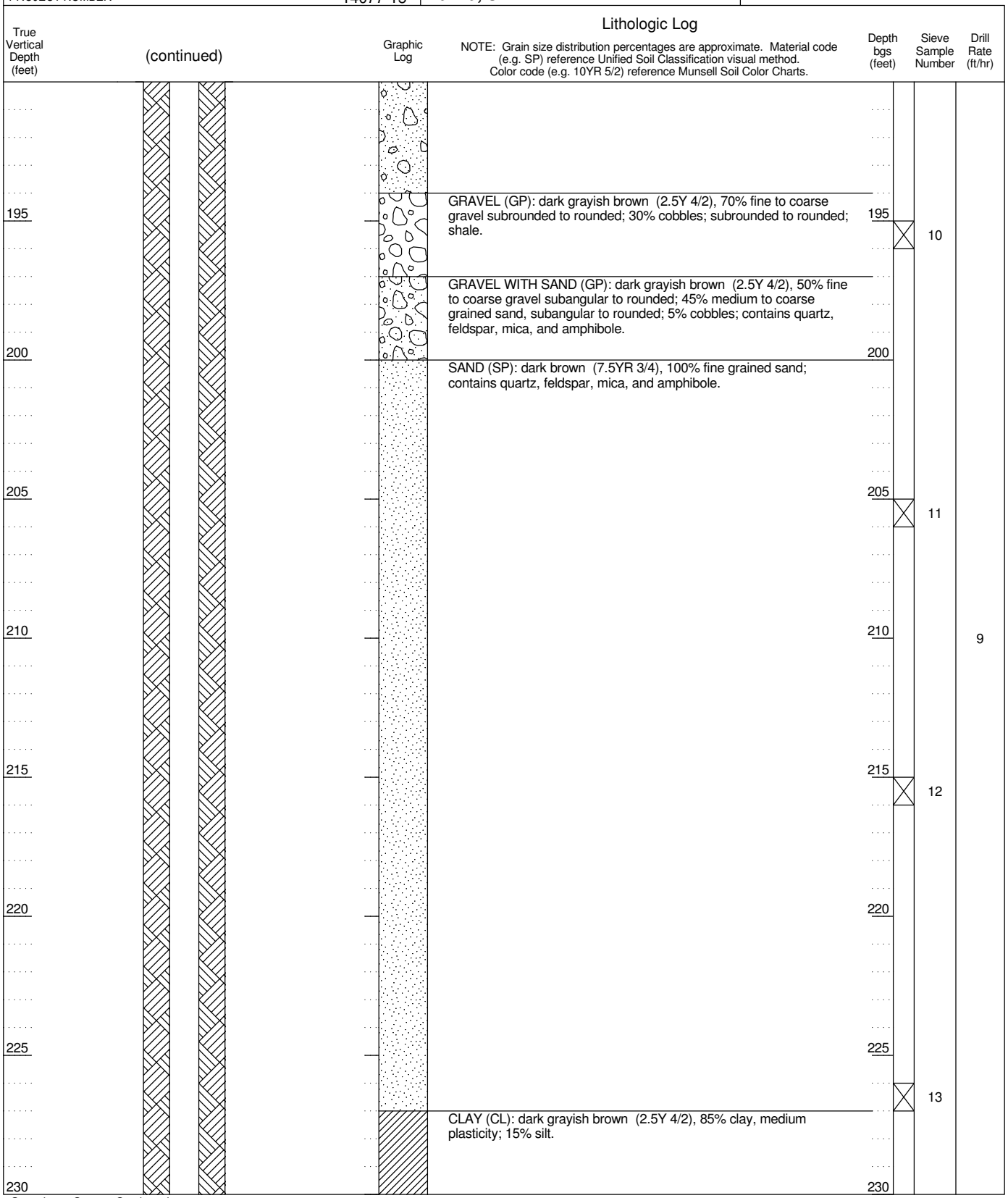
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WELL NUMBER **MPWSP MW-9D**

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am
PROJECT NUMBER 14077-15
LOCATION **Marina, CA**



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WELL NUMBER **MPWSP MW-9D**

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am
PROJECT NUMBER 14077-15
LOCATION **Marina, CA**

True Vertical Depth (feet)	(continued)	Graphic Log	Lithologic Log NOTE: Grain size distribution percentages are approximate. Material code (e.g. SP) reference Unified Soil Classification visual method. Color code (e.g. 10YR 5/2) reference Munsell Soil Color Charts.	Depth bgs (feet)	Sieve Sample Number	Drill Rate (ft/hr)
235			SAND (SP): dark olive brown (2.5Y 3/3), 95% fine grained sand; 5% silt; contains quartz, feldspar, mica, and amphibole. CLAY (CL): greenish gray (10Y 5/1), 90% clay, low to medium plasticity; 10% silt.	235		
240			SANDY FAT CLAY (CH): grayish brown (2.5Y 5/2), 65% clay, medium plasticity; 30% fine grained sand; 5% silt.	240		
245			CLAYEY SAND (SC): grayish brown (2.5Y 5/2), 80% fine grained sand; 15% clay, low plasticity; 5% silt; contains quartz, feldspar, mica, and amphibole.	245		9 4 4
250			SILTY SAND (SM): light olive brown (2.5Y 5/3), 80% fine grained sand; 15% silt; 5% clay, low plasticity; contains quartz, feldspar, mica, and amphibole. FAT CLAY WITH SAND (CH): dark greenish gray (10Y 4/1), 70% clay, medium to high plasticity; 25% fine grained sand; 5% silt. SAND WITH SILT (SP-SM): dark olive gray (5Y 3/2), 90% fine to medium grained sand, subangular to subrounded; 10% silt; contains quartz, feldspar, mica, and amphibole.	250		
255			FAT CLAY (CH): dark greenish gray (10Y 4/1), 100% clay, high plasticity.	255		
260			FAT CLAY WITH SAND (CH): olive brown (2.5Y 4/3), 75% clay, high plasticity; 20% fine grained sand; 5% silt.	260		8.5
265				265		
270				270		

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WELL NUMBER **MPWSP MW-9D**

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am
PROJECT NUMBER 14077-15
LOCATION **Marina, CA**

(continued)

True Vertical Depth (feet)	Graphic Log	Lithologic Log NOTE: Grain size distribution percentages are approximate. Material code (e.g. SP) reference Unified Soil Classification visual method. Color code (e.g. 10YR 5/2) reference Munsell Soil Color Charts.	Depth bgs (feet)	Sieve Sample Number	Drill Rate (ft/hr)
275		SAND WITH GRAVEL (SP): light olive brown (2.5Y 5/4), 75% fine to coarse grained sand, subangular to rounded; 20% fine to coarse gravel subangular to rounded; 5% cobbles; contains quartz, feldspar, mica, and amphibole; shale.	275		
		SAND (SW): olive brown (2.5Y 4/4), 95% fine to coarse grained sand, subangular to subrounded; 5% fine gravel subangular to subrounded; contains quartz, feldspar, mica, and amphibole.		14	
		FAT CLAY (CH): light olive brown (2.5Y 5/4), 100% clay, low to medium plasticity; trace sand.			
280			280		
285			285		
		SANDY CLAY (CL): light olive brown (2.5Y 5/4), 60% clay, low to medium plasticity; 35% fine grained sand, subangular to subrounded; 5% fine to coarse gravel subangular to subrounded; sandstone and claystone.			
290			290		8.5
295			295		
		FAT CLAY (CH): light olive brown (2.5Y 5/3), 90% clay, high plasticity; 10% fine grained sand, subangular to subrounded; contains quartz, feldspar, mica, and amphibole.			
300			300		
		CLAYEY SAND (SC): light olive brown (2.5Y 5/3), 85% fine grained sand, subangular to subrounded; 15% clay; well sorted; contains quartz, feldspar, mica, and amphibole.			
305			305		
		FAT CLAY (CH): light olive brown (2.5Y 5/3), 100% clay, high plasticity; trace fine grained sand, subangular to subrounded; strong cementation; contains mica, and amphibole; mudstone.			
310			310		

8 in. borehole (300-395 ft bgs)

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BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am
PROJECT NUMBER 14077-15
LOCATION **Marina, CA**

True Vertical Depth (feet)	(continued)	Graphic Log	Lithologic Log NOTE: Grain size distribution percentages are approximate. Material code (e.g. SP) reference Unified Soil Classification visual method. Color code (e.g. 10YR 5/2) reference Munsell Soil Color Charts.	Depth bgs (feet)	Sieve Sample Number	Drill Rate (ft/hr)
						8.5
315			SANDY FAT CLAY (CH): light olive brown (2.5Y 5/3), 60% clay, high plasticity; 40% fine grained sand, subangular to subrounded, predominantly between 315.5-316 ft bgs; moderate cementation; contains quartz, feldspar, mica, and amphibole.	315		
			SANDY FAT CLAY (CH): light olive brown (2.5Y 5/3) and grayish brown (2.5Y 5/2), 60% clay, high plasticity; 40% fine grained sand, subangular to subrounded; moderate cementation.			
320			CLAYEY SAND (SC): light olive brown (2.5Y 5/3) and grayish brown (2.5Y 5/2), 60% fine grained sand, subangular to subrounded, trace medium grained; 40% clay, high plasticity; well sorted; moderate cementation; contains quartz, feldspar, mica, and amphibole.	320		
325				325		
			FAT CLAY (CH): greenish gray (10GY 5/1) and (10B 4/1), 100% clay, medium to high plasticity; trace fine grained sand, subangular to subrounded, predominantly 334.4-335 ft bgs; trace silt; strong cementation; contains quartz, feldspar, mica, and amphibole.			
330				330		
335				335		
			FAT CLAY (CH): olive (5Y 5/3), 90% clay, high plasticity; 10% silt; trace fine grained sand, subangular to subrounded; strong cementation; contains quartz, feldspar, mica, and amphibole.		
340	CEMEX Monterey Lapis Lustre #60 fine sand seal (339 - 343 ft bgs)			340		
345	CEMEX Monterey Lapis Lustre #3 filter pack (343 - 395 ft bgs)			345		
			SANDY FAT CLAY (CH): grayish brown (2.5Y 5/2), 60% clay, high plasticity; 40% fine to coarse grained sand, angular to subrounded; trace fine to coarse gravel up to 70 mm, angular to subrounded; moderate cementation; contains quartz, feldspar, mica, and amphibole; petrified wood.			
350				350		

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WELL NUMBER **MPWSP MW-9D**

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am
PROJECT NUMBER 14077-15
LOCATION **Marina, CA**

True Vertical Depth (feet)	(continued)	Graphic Log	Lithologic Log NOTE: Grain size distribution percentages are approximate. Material code (e.g. SP) reference Unified Soil Classification visual method. Color code (e.g. 10YR 5/2) reference Munsell Soil Color Charts.	Depth bgs (feet)	Sieve Sample Number	Drill Rate (ft/hr)
			SAND WITH CLAY (SP-SC): light yellowish brown (2.5Y 6/3), 90% fine to coarse grained sand, angular to subrounded; 10% clay; trace fine to coarse gravel up to 65 mm, angular to subrounded; poorly sorted; contains quartz, feldspar, mica, and amphibole.			
			CLAYEY SAND WITH GRAVEL (SC): light yellowish brown (2.5Y 6/3), 60% fine to coarse grained sand, angular to subrounded; 25% clay; 15% fine to coarse gravel up to 25 mm, angular to subrounded; poorly sorted; contains quartz, feldspar, mica, and amphibole.			
355	4 in. ID x Sch 80 wall PVC well screen with 0.040 in. slots (352.5-392.5 ft bgs)		SAND (SP): light yellowish brown (2.5Y 6/3), 90% fine to coarse grained sand, angular to subrounded; 5% fine to coarse gravel up to 35 mm, angular to subrounded; 5% clay; poorly sorted; contains quartz, feldspar, mica, and amphibole.	355		
			SAND (SP): light yellowish brown (2.5Y 6/3), 90% fine to coarse grained sand, angular to subrounded; 5% fine to coarse gravel up to 50 mm, angular to subrounded; 5% clay; poorly sorted; contains quartz, feldspar, mica, and amphibole.			
360				360		
			SAND (SP): light olive brown (2.5Y 5/3), 90% fine to coarse grained sand, angular to subrounded; 5% fine to coarse gravel up to 35 mm, angular to subrounded; 5% clay; poorly sorted; contains quartz, feldspar, mica, and amphibole.			
365			SANDY FAT CLAY WITH GRAVEL (CH): light olive brown (2.5Y 5/3), 50% clay, medium plasticity; 35% fine to coarse grained sand; 15% fine to coarse gravel up to 40 mm; strong cementation; contains quartz, feldspar, mica, and amphibole; red alteration; mudstone.	365		
			FAT CLAY (CH): light olive brown (2.5Y 5/4), 100% clay, high plasticity; strong cementation.			
			SAND WITH CLAY (SP-SC): light olive brown (2.5Y 5/3), 90% fine to coarse grained sand, angular to subrounded; 10% clay; trace fine to coarse gravel up to 28 mm, angular to subrounded; poorly sorted; contains quartz, feldspar, mica, and amphibole.			
370			SAND (SP): light yellowish brown (2.5Y 6/3), 95% fine to coarse grained sand, angular to subrounded; 5% fine to coarse gravel up to 70 mm, angular to subrounded; trace clay; poorly sorted; contains quartz, feldspar, mica, and amphibole; grades finer with depth; mudstone.	370		
375				375		
			SAND WITH GRAVEL (SP): light yellowish brown (2.5Y 6/3), 80% fine to coarse grained sand, angular to subrounded; 20% fine to coarse gravel up to 45 mm, angular to subrounded; trace clay; poorly sorted; contains quartz, feldspar, mica, and amphibole.			
380				380		
			SANDY FAT CLAY WITH GRAVEL (CH): light olive brown (2.5Y 5/4), 50% clay; 30% fine to coarse grained sand, angular to subrounded; 20% fine to coarse gravel up to 70 mm, angular to subrounded; strong cementation; contains quartz, feldspar, mica, and amphibole.			
385			SAND WITH CLAY AND GRAVEL (SP-SC): light yellowish brown (2.5Y 6/3), 70% fine to coarse grained sand, angular to subrounded; 20% fine to coarse gravel up to 65 mm, angular to subrounded; 10% clay; poorly sorted; contains quartz, feldspar, mica, and amphibole; mudstone.	385		
			SAND WITH CLAY AND GRAVEL (SP-SC): light olive brown (2.5Y 5/3), 70% fine to coarse grained sand, angular to subrounded; 20% fine to coarse gravel up to 60 mm, angular to subrounded; 10% clay; poorly sorted; contains quartz, feldspar, mica, and amphibole; mudstone.			
390				390		

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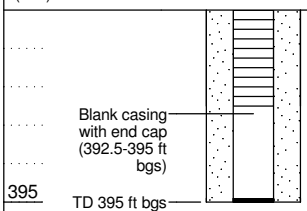
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WELL NUMBER **MPWSP MW-9D**

BOREHOLE LITHOLOGIC LOG (continued)

CLIENT Cal Am
PROJECT NUMBER 14077-15
LOCATION **Marina, CA**



True Vertical Depth (feet)	(continued) Lithologic Log NOTE: Grain size distribution percentages are approximate. Material code (e.g. SP) reference Unified Soil Classification visual method. Color code (e.g. 10YR 5/2) reference Munsell Soil Color Charts.	Graphic Log	Depth bgs (feet)	Sieve Sample Number	Drill Rate (ft/hr)
	SAND WITH CLAY (SP-SC): light olive brown (2.5Y 5/4), 80% fine to coarse grained sand, angular to subrounded; 10% fine to coarse gravel up to 40 mm, angular to subrounded; 10% clay; medium sorted; contains quartz, feldspar, mica, and amphibole.				
395	SAND WITH GRAVEL (SP): light olive brown (2.5Y 5/4), 70% fine to coarse grained sand, angular to subrounded; 30% fine to coarse gravel up to 40 mm, angular to subrounded; trace clay; poorly sorted; contains quartz, feldspar, mica, and amphibole.		395		
	Bottom of borehole at 395 feet.				

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APPENDIX C

PACIFIC SURVEYS

TEMPERATURE
DELTA TEMPURATURE
FLUID RESISTIVITY
DELTA FLUID RESISTIVITY

Job No. 19633

File No.

Company CASCADE DRILLING

Well MW-9D

Field SALINAS

County MONTEREY State CA

Location

NORTH OF SALINAS RIVER ON MONTE RD.
GPS: N 36o 44.026' W 121o 46.750'

Other Services:

DIL/GR

			Elevation	Elevation
Permanent Datum	G.L.			
Log Measured From	G.L.	0'	above perm. datum	K.B.
Drilling Measured From	G.L.			D.F.
				G.L.

Date	05-28-2015		
Run Number	ONE		
Depth Driller	395'		
Depth Logger	395'		
Bottom Logged Interval	395'		
Top Log Interval	0'		
Open Hole Size	10.75" (65'-149')	9.875" (149'-249')	8" (249'-395')
Type Fluid	WATER		
Density / Viscosity	N/A		
Fluid Level	22'		
Bentonite Seal	N/A		
Time Well Ready	1300		
Time Logger on Bottom	1330		
Equipment Number	PS-3		
Location	LA		
Recorded By	SCHUMACHER		
Witnessed By	A KHALIGHI		

Borehole Record				Tubing Record			
Run Number	Bit	From	To	Size	Weight	From	To
ONE	10.75"	0'	149'				
TWO	9.875"	149'	249'				
THREE	8"	249'	395'				

Casing Record	Size	Wgt/Ft	Top	Bottom
Surface String	10.75" OD	N/A	0'	65'
Prot. String				
Production String	4" PVC	SCH 80	0'	395'
Liner				

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All interpretations are opinions based on inferences from electrical or other measurements and Pacific Surveys cannot and do not guarantee the accuracy or correctness of any interpretation, and we shall not, except in the case of gross or willful negligence on our part, be liable or responsible for any loss, costs, damages, or expenses incurred or sustained by anyone resulting from any interpretation made by any of our officers, agents or employees. These interpretations are also subject to Pacific Surveys' general terms and conditions set out in our current Price Schedule.

Comments

Calibration Report

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Dataset Creation Thu May 28 13:17:56 2015

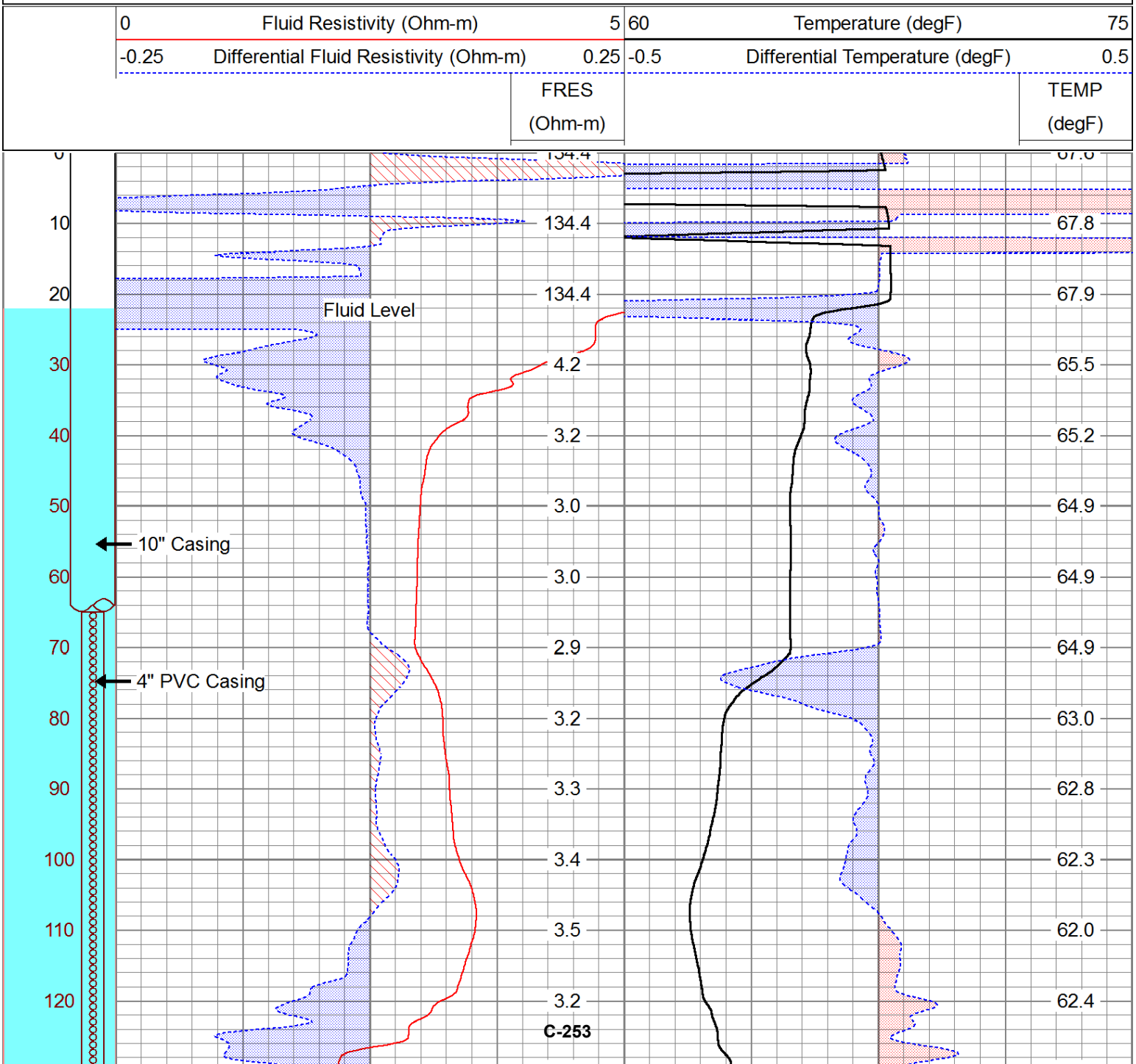
C-252

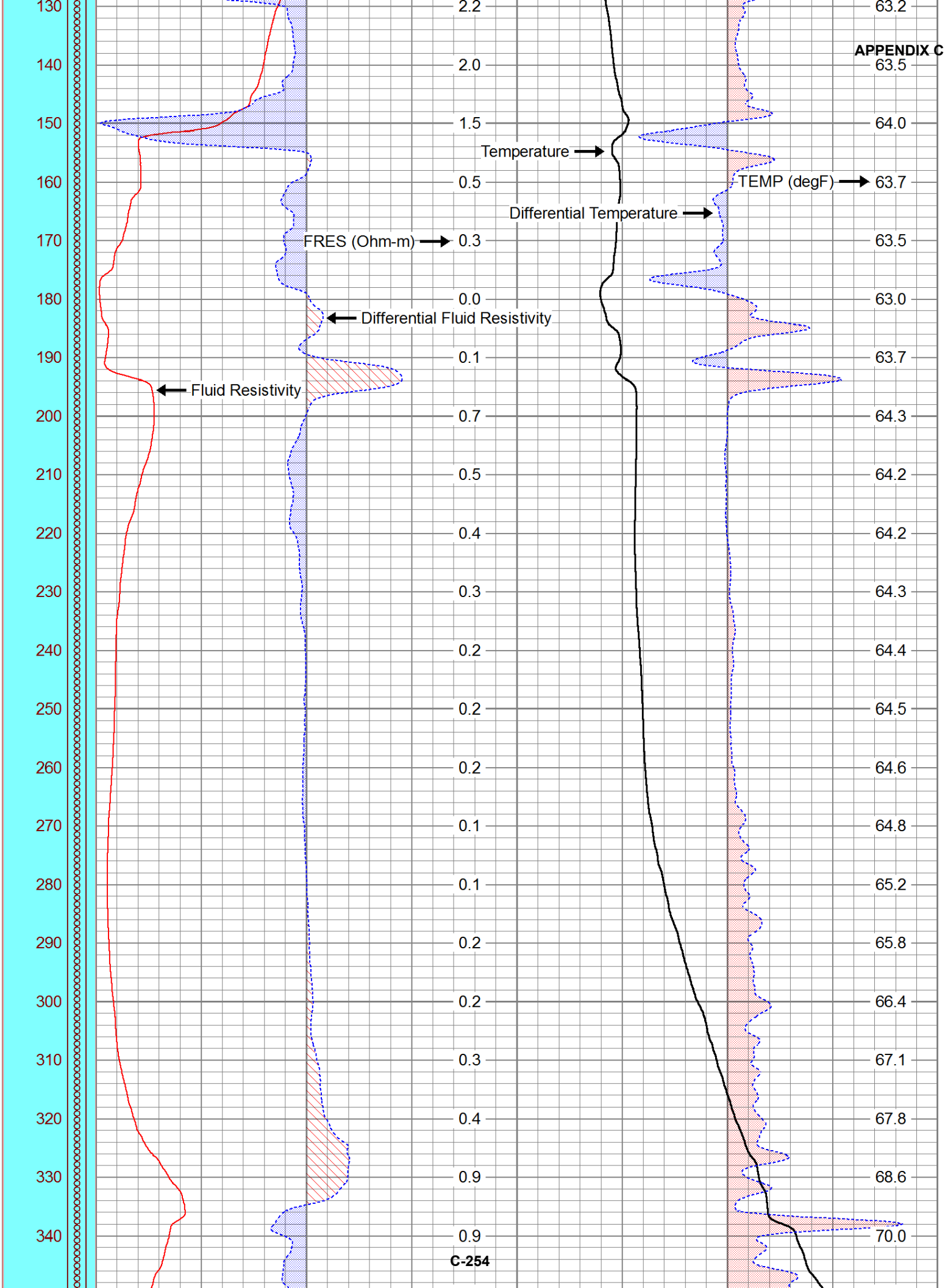
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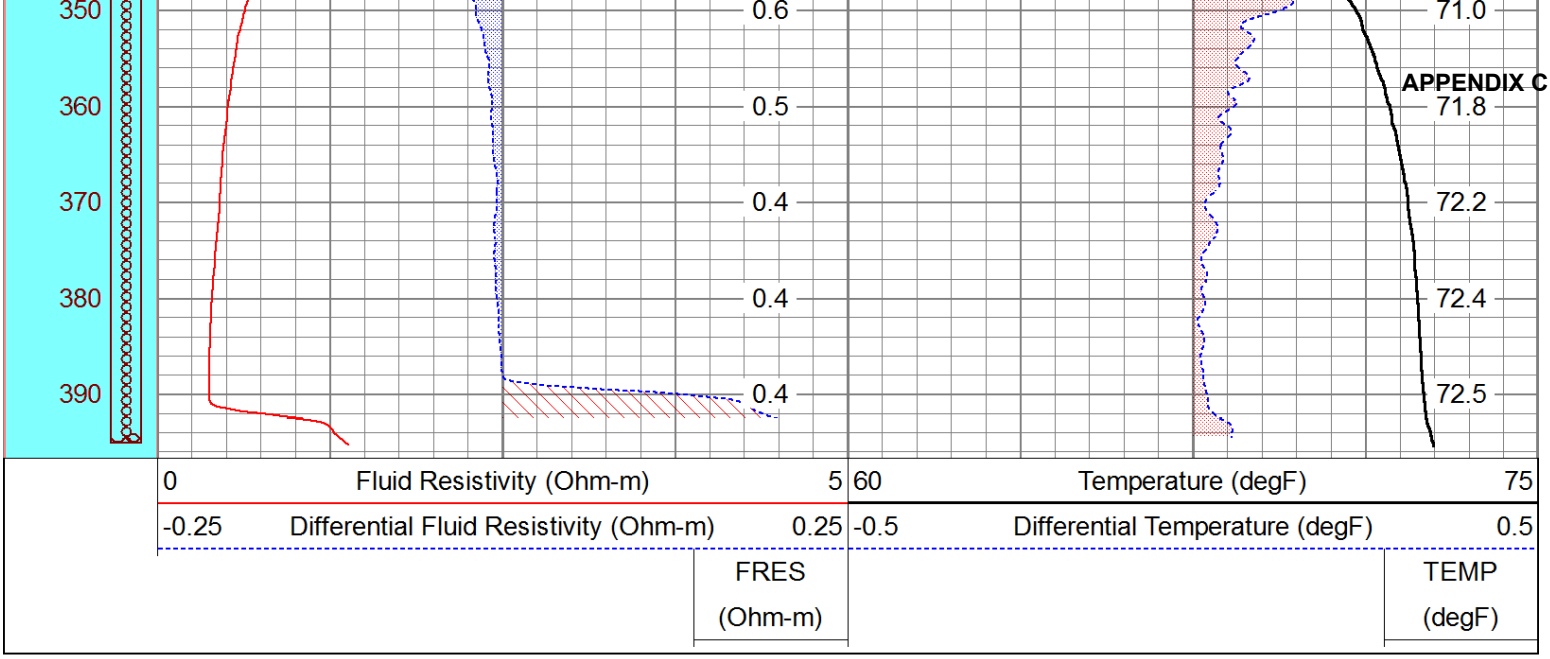
APPENDIX C

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Presentation Format	frttemp2
Dataset Creation	Thu May 28 13:17:56 2015
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160
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0.3
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63.7
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64.3
64.4
64.5
64.6
64.8
65.2
65.8
66.4
67.1
67.8
68.6
70.0
Temperature
TEMP (degF)
Differential Temperature
FRES (Ohm-m)
Differential Fluid Resistivity
Fluid Resistivity


350
360
370
380
390
0.6
0.5
0.4
0.4
0.4
71.0
71.8
72.2
72.4
72.5
APPENDIX C
0
Fluid Resistivity (Ohm-m)
5
60
Temperature (degF)
75
-0.25
Differential Fluid Resistivity (Ohm-m)
0.25
-0.5
Differential Temperature (degF)
0.5
FRES
(Ohm-m)
TEMP
(degF)

APPENDIX C

PACIFIC SURVEYS

DUAL INDUCTION GAMMA-RAY

Job No. 19633

File No.

Company CASCADE DRILLING

Well MW-9D

Field SALINAS

County MONTEREY State CA

Location

NORTH OF SALINAS RIVER ON MONTE RD.
GPS: N 36o 44.026' W 121o 46.750'

Other Services:

TRMPERATURE
FLUID RESISTIVITY

			Elevation	Elevation
Permanent Datum	G.L.			
Log Measured From	G.L.	0'	above perm. datum	K.B.
Drilling Measured From	G.L.			D.F.
				G.L.

Date	05-28-2015		
Run Number	ONE		
Depth Driller	395'		
Depth Logger	395'		
Bottom Logged Interval	395'		
Top Log Interval	0'		
Open Hole Size	10.75" (65'-149')	9.875" (149'-249')	8" (249'-395')
Type Fluid	WATER		
Density / Viscosity	N/A		
Fluid Level	22'		
Bentonite Seal	N/A		
Time Well Ready	1300		
Time Logger on Bottom	1330		
Equipment Number	PS-3		
Location	LA		
Recorded By	SCHUMACHER		
Witnessed By	A KHALIGHI		

Borehole Record				Tubing Record			
Run Number	Bit	From	To	Size	Weight	From	To
ONE	10.75"	0'	149'				
TWO	9.875"	149'	249'				
THREE	8"	249'	395'				

Casing Record	Size	Wgt/Ft	Top	Bottom
Surface String	10.75" OD	N/A	0'	65'
Prot. String				
Production String	4" PVC	SCH 80	0'	395'
Liner				

<<< Fold Here >>>

All interpretations are opinions based on inferences from electrical or other measurements and Pacific Surveys cannot and do not guarantee the accuracy or correctness of any interpretation, and we shall not, except in the case of gross or willful negligence on our part, be liable or responsible for any loss, costs, damages, or expenses incurred or sustained by anyone resulting from any interpretation made by any of our officers, agents or employees. These interpretations are also subject to Pacific Surveys' general terms and conditions set out in our current Price Schedule.

Comments

Calibration Report

Database File 19633.db
Dataset Pathname DIL
Dataset Creation Thu May 28 14:22:35 2015

C-256

Dual Induction Calibration Report

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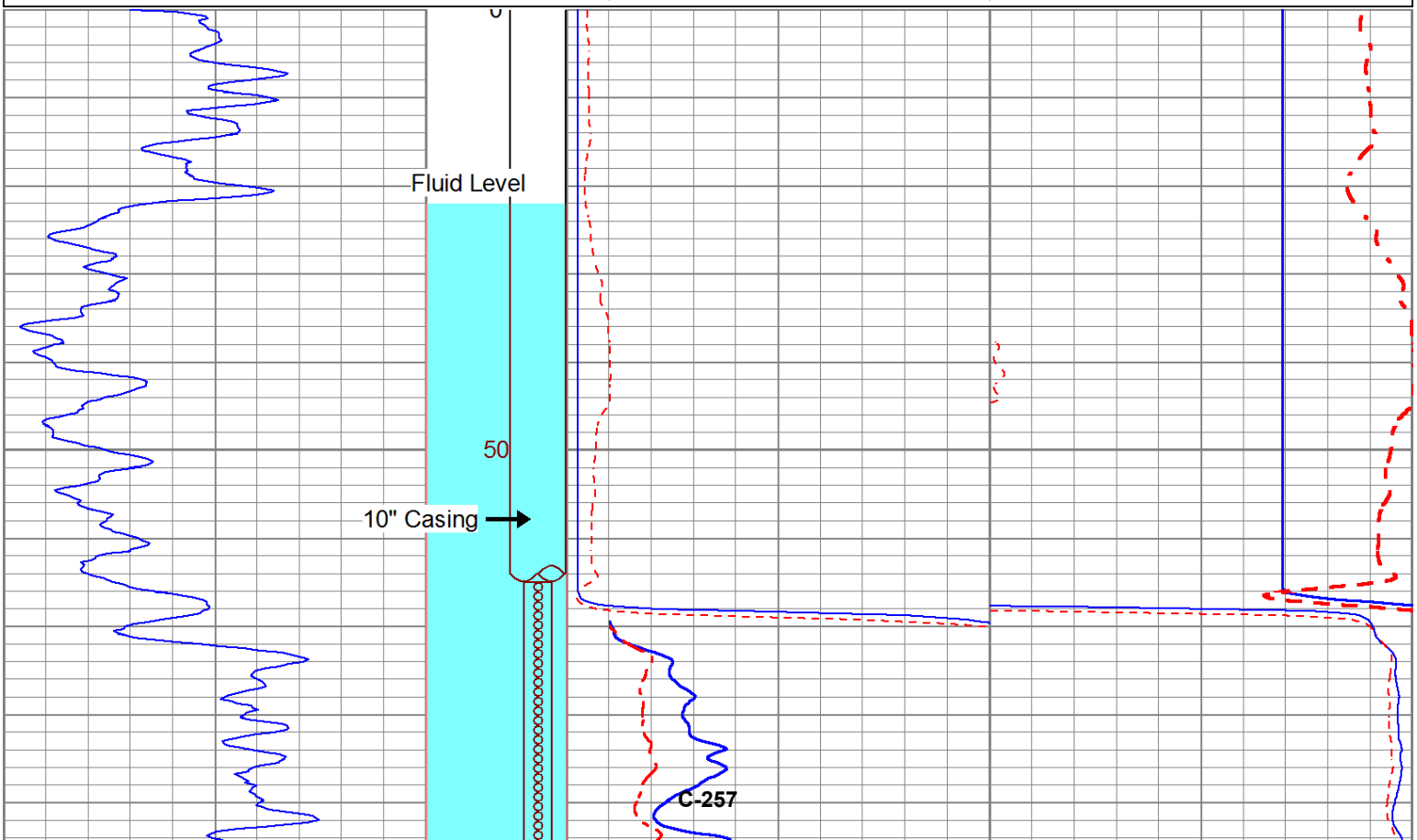
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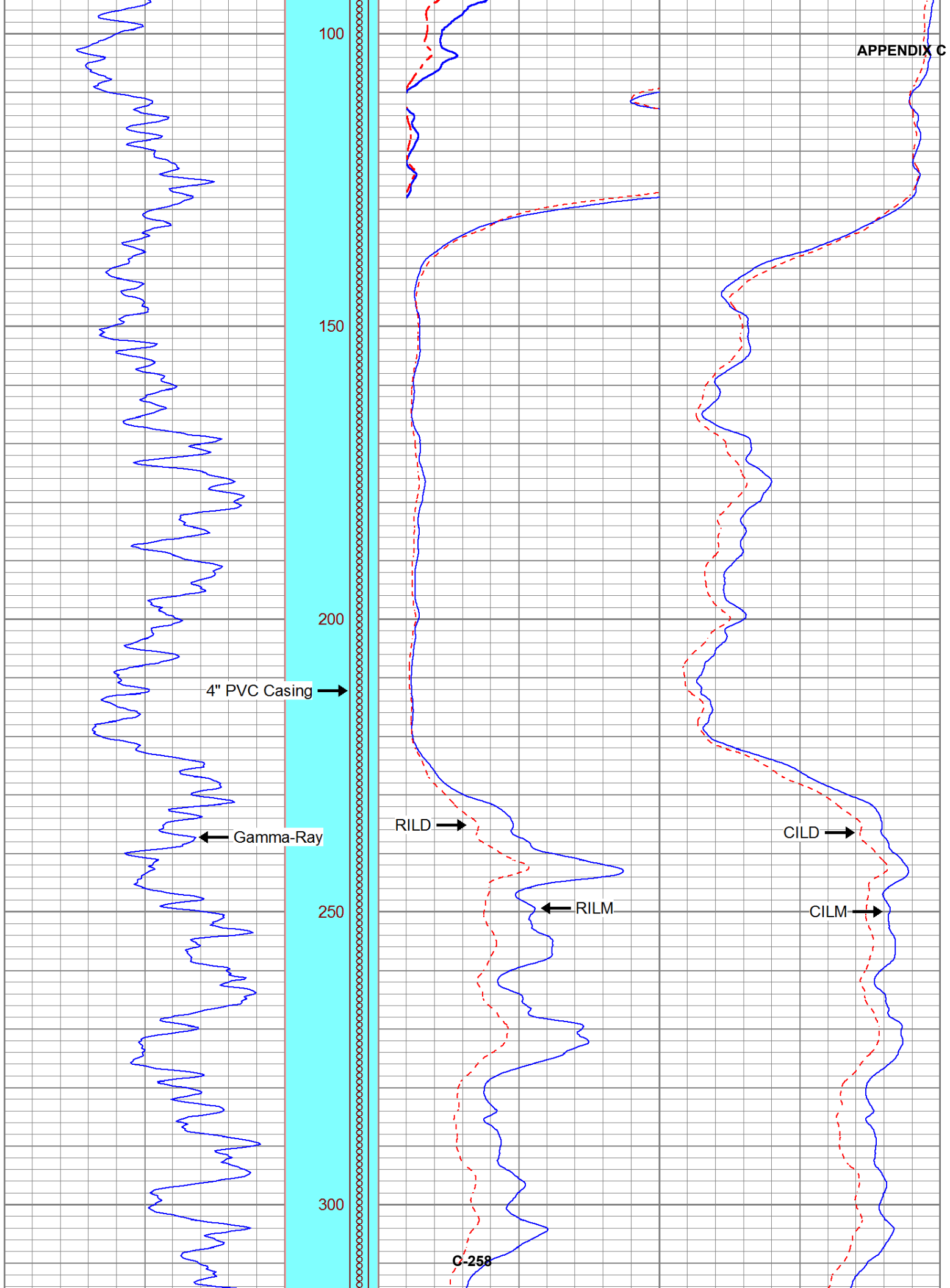
Gamma Ray Calibration Report

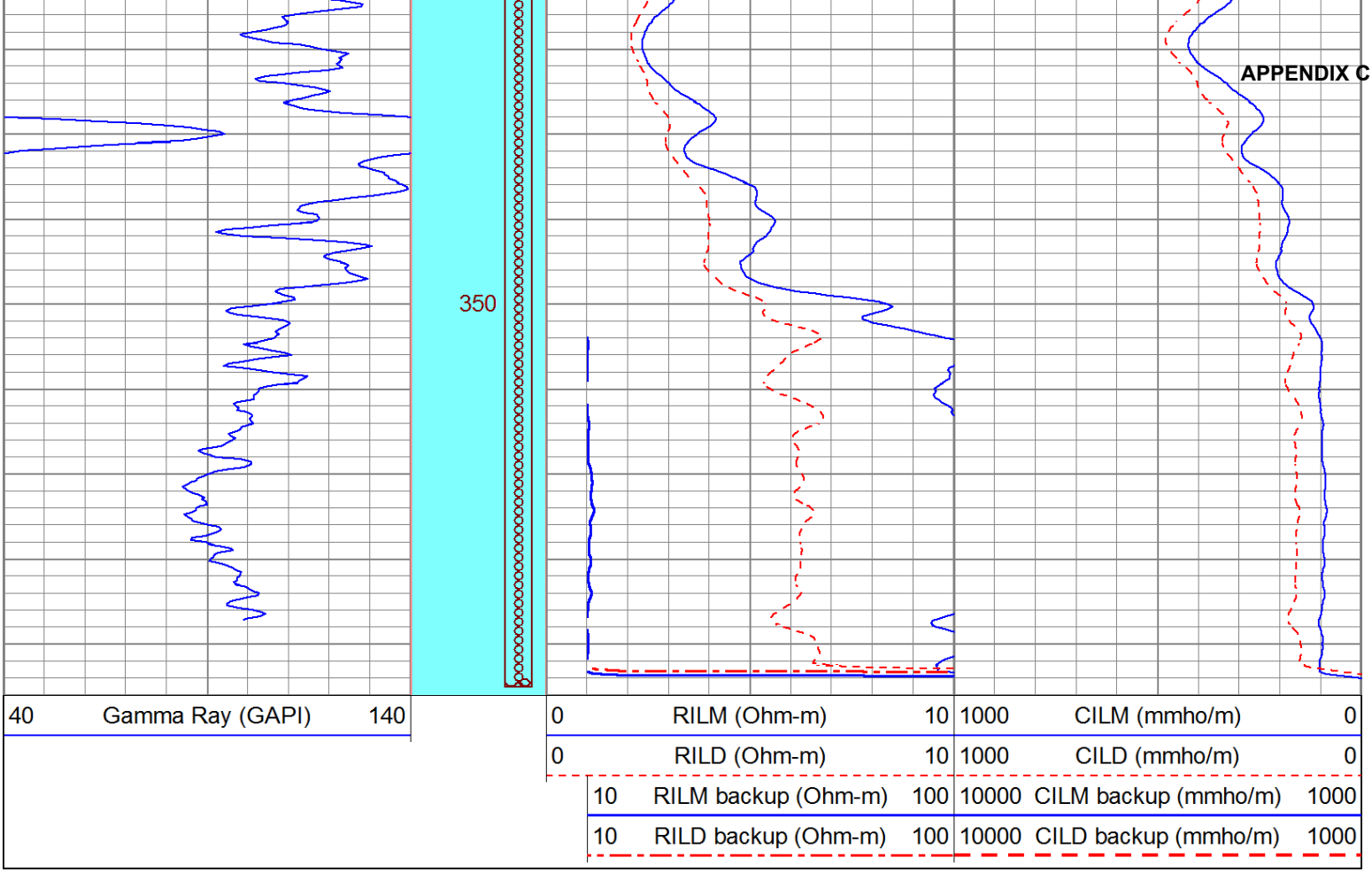
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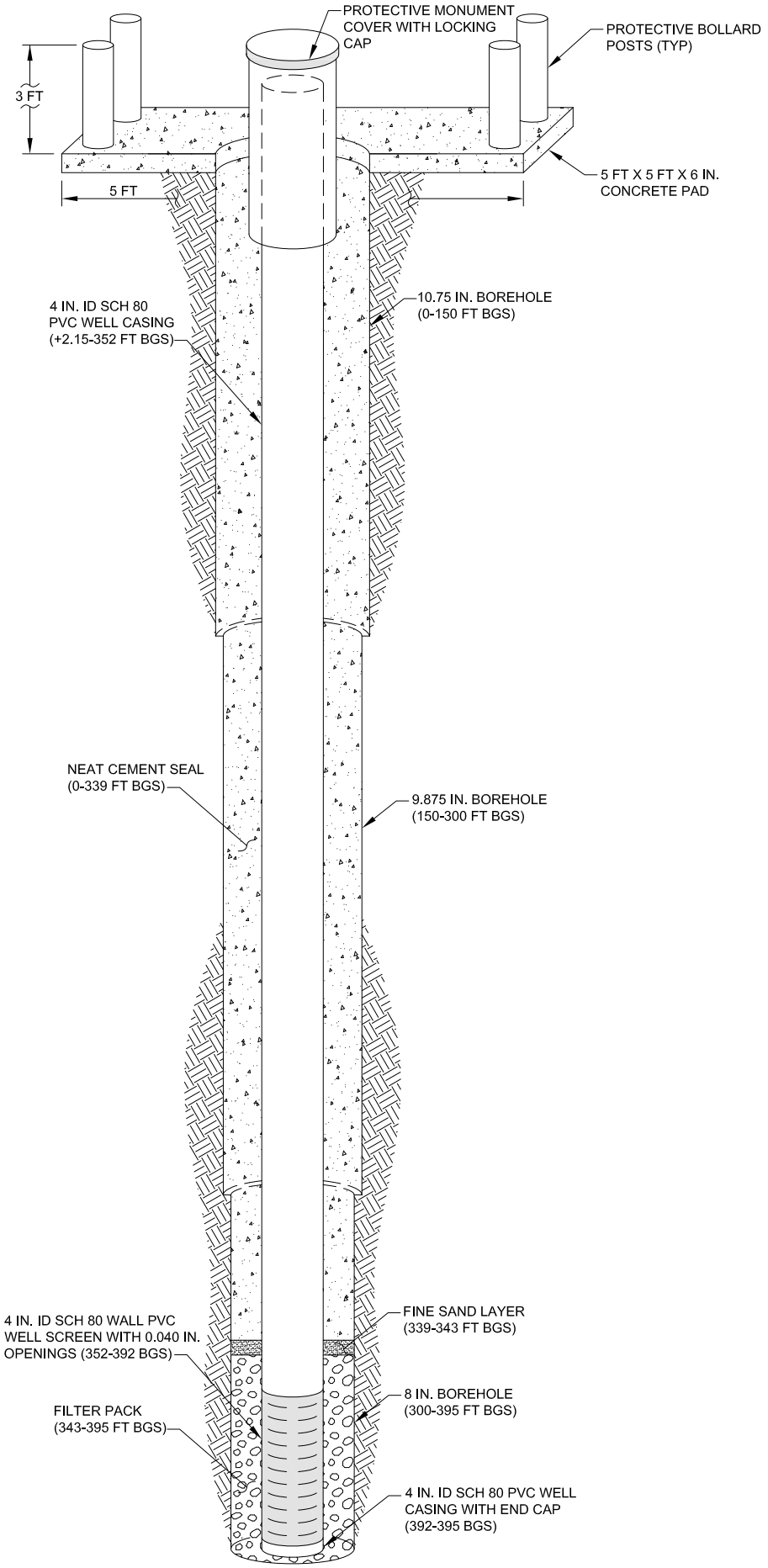
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Charted by	Depth in Feet scaled 1:240

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			0	RILD (Ohm-m)	10	1000	CILD (mmho/m)	0
			10	RILM backup (Ohm-m)	100	10000	CILM backup (mmho/m)	1000
			10	RILD backup (Ohm-m)	100	10000	CILD backup (mmho/m)	1000




100
150
200
250
300
4" PVC Casing
Gamma-Ray
RILD
RILM
CILD
CILM


350
40 Gamma Ray (GAPI) 140
0 RILM (Ohm-m) 10
0 RILD (Ohm-m) 10
10 RILM backup (Ohm-m) 100
10 RILD backup (Ohm-m) 100
1000 CILM (mmho/m) 0
1000 CILD (mmho/m) 0
10000 CILM backup (mmho/m) 1000
10000 CILD backup (mmho/m) 1000



WELL PROFILE

NOT TO SCALE

APPENDIX 5.B – MCWRA MONITORING PROTOCOLS

Quality Assurance Project Plan (QAPP)
For
Water Quality Monitoring
Associated with the Salinas Valley Integrated Water Management Plan (SVIWMP)

EPA R9#03-238
X-97994701-0

UNDER REVISION
(10/19)

Monterey County Water Resources Agency
P.O. Box 930
Salinas, CA 93902
Telephone: (831) 755-4860
Fax: (831) 424-7935
Website: http://www.mcwra.co.monterey.ca.us

WATR0584QV4 (copy 2)

1.0 PROJECT MANAGEMENT

1.1 TITLE AND APPROVAL PAGE

Quality Assurance Project Plan
For
Water Quality Monitoring Associated with
The Salinas Valley Integrated Water Management Plan (SVIWMP)
EPA R9#03-238
X-97994701-0

Prepared by:
Monterey County Water Resources Agency (MCWRA)
P.O. Box 930
Salinas, CA 93902

Prepared for:
US EPA Region 9
75 Hawthorne Street
San Francisco, CA 94105-3901

Approval Signatures

Elizabeth Krafft Agency Project Manager:	Date: 8/17/07
Kathleen Thomasberg Agency Project QA/Task Manager:	Date: 8/17/07
Eugenia McNaughton, Ph.D. USEPA Region 9 QA Program Manager:	Date: 10/22/07
Carolyn Yale USEPA Region 9 Project Officer:	Date: 12/3/07
Mark Kutnink USEPA Region 9 Chemist:	Date: 22 Oct 2007

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D-6 Anions

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1.3 DISTRIBUTION LIST

The following is a list of organizations and persons who will receive copies of the approved QA Project Plan and any subsequent revisions:

Monterey County Water Resources Agency (Agency)
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Salinas, CA 93902

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Carolyn Yale
Project Officer
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Mark Kutnink
Chemist
(415) 972-3801

UNDER REVISION (10/2019)

Monterey County Consolidated Chemistry Laboratory (CCL)
1270 Natividad Road, Room A15
Salinas, CA 93906

Germain Guibert
Laboratory Director
(831) 755-4516

1.4 PROJECT/TASK ORGANIZATION

The organization responsible for overseeing this ground water monitoring program is the Monterey County Water Resources Agency (Agency). This project is funded through a grant from the Environmental Protection Agency (EPA), under the authority of Section §104 (b)(3) of the Clean Water Act. This project falls under the Monitoring and Assessment funding category. The Monterey County Health Department's Consolidated Chemistry Laboratory is a California state certified laboratory that will perform the chemical analyses for this ground water monitoring program. The laboratory will use standard analytical methods.

The roles and responsibilities of those involved in the implementation of the ground water monitoring program are described below. An organizational chart for the program is shown below.

Project Manager is the responsible official who will oversee the preparation of grants and the fiscal management of the project.

Project QA Manager is in charge of establishing the QA/QC protocols found in the QAPP as part of the sampling and analysis procedures. The QA Manager will also review and assess all analytical data from the contract laboratory and will be the liaison regarding data quality issues and concerns. She may stop all actions, including those conducted by the contract laboratory and will be responsible for ensuring that any amended versions of the QAPP are distributed to the organizations and individuals listed in Section 1.3.

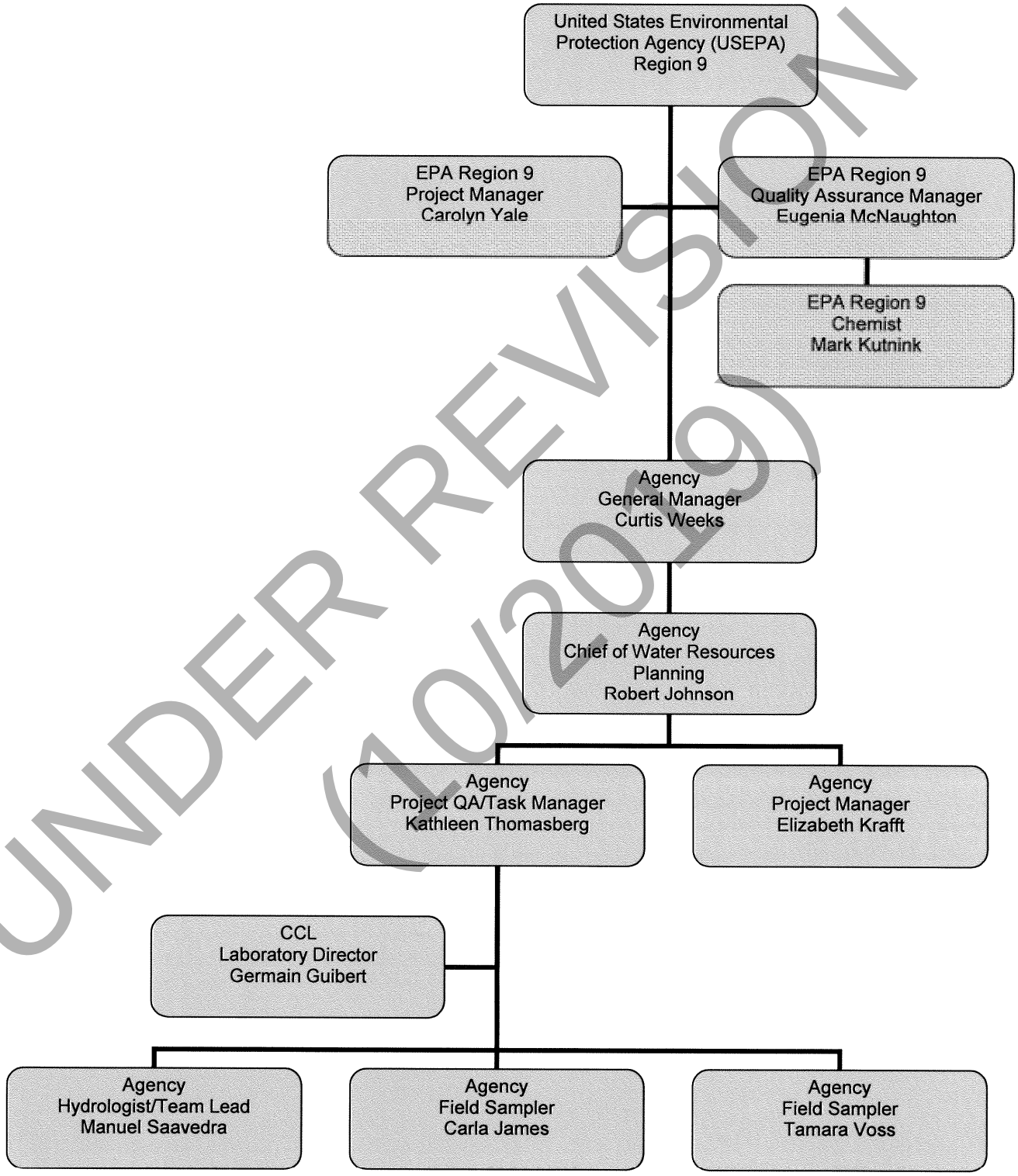
Project Task Manager will oversee the ground water monitoring program. She will ensure that all QAPP protocols are followed and will oversee the writing and revisions of the QAPP. Since the Agency's Water Quality Department is not large, the Project Task Manager will function in the dual role of Task Manager and QA Manager.

Hydrologist/Team Lead will be responsible for coordinating with the Water Resources Technicians/ Field Samplers to review field and analytical requirements, documentation, and sampling schedules.

Water Resources Technicians/Field Samplers will be responsible for sample collection and communication with the contract laboratory regarding the sampling shipment schedule. They are also responsible for writing the QAPP.

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ORGANIZATIONAL CHART



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1.5 PROBLEM DEFINITION/BACKGROUND

1.5.1 Background

The Monterey County Water Resources Agency's (Agency) mission is to manage, protect, and enhance the quantity and quality of water for present and future generations of Monterey County (County). Monterey County, located along the California Central Coast, covers 3,322 square miles (8604 km^2) and has a resident population of 424,842 (Fact Finder, 2007). The County supports a $3.4 billion agricultural industry (Ag Commission, 2006) and a $1.75 billion tourism industry (EPA Grant R9#03-238). The primary land use within the Salinas Valley is agricultural. Since the 1940's, irrigated acreage within the valley has increased substantially. Coastal regions of California are subject to rapid urbanization, and the milder coastal climate supports year-round intensive cultivation of many high-value crops (Hunt et al, 2003). As agricultural and urban areas have expanded, so have the water needs of the County (EPA Grant R9#03-238).

The Agency uses a network of wells to monitor ground water conditions in the Salinas Valley Ground Water Basin (Basin) (Geomatrix, 2001). The Basin is situated entirely within the County (EPA Grant R9#03-238). The Salinas Valley is surrounded by the Gabilan and Diablo Ranges on the east, by the Sierra de Salinas and Santa Lucia Range on the west, and is drained by the Salinas River, which empties into Monterey Bay in the north (DWR 1946a) (Fig 1). Four subareas based on differences in local hydrogeology and recharge have been identified (White Paper, 1995; DWR, 2003). These are known as the Pressure, East Side, Forebay, and Upper Valley subareas (Fig 2). These subareas are hydrologically and hydraulically connected (EPA Grant R9#03-238); all information collected to date indicates there are no barriers to the horizontal flow (of ground water) between these subareas (White Paper, 1995). The "boundaries" between these subareas have been identified as zones of transition between different depositional environments in past millennia (White Paper, 1995).

The primary surface water features overlying and influencing the Basin's hydrology are the Salinas River and its tributaries, the Nacimiento and San Antonio reservoirs, and the Monterey Bay (EPA Grant R9#03-238). The Salinas River extends approximately 120 miles from the river's headwaters in San Luis Obispo County, near Santa Margarita, and flows north/northwest and discharges into the Monterey Bay National Marine Sanctuary near Moss Landing in Monterey County (EPA Grant R9#03-238). The Nacimiento and San Antonio reservoirs, located in the upper watershed, serve as storage and flood control for the Basin.

Ground water recharge in Salinas Valley is principally from infiltration from the Salinas River, Arroyo Seco Cone, and to a much lesser extent, from deep percolation of rainfall (White Paper, 1995). Deep percolation of applied irrigation water is the second largest component of the ground water budget, but because it represents recirculation of existing ground water rather than an inflow of "new" water, it is not considered a source of recharge (White Paper, 1995). Nitrate contamination of ground water poses a significant threat to the beneficial use of ground water for drinking water and for some agricultural water uses (White Paper, 1995). Nitrate concentrations exceed drinking water standards in some parts of the Basin (MCWRA, 1997). The principal source of nitrates to ground water is almost certainly excess fertilizer that is leached by rainfall and applied irrigation water (White Paper, 1995).

Seawater intrusion is another source of inflow to the Basin, but because it is not usable freshwater it is also excluded as a source of recharge (White Paper, 1995). Historically, ground water flowed from subareas to the south and east through the (Pressure) and seaward to discharge zones in the walls of the submarine canyon in Monterey Bay (Durbin et al 1978; Greene 1970). Within the Pressure subarea, due to the impermeable nature of the clay aquitard above the 180-Foot Aquifer,

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recharge from precipitation, agricultural return flows, or river flow is nil (DWR, 2003). Instead, recharge is from underflow originating in Upper Valley areas such as the Arroyo Seco Cone and Salinas River bed or the East Side subarea, and more recently, from seawater intrusion (DWR, 2003). Heavy pumping of the Pressure-180 Foot and Pressure-400 Foot aquifers has caused significant seawater intrusion into both of these aquifers, which was first documented in the1930's (DWR 1946a). Ground water flow in the northernmost area of the Pressure subarea has been directed from the Monterey Bay inland since this time (DWR, 2003). With increased pumping in the East Side subarea since the 1970's, ground water flow is dominantly northeast in the Pressure's central and southern locations (DWR, 2003).

Declining ground water levels in the Pressure and East Side subareas, Basin overdraft, ground water contamination, including nitrate and seawater intrusion are serious concerns for the Agency. (EPA Grant R9#03-238)

1.5.2 Program Objectives

The Agency is charged with management of the Basin's ground water resources. Much of the Agency's investigative work pertaining to the occurrence and use of ground water is to identify the quality, quantity, and temporal trends of ground water resources within the County. A network of monitoring wells provides the information needed to manage and protect ground water resources and sustain beneficial uses. In order for the Agency to develop projects to mitigate problems, such as seawater intrusion, local ground water overdraft, and high nitrate concentrations, the Agency must first implement an effective and accurate monitoring program to identify the extent of the potential problem.

The Ground Water Quality Monitoring Objectives are:
-continued monitoring of the ambient ground water quality, including general minerals
-continued monitoring of coastal aquifers (including Pressure Deep Aquifer) for detection of advancing seawater intrusion
-continued monitoring to determine distribution of conductivity in ground water
-continued monitoring to determine distribution of nitrate in ground water and identification of problem areas

Ambient ground water quality will be used to establish a cohesive and succinct Water Quality Management Plan in accordance to the work begun under EPA-I and continued under EPA-II. For the purposes of this QAPP, the EPA-I grant has funded the Agency to develop this QAPP. The EPA-II grant is funding the Agency to implement the sampling described in the QAPP.

1.5.3 Program Goals

The ground water monitoring objectives in the Salinas Valley will be met by the goal of sampling all 344 wells located throughout the four subareas within the Salinas Valley Ground Water Basin, during the 2007 summer field season.

The ground water monitoring objectives along the coast, specifically located within the Pressure subarea will be met by the goal of sampling all 85 monitoring wells, during the 2007 summer field season.

The Agency's overarching goal for this program is the continued monitoring of the Basin's ambient ground water for use in the management of this important resource, and *not* for the purpose of regulatory control.

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1.6 PROJECT/TASK DESCRIPTION

1.6.1 Work Statement and Produced Products

The Salinas Valley Ground Water monitoring will sample 344 wells located throughout the Salinas Valley Ground Water Basin for ten constituents (Table 1). Each well will be sampled once. Samples will be collected during the 2007 summer agricultural growing season and analyzed for a complete mineral panel. The Coastal Ground Water monitoring will sample 85 wells located within the area of historic seawater intrusion. Each well in the Coastal Program will be sampled once a month during the agricultural growing season. The first month's sample will be analyzed for complete mineral panel and the two remaining sampling events will by analyzed for partial mineral panel (three constituents) (Table 1). All water monitoring samples will be delivered the same day as collected to the contract laboratory for analysis.

All ground water sampling locations are accessible using a 4-wheel drive vehicle. All samples will be collected as a grab sample. All sampling locations will be recorded using global positioning system (GPS) equipment, and digital pictures will be taken at each site.

After laboratory analysis and data validation is completed, a technical memorandum (EPA II, XP-96995301 Task 2 Water Quality Assessment) will be written and submitted to US EPA. The technical memorandum, EPA II, XP-96995301 Task 2 Water Quality Assessment, will include result tables for chloride, nitrate, and specific conductivity, and maps of chloride, nitrate, and specific conductivity gradient contours.

1.6.2 Constituents to be monitored and measurement techniques

Samples will be sent to an off-site laboratory for analysis. Ground water samples will be analyzed for either complete or partial mineral panels. A complete mineral panel includes calcium, cation-anion balance, chloride, conductivity, magnesium, nitrate, pH, potassium, sodium, sulfate, and total alkalinity. A partial mineral panel consists of chloride, conductivity, and nitrate.

Sample analysis will be preformed at the Monterey County Consolidated Chemistry Laboratory (CCL), which is part of the Environmental Health Department. Listed below is the laboratory's contact information and ELAP Certification number.

Laboratory Name	*Contact Information*	*Abbreviation*
Monterey County Consolidated Chemistry Laboratory ELAP Certification No 1395	1270 Natividad Road Salinas, CA 93906 Phone: 831-755-4516 Fax: 831-755-4652 http://www.co.monterey.ca.us/health	CCL

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1.6.3 Project Schedule

The proposed project schedule is summarized below.

Prior to Sample Collection	
January 2006 - January 2007	: Develop project strategy
15 January, 2007	: Submit Draft QA Project Plan
22 March, 2007	: Receive review comments on QA Project Plan from US EPA
6 July, 2007	: Submit Draft Final QA Project Plan
13 July, 2007	: Obtain QA Project Plan approval (to begin fieldwork)
20 July, 2007	: Submit Final QA Project Plan (signatory copy) EPA R9#03-238; X-97994701-0
Sample Collection	
August 2007 - September 2007	: Coastal Ground Water (each well 3x, once per month)
August 2007 - September 2007	: Salinas Valley Ground Water (each well 1x)
Post Sample Collection	
November 2007	: Compile all remaining laboratory analyses reports
1 - 15 December, 2007	: Evaluate laboratory data for QA/QC requirements
15 December, 2007	: Copy of analytical results sent to well owner/operators
16 - 31 December, 2007	: Summarize and tabulate data
January 2008	: Write Technical Memorandum (EPA II, XP-96995301 Task 2 Water Quality Assessment)
March 2008	: Submit Technical Memorandum (EPA II, XP-96995301 Task 2 Water Quality Assessment) to US EPA

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1.6.4 Geographical Setting

The Salinas Ground Water Basin encompasses approximately 537.5 square miles (1,392 km^2). The regional ground water flow is to the northwest. Seawater intrusion is a result of coastal pumping (Figure 3). Ground water pumping can dramatically impact localized coastal ground water flow.

1.6.5 Constraints

Ground water samples must be taken from the well while the pump is operating to ensure that the sample is representative of the aquifer and not standing water within the well casing. The Agency wants to measure the water quality when the aquifers are stressed due to pumping. For this reason the 2007 field sampling season will coincide with the agricultural irrigation season.

1.7 DATA QUALITY OBJECTIVES FOR MEASUREMENT DATA

This section describes the data objectives of the project and defines the measurement performance criteria deemed necessary to meet those objectives.

1.7.1 Objectives and Project Decisions

In Monterey County the Salinas Valley and Coastal Ground Water ambient monitoring programs are designed to characterize the ground water quality conditions of the Basin. All data generated from the sampling program in this project are tabulated as they have been over the many years of the program. Data generated from these monitoring activities allows the Agency to track changes in ground water quality over time and to assess potential impacts to ground water in the Basin. Water resource management and policy decisions may follow based on maps and tabulated data generated as a part of this project (program).

For the coastal ground water sampling program, the general mineral data are evaluated to determine if seawater intrusion is progressing landward as indicated by increasing well chloride values. The chloride values for all wells are evaluated, and then the 500mg/L chloride isochlor contours are mapped for the two coastal aquifers. When the maps are published, the information generated by MCWRA staff and approved by the MCWRA Board of Directors, is posted and passed on to Monterey County departments, regional government regulatory agencies, and public / private entities via the MCWRA web page, presentations, public meetings, and networking.

Monterey County departments such as the Planning Department and Health Department utilize the advancement of seawater as it relates to potable water and public health, while the agricultural community becomes aware of the proximity of their wells to the intrusion advancement, and the possible need for funds to drill new, deeper, wells and destroy the older high nitrate wells. Actions by regulators, depending on the entity, are related to prioritization of Regional Watershed and Water Quality Action Plans, and the associated success of MCWRA capital projects to halt seawater intrusion as governed by the State Water Resources Control Board adjudication process.

Actions by the MCWRA after the landward advancement of seawater have been ongoing for many years. Actions include consideration of more stringent Monterey County well drilling ordinances for assuring the continued prevention of cross-aquifer contamination in the coastal Salinas Valley, *"Zone 6 Drilling Standards", April 19, 1988;* the development and implementation of the Monterey County Recycling Projects, a tertiary treatment plant and treated water distribution system, to help further reduce agricultural pumping in the coastal Salinas Valley for halting seawater intrusion; and future use of these data will be utilized by the newly established Seaside Watermaster for comparison to and the development of the Monterey Peninsula seawater intrusion front.

For the Salinas Valley general mineral ground water sampling program, nitrate data tabulation and map representation has been the focus of the MCWRA for many years. All results over the laboratory's practical quantitative limit generated from this program are tabulated to evaluate the minimum, maximum, median, and mean value of nitrate as NO_3 in mg/L for each of the Salinas Valley Hydrogeologic Subareas.

For the Salinas Valley monitoring program, the Agency sends the general mineral testing results, including nitrate, to the well owners/growers who operate the wells sampled. Also, in this transmittal, the well operators are also provided with a conversion sheet of the nitrate concentration *from mg/L nitrate as NO_3 to pounds of nitrate per acre inch of water*, agricultural terms. If a nitrate

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value in ground source water is elevated, then that growers can incorporate this available nitrate into their fertilizer crop scheduling. This is a method for growers to reduce applied nitrate to crops, while maintaining maximum crop productivity.

And, as with the Coastal monitoring program, the tabulated and mapped Salinas Valley nitrate data are posted and passed on to Monterey County departments, regional government regulatory agencies, and public / private entities via the MCWRA web page.

The MCWRA uses the well nitrate data during the technical well application review process. Monterey County Health Department (Heatlh Department) issues well permits after the Agency provides a technical review of well applications for new, abandoned, or repaired wells. The well application proposal is evaluated with other well construction and water quality within a one miles radius of the new well and represented on a map. Agency staff makes qualitative recommendations to the Health Department on the new well's sanitary seal based on other well seals, the perforated intervals, and the nitrate values of wells in the area. The final decision for the well construction is made by the Health Department after the well drilling progresses.

Actions taken by the MCWRA are conditional. If extreme nitrate values are observed in agricultural production wells, then re-sampling of the wells may take place to confirm the elevated concentrations and may lead to increased sampling points for wells in the same vicinity and with the same well design. Continued increases in Salinas Valley ground water nitrate values could lead to special nitrate investigations on movement of nitrate in ground water and also outreach to the public on the reduction of nitrate to the environment.

1.7.2 Action Limits/Levels

Since the overarching goal for this project is the continued monitoring of ambient ground water, the Agency has set no specific water quality standards. As a result, the laboratory's practical quantitation limits (PQL) will serve as the Project Action Levels (PALs). Table 1 provides a listing of the parameter to be sampled and a summary of the laboratory's method detection limit, those minimum concentrations that can be detected above the instrumental background/baseline signal noise. Table 1 also provides the PQL, lowest calibration standard and PALs required by the Agency for the QAPP. The quality limits listed are deemed acceptable by the Agency to meet the project objectives.

1.7.3 Measurement Performance Criteria

The objective of data collection for this Monitoring Project is to produce data that represent the *in situ* conditions of the ground water. This objective will be achieved by using accepted standard methods for water collection and analysis and defining data quality indicators (DQIs) for each analytical parameter. The DQIs include accuracy, precision, comparability, sensitivity, completeness, and representativeness and are defined below and presented in Table 2. Some DQIs will be assessed quantitatively, while others will be qualitatively assessed. Example calculations have been provided for quantitative assessments and appropriate quality control (QC) samples have been identified. Laboratory Data Quality Objectives are given in Table 3.

Accuracy, or bias, is a measure of how close a result is to the expected value of the target analyte in a sample. Accuracy will be determined by the analysis of certified reference materials and matrix spikes, where the results can be compared with an expected value and expressed as %recovery. This is an assessment of laboratory analytical methods. For Laboratory Control Samples (LCS), it will be expressed as %recovery by the following equation:

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$$\%Recovery = \frac{X}{T} \times 100$$

where,

X = Measured concentration
T = True spiked concentration

or, for Matrix Spike (MS) samples, by the following equation:

$$\%Recovery = \frac{(B - A)}{T} \times 100$$

where,

B = Measured concentration of spiked sample
A = Measured concentration of unspiked sample
T = True spiked concentration

The frequency of the LCS and MS samples associated with the analytical parameters will be 5%. MS and MSD samples will be spiked at 3-10 times the native sample concentration.

Accuracy/bias as related to contamination involves both field and laboratory components. Field blanks will be collected at a frequency of 5%. Laboratory blanks will be prepared and analyzed at a one per batch or 5% frequency.

Precision is concerned with the ability to quantitatively repeat results. To demonstrate the precision of a method or instrument, field duplicates will be collected, analyzed, and their results compared. Precision is expressed as relative percent difference (RPD) by the following equation:

$$RPD\ (\%) = \frac{|X_1 - X_2|}{(X_1 + X_2)/2} \times 100$$

where,

X_1 = Original sample concentration
X_2 = Duplicate sample concentration
$|X_1 - X_2|$ = Absolute value of $X_1 - X_2$

Field duplicates will be collected at a frequency of 10% for the first two sampling events. If the criterion of <25% RPD is met, then the remaining field duplicates will be collected at a 5% frequency. Laboratory duplicates will be prepared and analyzed at a one per batch or 5% frequency.

Comparability of the data can be defined as the similarity of data generated by different monitoring programs. Comparability helps to measure the scientific coherence and validity of a project. This objective is addressed primarily by using standard sampling and analytical procedures. Additionally, comparability of analytical data is addressed by result comparison of certified reference materials.

Sensitivity of the analytical instrument or method is the ability to detect and quantify an analytical parameter at the concentration level of interest. Sensitivity can be evaluated by method or instrument detection limit studies (MDL and IDL) or calculated practical quantitative limits (PQL) and method report limits (MRL).

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Completeness is a measure of the amount of successfully collected and validated data relative to the amount of data planned to be collected for the project. Project completeness is typically based on the percentage of the data needed for the program or study to reach statistically valid conclusions. Because the SVIWMP is a monitoring program, data that are not successfully collected for a specific sample event or site can typically be recollected at a later sampling event. For this reason, most of the data planned for collection can not be considered statistically critical, and it is difficult to set a meaningful objective for data completeness. However, some reasonable objectives for the data are desirable, if only to measure the effectiveness of the Monitoring Program. %Completeness will be expressed by the following equation:

$$\%\text{Completeness} = \frac{N}{T} \times 100$$

where,

N = Number of usable results
T = Total number of samples planned to be collected

A completeness goal of 90% has been set for the ground water monitoring program.

Representativeness can be defined as the degree to which the environmental data generated by the monitoring program accurately and precisely represent actual environmental conditions. This objective is addressed by the overall design of the monitoring program. Specifically, assuring the representativeness of the data is addressed primarily by selecting appropriate locations, methods, times, and frequencies of sampling for each environmental parameter, and by maintaining the integrity of the sample after collection. Representativeness judges how well a single sample can describe the conditions of an entire sample population. Accurate, artifact-free sampling procedures and appropriate sample homogenization achieve representativeness.

1.8 TRAINING REQUIREMENTS/CERTIFICATION

1.8.1 Training of Field Personnel

A specialized training requirement for this project is for the use of Global Positioning Systems (GPS) Technology. Training in the use of handheld GPS units and software will be performed on an individual basis between the trainer and the trainee. Training will be provided by staff experienced in the use of GPS and Geographic Information Systems (GIS).

Field personnel will also be given initial instructions prior to the beginning of sample collection activities. These initial instructions will help familiarize the field personnel with sample collection containers, sample handling techniques, chain-of-custody forms, and sample transport. New field personnel will be accompanied by a trainer in the field as part of the initial instructions. All field samplers have completed a four-hour training session in the field. Training included confirmation of the well ID electrical meter tag number and MCWRA tag number, recognizing the appropriate sampling port, sample collection technique, proper handling of the sample during transportation to the lab, and accurate completion of the chain-of-custody forms. The completion of field training session has been documented in the Agency's personnel files.

All field personnel will follow sample collection procedures from accepted methods for the collection of ground water. Sample collection will follow protocols in accordance with recommended guidelines established by the U.S. Geological Survey (USGS) for ground water collection as described in the

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National Field Manual for the Collection of Water-Quality Data, U.S. Geological Survey, Techniques of Water-Resources Investigations, Book 9, Chapters A1-A9. Field personnel will be familiar with the above-mentioned document.

Field personnel will also read and be familiar with this Quality Assurance Project Plan (QAPP) prior to beginning any sample collection activities.

1.8.2 Training of Laboratory Personnel

No specialized training of laboratory personnel is required for this project. The ground water constituents to be analyzed by the laboratory are routine and do not require additional expertise. In addition, the laboratory's QA plan notes that analysts 'must conduct sufficient preliminary tests using the methodology and typical samples to demonstrate competence in the use of the measurement procedure'.

1.8.3 GPS Training Documentation

Documentation of field personnel training for GPS includes: the name of the staff member being trained, the training date, the name of the trainer (instructor), and a checklist of satisfactory completion of each step. These training records are stored inside a monitoring binder and filed in the Agency's Water Quality Section. A sample GPS training record is attached in Appendix A.

Training documentation of laboratory personnel for routine methods is kept on file at the Consolidated Chemistry Laboratory (CCL). The CCL has written a policy regarding laboratory personnel training in their lab QA plan.

1.9 DOCUMENTATION AND RECORDS

1.9.1 QA Project Plan Distribution

The MCWRA Hydrologist/ Team Lead will safeguard the original QAPP and any subsequent revisions (both hard and electronic), plus keep a record of the distribution list in order to send out amendments to the QAPP and retrieve any obsolete versions (from the individuals listed earlier in section 1.3).

1.9.2 Field Documentation and Records

All field documentation generated by the sampling program will be kept on file in the Water Quality Section of the Agency. Field documentation includes field sheets, chain of custody (COC) forms, photographs, and labels (see Appendix B for examples of each).

1.9.2.1 Field Sheets

Field sheets are used to aid in the identification of each ground water source (well). The field sheets list the name of each well (as assigned by the well owner) and the State Well Number. The field sheets also contain a section that describes who the sampler should contact in order to have a well turned on, where to find the sample port, etc. The sampler is responsible for recording the sample date and time on the field sheet. Site observations should be written in the comments section of the field sheet, and initialed by the sampler. Site observations may include information such as detailed directions to the well location, changes to the electrical meter tag number, and the owner contact name and phone number. Field sheets also contain PG&E electrical meter numbers, which can be either verified or updated while the sampler is in the field.

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Field sheets are double-checked by the sampler for completeness and accuracy while still in the field. The sampler should look for: incomplete and/or missing data/omissions, incorrect or invalid information, and clarity problems. Any discrepancies should be cleared up before the sampler leaves the field. Data that has been entered by one field sampler will be reviewed by a different field sampler to verify that no transcription errors have occurred. These data entry reviews will take place at least weekly.

Original field sheets are categorized (according to Coastal wells or Salinas Valley wells) inside binders which are kept in the Water Quality Section at the Agency for a period of 10 years. After such time, the copies are transferred to the Monterey County Record Retention Center and archived for a period of 5 years.

Data collected on field sheets will also be recorded electronically and stored in an Access database inside a shared network drive that is backed-up on a daily basis. These electronic records will be retained permanently.

1.9.2.2 Chain Of Custody (COC) Forms

Chain-of-custody (COC) forms will be provided by the Consolidated Chemistry Laboratory and filled out while the sampler is in the field. The COC will accompany the samples at all times in order to insure the custodial integrity of the samples. A sample is considered to be in custody if it is: in someone's physical possession, in someone's view, locked up, or secured in an area that is restricted to authorized personnel.

Care should be taken to protect the COC from physical damage (i.e., water, wind, etc). The COC will have the following information:

- Client Code
- Client Name
- Client Address
- Client Phone Number
- Client Fax Number
- Report Attention
- Sampler Name
- Collection Date
- Collection Time
- Sample Site (identified by state well identification number) or QC sample (if appropriate)
- Sample Type (all of the samples in this project will be **grab** samples)
- Matrix (all of the samples in this project will be **ground water** samples)
- Analyses Requested

Upon relinquishing the sample(s) to the Consolidated Chemistry Laboratory, the sampler will sign and date the COC form. Lab personnel will then receive the sample(s), mark the date and time received, assign unique lab identification numbers (lab IDs) to each sample, and sign the COC form. The signed COC form is then photocopied; the lab keeps the original, and a copy is given to the sampler.

Hard copies of COC forms are categorized (Coastal wells or Salinas Valley wells) inside binders which are kept in the Water Quality Section at the Agency for a period of 10 years. After such time,

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the copies are transferred to the Monterey County Record Retention Center and archived for a period of 5 years.

Electronic COC information is also stored in an Access database inside a shared network drive that is backed-up on a daily basis. These electronic records will be retained permanently.

1.9.2.3 Photographs

The Agency maintains a photo catalog which contains photographs of the Coastal well site locations. The photo catalog is carried into the field to assist with the identification of each well. If there are significant changes to the appearance of the well site, then staff will take a new digital photo. The old photo in the catalog will then be replaced with a copy of the new photo. Photographs will be taken of the Salinas Valley wells after confirming the correct well location of each.

Two photographs of each well location will be taken using a high resolution digital camera. One photograph will be from a distance of 100 ft. or more to aid in the identification of the correct site location. The second photograph will be a close up of the well and pump head, which will be used to verify location of the correct sampling port. Printed hard copies of these two photographs for each well will be kept in the photo log book and labeled with the state well identification number as listed on the field sheets.

Photographs will serve to help verify information entered into the field sheets. Photographs are stored in an electronic database and labeled according to site number and date last photographed. Previous photos will be archived electronically for retrieval purposes if the need arises.

1.9.2.4 Labels

Labels for each sample site are pre-printed on Avery (size 5163) sheets (10 labels per sheet). Indelible ink will be used on the labels and clear packing tape will be applied over the label to prevent it from coming off if it gets wet. Each label will have the following information:

- Sample Site (pre-printed)
- Collection Date (to be filled out in the field)
- Collection Time (to be filled out in the field)
- Analyses Requested (complete or partial mineral panel)
- Sampler Name (to be filled out in the field)
- Comments (if any)

The sample site name (state well identification number) will serve as the unique identifier for each sample (e.g. 14S/02E-08M02). When the samplers arrive at the CCL a unique in-house lab number is assigned to each sample.

1.9.2.5 Field Quality Control Sample Records

Quality Control samples from the field will be identified using the state well identification number plus either -1 or -2 (e.g. 14S/02E-08M02-1, for a field blank).

- -1 = Field Blank
- -2 = Field Duplicate

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1.9.3 Laboratory Documentation and Records

The Consolidated Chemistry Laboratory will keep a sample receiving log containing the completed COC forms submitted with the samples collected for this project. The CCL will keep records of all analyses performed as well as associated QC information, including: laboratory blanks, laboratory duplicates, matrix spikes, matrix spike duplicates and laboratory control samples. Hard copy data of analytical results will be maintained for three years by the CCL. The CCL maintains a Laboratory Information Management System (LIMS) which will be used to store electronic data.

The data generated by the CCL for each sampling event will be compiled into individual data reports. The individual data reports will include the following information:

- Sample results and associated Quantitative Limits (QLs)
- Cation-Anion Balance Sheet
- QC check sample records and acceptance criteria for the following:
    - Laboratory Control Sample(s)
    - Matrix Spike(s)
    - Matrix Spike Duplicate(s)
    - Analytical Duplicate(s)
    - Method Blank(s)
- Project narrative including a discussion of problems or unusual events (including, but not limited to, topics such as: receipt of samples in incorrect, broken, or leaky containers, with improperly or incompletely filled out COC forms; receipt and/or analysis of samples after the holding times have expired; summary of QC results exceeding acceptance criteria; etc.)

The above information is logged into the LIMS database at CCL.

The Public Health Chemist of the Consolidated Chemistry Laboratory will be responsible for reviewing, validating, and/or qualifying results on the data reports. Any deviations from sample preparation, analysis, and/or QA/QC procedures will be documented. Departure from QC acceptance limits will be highlighted. Once the data reports are finalized, the hard copy will be sent to the Project QA Manager at the Agency.

At the end of the sampling season, all data for both programs (Coastal and Salinas Valley) will be electronically transferred to the Agency. After data verification, the Agency Hydrologist/ Team Lead will upload the data to the Agency's Water Resources Agency Information Management System (WRAIMS) relational database.

1.9.4 Technical Reviews and Evaluations

Technical reviews and evaluations are limited to Field Activities and Laboratory Data Review Checklists.

1.9.4.1 Field Activities Review Checklist

Field personnel will be required to fill out a Field Activities Review Checklist as part of the double-check process upon returning from the field after each sampling event (see Appendix C).

1.9.4.2 Laboratory Data Review Checklist

Laboratory data reports from the CCL will be routed to the Project QA Manager at the Agency, who will do a preliminary assessment of the data. The data reports will then be given to the Agency

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Hydrologist/ Team Lead who will be responsible for completing a Laboratory Data Review Checklist (see Appendix C).

1.9.5 Technical Memorandum

The Agency Project QA Manager is responsible for the preparation of the technical memorandum. The technical memorandum will be written in the "post sample collection" phase (see section 1.6.3). The technical memorandum will be submitted to USEPA for review by the EPA Region 9 Project Manager.

The technical memorandum will contain the following elements:

- Table of results for Chloride
- Table of results for Nitrate
- Table of results for Specific Conductance
- Map of Chloride contours for 500 mg/L values
- Map of Nitrates showing those sites which have values above and below the Drinking Water Standard Limit of 45 mg/L (nitrate as NO3)
- Map of Conductivity contours

2.0 DATA GENERATION AND ACQUISITION

2.1 SAMPLING DESIGN

In the Salinas Valley, there are four hydrogeologic subareas: Pressure, East Side, Forebay, and Upper Valley. All four subareas were selected using a directed sampling design approach. These subareas were selected deliberately based on knowledge from previous monitoring work to contain analytes of interest, specifically nitrate and conductivity in the Salinas Valley Program, and chloride and conductivity in the Coastal Program. Actual sampling sites/wells within the Salinas Valley Basin Monitoring Program were chosen using a non-deliberate sampling approach. The wells included are acquired opportunistically. Site accessibility is a key issue for sampling. Permission of property owners must be secured before accessing private wells.

There are just over 1700 active wells in the Salinas Valley. Of this total number of wells, 344 wells make up the Salinas Valley Ground Water program and 85 wells make up the Coastal Ground Water program. The wells that make up these two programs have all been sampled in the past; some have data sets as far back as the 1950's, when this was a State of CA Department of Public Works (now the Department of Water Resources) program. The Agency wants to keep as complete and continuous a data set for each of these wells as possible.

Due to the time constraints the Agency is facing during this shortened 2007 field season, June - September, staff will prioritize which wells within the Salinas Valley portion of this project will be sampled. Wells to be sampled first will be located within approximately one mile radius of municipalities and industries (such as vegetable packing plants). We refer to these areas as high beneficial use areas. Ground water wells will be identified by State Well Numbers (Township, Range, Section, and Subsection).

All wells are high production agricultural wells. All wells are sampled in the same way, if the pump is in operation then a sample will be collected. If the pump if not operating then the field sampler will note it on the field sheets and come back to the well at a later date when the well is in operation. The pump must be operating for a sample to be collected. The age of well does not alter sampling

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protocols. If a well is found to have been abandoned since the Agency last sampled the well, a notation will be made on the field sheets and the well will be removed from future sampling efforts.

2.1.1 Salinas Valley Ground Water

While it is known that high levels of nitrates exist in some aquifers of the Salinas Valley Ground Water Basin, a significant sampling effort to determine the extent in the ground water has not been conducted by the Agency for several years. There are a total of 344 sample locations within the Salinas Valley monitoring program. Sample locations are operational ground water wells, the majority of which are used for agricultural irrigation. The Pressure subarea has 158 wells, the East Side subarea has 66 wells, the Forebay has 84 wells, and the Upper Valley has 35 wells (Figures 4-7). Each of these wells will be sampled once during the 2007 summer field season (July-September). The primary criterion currently used to determine if a well will be included in the Salinas Valley monitoring program has been its status as previously sampled. This program is an ongoing ambient ground water monitoring program and continuity in sampling the same wells each field year is of prime importance, especially for water quality trend analysis. Other factors that are important in deciding if a well should be included in the monitoring program are; copy of the well completion report (commonly referred to as the driller's log), location of the perforation interval along the well casing to determine which aquifer is sampled, age of the well, and construction method used to drill the well. Additionally it is useful to know the proximity of the well to other water use (industrial, municipal, or domestic) areas. A list of Salinas Valley well names and locations are given in Table 4. All wells on this program are planned to be part of the monitoring design for subsequent years. Until these monitoring wells are abandoned or destroyed, they will remain part of this program.

2.1.2 Coastal Ground Water

The Agency currently conducts a seawater intrusion monitoring and mapping program (EPA II). This program will continue to evaluate the extent and status of seawater intrusion in the coastal areas of the Salinas Valley Basin (EPA II). The Coastal portion of the ground water program contains 85 wells, most of which are located in the Pressure subarea (Figure 8). Each well will be sampled three times, once each month of the summer 2007 field season (July-September). The first sample collection at each well will be analyzed for a complete mineral panel (Table 1), and following two collections will be analyzed for a partial mineral panel (Table 1). There are 21 wells located in the Pressure 180-Foot Aquifer, 52 wells within the Pressure 400-Foot Aquifer, two wells with perforations within both the Pressure180-Foot and 400-Foot Aquifers, four wells are located within the Pressure Deep Zone Aquifer, three in the East Side Deep Aquifer, one in the East Side Shallow Aquifer, and one in the Prunedale Aquifer. The principal criterion for inclusion in the Coastal monitoring program is historical sampling and well availability. Additional criteria for selecting a well for inclusion into the Coastal monitoring program are: a well completion report, location of the perforation interval along the well casing to determine which aquifer is sampled (180, 400, or deep zone AQ), well age, and well construction type. A list of Coastal sites and their representative aquifers are listed in Table 5.

It can not be stressed enough how important the continued monitoring of these ground water wells are for the Agency to meet its mission of monitoring the quality of the County's ground water resources. Some of these well have been sampled since the 1950's and the loss of such a long term water quality record within the County of Monterey would irreplaceable.

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2.2 SAMPLING METHODS

The objectives of the sampling procedure are to minimize changes in ground water chemistry during sample collection and transport to the laboratory, and to maximize the probability of obtaining a representative, reproducible ground water sample. This well-volume purging procedure provides a reproducible sampling technique with the goal that the samples obtained will represent water quality over the entire screen interval of the well.

Standing water in the well casing can be of a different chemical composition than that contained in the aquifer to be sampled. Solutes may be adsorbed on to, or desorbed from the well casing material, oxidation may occur, and biological activity is possible. Therefore, the stagnant water within the well must be purged so that the sample is representative of the aquifer. As a result, a well may be sampled only after the pump has been in operation for at least 15-20 minutes.

All the wells included in this project, from both the Salinas Valley area and the Coastal monitoring area are high production agricultural wells that contain deep turbine pumps operating at 500-1200 gallons per minute (gpm). Over the years of managing the ambient monitoring program, the Agency has determined that operating a deep turbine pump for 15-20 minutes before taking a sample is sufficient time to clear the entire well casing of three well volumes for ensuring a representative well sample. For referencing well casing volume, the Agency uses the well casing size provided in the well completion reports (driller's log) for each of the wells included in this monitoring program (National Field Manual for the Collection of Water-Quality Data, Chapter A2).

Sample bottles and caps are rinsed three times with ambient ground water prior to collection. The sample container is then filled, tightly capped, and labeled. No field sample filtration is required. Samples are put into a cooler with ice immediately and maintained at 4°C and delivered to the laboratory daily. See Table 6 for sample collection requirements. Extra sample containers, caps and field supplies will be carried in the truck as back-up should any problem arise in the field. Additionally, the Field Sampler will carry and maintain an updated hardcopy of the QAPP in the field to be used as a reference.

The following precautions will be followed in order to limit sampling error at the wellhead:

- Operate the pump long enough to produce water that is representative of the aquifer and not stagnant water from the casing.
- Take samples at the wellhead or near the wellhead and away from fertilizer injection ports.

Sample collection will follow protocols in accordance with recommended guidelines established by the U. S. Geological Survey (USGS) for ground water collection as described in the National Field Manual for the Collection of Water-Quality Data.

The National Field Manual for the Collection of Water-Quality Data, U.S. Geological Survey, Techniques of Water-Resources Investigations, Book 9, Chapters A1-A9 is maintained as a web-based document and is located at http://pubs.water.usgs.gov/twri9A. Updates and revisions for the National Field Manual can be found using this web-based approach.

2.3 SAMPLE HANDLING AND CUSTODY

This section describes how all samples will be treated after collection, during transport, and upon arrival at the CCL. It also includes information on proper sample disposal after laboratory analysis.

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2.3.1 *Sample Containers and Preservatives*

Sample containers to be used in this project are high density polyethylene (HDPE), one pint (~0.5 L) and 0.5 gallon (~2 liter) sizes, for partial mineral or complete mineral analyses, respectively. The Agency has used these same sample container types during previous years of this ongoing ambient monitoring program and has never had any problems with container contamination issues. Field blanks will be closely monitored and, should a problem arise, corrective actions will be taken. Only one container (pint *or* half gallon) is needed per sampling site to provide the necessary volume to run the required lab analyses (see Table 6). Sample containers and caps are purchased in bulk from a plastic container manufacturer (Consolidated Container Company). The caps for the containers are packaged separately. The containers and caps are clean upon receipt, as long as they arrive with the outer cardboard packaging intact. The containers will be kept in a closed, dry environment away from the outside elements. Sterility is not of importance because this sampling project does not include microbiological testing. As previously mentioned, all containers and caps will be rinsed three times with ambient sample water prior to sample collection.

Sample containers are labeled with pre-printed labels, which lists which panel of analytes is requested, either complete mineral or partial mineral. The collection date, collection time, and sampler name are recorded in the field with an indelible marker. After being filled out, labels will be covered with clear plastic tape (packaging type) to protect the labels from destruction during transport.

No chemical *field preservation* of the samples is required. All samples will be kept at 4±2ºC.

Preservation of samples, if required prior to analysis, will be the responsibility of the contract lab (CCL). Part of the CC lab sample receiving protocols includes lab personnel verifying, at the time of sample receipt, if any samples require lab preservation. Refer to Table 6 for listings of preservatives for specific analytes.

2.3.2 *Sample Packaging and Transport*

All samples will be handled, prepared, transported and stored in a manner so as to minimize contamination and spills. After collection, sample caps will be checked for tightness, and the samples will be put in ice chests immediately. During travel between sites, ice chest lids will be kept tightly closed in order to keep the samples at the correct temperature and protect them from sunlight. Ice used for maintaining sample temperature will be double-bagged inside durable plastic bags (Ziploc type) and be of sufficient quantity so that all samples will stored at 4±2ºC. Maximum holding times for specific analytes are listed in Table 6.

2.3.3 *Sample Custody*

Chain of custody (COC) procedures require that possession of samples be traceable from the time the samples are collected until completion and submittal of the analytical results. A completed chain of custody form is to accompany the samples to the contract laboratory (CCL). Requirements for COC paperwork can be found in Section 1.9.2.2 of this document.

All samples collected for this project will be transported from the field to the CCL via an Agency vehicle. The field sampler will deliver the samples directly to the CCL daily; there will be no intermediary transfers. Samples need to arrive at the CCL no later than 15:00, to ensure log-in and laboratory preservation. Personnel at the CCL will examine the samples for correct documentation and holding times. The CCL will follow sample custody procedures as outlined in their QA plan (see Appendix D).

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2.3.4 Sample Disposal

All samples remaining after successful completion of analyses will be disposed of properly. It is the responsibility of the personnel at the CCL to ensure that all applicable regulations are followed in the disposal of samples or related chemicals. Sample disposal procedures used by the CCL are discussed in their QA plan (see Appendix D).

2.4 ANALYTICAL METHODS

All samples will be analyzed at the County Consolidated Chemistry Laboratory (CCL). Analyses will be performed following either EPA approved methods or methods from *Standard Method for the Examination of Water and Wastewater, 18th Edition,* see Table 1 (CCL's QA Manual cites *18th Edition,* see Appendix D). Standard operating procedures (SOPs) from CCL have been included in Appendix D for each of the analyses. Should there be any deviation from these SOPs the Laboratory Director must contact the Project QA Manager.

The CCL will submit a data report and associated QC results after analyses are complete to the Project QA Manager. This data report is described in Section 1.9.3. After a preliminary assessment the Project QA Manager will pass the data on to the Team Lead, who will review the data report and QC results and evaluate its quality and usability in addressing the Project objectives.

2.5 QUALITY CONTROL

2.5.1 Field Sampling Quality Control

The assessment of field measurements will be determined from the collection and analysis of field blanks and field duplicates. For this monitoring program the field blanks will be collected at one every 20 samples or a frequency of 5%. Field duplicates will be collected at a frequency of 10% for the first two sampling events. If the criterion of <25% RPD is met, then the remaining field duplicates will be collected at a 5% frequency. Analytical acceptance criteria and corrective actions for field QC are listed in Table 2.

Deionized (DI) water will be acquired from the CCL and kept at 4±2ºC, while transported into the field. Field blank samples will be obtained by pouring DI water into a pint (~500 mL) HDPE sample container that has been triple-rinsed with DI water at the sampling location. The container will be tightly capped, placed in the cooler and delivered to the contract laboratory. Field blanks are labeled with the sampling location (State Well Number) followed by "-1".

Field blanks will be used to evaluate the collection process (from field sampling through sample analysis) for contamination from exposure to ambient conditions, from sample containers or from improper sampling and handling technique. If target analytes are found in field blanks, sampling and handling procedures will be reevaluated and corrective actions taken. Corrective actions may consist of, but are not limited to, re-training of field personnel, discussions with the contract laboratory, invalidation or qualifying of results.

Field duplicates will be collected for every analytical parameter. The duplicate sample will be collected immediately after collection of the native, following the same sampling protocols. Field duplicates are labeled with the sampling location (State Well Number) followed by "-2".

Field duplicates will be used to evaluate the precision of the sample collection through analysis. The combined variability from sampling and analysis technique, in addition to sample heterogeneity, will

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be assessed using field duplicates. If acceptance criteria are exceeded, field sampling and handling protocols will be reviewed and problems corrected. These may consist of, but are not limited to, additional training, revised sampling techniques and reevaluation of sampling location.

2.5.2 Laboratory Analyses Quality Control (Contract Laboratory)

The Monterey County Consolidated Chemistry Laboratory's (CCL) personnel are responsible for analytical Quality Control. Standard laboratory quality control elements include method blanks, laboratory control samples, analytical duplicates, matrix spikes and calibration procedures. Laboratory data quality objectives include QC acceptance criteria, frequency of analysis, and corrective actions. These data quality objectives and quality control elements for CCL are described in its QA Manual (Appendix D) and SOPs (Appendix D) and are listed in Table 3. After examination of these documents, the Agency believes that the laboratory will be able to meet the project data quality needs. Any deviation from these written procedures must be documented by the laboratory and reported to the Project QA Manager.

2.6 INSTRUMENT/EQUIPMENT TESTING, INSPECTION, AND MAINTENANCE REQUIREMENTS

Testing, inspection, and maintenance of laboratory equipment are the responsibility of the Monterey County Consolidated Chemistry Laboratory and are detailed in its QA manual in Appendix D.

2.7 INSTRUMENT CALIBRATION AND FREQUENCY

Instrument calibrations are the responsibility of the Monterey County Consolidated Chemistry Laboratory and acceptance criteria for calibrations are detailed in its QA manual in Appendix D.

2.8 INSPECTION/ACCEPTANCE REQUIREMENTS FOR SUPPLIES

2.8.1 Initial Inspection of Supplies

As mentioned previously in Section 2.3.1, sample containers are purchased in bulk from an outside vendor who specializes in supplying plastics to the beverage industry. An initial inspection will be conducted upon receipt of each shipment. Each shipment will be considered acceptable for use if *all* of the following are true:

- The shipment arrives with the outer cardboard packaging intact.
- The containers are the correct type (HDPE) and size (0.5 gal/~2L *or* 1 pint/~0.5L).
- The insides of the containers are dry.
- The insides of the containers are free of dirt or any particulate matter.

2.8.2 Field Inspection of Supplies

Immediately prior to sample collection, field samplers will visually inspect each sample container for the following:

- Dirt or any particulate matter
- Cracks of any size
- Improper fit of the cap on the container

If the field sampler observes any of the above, then the container will be discarded and an acceptable container will be used instead.

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2.8.3 Laboratory Inspection of Supplies

CCL will be responsible for establishing inspection and acceptance criteria for supplies that adhere to their internal QA/QC policies.

2.9 DATA ACQUISITION REQUIREMENTS (NON-DIRECT MEASUREMENTS)

Non-direct measurement data will not be used during this monitoring program. Should at some time in the future the Agency decide to use data from an external source, QA/QC requirements will be established. Should this occur, an addendum to this QAPP will be submitted to USEPA.

2.10 DATA MANAGEMENT

Data, as related to documentation and records, will be managed as outlined earlier in Section 1.9 of this QAPP.

In addition, the CCL will group QA/QC data under a separate client code so that QA/QC data can be filtered from regular sample data before being uploaded into the Agency's Data Management System (WRAIMS). This allows the Agency a greater flexibility both in quickly and easily accessing the data that included QA/QC samples for initial review, and increased flexibility in uploading and moving large data sets.

3.0 ASSESSMENT AND RESPONSE ACTIONS

This section lists review procedures that will be taken to ensure all the protocols outlined in the QAPP are consistently followed.

3.1 REVIEWS

3.1.1 Readiness Reviews

Water Resources Technicians/ Field Samplers will be trained by the Hydrologist/Team Lead before any field sampling begins. Training will cover proper sample collection and handling and the completion of all paperwork (COCs, field logbooks, etc). The Team Lead will ensure that Field Samplers have properly prepared all collection containers, paperwork and other supplies needed to complete a successful sampling event. Any problems discovered during the readiness review will be corrected before the Samplers begin work.

3.1.2 Field Reviews

The Team Lead will be responsible for overseeing that all field activities are incompliance with Agency protocols. The Team Lead will be available via phone should any questions arise while the Samplers are in the field. The Team Lead will also review all field paperwork such as COCs and field logbooks for completion. Additionally the field QC samples (field blanks and duplicates) will be used to evaluate the individual Sampler's technique. If problems are exposed they will be corrected straight away so that all further samples are valid. A stop-work order may be issued by the Project QA Manager at any time if a discrepancy or error is found that could negatively affect the data being collected.

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3.1.3 Post Sampling Reviews

Post sampling reviews will be conducted following each sampling event in order to ensure all information is complete. Reviews will be conducted by the Field Sampler due to the small size of the staff. They will include evaluation of sampling activities and field documentation and will take place in the office, not in the field. Findings will be passed on to the Team Lead and the Project QA Manager to be incorporated into the next field event.

3.1.4 Laboratory Data Reviews

The Team Lead will be responsible for reviewing the laboratory's data for completeness and accuracy. The data will also be checked to determine that all specified methods were used and all related QC data was provided with the sample analytical results. These reviews will take place immediately upon receipt of data reports from the laboratory. This will ensure that any method deviations are corrected or explained, and any missing or incomplete data are provided. The Project QA Manager has the authority to request re-testing of laboratory data if it is invalid or would otherwise compromise the quality of the resulting project conclusions.

3.2 REPORTS

The Project QA Manager will be responsible for the technical memorandum (EPA R9# 03-238 Task 3.3) which will be provided in March 2008 to US EPA. The technical memorandum (EPA R9# 03-238 Task 3.3) will include result tables for chloride, nitrate, and specific conductivity, and maps of chloride, nitrate, and specific conductivity gradients. The technical memorandum will include a summary of any significant QA/QC issues and how they were resolved. It is currently understood that this project is of short enough duration that only a final technical memorandum to the EPA is necessary.

4.0 DATA VALIDATION AND USABILITY

4.1 DATA VERIFICATION AND VALIDATION

Data review is the in-house examination to ensure that the data have been recorded, transmitted, and processed correctly. The Team Lead is responsible for the data review. This examination will check for data entry errors, calculation errors, and data omission errors. If possible these errors will be corrected.

4.1.1 Field Data

Field data include logbooks, photographs, and COCs. The Field Sampler is responsible for reviewing the field data at the end of the sampling event. This includes determining that all information is complete and any deviations from the sampling methodologies are documented using the Field Activities Review Checklist (Appendix C).

4.1.2 Laboratory Data

Initial evaluation of the laboratory data are carried out by the CCL in agreement with protocols listed in their SOPs and QA manual. The Team Lead will also conduct an independent review of the data and QC parameters as described in sections 3.1.4 and using the Laboratory Data Review Checklist as detailed in section 1.9.4.4 and Appendix C.

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4.2 RECONCILIATION WITH USER REQUIREMENTS

The purpose of the continued ambient monitoring of the Salinas Valley Basin Ground Water is to assess the water quality to manage and protect ground water resources. For data to be useful in developing the overreaching Salinas Valley Integrated Water Management Plan, it must first meet the requirement of this QA project Plan. The Project QA Manager will be responsible for making the final evaluation of the data's usability in meeting the Project objectives. All data passing this final evaluation will then be used to establish a cohesive and succinct Water Quality Management Plan in accordance to the work begun under EPA-I and continued under EPA-II. Additionally, the Agency will integrate these ground water quality data with previously collected data for use in trend analysis.

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5.0 REFERENCES

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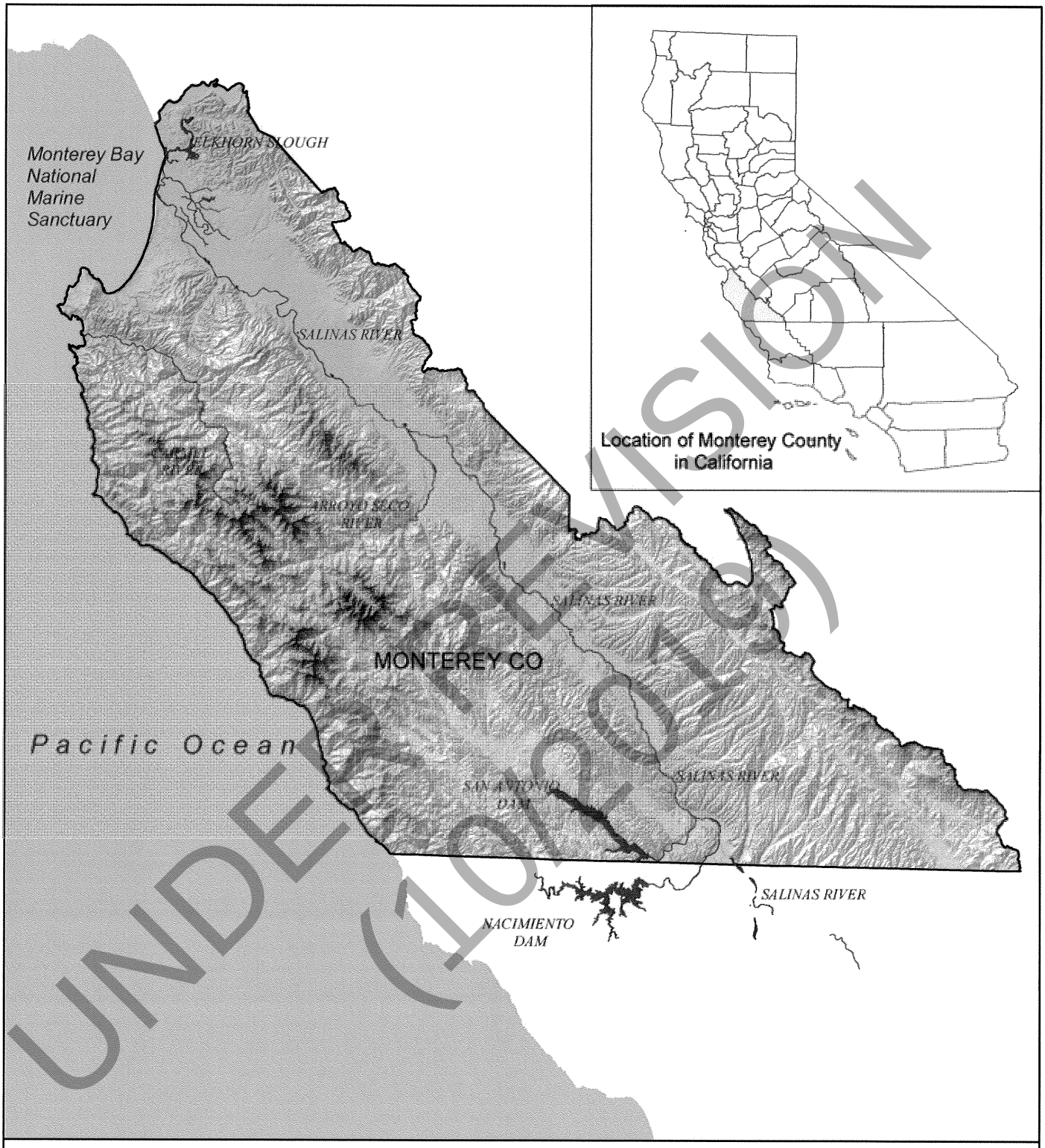
US EPA. 2002. *Guidance for Quality Assurance Project Plans.*

US EPA Grant R9# 03-238. 2003. *Salinas Valley Integrated Water Management Plan.* Prepared by The Monterey County Water Resources Agency. Prepared for US EPA Region 9. Grants Management Office.

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FIGURES

UNDER REVISION
(10/2019)



UNDER REVISION
(10/2010)

Legend

Water Bodies/ Channels

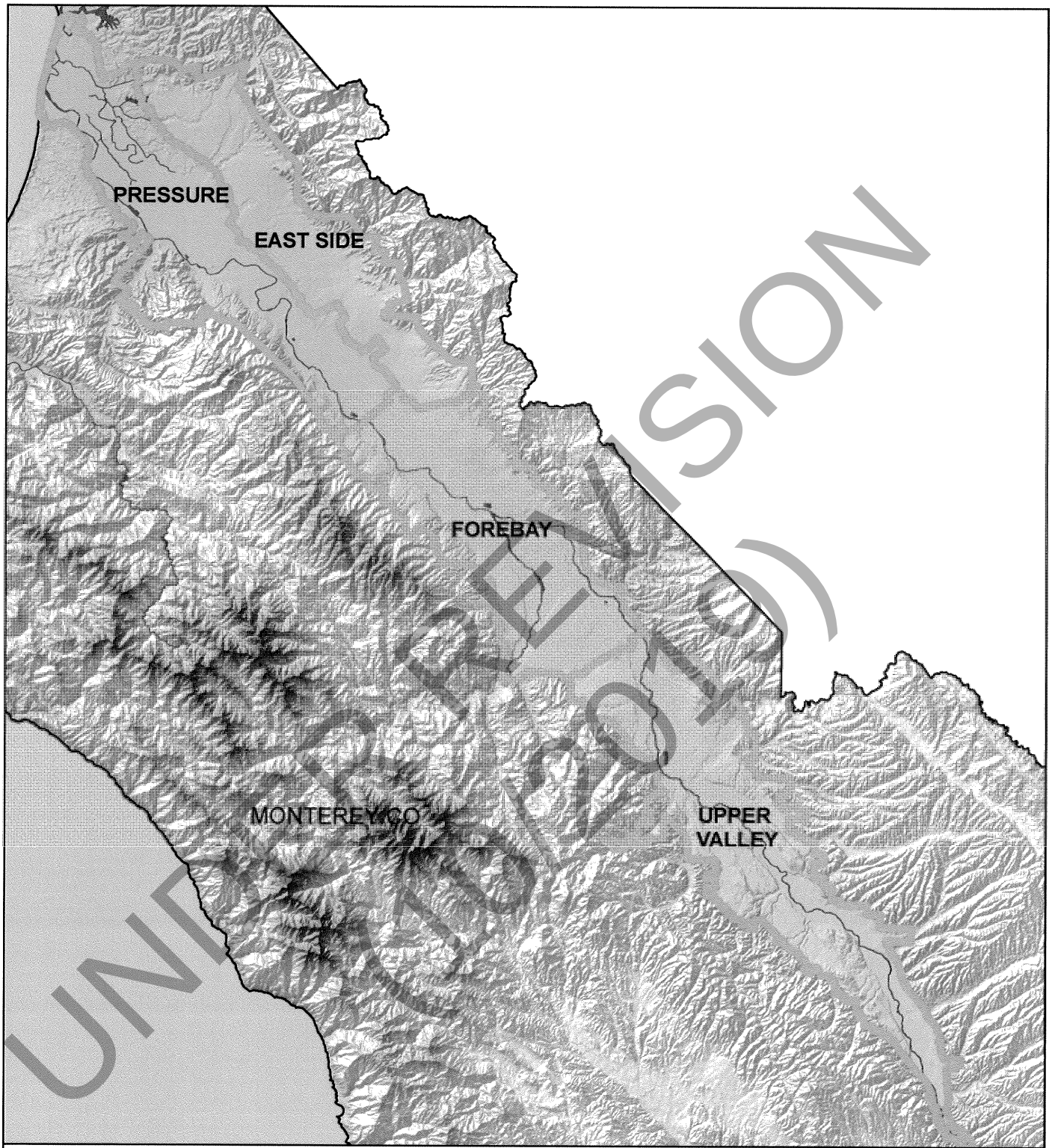
Monterey County, California

Figure 1

0 4 8 12 16 Miles

Note: The scale and configuration of all information shown hereon are approximate and are not intended as a guide for survey or design work.

Map Date: July 5, 2007



UNDER REVISION

Legend

Water Bodies/ Channels

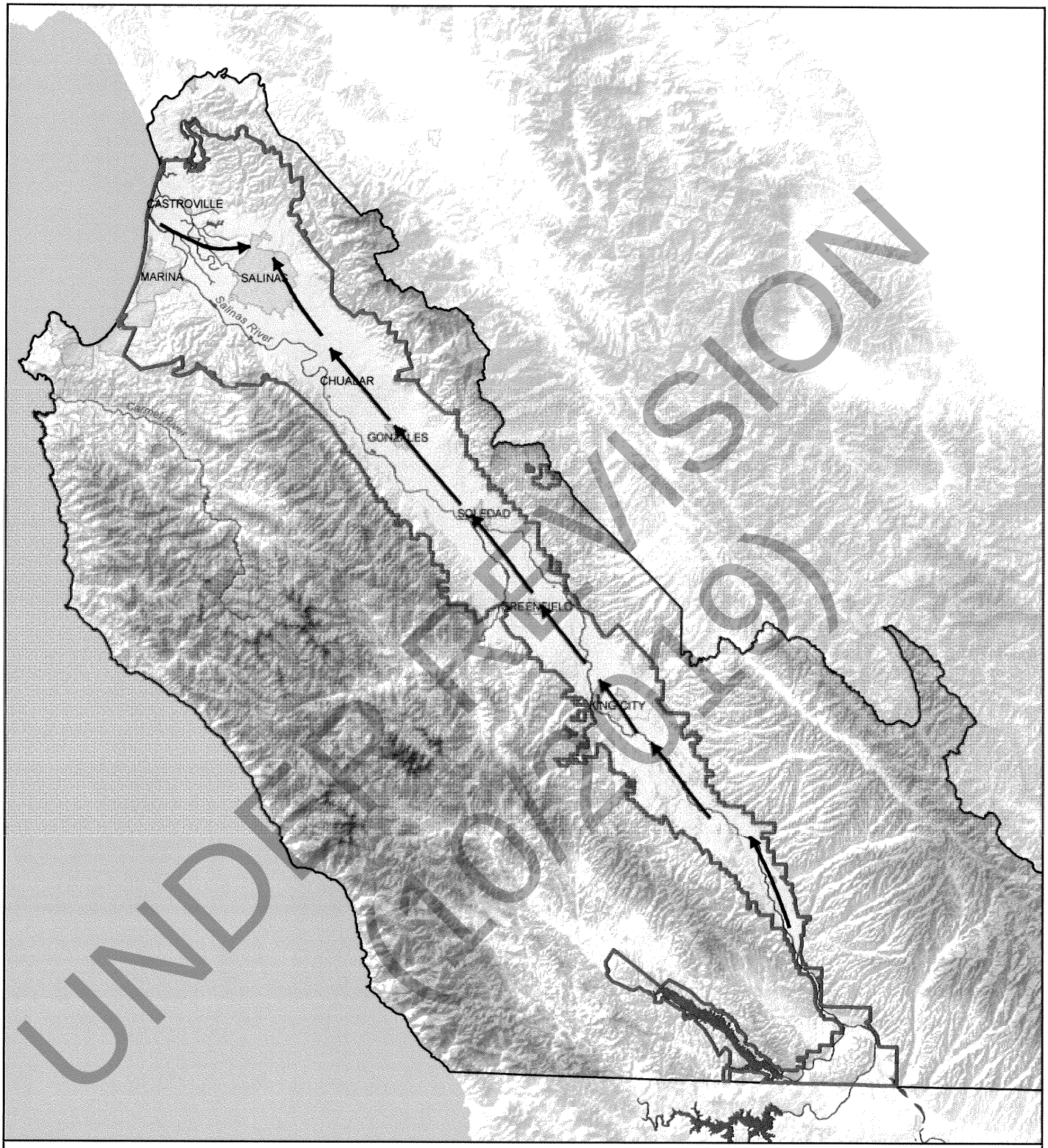
Salinas Valley Aquifers

Figure 2

0 2 4 6 8 Miles

Note: The scale and configuration of all information shown hereon are approximate and are not intended as a guide for survey or design work.

Map Date: July 5, 2007



UNDER REVISION (2019)

Ground Water Flow Direction in the Salinas Valley

Figure 3

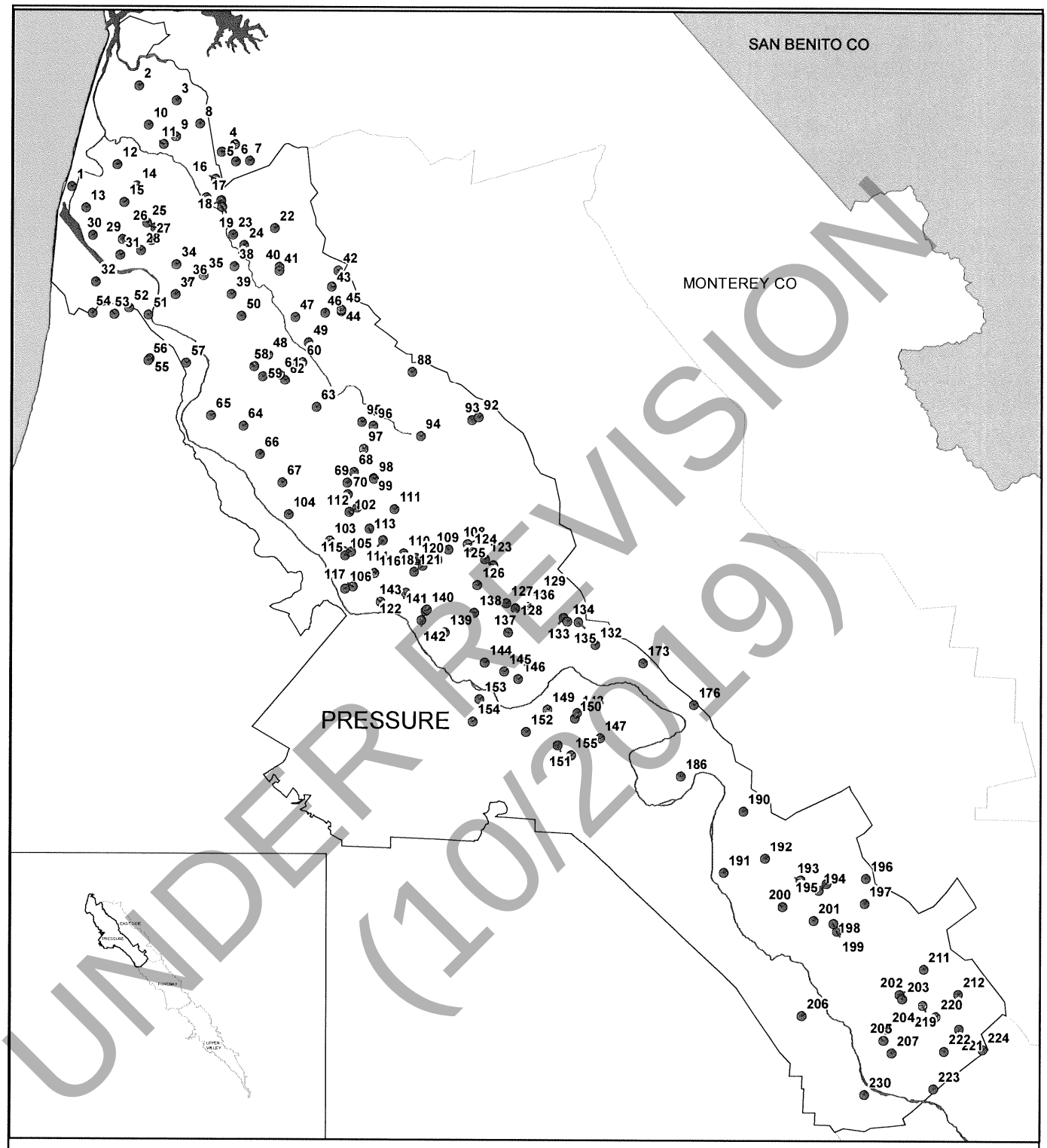
Legend

- Ground Water Flow Direction
- Assessment Zone 2C
- Monterey County
- Rivers and Other Bodies of Water

0 10 20 Miles

Note: The scale and configuration of all information shown hereon are approximate and are not intended as a guide for survey or design work.

Map Date: July 6, 2007



UNDER REVISION
(10/2019)

Legend:

- Study Well
- Rivers

SUBAREA

- SUBAREA
- PRESSURE

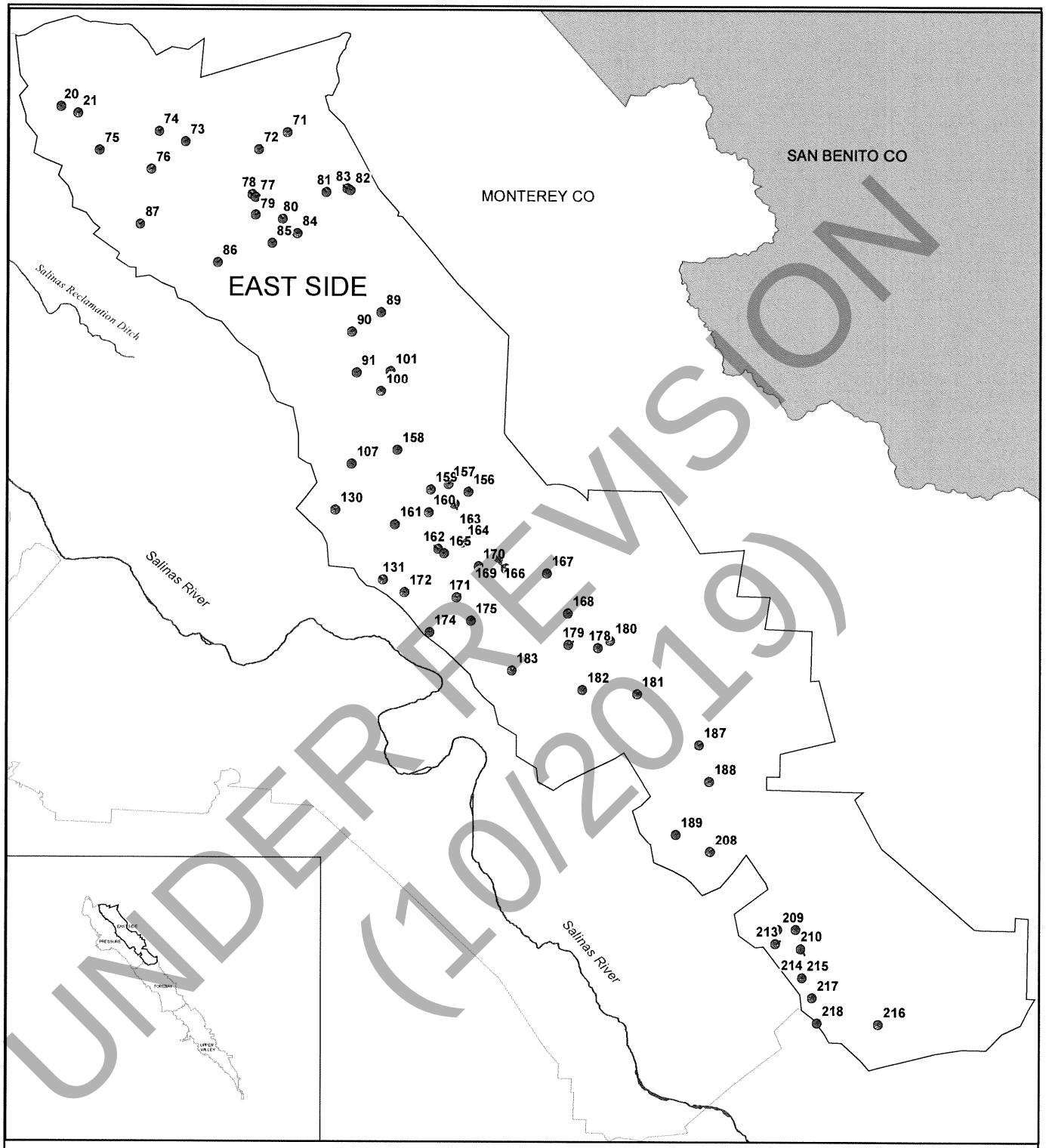
Salinas Valley Wells in the Pressure Subarea

Figure 4

0 0.75 1.5 2.25 3 Miles

Note: The scale and configuration of all information shown hereon are approximate and are not intended as a guide for survey or design work.

Map Date: July 5, 2007



Legend:

- Study Well
- Rivers

SUBAREA

- SUBAREA
- EAST SIDE

Salinas Valley Wells in the East Side Subarea

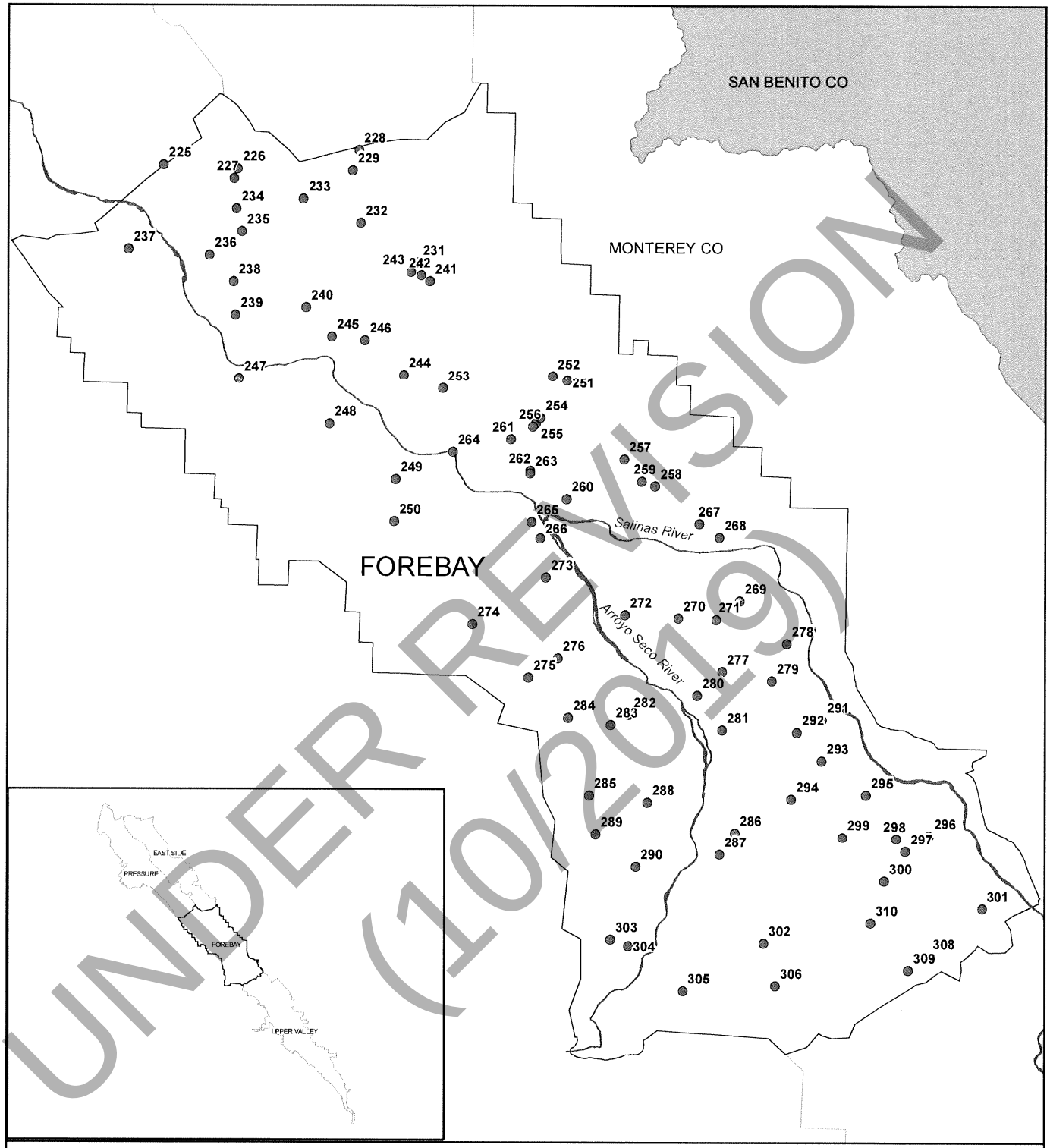
Figure 5

N W E S

0 0.75 1.5 2.25 3 Miles

Note: The scale and configuration of all information shown hereon are approximate and are not intended as a guide for survey or design work.

Map Date: July 5, 2007



Legend:

- Study Well
- Rivers

SUBAREA

- SUBAREA
- FOREBAY

Salinas Valley Wells in the Forebay Subarea

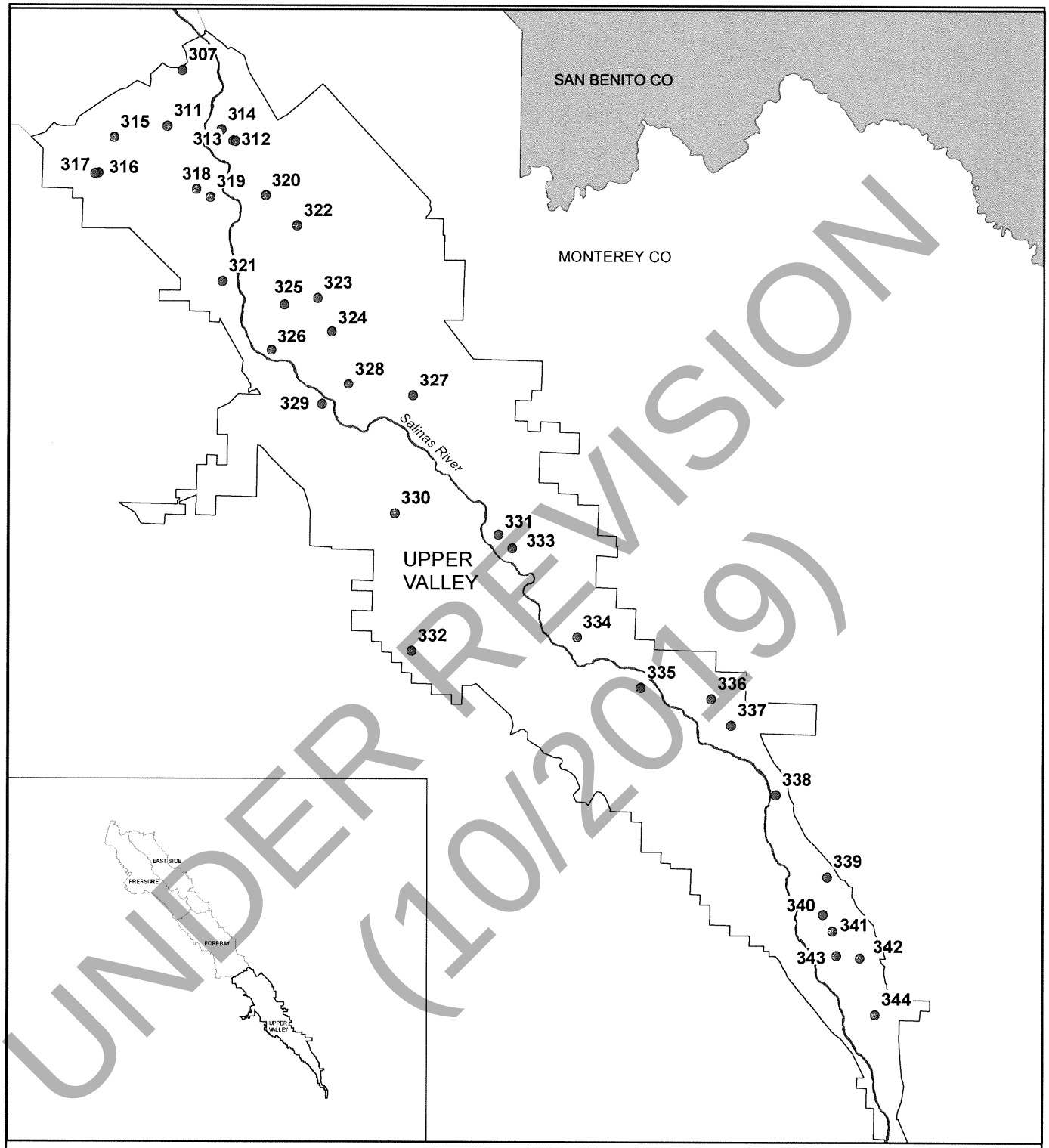
Figure 6

N
W
E
S

0 0.75 1.5 2.25 3 Miles

Note: The scale and configuration of all information shown hereon are approximate and are not intended as a guide for survey or design work.

Map Date: July 5, 2007



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Salinas Valley Wells in the Upper Valley Subarea

Figure 7

Legend:

- Study Well
- Rivers

SUBAREA

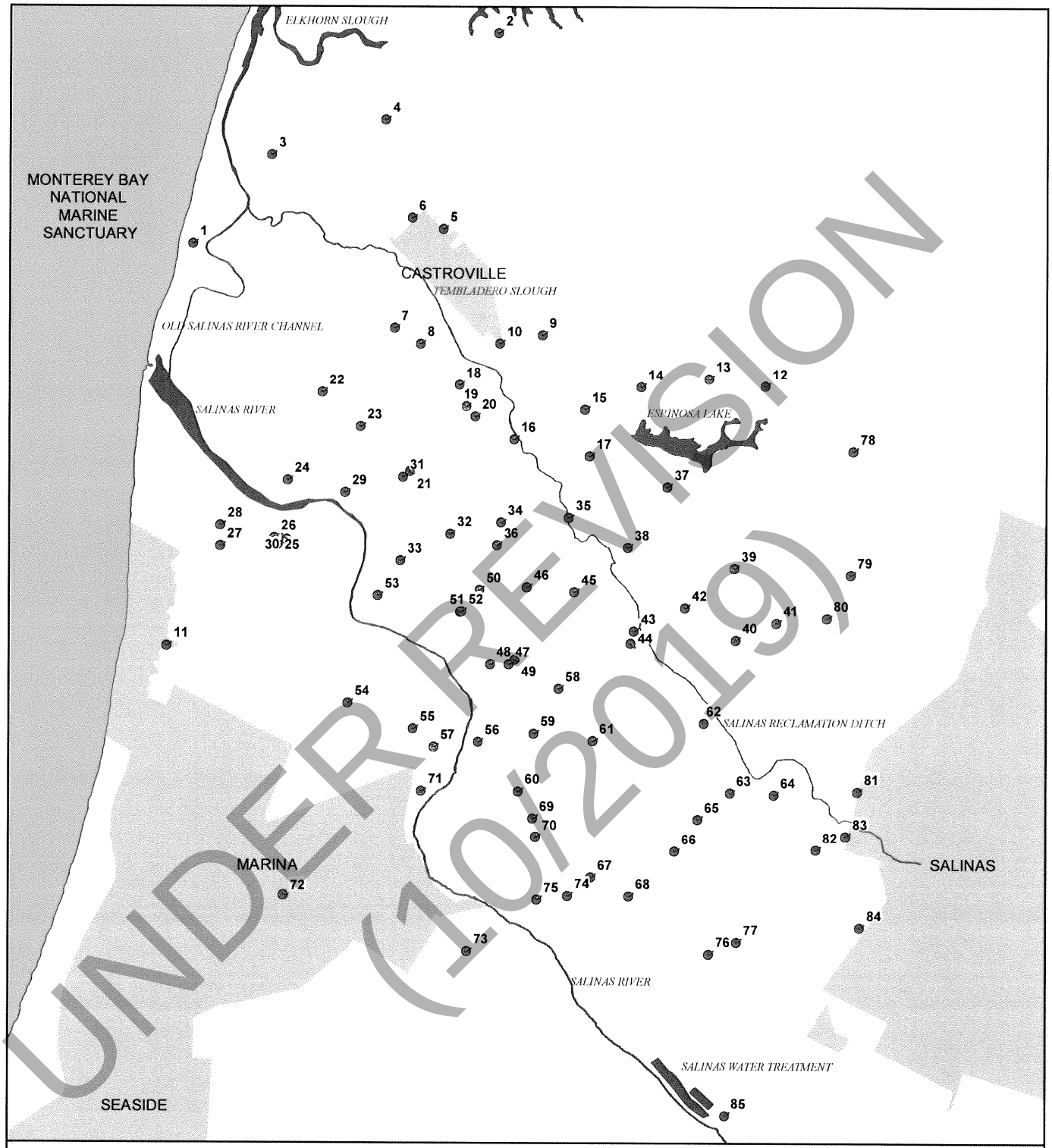
- SUBAREA
- UPPER VALLEY

N
W E
S

0 0.75 1.5 2.25 3 Miles

Note: The scale and configuration of all information shown hereon are approximate and are not intended as a guide for survey or design work.

Map Date: July 5, 2007



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Coastal Ground Water Monitoring Program Wells

Figure 8

Legend:

- Study Well
- Cities
- Water Bodies/ Channels

N W E S

0 0.5 1 1.5 2 Miles

Note: The scale and configuration of all information shown hereon are approximate and are not intended as a guide for survey or design work.

Map Date: July 02, 2007

TABLES

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Table 1 COMPLETE MINERAL PANEL ANALYTES

ANALYTE	*METHOD*	*LABORATORY MDL***	*LABORATORY PQL*	*LOWEST CALIB. STD.*	*PAL*
Calcium (Ca)	SM 3111 B[1]	0.02 mg/L	1.0 mg/L	1.0 mg/L	1.0 mg/L
CATION ANION BALANCE	Calculated	--	--	--	--
*Chloride (Cl)	EPA 300.0[2]	0.01 mg/L	1.0 mg/L	0.1 mg/L	1.0 mg/L
*Conductivity (SEC)	SM 2510 B	1 umho/cm @ 25 C	1 umho/cm @ 25 C	N/A	1 umho/cm @ 25 C
Magnesium (Mg)	SM 3111 B	0.005 mg/L[1]	1.0 mg/L	0.1 mg/L	1.0 mg/L
*Nitrate (NO3)	EPA 300.0	0.002 mg/L[2]	1.0 mg/L	0.1 mg/L	1.0 mg/L
pH (Laboratory)	SM 4500-H B	pH Units (2 sig figs)	pH Units (2 sig figs)	N/A	pH Units (2 sig figs)
Potassium (K)	SM 3111 B	0.025 mg/L[1]	0.1 mg/L	0.1 mg/L	0.1 mg/L
Sodium (Na)	SM 3111 B	0.03 mg/L[1]	1.0 mg/L	0.1 mg/L	1.0 mg/L
Sulfate (SO4)	EPA 300.0	0.03 mg/L[2]	1.0 mg/L	0.1 mg/L	1.0 mg/L
Total Alkalinity (as CaCO3)	SM 2320 B	1.0 mg/L	1.0 mg/L	N/A	1.0 mg/L

[1] = MDL study completed February 2007

[2] = MDL study completed May 2007

* = Partial Mineral Panel analytes

** = These are the laboratory's latest MDLs and supersede the MDLs listed in Appendix D-1.

MDL = method detection limit; PQL = practical quantitative limit; PAL = project action level

All laboratory results are bracketed by calibration standards. No "estimated" results (below the lowest calib std and above the MDL) are given to the Agency.

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Table 2 QUALITY CONTROL REQUIREMENTS FOR LABORATORY ANALYSES

QA PROCEDURE	QA PARAMETER	FREQUENCY	CRITERION	CORRECTIVE ACTION
Field Blank	Field Contamination	1/20 field samples; 5% frequency	<MDL	Recollect sampling event or flag data if unable recollect
Field Duplicate	Field Precision	1/10 field samples for first two events; if criterion is met, then 1/20 field samples	RPD < 25%	Recollect sampling event or flag data if unable recollect
Method Blank	Analytical Contamination	3 per analytical batch	< RL	Reanalyze analytical batch
LCS (CRM)	Accuracy	1 per analytical batch	80-120% REC	Reanalyze analytical batch
Analytical Duplicate	Analytical Precision	1 per analytical batch	RPD < 25%	Reanalyze analytical batch
Matrix Spike	Matrix Interference and Accuracy	1 per analytical batch; at 3-10x the native conc.	75-125% REC	Reanalyze analytical batch
Matrix Spike Duplicate	Precision and Accuracy	1 per analytical batch; at 3-10x the native conc.	RPD <25%	Reanalyze analytical batch
Continuing Calibration	Analytical Control	1 per 10 sample runs	80-120% of initial slope	Reanalyze analytical batch
Assess percent of data successfully collected	Data Completeness	N/A	90%	N/A

MDL=Method Detection Limit; RPD=Relative Percent Difference; RL=Report Limit;
REC=Recovery; LCS=Laboratory Control Sample; CRM=Certified Reference Material
An analytical batch is defined as 20 or fewer samples.

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Table 3 LABORATORY DATA QUAILITY OBJECTIVES (DQOs)

ANALYTE	METHOD BLANK	LCS (CRM)	ANALYTICAL DUPLICATE	MATRIX SPIKE	MATRIX SPIKE DUPLICATE	CONTINUING CALIBRATION
Calcium (Ca)	yes	yes	yes	yes	yes	yes
Chloride (Cl)	yes	yes	yes	yes	yes	yes
Conductivity (SEC)	yes	yes	yes	no	no	yes
Magnesium (Mg)	yes	yes	yes	yes	yes	yes
Nitrate (NO3)	yes	yes	yes	yes	yes	yes
pH (Laboratory)	no	yes	yes	no	no	yes
Potassium (K)	yes	yes	yes	yes	yes	yes
Sodium (Na)	yes	yes	yes	yes	yes	yes
Sulfate (SO4)	yes	yes	yes	yes	yes	yes
Total Alkalinity (as CaCO3)	yes	yes	yes	no	no	yes

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Table 4 SALINAS VALLEY WELLS AND LOCATIONS

STATE WELL NUMBER	AQUIFER	MAP ID	FALSE EASTING[1]	FALSE NORTHING[1]
13S/01E-36J01	PRESSURE 900	1	5741483.0	2170847.00002
13S/02E-20M02	PRESSURE 400	2	5748878.5	2182094.25003
13S/02E-21N01	PRESSURE 400	3	5753018.5	2180456.75002
13S/02E-27L01	PRESSURE 180	4	5759500.0	2175572.50002
13S/02E-27M01	PRESSURE 400	5	5758010.0	2174784.50002
13S/02E-27P01	PRESSURE 400	6	5759593.5	2173660.50002
13S/02E-27Q02	PRESSURE 400	7	5761129.5	2173768.75002
13S/02E-28B01	PRESSURE 400	8	5755624.0	2177900.75002
13S/02E-28E01	PRESSURE 400	9	5752984.0	2176434.75002
13S/02E-29F02	PRESSURE 400	10	5749961.0	2177732.25002
13S/02E-29J01	PRESSURE 400	11	5751657.5	2175604.25002
13S/02E-31A02	PRESSURE 900	12	5746516.5	2173308.00002
13S/02E-31N02	PRESSURE 400	13	5743060.5	2168496.25002
13S/02E-32M02	PRESSURE 900	14	5748673.0	2170965.00002
13S/02E-32N01	PRESSURE 400	15	5747285.0	2169132.75003
13S/02E-33H03	PRESSURE 180	16	5757325.5	2171726.00002
13S/02E-33R01	PRESSURE 180	17	5756359.5	2169699.75003
13S/02E-34M02	PRESSURE 180	18	5757952.0	2169365.25003
13S/02E-34N01	PRESSURE 180	19	5758043.5	2168657.25003
13S/02E-36J01	EAST SIDE BOTH	20	5772057.0	2168257.00002
14S/02E-01A01	EAST SIDE	21	5773736.0	2167596.00002
14S/02E-02E02	PRESSURE 400	22	5763989.0	2166284.00003
14S/02E-03F02	PRESSURE 180	23	5759284.0	2165549.00003
14S/02E-03K02	PRESSURE 400	24	5760546.0	2164390.00002
14S/02E-05F04	PRESSURE 400	25	5749784.5	2166850.50002
14S/02E-05G03	PRESSURE 400	26	5750701.5	2166258.50002
14S/02E-05K01	PRESSURE 400	27	5750303.5	2164892.00002
14S/02E-05P02	PRESSURE 400	28	5749120.0	2163754.25002
14S/02E-06J03	PRESSURE 400	29	5747119.5	2164986.75002
14S/02E-06L01	PRESSURE 900	30	5743826.5	2165438.75002
14S/02E-06R02	PRESSURE 400	31	5746852.5	2163229.50003
14S/02E-07K01	PRESSURE 400	32	5744199.0	2160286.75002
14S/02E-08A01	PRESSURE 400	33	5751818.0	2162226.75002
14S/02E-09D03	PRESSURE 400	34	5753098.5	2162246.50002
14S/02E-09H03	PRESSURE 400	35	5756070.0	2161048.75002

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STATE WELL NUMBER	AQUIFER	MAP ID	FALSE EASTING[1]	FALSE NORTHING[1]
14S/02E-09L02	PRESSURE 400	36	5754291.5	2160250.25002
14S/02E-09N01	PRESSURE 400	37	5752950.5	2158867.00003
14S/02E-10C01	PRESSURE 400	38	5759437.0	2162015.75002
14S/02E-10P02	PRESSURE 400	39	5759125.0	2158942.75002
14S/02E-11C01	PRESSURE 180	40	5764471.5	2161959.50002
14S/02E-11D01	PRESSURE 180	41	5764508.5	2161568.25002
14S/02E-12B01	PRESSURE 400	42	5771184.5	2161614.00002
14S/02E-12L02	PRESSURE 400	43	5770434.5	2159815.50002
14S/02E-12Q01	PRESSURE 400	44	5771537.0	2157088.75002
14S/02E-13B02	PRESSURE 180	45	5771526.0	2157219.75003
14S/02E-13D01	PRESSURE 180	46	5769699.5	2156883.75002
14S/02E-14B01	PRESSURE 180	47	5766275.0	2156434.00002
14S/02E-14N03	PRESSURE 400	48	5763230.0	2152205.50003
14S/02E-14R01	PRESSURE 180	49	5767842.5	2153580.50002
14S/02E-15B01	PRESSURE 400	50	5760275.5	2156533.25002
14S/02E-17B02	PRESSURE 400	51	5749990.5	2156598.25002
14S/02E-17C01	PRESSURE 180	52	5747844.0	2157381.75003
14S/02E-18A01	PRESSURE 400	53	5746233.0	2156686.25002
14S/02E-18C01	PRESSURE 400	54	5743827.5	2156787.25002
14S/02E-20B01	PRESSURE 180	55	5750165.5	2151711.75003
14S/02E-20B02	PRESSURE 180	56	5750001.0	2151554.75003
14S/02E-21F02	PRESSURE 180	57	5754169.5	2151251.50002
14S/02E-22H01	PRESSURE 400	58	5761690.5	2150902.75002
14S/02E-22H02	PRESSURE 180	59	5762674.0	2149777.00002
14S/02E-23A01	PRESSURE 180	60	5767130.0	2151399.50002
14S/02E-23F01	PRESSURE 180	61	5764570.5	2149971.00002
14S/02E-23L03	PRESSURE 400	62	5765164.5	2149382.00002
14S/02E-25D03	PRESSURE 400	63	5768753.5	2146325.50002
14S/02E-27K01	PRESSURE 180	64	5760536.0	2144212.25002
14S/02E-28H02	PRESSURE 180	65	5756940.5	2145354.75002
14S/02E-34A03	PRESSURE 400	66	5762394.5	2141097.75002
14S/02E-35L02	PRESSURE 400	67	5764879.0	2137944.25002
14S/02E-36H01	PRESSURE 180	68	5773015.5	2139158.50003
14S/02E-36J02	PRESSURE 400	69	5772268.5	2137939.00002
14S/02E-36R02	PRESSURE 400	70	5772326.5	2136698.50002
14S/03E-02E03	EAST SIDE BOTH	71	5794727.5	2165742.50002
14S/03E-03K01	EAST SIDE BOTH	72	5791884.0	2164011.25002

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STATE WELL NUMBER	AQUIFER	MAP ID	FALSE EASTING[1]	FALSE NORTHING[1]
14S/03E-04E01	EAST SIDE BOTH	73	5784479.5	2164809.75002
14S/03E-05B02	EAST SIDE BOTH	74	5781839.5	2165837.25002
14S/03E-06L01	EAST SIDE SHALLOW	75	5775895.0	2163924.50003
14S/03E-08C01	EAST SIDE BOTH	76	5781050.5	2162072.25002
14S/03E-10F02	EAST SIDE	77	5791569.0	2159330.50002
14S/03E-10F03	EAST SIDE BOTH	78	5791236.5	2159578.00002
14S/03E-10P01	EAST SIDE	79	5791544.0	2157558.25002
14S/03E-10R02	EAST SIDE BOTH	80	5794251.5	2157151.00002
14S/03E-11H01	EAST SIDE SHALLOW	81	5798504.0	2159823.00002
14S/03E-12E01	EAST SIDE SHALLOW	82	5800865.5	2160009.25003
14S/03E-12E02	EAST SIDE	83	5800608.5	2160173.25003
14S/03E-14D01	EAST SIDE SHALLOW	84	5795697.5	2155748.25003
14S/03E-15H03	EAST SIDE BOTH	85	5793222.5	2154777.00002
14S/03E-16K03	EAST SIDE	86	5787748.0	2152845.50003
14S/03E-17D01	EAST SIDE	87	5779979.0	2156594.00002
14S/03E-20D01	PRESSURE 400	88	5779540.0	2150357.75002
14S/03E-24H01	EAST SIDE SHALLOW	89	5803951.0	2147934.50002
14S/03E-24N01	EAST SIDE	90	5801060.0	2146002.50002
14S/03E-25L02	EAST SIDE BOTH	91	5801508.5	2141975.75002
14S/03E-28B02	PRESSURE 400	92	5786919.0	2145249.50002
14S/03E-28F02	PRESSURE 400	93	5786200.6	2144963.98574
14S/03E-29L04	PRESSURE 180	94	5780547.4	2143125.21920
14S/03E-30E01	PRESSURE 180	95	5773899.5	2144670.25003
14S/03E-30F02	PRESSURE 180	96	5775180.5	2144268.50002
14S/03E-30N01	PRESSURE 180	97	5774083.5	2141696.50002
14S/03E-31F01	PRESSURE 180	98	5775271.5	2138346.50003
14S/03E-31F02	PRESSURE 400	99	5775228.5	2138492.00002
14S/03E-36A01	EAST SIDE SHALLOW	100	5803921.0	2140085.50002
14S/04E-30N01	EAST SIDE BOTH	101	5804847.5	2142132.00001
15S/02E-01A03	PRESSURE 400	102	5772482.0	2134724.00002
15S/02E-01K01	PRESSURE 180	103	5770291.5	2131514.75002
15S/02E-02G01	PRESSURE 400	104	5765615.0	2134401.50002
15S/02E-12A01	PRESSURE 400	105	5772051.5	2129878.50002
15S/02E-12R01	PRESSURE 400	106	5772057.5	2126203.25003
15S/03E-01L01	EAST SIDE	107	5801038.5	2132896.75002
15S/03E-04K03	PRESSURE 400	108	5785732.5	2131172.00002
15S/03E-04N03	PRESSURE 400	109	5783621.0	2130577.75002

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STATE WELL NUMBER	AQUIFER	MAP ID	FALSE EASTING[1]	FALSE NORTHING[1]
15S/03E-05N01	PRESSURE 180	110	5778619.0	2130164.00003
15S/03E-06A03	PRESSURE 180	111	5777613.0	2135010.00002
15S/03E-06D02	PRESSURE 400	112	5773392.0	2135175.75002
15S/03E-06F02	PRESSURE 400	113	5774781.5	2132857.75002
15S/03E-06K01	PRESSURE 400	114	5776302.5	2131605.50002
15S/03E-07D02	PRESSURE 400	115	5772729.0	2130304.25002
15S/03E-07G01	PRESSURE 400	116	5775356.0	2127909.75002
15S/03E-07N01	PRESSURE 180	117	5772911.5	2126430.50002
15S/03E-08B04	PRESSURE 400	118	5780790.5	2128738.25002
15S/03E-08C06	PRESSURE 180	119	5780025.5	2129640.75003
15S/03E-08C07	PRESSURE 400	120	5780124.5	2129385.50002
15S/03E-08F07	PRESSURE 400	121	5779786.0	2128096.50002
15S/03E-08N03	PRESSURE 400	122	5778859.5	2125760.50002
15S/03E-09B01	PRESSURE 180	123	5787613.5	2129526.50003
15S/03E-09C01	PRESSURE 180	124	5785912.0	2130387.75002
15S/03E-09H02	PRESSURE 180	125	5788543.5	2128841.50003
15S/03E-09K04	PRESSURE 400	126	5786815.0	2126625.50003
15S/03E-10P01	PRESSURE 180	127	5789973.0	2124641.25002
15S/03E-10P03	PRESSURE 180	128	5790992.5	2124075.25002
15S/03E-10R02	PRESSURE 180	129	5793537.5	2125764.25002
15S/03E-12E02	EAST SIDE BOTH	130	5799472.0	2128349.25000
15S/03E-13J02	EAST SIDE	131	5804170.5	2121482.50002
15S/03E-13N01	PRESSURE 180	132	5799834.5	2120075.00003
15S/03E-14C01	PRESSURE 180	133	5796323.5	2123063.75002
15S/03E-14G01	PRESSURE 180	134	5796738.0	2122656.50003
15S/03E-14H01	PRESSURE 180	135	5797941.0	2122606.00002
15S/03E-15B01	PRESSURE 400	136	5792336.0	2124219.00002
15S/03E-15L02	PRESSURE 180	137	5790177.0	2121393.00002
15S/03E-16B03	PRESSURE 400	138	5786481.0	2123545.50002
15S/03E-16M01	PRESSURE 180	139	5783233.5	2121388.25002
15S/03E-17B01	PRESSURE 180	140	5781259.5	2123911.75003
15S/03E-17B02	PRESSURE 180	141	5781099.5	2123757.50002
15S/03E-17G01	PRESSURE 180	142	5780630.0	2122750.25002
15S/03E-18B01	PRESSURE 180	143	5776074.5	2124737.50002
15S/03E-21A01	PRESSURE 180	144	5787617.0	2118056.00002
15S/03E-22F02	PRESSURE 180	145	5789756.5	2117099.00002
15S/03E-22G01	PRESSURE 180	146	5791343.0	2116241.25002

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STATE WELL NUMBER	AQUIFER	MAP ID	FALSE EASTING[1]	FALSE NORTHING[1]
15S/03E-25L01	PRESSURE 180	147	5800408.5	2109728.50003
15S/03E-26A01	PRESSURE 400	148	5797857.5	2112518.00002
15S/03E-26D01	PRESSURE 180	149	5794548.5	2112893.75003
15S/03E-26H02	PRESSURE 180	150	5797573.5	2111904.75002
15S/03E-26P01	PRESSURE 400	151	5795686.5	2108925.25002
15S/03E-27J01	PRESSURE 400	152	5792207.5	2110413.00002
15S/03E-28B02	PRESSURE 400	153	5787075.5	2113993.25002
15S/03E-28G01	PRESSURE 180	154	5786358.0	2111546.50003
15S/03E-35B05	PRESSURE 180	155	5797153.0	2107813.50003
15S/04E-05K01	EAST SIDE	156	5812585.0	2130171.00001
15S/04E-05M01	EAST SIDE BOTH	157	5810608.5	2130920.50001
15S/04E-06D04	EAST SIDE BOTH	158	5805535.0	2134296.75001
15S/04E-06R01	EAST SIDE BOTH	159	5808832.0	2130397.50001
15S/04E-07A01	EAST SIDE BOTH	160	5808667.0	2128112.25001
15S/04E-07E02	EAST SIDE	161	5805290.0	2126918.25001
15S/04E-07R01	EAST SIDE SHALLOW	162	5809617.5	2124497.75001
15S/04E-08C01	EAST SIDE SHALLOW	163	5811226.0	2128961.75001
15S/04E-08L01	EAST SIDE BOTH	164	5812038.0	2125163.50001
15S/04E-08N01	EAST SIDE BOTH	165	5810237.5	2124086.00001
15S/04E-09N01	EAST SIDE	166	5815679.0	2123673.25001
15S/04E-15D02	EAST SIDE SHALLOW	167	5820525.5	2122131.50001
15S/04E-15P02	EAST SIDE BOTH	168	5822591.0	2118164.75001
15S/04E-16D01	EAST SIDE BOTH	169	5816370.5	2122604.00001
15S/04E-17B01	EAST SIDE	170	5813674.5	2122802.00001
15S/04E-17P02	EAST SIDE SHALLOW	171	5811444.0	2119748.75001
15S/04E-18L01	EAST SIDE	172	5806258.0	2120249.25001
15S/04E-19D02	PRESSURE 400	173	5805231.0	2118084.25001
15S/04E-19H03	EAST SIDE	174	5808765.0	2116311.75003
15S/04E-20B02	EAST SIDE SHALLOW	175	5812893.0	2117437.00001
15S/04E-20N01	PRESSURE 400	176	5810999.0	2113437.25001
15S/04E-20Q01	EAST SIDE	177	5813019.5	2113916.75003
15S/04E-22J01	EAST SIDE	178	5825620.5	2114797.50001
15S/04E-22L02	EAST SIDE BOTH	179	5822626.0	2115130.25001
15S/04E-23M01	EAST SIDE	180	5826800.0	2115510.00001
15S/04E-26G01	EAST SIDE	181	5829452.0	2110273.75001
15S/04E-27G01	EAST SIDE BOTH	182	5824082.0	2110658.00001
15S/04E-28C01	EAST SIDE	183	5817013.0	2112539.50001

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STATE WELL NUMBER	AQUIFER	MAP ID	FALSE EASTING[1]	FALSE NORTHING[1]
15S/04E-28C01	EAST SIDE	184*	*	*
15S/04E-29K03	EAST SIDE	185*	*	*
15S/04E-32E01	PRESSURE 180	186	5809573.0	2105524.75003
15S/04E-36H01	EAST SIDE BOTH	187	5835591.5	2105235.00001
15S/04E-36R02	EAST SIDE BOTH	188	5836592.5	2101652.75001
16S/04E-01L02	EAST SIDE	189	5833261.5	2096387.25003
16S/04E-04C01	PRESSURE 400	190	5816563.5	2101653.00001
16S/04E-08J01	PRESSURE 180	191	5814399.5	2094772.87501
16S/04E-09A01	PRESSURE 180	192	5818962.5	2096385.75001
16S/04E-10K01	PRESSURE 400	193	5822871.5	2093933.87501
16S/04E-10R02	PRESSURE 400	194	5824891.5	2092808.00001
16S/04E-11E02	PRESSURE 400	195	5825734.0	2093587.12501
16S/04E-12M01	PRESSURE 400	196	5830110.0	2094179.62501
16S/04E-13D01	PRESSURE 400	197	5829977.5	2091400.75001
16S/04E-14M01	PRESSURE 400	198	5826507.0	2089158.00001
16S/04E-14M02	PRESSURE 400	199	5826934.0	2088314.12501
16S/04E-15D01	PRESSURE 180	200	5820915.5	2091029.00003
16S/04E-15H02	PRESSURE 400	201	5824314.0	2089470.00001
16S/04E-24R01	PRESSURE 400	202	5833826.5	2081330.00003
16S/04E-25A01	PRESSURE 400	203	5834115.0	2080854.00001
16S/04E-25K01	PRESSURE 180	204	5832503.0	2077482.12501
16S/04E-25Q01	PRESSURE 400	205	5832125.5	2076199.75001
16S/04E-27G01	PRESSURE 180	206	5823057.0	2078926.75001
16S/04E-36B01	PRESSURE 180	207	5833029.5	2074811.87501
16S/05E-07G01	EAST SIDE BOTH	208	5836648.0	2094674.00003
16S/05E-17P01	EAST SIDE BOTH	209	5843361.0	2086999.12503
16S/05E-17R01	EAST SIDE SHALLOW	210	5845212.0	2087024.25003
16S/05E-19F01	PRESSURE 180	211	5836477.0	2084158.37503
16S/05E-19R01	PRESSURE 180	212	5840423.0	2081360.37503
16S/05E-20C01	EAST SIDE	213	5843125.0	2085585.12503
16S/05E-20H01	EAST SIDE	214	5845691.0	2085074.25003
16S/05E-20R01	EAST SIDE BOTH	215	5845834.0	2082220.00003
16S/05E-27G01	EAST SIDE	216	5853466.8	2077678.05320
16S/05E-28D01	EAST SIDE BOTH	217	5846865.0	2080272.25003
16S/05E-28P01	EAST SIDE BOTH	218	5847355.5	2077784.37503
16S/05E-30C01	PRESSURE 180	219	5836401.5	2080129.50003
16S/05E-30G01	PRESSURE 180	220	5837912.0	2078876.87503

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STATE WELL NUMBER	AQUIFER	MAP ID	FALSE EASTING[1]	FALSE NORTHING[1]
16S/05E-30J02	PRESSURE 400	221	5840526.5	2077512.50003
16S/05E-31A01	PRESSURE 180	222	5838804.0	2075067.12503
16S/05E-31Q01	PRESSURE 180	223	5837656.0	2070857.75003
16S/05E-32C01	PRESSURE 180	224	5843159.0	2075228.62503
16S/05E-32M01	FOREBAY	225	5840439.0	2072879.00003
16S/05E-33F01	FOREBAY	226	5847064.0	2072544.75003
16S/05E-33Q01	FOREBAY	227	5846731.0	2071679.00003
16S/05E-35C01	FOREBAY	228	5857923.0	2074215.75003
16S/05E-35L01	FOREBAY	229	5857341.0	2072381.25003
17S/04E-01D01	PRESSURE 180	230	5829970.4	2070190.88233
17S/05E-01R01	FOREBAY	231	5863270.5	2064114.75003
17S/05E-02G01	FOREBAY	232	5858061.5	2067655.75001
17S/05E-03B01	FOREBAY	233	5852910.5	2069821.37503
17S/05E-04C01	FOREBAY	234	5846947.5	2068985.25003
17S/05E-04K01	FOREBAY	235	5847433.5	2066928.37503
17S/05E-04N01	FOREBAY	236	5844523.0	2064819.50003
17S/05E-06Q01	FOREBAY	237	5837274.0	2065350.12503
17S/05E-09G01	FOREBAY	238	5846689.0	2062431.75003
17S/05E-09Q01	FOREBAY	239	5846868.5	2059437.25003
17S/05E-10Q01	FOREBAY	240	5853142.5	2060133.00003
17S/05E-12B01	FOREBAY	241	5864362.0	2062470.37503
17S/05E-12B02	FOREBAY	242	5863570.5	2063023.50003
17S/05E-12B03	FOREBAY	243	5862636.0	2063300.00003
17S/05E-13L02	FOREBAY	244	5861995.0	2054065.12503
17S/05E-14D01	FOREBAY	245	5855476.7	2057512.98904
17S/05E-14G01	FOREBAY	246	5858431.5	2057156.87503
17S/05E-21A01	FOREBAY	247	5847203.9	2053734.78530
17S/05E-23L01	FOREBAY	248	5855276.5	2049667.00003
17S/05E-25L01	FOREBAY	249	5861282.5	2044709.87503
17S/05E-36F02	FOREBAY	250	5861156.5	2040988.13679
17S/06E-16N01	FOREBAY	251	5876658.0	2053579.37503
17S/06E-17R01	FOREBAY	252	5875370.0	2053960.00003
17S/06E-19D01	FOREBAY	253	5865512.0	2052870.75003
17S/06E-20K01	FOREBAY	254	5874270.5	2050202.50003
17S/06E-20Q02	FOREBAY	255	5873861.0	2049734.12503
17S/06E-20Q03	FOREBAY	256	5873624.0	2049413.37503
17S/06E-27E03	FOREBAY	257	5881725.5	2046512.12503

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STATE WELL NUMBER	AQUIFER	MAP ID	FALSE EASTING[1]	FALSE NORTHING[1]
17S/06E-27K01	FOREBAY	258	5884526.5	2044144.50003
17S/06E-27L01	FOREBAY	259	5883319.0	2044534.62503
17S/06E-28N01	FOREBAY	260	5876603.5	2042971.37503
17S/06E-29C01	FOREBAY	261	5871659.0	2048323.00003
17S/06E-29K01	FOREBAY	262	5873377.5	2045490.50003
17S/06E-29Q01	FOREBAY	263	5873361.0	2045274.25003
17S/06E-30F01	FOREBAY	264	5866434.0	2047190.00003
17S/06E-32G01	FOREBAY	265	5873481.5	2040947.12503
17S/06E-32J02	FOREBAY	266	5874264.0	2039466.50003
17S/06E-35F01	FOREBAY	267	5888535.0	2040776.00003
17S/06E-35J01	FOREBAY	268	5890370.5	2039573.75003
18S/06E-01E01	FOREBAY	269	5892201.0	2033873.12503
18S/06E-02N01	FOREBAY	270	5886656.0	2032336.12503
18S/06E-02R01	FOREBAY	271	5890070.0	2032210.75003
18S/06E-03P01	FOREBAY	272	5881836.0	2032629.37503
18S/06E-05H01	FOREBAY	273	5874765.0	2035980.12503
18S/06E-07A01	FOREBAY	274	5868250.5	2031805.25003
18S/06E-08R01	FOREBAY	275	5873246.0	2027074.87503
18S/06E-09M02	FOREBAY	276	5875856.5	2028751.00003
18S/06E-11J01	FOREBAY	277	5890622.5	2027590.87503
18S/06E-12A01	FOREBAY	278	5896424.0	2030093.87503
18S/06E-12R02	FOREBAY	279	5895096.5	2026768.25003
18S/06E-14B01	FOREBAY	280	5888379.5	2025469.87503
18S/06E-14R01	FOREBAY	281	5890625.0	2022391.37503
18S/06E-15F01	FOREBAY	282	5882187.0	2023781.12503
18S/06E-15M01	FOREBAY	283	5880584.0	2022838.50003
18S/06E-16L01	FOREBAY	284	5876773.5	2023478.50003
18S/06E-21Q01	FOREBAY	285	5878665.0	2016542.37503
18S/06E-25F01	FOREBAY	286	5891762.0	2013188.12503
18S/06E-26R01	FOREBAY	287	5890408.5	2011271.25003
18S/06E-27A01	FOREBAY	288	5883864.0	2015914.75003
18S/06E-28J01	FOREBAY	289	5879251.0	2013091.87503
18S/06E-34B01	FOREBAY	290	5882838.0	2010128.37503
18S/07E-18K01	FOREBAY	291	5899619.5	2023322.62503
18S/07E-18P01	FOREBAY	292	5897367.5	2022162.75003
18S/07E-19G02	FOREBAY	293	5899561.5	2019657.12503
18S/07E-19N01	FOREBAY	294	5896875.0	2016213.75002

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STATE WELL NUMBER	AQUIFER	MAP ID	FALSE EASTING[1]	FALSE NORTHING[1]
18S/07E-20K01	FOREBAY	295	5903526.5	2016596.50003
18S/07E-28K01	FOREBAY	296	5909064.5	2012996.12503
18S/07E-28N02	FOREBAY	297	5906995.5	2011573.25003
18S/07E-29J01	FOREBAY	298	5906172.5	2012704.50003
18S/07E-29M01	FOREBAY	299	5901432.0	2012790.87503
18S/07E-32G02	FOREBAY	300	5905129.0	2008896.37503
18S/07E-34P02	FOREBAY	301	5913853.5	2006429.50003
19S/06E-01H01	FOREBAY	302	5894418.0	2003322.50003
19S/06E-03E02	FOREBAY	303	5880577.0	2003637.62503
19S/06E-03K01	FOREBAY	304	5882172.5	2003068.00003
19S/06E-11C01	FOREBAY	305	5887118.5	1999053.25003
19S/06E-12A01	FOREBAY	306	5895441.5	1999532.50003
19S/07E-03H02	UPPER VALLEY	307	5916058.0	2002263.25003
19S/07E-04G01	FOREBAY	308	5908976.0	2002192.50003
19S/07E-04Q01	FOREBAY	309	5907241.5	2000938.12503
19S/07E-05B02	FOREBAY	310	5903922.5	2005128.00003
19S/07E-10P02	UPPER VALLEY	311	5914112.0	1994937.37503
19S/07E-13D01	UPPER VALLEY	312	5923060.5	1993005.87503
19S/07E-13D02	UPPER VALLEY	313	5922703.0	1993016.87503
19S/07E-13D03	UPPER VALLEY	314	5921177.5	1994464.25003
19S/07E-16D01	UPPER VALLEY	315	5907215.0	1993447.25003
19S/07E-20A01	UPPER VALLEY	316	5904728.0	1988737.75003
19S/07E-20A02	UPPER VALLEY	317	5905140.0	1988780.50003
19S/07E-23F01	UPPER VALLEY	318	5917918.5	1986682.87503
19S/07E-23G01	UPPER VALLEY	319	5919819.5	1985678.50003
19S/07E-24H02	UPPER VALLEY	320	5927076.5	1985899.12503
19S/07E-36N01	UPPER VALLEY	321	5921376.0	1974705.75003
19S/08E-30A01	UPPER VALLEY	322	5931268.5	1981945.62503
20S/08E-05C02	UPPER VALLEY	323	5933968.0	1972500.37503
20S/08E-05R03	UPPER VALLEY	324	5935855.5	1968133.00003
20S/08E-06B01	UPPER VALLEY	325	5929631.0	1971657.50003
20S/08E-07E01	UPPER VALLEY	326	5927847.5	1965744.25003
20S/08E-15H03	UPPER VALLEY	327	5946414.0	1959720.37503
20S/08E-16C01	UPPER VALLEY	328	5938055.0	1961243.37501
20S/08E-17K03	UPPER VALLEY	329	5934573.0	1958618.62503
20S/08E-34G01	UPPER VALLEY	330	5944061.5	1944379.50003
20S/08E-36R01	UPPER VALLEY	331	5957517.0	1941628.62503

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STATE WELL NUMBER	AQUIFER	MAP ID	FALSE EASTING[1]	FALSE NORTHING[1]
21S/08E-15J01	UPPER VALLEY	332	5946267.0	1926489.62503
21S/09E-06C01	UPPER VALLEY	333	5959365.5	1939884.62503
21S/09E-16E02	UPPER VALLEY	334	5967913.5	1928310.37503
21S/09E-22J01	UPPER VALLEY	335	5976378.5	1921774.75003
21S/09E-24Q01	UPPER VALLEY	336	5985537.5	1920320.00003
21S/10E-30E02	UPPER VALLEY	337	5988110.5	1916891.25003
21S/10E-32N01	UPPER VALLEY	338	5993930.5	1907839.00003
22S/10E-09P01	UPPER VALLEY	339	6000619.0	1897117.87503
22S/10E-16P01	UPPER VALLEY	340	6000072.0	1892154.87503
22S/10E-21C01	UPPER VALLEY	341	6001268.5	1890089.75003
22S/10E-22N01	UPPER VALLEY	342	6004921.0	1886561.87503
22S/10E-28B01	UPPER VALLEY	343	6001816.0	1886849.25003
22S/10E-34G01	UPPER VALLEY	344	6007012.0	1879185.87503

[1] State Plane Coordinate System, California Zone IV, Feet, North American Datum 1983

*Coordinates to be collected

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Table 5 COASTAL WELLS AND LOCATIONS

STATE WELL NUMBER	AQUIFER	MAP ID	FALSE EASTING[1]	FALSE NORTHING[1]
13S/01E-25R01	PRESSURE 900	1	5742345.5	2174687.00002
13S/02E-15M01	PRUNEDALE	2	5757881.5	2185405.50002
13S/02E-19Q03	PRESSURE 900	3	5746313.5	2179184.50002
13S/02E-20J01	PRESSURE 400	4	5752096.0	2180981.25002
13S/02E-28L02	PRESSURE BOTH	5	5755055.5	2175441.75002
13S/02E-28M02	PRESSURE 400	6	5753447.0	2175997.50002
13S/02E-32J03	PRESSURE 400	7	5752560.0	2170401.75002
13S/02E-33N04	PRESSURE 400	8	5753898.0	2169605.00002
13S/02E-34G01	PRESSURE 400	9	5760129.5	2170052.25002
13S/02E-34M01	PRESSURE 400	10	5757997.5	2169621.75002
14S/01E-13J02	PRESSURE 400	11	5741048.0	2154289.50002
14S/02E-01C01	EASTSIDE DEEP	12	5771477.5	2167454.25002
14S/02E-02A02	EASTSIDE DEEP	13	5768561.0	2167823.50002
14S/02E-02C03	PRESSURE 400	14	5765109.0	2167416.00002
14S/02E-03H01	PRESSURE 400	15	5762283.0	2166255.50002
14S/02E-03M02	PRESSURE 400	16	5758710.5	2164740.50002
14S/02E-03R02	PRESSURE 400	17	5762517.0	2163892.75002
14S/02E-04B01	PRESSURE 400	18	5755909.0	2167499.00002
14S/02E-04G02	PRESSURE 400	19	5756262.0	2166403.75002
14S/02E-04H01	PRESSURE 400	20	5756715.0	2165886.25002
14S/02E-04N03	PRESSURE 400	21	5753365.0	2163112.75002
14S/02E-05C03	PRESSURE 400	22	5748893.5	2167132.50002
14S/02E-05K02	PRESSURE 400	23	5750829.0	2165370.75002
14S/02E-07A01	PRESSURE 400	24	5747142.5	2162655.25002
14S/02E-07J02	PRESSURE 400	25	5746655.0	2159408.25002
14S/02E-07J03	PRESSURE DEEP ZONE	26	5746476.9	2159735.06998
14S/02E-07L04	PRESSURE 400	27	5743780.0	2159328.00002
14S/02E-07L05	PRESSURE 400	28	5743784.5	2160380.50002
14S/02E-08C03	PRESSURE 400	29	5750055.0	2162036.75002
14S/02E-08M02	PRESSURE 400	30	5747103.0	2159672.50002
14S/02E-09D04	PRESSURE 400	31	5753016.5	2162818.75002
14S/02E-09K02	PRESSURE 400	32	5755450.0	2159946.25002
14S/02E-09N02	PRESSURE 400	33	5752897.5	2158609.50002
14S/02E-10E02	PRESSURE 400	34	5758062.0	2160525.75002
14S/02E-10H01	PRESSURE 400	35	5761492.0	2160761.75002

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STATE WELL NUMBER	AQUIFER	MAP ID	FALSE EASTING[1]	FALSE NORTHING[1]
14S/02E-10M02	PRESSURE 400	36	5757853.5	2159387.75002
14S/02E-11B01	PRESSURE 400	37	5766446.0	2162325.25002
14S/02E-11M03	PRESSURE 400	38	5764448.5	2159266.75002
14S/02E-12N02	PRESSURE 180	39	5769893.5	2158219.50002
14S/02E-13F01	PRESSURE 180	40	5769952.5	2154587.75002
14S/02E-13G01	PRESSURE 400	41	5772057.5	2155470.50002
14S/02E-14A01	PRESSURE 400	42	5767367.0	2156210.25002
14S/02E-14L02	PRESSURE 180	43	5764775.5	2155024.75003
14S/02E-14L03	PRESSURE 400	44	5764610.5	2154419.75002
14S/02E-15A01	PRESSURE 400	45	5761774.5	2157015.50002
14S/02E-15C02	PRESSURE 400	46	5759385.5	2157259.00002
14S/02E-15L02	PRESSURE 180	47	5758452.0	2153366.00003
14S/02E-15N01	PRESSURE 400	48	5757522.5	2153353.25002
14S/02E-15P01	PRESSURE 400	49	5758767.5	2153584.50002
14S/02E-16A02	PRESSURE 400	50	5756957.5	2157123.50002
14S/02E-16G01	PRESSURE 400	51	5755957.0	2155999.50002
14S/02E-16H01	PRESSURE 400	52	5756041.0	2156035.25002
14S/02E-17A02	PRESSURE 400	53	5751744.5	2156837.50002
14S/02E-20B03	PRESSURE 900	54	5750210.5	2151407.25003
14S/02E-21E01	PRESSURE 400	55	5753561.0	2150101.50003
14S/02E-21J01	PRESSURE 180	56	5756896.0	2149447.75002
14S/02E-21L01	PRESSURE 180	57	5754605.0	2149175.75002
14S/02E-22B01	PRESSURE 400	58	5760986.0	2152124.75002
14S/02E-22L01	PRESSURE 400	59	5759725.0	2149855.00002
14S/02E-22P02	PRESSURE 180	60	5758952.5	2146937.25002
14S/02E-23M01	PRESSURE 180	61	5762708.0	2149478.75002
14S/02E-24E01	PRESSURE 180	62	5768326.5	2150393.25002
14S/02E-24P02	PRESSURE 400	63	5769670.0	2146858.75002
14S/02E-24Q01	PRESSURE 180	64	5771942.5	2146772.50003
14S/02E-25D04	PRESSURE 180	65	5768019.0	2145519.50003
14S/02E-26J03	PRESSURE 400	66	5766847.5	2143883.00002
14S/02E-26N03	PRESSURE 180	67	5762617.0	2142567.75002
14S/02E-26P01	PRESSURE 180	68	5764519.0	2141615.00003
14S/02E-27C02	PRESSURE 400	69	5759686.0	2145562.00002
14S/02E-27F02	PRESSURE 180	70	5759825.0	2144647.75002
14S/02E-28C01	PRESSURE 400	71	5753983.5	2146953.50002
14S/02E-32D06	PRESSURE 180	72	5746981.0	2141653.75003

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STATE WELL NUMBER	AQUIFER	MAP ID	FALSE EASTING[1]	FALSE NORTHING[1]
14S/02E-33P01	PRESSURE BOTH	73	5756348.0	2138806.75003
14S/02E-34A04	PRESSURE 180	74	5761465.0	2141623.00002
14S/02E-34B03	PRESSURE 180	75	5759909.5	2141431.00002
14S/02E-36E01	PRESSURE 180	76	5768600.0	2138685.00002
14S/02E-36G01	PRESSURE 400	77	5770039.0	2139297.50002
14S/03E-06L02	EASTSIDE DEEP	78	5775957.0	2164155.50002
14S/03E-07P02	EASTSIDE SHALLOW	79	5775832.0	2157899.00003
14S/03E-18E02	PRESSURE 400	80	5774633.5	2155704.50003
14S/03E-19Q02	PRESSURE 180	81	5776192.0	2146948.50002
14S/03E-30E03	PRESSURE 400	82	5774081.0	2143975.75002
14S/03E-30F01	PRESSURE 180	83	5775609.5	2144673.00002
14S/03E-31B01	PRESSURE 180	84	5776312.0	2140030.50002
15S/02E-12C01	PRESSURE 180	85	5769441.0	2130513.75002

[1] State Plane Coordinate System, California Zone IV, Feet, North American Datum 1983

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Table 6 REQUIREMENTS FOR SAMPLE COLLECTION[1]

ANALYTE	CONTAINER TYPE	SAMPLE VOLUME	PRESERATIVE	HOLDING TIME
Calcium (Ca)	polyethylene (HDPE[2])	200 mL[3]	HNO_3 pH<2	3 days w/o pres. 6 months w/ pres.
CATION ANION BALANCE[4]	N/A Calculation	N/A Calculation	N/A Calculation	N/A Calculation
Chloride (Cl)[5]	polyethylene (HDPE[1])	100 mL[2]	4±2ºC	28 days
Conductivity (SEC)[5]	polyethylene (HDPE[1])	100 mL[2]	4±2ºC	28 days
Magnesium (Mg)	polyethylene (HDPE[1])	200 mL[2]	HNO_3 pH<2	3 days w/o pres. 6 months w/ pres.
Nitrate (NO3)[5]	polyethylene (HDPE[1])	100 mL[2]	none HSO_4; pH<2	48 hours at 4° C 28 days
pH (Laboratory)	polyethylene (HDPE[1])	30 mL[2]	none	48 hours at 4° C
Potassium (K)	polyethylene (HDPE[1])	200 mL[2]	HNO_3 pH<2	3 days w/o pres. 6 months w/ pres.
Sodium (Na)	polyethylene (HDPE[1])	200 mL[2]	HNO_3 pH<2	3 days w/o pres. 6 months w/ pres.
Sulfate (SO4)	polyethylene (HDPE[1])	100 mL[2]	4±2ºC	28 days
Total Alkalinity (as CaCO3)	polyethylene (HDPE[1])	100 mL[2]	4±2ºC	14 days

[1] = CCL QA Manual and SOPs

[2] = High Density Polyethylene

[3] = only one 0.5 gal (~2L) container is needed for all analyses

[4] = Cation anion balance is a calculation

[5] = Analytes in partial mineral panel, one pint (~500 mL) container is need for analyses

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APPENDICES

UNDER REVISION
(10/2019)

APPENDIX A

GLOBAL POSITIONING SYSTEM (GPS) TRAINING

Appendix A-1: GPS Training Record

Appendix A-2: TSC1 Asset Surveyor Manual

Appendix A-3: Pro XR/XRS Receiver Manual

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Geographic Positioning System (GPS) Training Record

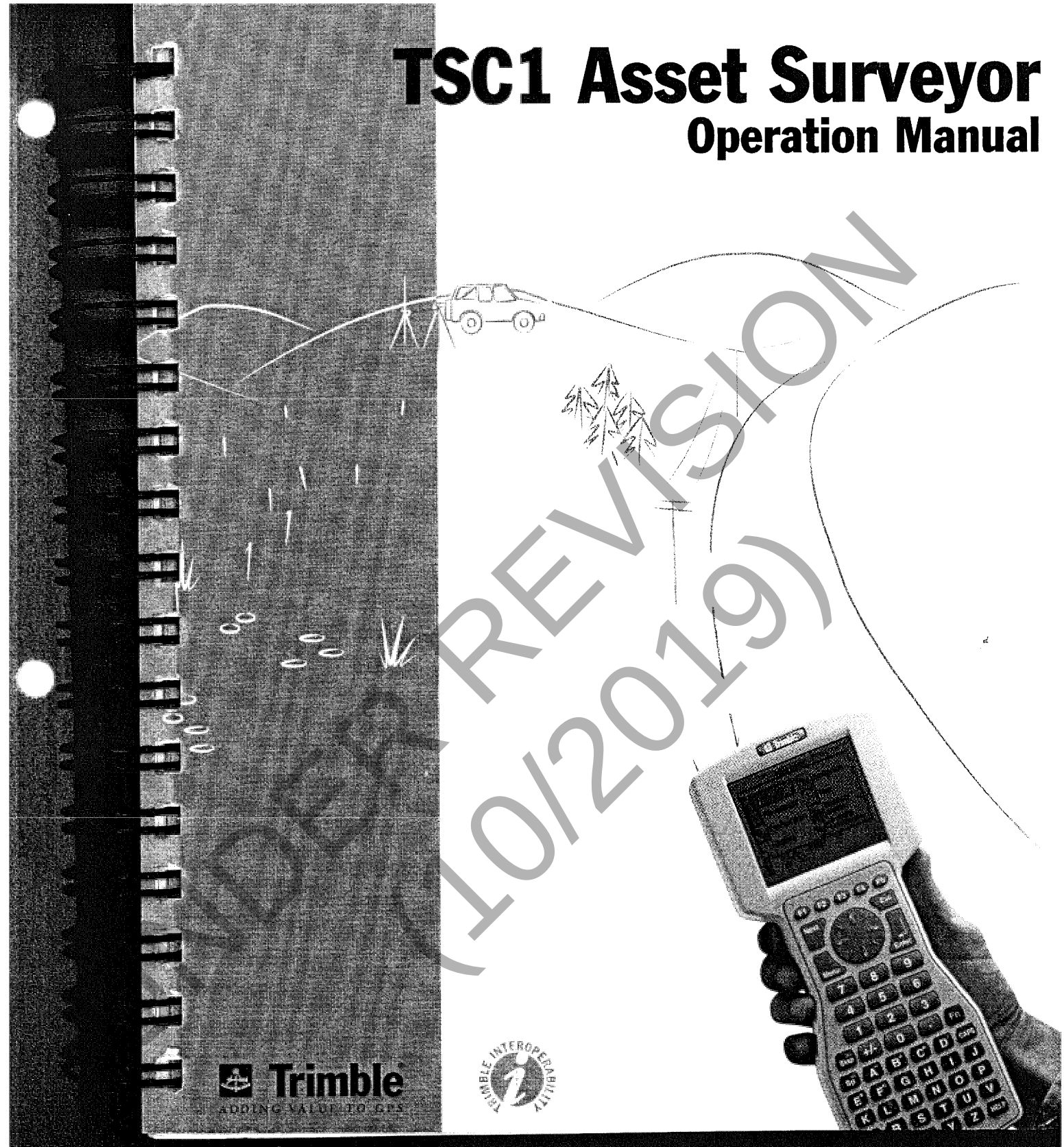
Name of Trainee Name of Trainer Date of Training

	Satisfactory Completion / Understanding
Verification of access to Pathfinder Office software	
Preparation of data dictionary	
Set-up of equipment	
Trimble® TSC1 Asset Surveyor[1]	
Trimble® Pro XR Receiver[1]	
Connector cables	
Batteries (Asset Surveyor and Receiver)	
Confirmation of communication between Asset Surveyor and Receiver	
Acquiring satellites	
Setting up and checking critical settings	
-logging intervals	
-PDOP mask[2]	
Proper packing and unpacking of equipment	
Transferring data files from Asset Surveyor to the computer	

[1] The Agency uses Trimble® products, the GPS industry standard.
[2] PDOP = Position Dilution Of Precision

UNDER REVISION (10/2019)

TSC1 Asset Surveyor
Operation Manual



Trimble
ADDING VALUE TO GPS

REVISION
(10/2019)

TSC1 Asset Surveyor

Operation Manual

Part Number 34182-05-ENG

Version 5.00

October 1999

Revision A

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1 Quick Setup

The instructions in this chapter are a simplified version of the various steps found in Chapters 4, 5, and 6 of this manual. The purpose of the simplified version is to provide quick setup guides with reasonable default values that can be distributed to field crews to ensure proper setup of rover or base station receivers.

Data is logged to the TSC1 with the Asset Surveyor software. For full details on configuration and data collection, refer to the *TSC1 Asset Surveyor Software User Guide*.



Note – The steps outlined in this chapter do not include steps required to collect data using carrier phase information. For instructions on how to collect high accuracy features, see Chapter 7, Carrier Phase Data Collection.

1.1 Before Leaving the Office

1. Install the Pathfinder Office software on your office computer (refer to the *Pathfinder Office Getting Started Guide*).
2. Using the Pathfinder Office software, prepare any data files or data dictionaries you require, and transfer them to the TSC1. If you want to update GPS or attribute information on features stored in a GIS, import the data files and data dictionary into Pathfinder Office and then transfer them to the TSC1. You may also want to transfer any waypoint and coordinate system files to the datalogger.

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3. Check that you have all the required equipment, and that it is operational. Set up and connect your GPS system (the appendix for your GPS receiver lists the equipment and shows you how to connect it).

4. If the GPS receiver has an On/Off switch, turn it on (the Series 4000, GPS Total Station 4700, GPS Total Station 4800, Site Surveyor 4400 and 4600LS receivers have an On/Off switch).

   Start the Asset Surveyor software to check that it and the GPS receiver are communicating correctly. If communication is established, the GPS status line appears. If communication fails, an error message pops up on the screen.

5. Check all critical settings in the Asset Surveyor software.

   You should also check non-critical and display settings, especially if the system has been used by someone else recently. For details of how to configure Asset Surveyor, refer to the *TSC1 Asset Surveyor Software User Guide*.

6. Turn everything off and pack it into carrying cases if you have to travel a significant distance to the survey site. Pack spare sets of batteries if you expect to operate the receiver for any length of time.

1.2 In the Field

1. Travel to the survey site, remembering to carry all the required equipment with you.

2. Reassemble the system.

3. If the GPS receiver has an On/Off switch, turn it on. Then start the Asset Surveyor software, if it is not already on.

   Wait until the GPS receiver acquires enough satellites to start computing GPS positions, before beginning to work. The number of satellites being tracked displays on the status line.

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You should now change some of the configuration settings as follows:

Main menu

1.	*Configuration*	Highlight *Configuration* then press the Enter key

Configuration menu

2.	*GPS rover options*	Press Enter
3.	*Logging options*	Press Enter

Logging options screen

4.	*Point feature*	Synchronized with the base station
5.	*Line/area*	Synchronized with the base station
6.	*Not in feature*	Synchronized with the base station
7.	*Minimum positions*	3
8.	*Allow GPS update*	'Warn first'
9.	*Warning distance*	'Any'
10.	To accept	Press Enter

Position filters screen

11.	*Position mode*	'Manual 3D' or 'Overdet. 3D' depending on canopy density
12.	*PDOP mask*	4 or 6 (depending on receiver)
13.	To accept	Press Enter

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TSC1 Asset Surveyor Operation Manual Trimble

4. Create a new data file, associating the correct data dictionary with it. Alternatively, re-open an existing data file.
5. Begin collecting data. Collect, review and update all the features necessary.
6. Close the data file.
7. Disconnect and repack the components of the system. Remember to turn off the GPS receiver, if it has an On/Off switch. Return to your office.

1.3 Back in the Office

1. Transfer the data files from the TSC1 to the PC using the Pathfinder Office software.
2. Use the Pathfinder Office software for differential correction, plotting, and exporting the data file(s) to a GIS.
3. Recharge the TSC1 datalogger and GPS receiver batteries.

1.4 Rover Configuration

Use the following procedure to set up your system in a rover configuration.

From the *Utilities* menu, select *Factory defaults*. This resets the Asset Surveyor software to its default configuration and then restarts the datalogger.

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Antenna options screen

14. *Height*	Height to antenna's phase center
15. *Measure*	'Vertical'
16. *Type*	For a list of antenna types, see the *TSC1 Asset Surveyor Software User Guide*
17. *Confirm*	Select 'Per feature', 'Per file', or 'Never'
18. To accept	Press Enter

GPS rover options menu

19. To return to the *Configuration* menu	Press Esc

Configuration menu

20. *Communication options*	Press Enter
21. *Real-time input options*	Press Enter

Real-time input options screen

22. RTCM age limit	5 or 10 (depending on your radio)
23. To accept	Press Enter
24. To return to the *Configuration* menu	Press Esc

Configuration menu

25. To exit the *Configuration* menu	Press Esc

UNDER REVISION (10/2019)

1.4.1 Data Collection

Use the following procedure to set up your system for rover data collection.

Main menu

1. Select *Data collection* and press Enter

***Data collection* menu**

2.	Create a data file	Select *Create new file*: Press Enter and then press Enter
	-or-	-or-
	Open an existing data file	Select *Open existing file*. Press Enter Select an existing file to append to or update, and press Enter
3.	To exit *Data collection*	Press Esc and press Yes to confirm exit

1.5 Base Station Configuration

Use the following procedure to set up your system in a base station configuration.

Main menu

1.	*Configuration*	Highlight *Configuration* then press the Enter key

***Configuration* menu**

2.	*GPS base station options*	Press Enter
3.	*Logging options*	Press Enter

UNDER REVISION (10/2019)

Logging options screen

4.	*Measurements*	One to five seconds (depending on rover interval and free space)
5.	To accept	Press Enter
6.	To return to the *Configuration* menu	Press Esc

Configuration menu

7.	To exit the *Configuration* menu	Press Esc

UNDER REVISION (10/2019)

1.5.1 Base Station Data Collection

Use the following procedure to set up your system for base station data collection.

Main menu

1. *Data collection* — Press Enter

***Data collection* menu**

2. *Create base file* — Press Enter

***Create File* screen**

3. Create file — Press Enter

***Antenna options* screen**

4. *Height* — Height to antenna's phase center
5. *Measure* — 'Vertical'
6. *Type* — For a list of antenna types, see the *TSC1 Asset Surveyor Software User Guide*
7. To accept — Press Enter

UNDER REVISION (10/2019)

TSC1 Asset Surveyor Operation Manual Trimble

Reference Position screen

8.	Enter reference position	Type lat/lon (or north/east) and altitude, and press Enter
	-or-	-or-
	Use an existing waypoint	Press WayPt, select the waypoint and press Enter
	-or-	-or-
	Use an approximate position	Press Here and press Enter
	-or-	-or-
	Leave as is and set in the Pathfinder Office software	Press Enter

Base Station screen

9.	To exit *Base station*	Press Enter and press Yes to confirm exit.

UNDER REVISION (10/2019)

Key Symbols

The Asset Surveyor software uses both *hard* (that is, physical) keys on a keypad and *soft* (that is, visual) keys on the datalogger's screen.

Hard (physical) keys on the TSC1 keypad are indicated as follows:

Enter, ◄, F1, and so on.

Softkeys on the TSC1 screen are indicated as follows:

Create, Del, Edit, and so on.

A softkey is activated by pressing the corresponding function key (F1...F5) on the TSC1 keypad.

Warnings, Cautions, Notes, and Tips

Warnings, cautions, notes, and tips draw attention to important information, and indicate its nature and purpose.



Warning – Warnings alert you to situations that could cause personal injury or unrecoverable data loss.



Caution – Cautions alert you to situations that could cause hardware damage or software error.



Note – Notes give additional significant information about the subject to increase your knowledge, or guide your actions.



Tip – Tips indicate a shortcut or other time- or labor-saving hint that can help you make better use of the product.

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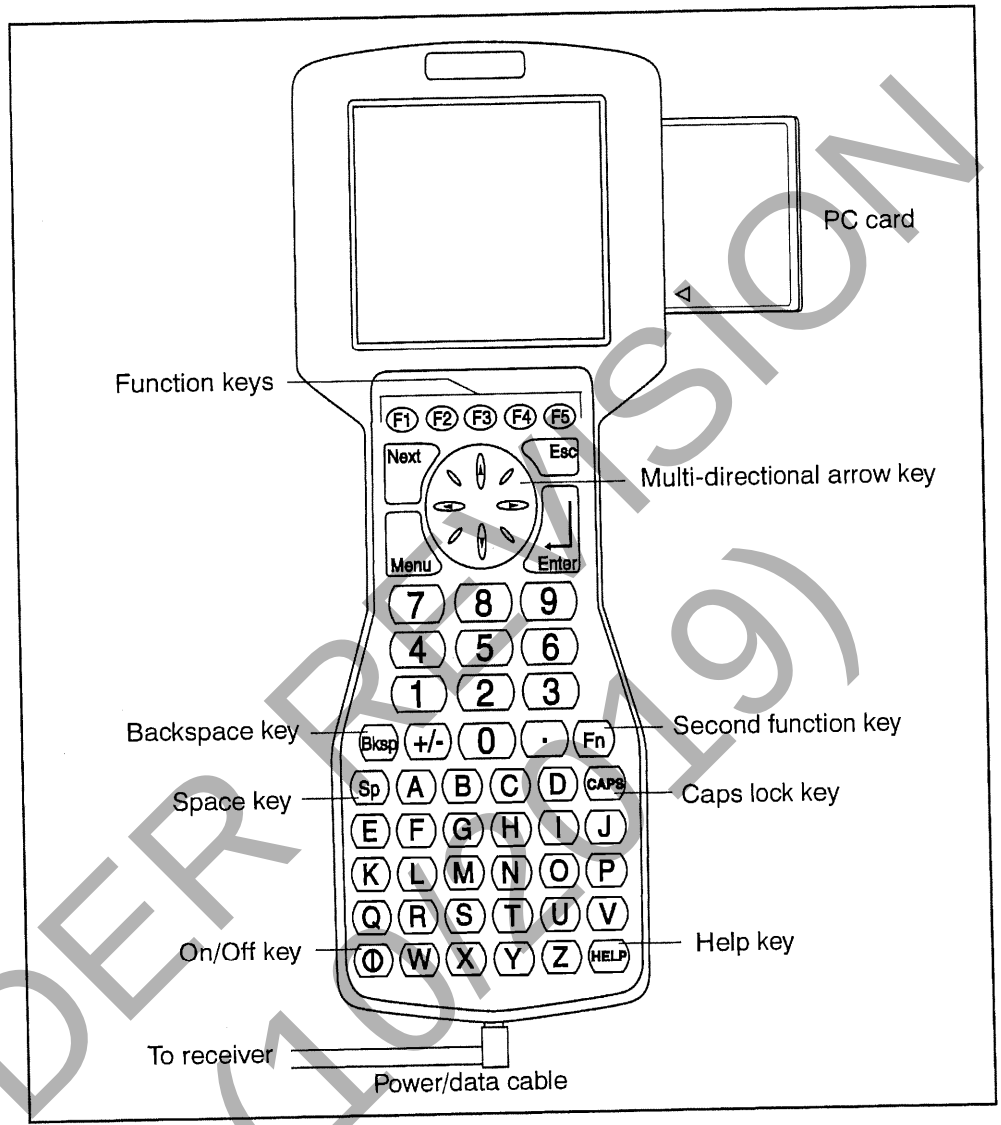


Figure 3-1 Front View of the TSC1 Datalogger

UNDER REVISION (10/19)

TSC1 Asset Surveyor Operation Manual Trimble

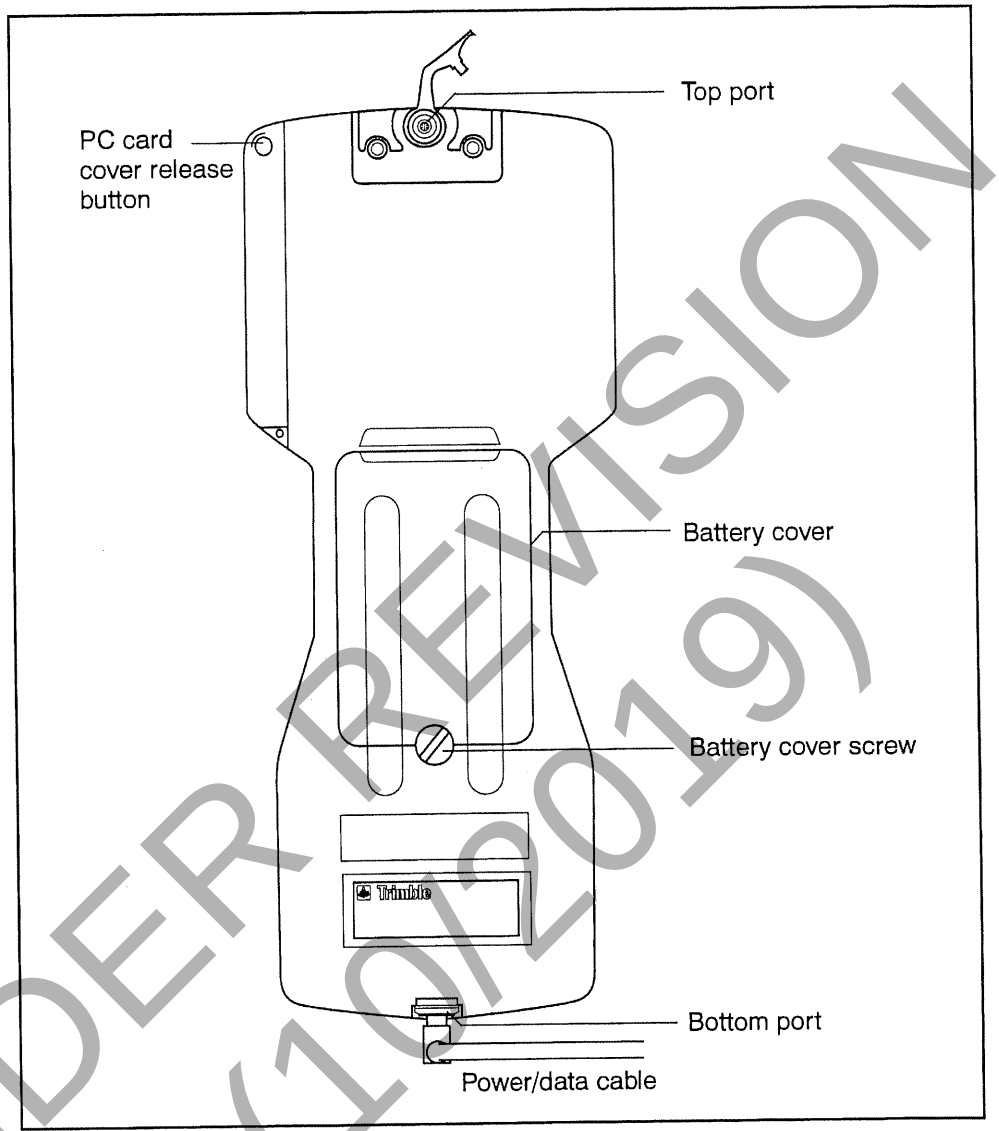


Figure 3-2 Back View of the TSC1 Datalogger

UNDER REVISION (10/2019)

3.2 Turning the TSC1 Datalogger On and Off

To turn on the TSC1 datalogger, make sure that power is supplied (see Power Sources, page 3-11). Then press the green on/off key marked [⏻].

To turn off the TSC1, hold down [⏻] for one second.

Tip – For the location of the [⏻] key and other keys on the TSC1 datalogger's keypad, refer to Figure 3-1.

3.2.1 Hard Keys

Hard keys are the physical keys on the TSC1 keypad, such as [1], [A], [Enter], [◄►], [▲▼], and [Esc]. Use these keys to enter data and to access different screens.

3.2.2 Alternate Keys

Alternate keys give some hard keys a second function. Some of the second functions are displayed on the hard keys in small yellow lettering. To use a second function, press the [Fn] hard key and then press the alternate hard key.

Table 3-1 shows some of the functions that you can access using alternate keys.

Table 3-1 Useful Second Functions

Keys	Function
[Fn] [▼]	Page down
[Fn] [▲]	Page up
[Fn] [◄]	Home
[Fn] [►]	End
[Fn] [Next]	Previous screen
[Fn] [E]	Contrast up
[Fn] [F]	Contrast down

UNDER REVISION (10/2010)

3.2.3 Softkeys

Softkeys are displayed on the bottom line of the TSC1 screen. A softkey corresponds to the adjacent hard key: F1, F2, F3, F4, F5. Press the hard key to activate the softkey on the screen. To activate the Pause softkey, for example, press F1. See Figure 3-3.

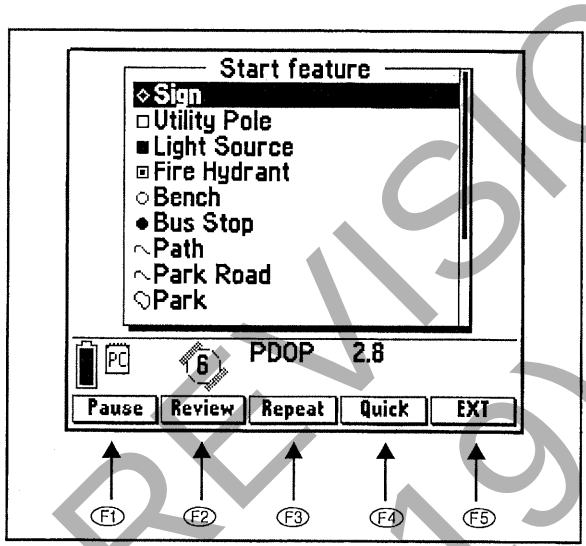


Figure 3-3 How Function Keys Correspond to Softkeys

Softkeys relate to particular forms or fields and only appear when these forms or fields are accessed. For example, the Seg softkey only appears when a line feature is opened for data collection, as this functionality applies to line features only.

3.2.4 Menu Key

To return to the *Main menu* at any time, press the Menu hard key. Use this key in conjunction with the Next key to move around the Asset Surveyor screens quickly.

UNDER REVISION (10/2019)

3.2.5 Next Key

To simplify the task of moving around menus, the Next hard key offers quick access to open screens (windows).

3.2.6 Help Key

Press the HELP hard key at any time to obtain further information about a topic. When you press it, the *Help* menu appears. To exit *Help*, press Esc from the *Help* menu.

3.3 Screen

The TSC1 has an LCD screen. This screen responds to heat, and prolonged exposure to full sunlight can cause it to darken. If the screen does darken, turn it away from direct sunlight until it returns to normal.

Caution – Repeated exposure to direct sunlight can cause the screen to degrade.

3.3.1 Contrast

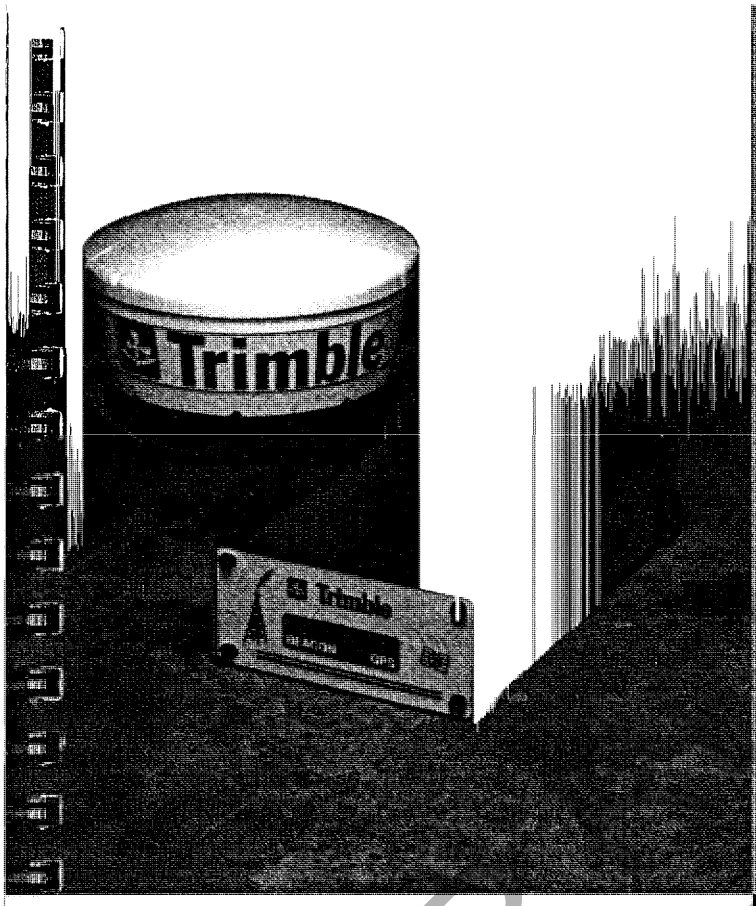
To increase the screen contrast, press Fn E.

To decrease the screen contrast, press Fn F.

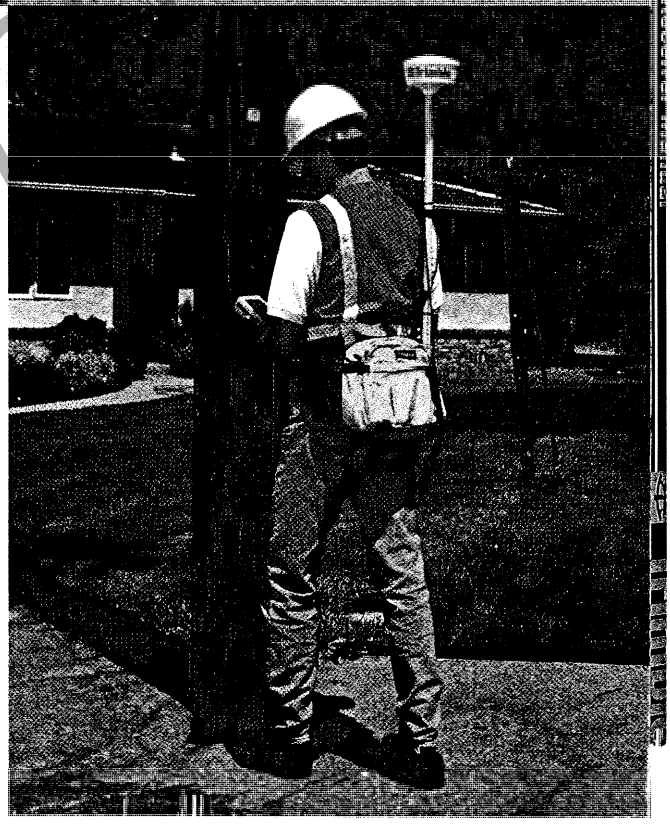
3.3.2 Backlight

To toggle the screen backlight on and off, press Fn L.

UNDER REVISION (10/2019)



Pro XR/XRS
Receiver Manual



UNDER
(10/

Trimble

Pro XR/XRS

Receiver Manual

Part Number 31172-20-ENG

Revision A

May 1998

Trimble Navigation Limited
Mapping and GIS Systems Division
645 North Mary Avenue
P.O. Box 3642
Sunnyvale, CA 94088-3642
U.S.A.

1-800-827-8000 in North America
+1-408-481-8000 International
Fax: +1-408-481-7744
www.trimble.com

UNDER REVISION (10/2019)

4 Pro XR/XRS System Equipment

This chapter provides details of the equipment associated with the Pro XR and Pro XRS receivers and shows how to assemble the equipment.

4.1 Pro XR Receiver Front Panel

The Pro XR receiver, shown in Figure 4-1, is mounted in a weatherproof housing.

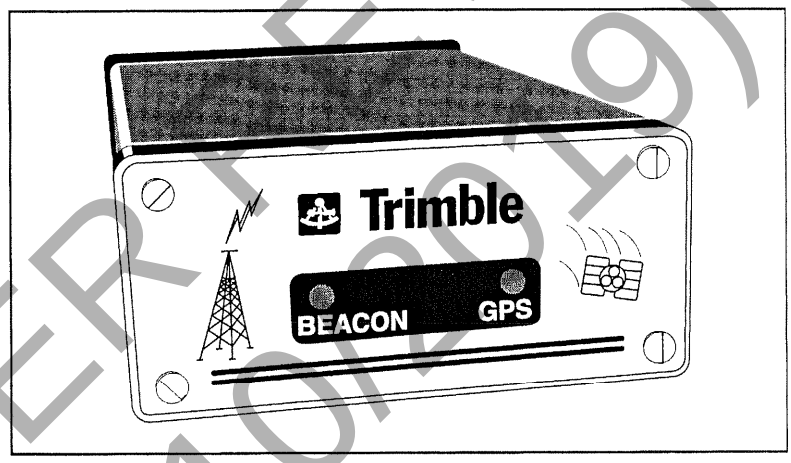


Figure 4-1 Pro XR Receiver Front Panel

UNDER REVISION (10/29/19)

4.2.1 Pro XR Status Lights

The two status lights on the front panel of the Pro XR receiver provide the status information listed in Table 4-1.

Table 4-1 Pro XR Status Lights

	GPS	Beacon
OFF	Unit not powered up	Unit not powered up or beacon function is disabled
FAST FLASH	Searching for satellites	Searching for MSK signals
SLOW FLASH	Found one or more satellites. Not enough for a position fix.	Found MSK signal. RTCM data has not been sent to GPS receiver.
ON	Performing position fixes	Good RTCM data is being provided to the GPS receiver

UNDER REVISION (10/2019)

4.3 Back Panel

The Pro XR and Pro XRS receivers have two serial communications ports (RS232) and an antenna cable port. The serial communications ports, shown in Figure 4-3, are 12-pin(m) bulkhead connectors located on the back panel of the Pro XR and Pro XRS receivers.

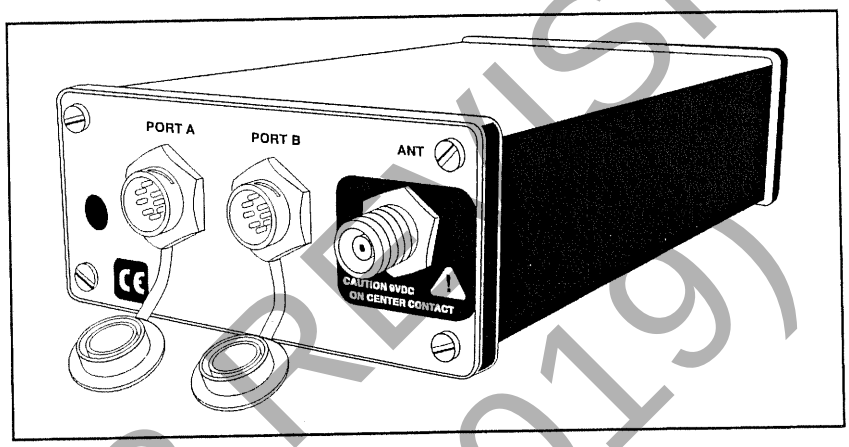


Figure 4-3 Pro XR/XRS Receiver Back Panel

4.3.1 Port A

Port A offers RS232 communication standards. It is designed for NMEA-0183 output and RTCM input.

4.3.2 Port B

Port B also offers RS232 communication standards. It is designed for two-way data flow, external sensor input and power.

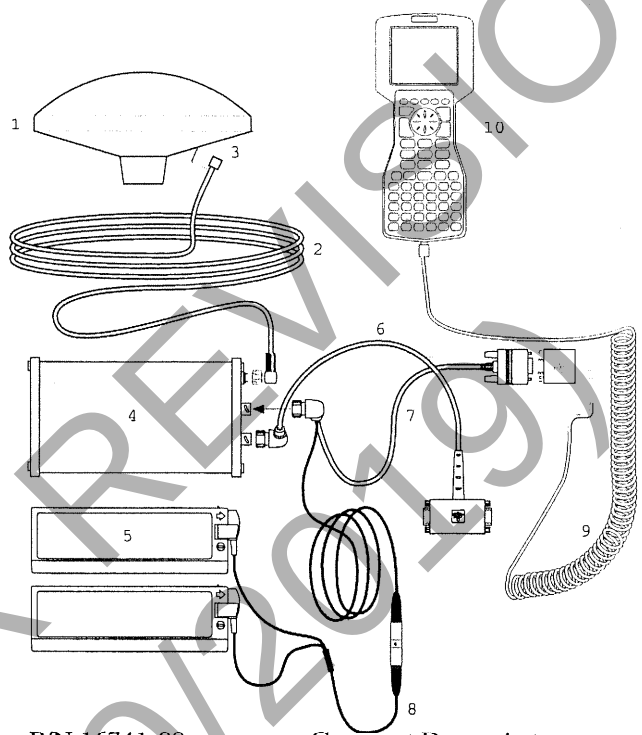
4.3.3 Antenna Port

The antenna connector is a TNC(f) connector located on the far right on the back panel of the Pro XR or Pro XRS receiver.

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4.4 GPS Pro XR Cabling

To use the TSC1 handheld with a GPS Pro XR receiver, connect the system as shown in Figure 4-4.



1	P/N 16741-00	Compact Dome Antenna
2	P/N 22628	Antenna Cable
3	P/N 31180	Antenna Cable Adapter
4	P/N 29654-11	12-channel Pro XR receiver
5	P/N 17466	Camcorder Batteries
6	P/N 30232-00	NMEA/RTCM Cable
7	P/N 30231-00	Data/Power Cable
8	P/N 24333	Dual Battery Cable
9	P/N 32287-00	TSC1 Data/ESP Cable
10	P/N 29673-50	TSC1 Handheld

Figure 4-4 GPS Pro XR / TSC1 Connection Diagram

UNDER REVISION 10/29/97

4.7 Pro XR/XRS System Hip Pack

The Pro XR and Pro XRS systems come equipped with an ergonomic hip pack carrying system, see Figure 4-18. The receiver, batteries and antenna are carried in the field using this hip pack/strapping system.

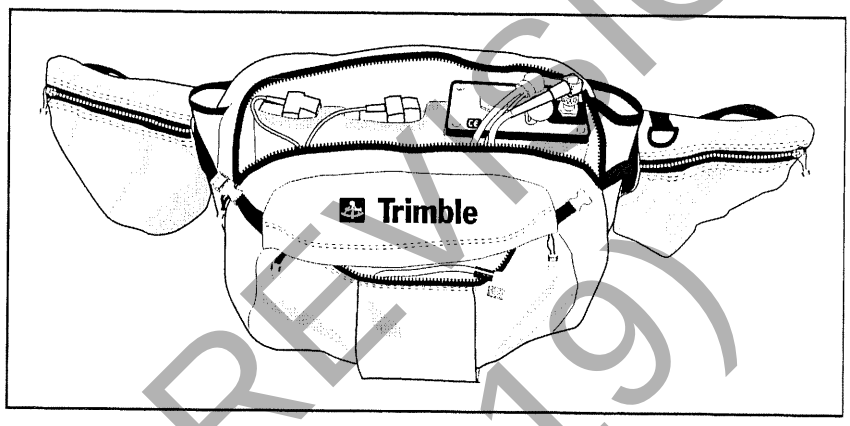


Figure 4-18 Pro XR/XRS System Hip Pack

4.7.1 Pro XR/XRS Hip Pack Contents

The Pro XR and Pro XRS systems are packed so that they are almost ready for use. The items not included in the hip pack are three 1-foot antenna poles, one 6-inch antenna pole and the data collector cable (P/N 30233-00 for TDC1, P/N 30234 for TDC2, or P/N 30236 for Field Computer/MC-V). These are located inside the shipping case.

The large interior of the hip pack contains: the Pro XR or Pro XRS receiver, two camcorder batteries, the power/data cable, and the camcorder power cable. All of these are set up inside the pack and ready for use. The exterior pocket of the hip pack contains a 3-meter antenna cable attached to the receiver and routed through a passage between the large interior pocket and exterior pocket. Both the data collector cable and antenna are routed out of the exterior pocket through the double zipper.

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To route the data collector cable:

1. Locate the data collector cable and connect it to the data power cable, DE-9 connector labeled TO RECEIVER.
2. Once connected, feed the coiled cable through the passage and into the exterior pocket.

4.7.2 Wearing and Adjusting the Hip Pack

The Pro XR/XRS hip pack, once adjusted to suit, is comfortable and easy to use. See Figure 4-19.

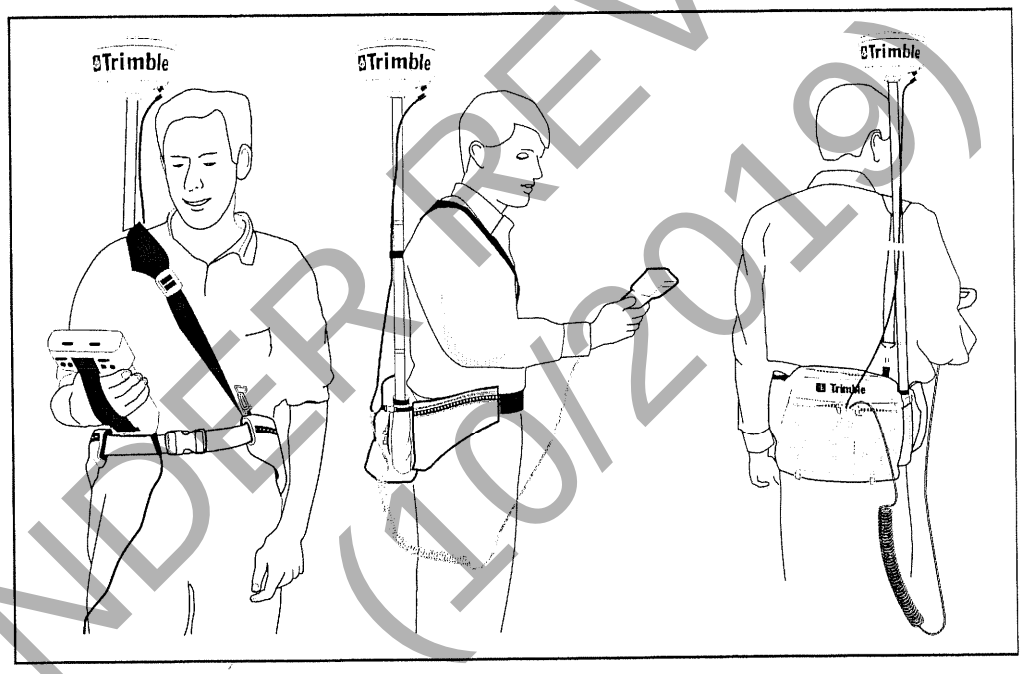


Figure 4-19 View of Hip Pack Setup

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Antenna

When wearing the hip pack, the antenna height should be 3-4 inches above your head. The number of antenna pole sections required varies depending on your height. For example, if you are 5'5" tall, you may need two 1-foot and one 6-inch pole sections. If you are 6'2" tall, you may need three 1-foot poles. Try out different pole heights.

To set up the antenna with the hip pack:

1. Attach the pole sections together and connect the antenna onto the top of the pole sections.
2. Attach the pole/antenna to the hip pack.
3. Choose the side of your body that you prefer the antenna to be on and slide the pole sections into the small sleeve on that side of the hip pack.

Hip Pack and Strap

To adjust the hip pack and strap:

1. Connect the strap to the rear D-ring on the side of the pack on which the antenna is located.
2. Connect the other end of the strap to the D-ring on the belt on the opposite of the bag.
3. Slide the antenna pole through the velcro connection on the strap.
4. Put the strap over your head and across your opposite shoulder.

   At this point, the shoulder strap should lead naturally from the antenna pole across your chest to the belt.
5. Buckle the hip pack around your waist/hip area so that the belt buckle is centered in the middle of your body.

   The pack should adjust to fit close to the small of your back.

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6. Adjust the front and back straps so the shoulder strap is situated squarely on your shoulder.

7. Put the pack on by slipping the strap over your head and across your body and then buckling the belt of the hip pack.

   The hip pack includes side compression straps that can be pulled towards you to hold the pack firmly and comfortably against your back.

Remove the hip pack/strap by unbuckling the belt and slipping the strap over your head.

The hip pack and strap can also double as a shoulder bag. Tuck the belt portion of the pack into the webbing material on the back of the pack and hook the strap on the large D-rings of the pack. The unit can now be carried on your shoulder instead of around your waist.

The pack has extra room in the interior and exterior pockets for additional items you may need in the field. The hip pack also includes straps on the bottom of the pack to secure an extra sweater or coat while in the field.

4.8 Optional Range Poles and Tripods

Range poles and tripods are very useful when collecting carrier phase data. The height of the antenna can be accurately measured, and the antenna can be held still easily, compared to an antenna mounted from the hip pack.

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APPENDIX B

FIELD DOCUMENTATION

Appendix B-1: Example of Field Sheet

Appendix B-2: Example of Chain of Custody Form (COC)

Appendix B-3: Example of Photo-Log

Appendix B-4: Example of Sample Labels

UNDER REVISION (10/2019)

UNDER REVISION (10/2019)

MONTEREY COUNTY WATER RESOURCES AGENCY - COASTAL GROUND WATER MONITORING PROGRAM **June 2007**

F CODE	SWID	STATUS	AQUIFER	USE	WELL NAME	METER No	PLANT No	SMPLE PT	VISIT DATE	APPT. DATE	SMPLE DATE	SMPLE TIME	SMPLER	REMARKS
886	14S/02E-24E01	ACTIVE	P400	AG	R5P1	4571R8	92205	DL						D'Arrigo Bros. R5P1. Tag #1164. Well is at corner of San Jon Rd an Hwy 183. Go twice then call Ed Mora 206-9164 or Jesse Aragon 90 9073. See photo
331	14S/02E-36E01	ACTIVE	P180	AG	BARDIN 12	0R1749	92428	faucet on booster						T & A. Bardin #12. Tag #1037. Well on Hitchcock Rd. off Blanco l office. Go twice, then call Dennis. See photo
673	14S/02E-13F01	ACTIVE	P180	AG	SAN JON B	R39873	95522	DL						Sea Mist. San Jon well B. Tag #1186. Call Chris. Three day notice. S photo
975	14S/02E-12N02	CSIP-SBI	P180	AG		92593R	91785	DL						Schneider. Domestic well. Tag #2960. Run for 30 min. to stabilize conductivity, EC = 2920 (Jul '04). Call Tim Schneider 449-0874. Tv week notice. Take EC meter, a bucket and last years results. See pho
1055	14S/02E-15A01	CSIP-SUPP	P400	AG	15A01	R69587	94951	DL			6/12/2007	9:05:00 AM		CSIP-SUPP. Well 15A1. PCA site #17. Go twice, then call Bill or Je See photo
1324	14S/02E-15C02	CSIP-SUPP	P400	AG	15C02	42542R		DL			6/12/2007	8:55:00 AM		CSIP-SUPP. Well 15C2. Tag #2838. PCA site #19. Go twice, then c Bill or Jesse. See photo
861	14S/02E-15P01	CSIP-SBA	P400	AG	MORO COJO#1 (YARD)	31535R	95209	DL						Higashi Farms. Moro Cojo #1. By house and shed. Call Peter. 2 day notice. See photo
279	14S/02E-16H01	CSIP-SBA	P400	AG	CONLEY	91R418		DL						Higashi Farms. Connely Ranch well. Tag #2856. Call Peter Odello 5 7926 or Charlie 578-7416. See photo. INACTIVE
2779	14S/02E-21E01	ABAN	P400	AG	MARINA-ARMSTRONG WELL	02384R		DL						Armstrong. Marina-Amstrong well. Tag #2962. SW of MRWPCA, sample from ball valve on pressure/flow control valve. Jack Armstro 455-1901 See photo. INACTIVE
766	14S/02E-22P02	ACTIVE	P180	AG	VIERRA#1	1843T	95485	truck fill valve						Crown Packing. Vierra #1. Tag #1095. Call Bill or Jose. Two day notice. See photo
859	14S/02E-15N01	CSIP-SBA	P400	AG	MORO COJO#2	3538R4	95037	DL						Higashi Farms. Moro Cojo #2. Big yellow truck-fill. Call Peter. 2 day notice. See photo
1282	14S/02E-24P02	ACTIVE	P400	AG	BORONDA SCHOOLHOUSE#1	93258T		DL						Crown Packing. Boronda Schoolhouse well. Tag #1099. Call Bill Sullivan 214-4650 or Jose Luis Lepe 970-6889. Well next to house/metal shed on McFadden Road, close to elem. school. Two day
22929	14S/02E-28H04	ACTIVE	PDEEP	AG	JACKS YARD									New Deep aquifer well located .54 mi W of Cooper Rd & .27 mi S of McFadden Rd on the Nissen Rch

ENVIRONMENTAL ANALYSIS REQUEST FORM

MONTEREY COUNTY CONSOLIDATED CHEMISTRY LABORATORY
1270 NATIVIDAD ROAD, SALINAS, CALIFORNIA 93906 Phone (831) 755-4516

Shaded areas for laboratory use only

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Chain of Custody:

Collected by (Print & sign):	Received by:	Date & Time:
Relinquished by:	Received for Laboratory:	Date & Time:

Client Name:	Report Attention:	
Address:	Copy to:	
City, State, Zip:	Phone:	Fax:

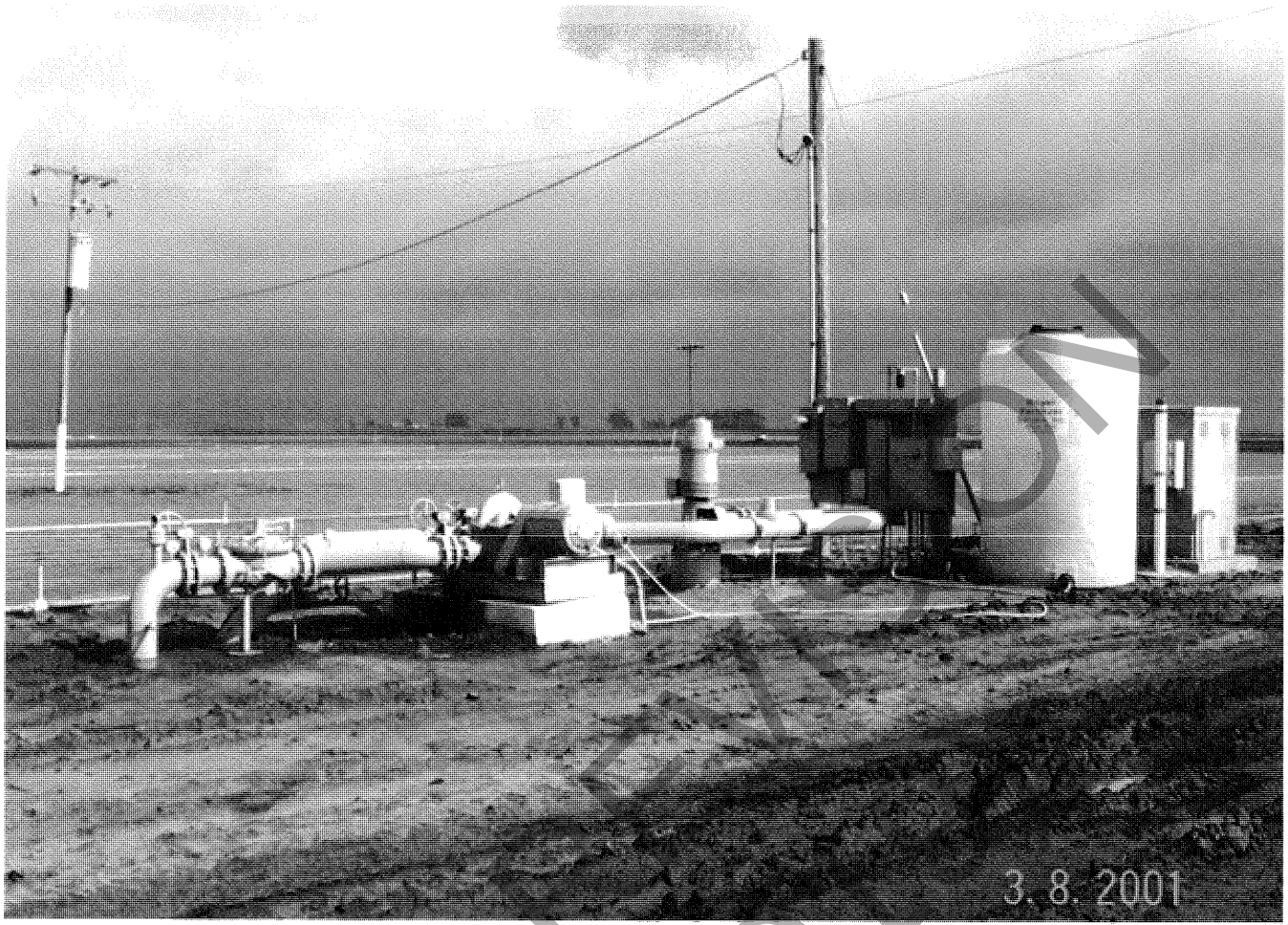
Laboratory Number	Sample ID or System #	Sample Site or Description	Collection Date & Time	Matrix[1] 1-Routine 2-Repeat 3-Replacement	No. of Containers	Coliform MMO..... ☐ Quanti..... ☐ Low-D..... ☐	Nitrate					

ANALYSES REQUESTED

[1] **D**=Drinking Water (Specify as routine, repeat or replacement) **W**=Wastewater (Specify as grab or composite) **O**=Other (identify)

[ ] Payment received with delivery Amount: _____
Check: _____ Initials: _____
Receipt #: _____ Date: _____

Sample comments (irregularities/preservation, billing information if different than reporting):





UNDER

15S/04E-07A01

Sampling Date: Sampler:

Sampling Time:

Comments:
Complete General Mineral Analyses

15S/04E-08M04

Sampling Date: Sampler:

Sampling Time:

Comments:
Complete General Mineral Analyses

15S/04E-15D02

Sampling Date: Sampler:

Sampling Time:

Comments:
Complete General Mineral Analyses

15S/04E-17P02

Sampling Date: Sampler:

Sampling Time:

Comments:
Complete General Mineral Analyses

15S/04E-19H03

Sampling Date: Sampler:

Sampling Time:

Comments:
Complete General Mineral Analyses

15S/04E-20B02

Sampling Date: Sampler:

Sampling Time:

Comments:
Complete General Mineral Analyses

15S/04E-26G01

Sampling Date: Sampler:

Sampling Time:

Comments:
Complete General Mineral Analyses

15S/04E-36H01

Sampling Date: Sampler:

Sampling Time:

Comments:
Complete General Mineral Analyses

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APPENDIX C

REVIEW CHECKLISTS

Appendix C-1: Field Activities Review Checklist

Appendix C-2: Laboratory Data Review Checklist

UNDER REVISION
(10/2019)

Field Activities Review Checklist

Sampling Location(s): _____

Sampling Date: _____

Item	Yes	No	NA	Comment
All required information was entered into field sheets in ink, and sheets were signed and dated by the field sampler.				
Deviations from SOPs, along with any pertinent verbal approval authorizations and dates, were documented on the field sheets.				
Samples were collected at the correct sites.				
The correct number of samples for each type of analysis and the correct volume was collected (0.5 gal/ ~2L for complete mineral panel OR one pint/ ~0.5L for partial mineral panel).				
Acceptable sample containers, appropriate for the intended analysis, were used.				
Field blanks were collected, and at the correct frequency (one every 25 samples).				
Field duplicates were collected, and at the correct frequency (one every 25 samples).				
Samples were packed with double-bagged ice and transported at the proper temperature (4±2°C).				
Chain of custody (COC) documents were completed properly.				
Sample holding times were not exceeded during field operations. See Table 6 (QAPP).				

Reviewer's Name (print): _____

Reviewer's Signature: _____

Reviewer's Title: _____

Date of Review: _____

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Laboratory Data Review Checklist

Sampling Location(s): _____

Sampling Date: _____

Item	Yes	No	NA	Comment
Samples arrived at the laboratory at the proper temperature (4±2°C).				
All requested analyses were performed and were documented in the analytical report.				
Analyses were performed according to the methods specified in the approved QA Project Plan.				
Holding times for extraction and analysis were not exceeded. See Table 6 (QAPP).				
Field Blanks results were below MDLs and were analyzed at a frequency of one every 25 samples.				
Field Duplicate results were ≤ 25% RPD and were analyzed at a frequency of one every 25 samples.				
Method detection limits were included in the report.				
A narrative summarizing the analyses and describing any analysis problems was included in the data report.				
Data qualifiers and flags were explained in the data report.				
Initial calibration data were within laboratory SOP defined acceptance criteria ($r^2 \geq 0.995$) for all analyses.				
Method blanks were performed at 3 per analytical batch, and were below MDL.				
Laboratory Control Sample (LCS) data were included for all analyses for every analytical batch.				
Laboratory Control Sample Results were within 80-120% recovery.				

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Item	Yes	No	NA	Comment
Analytical Duplicate data were included for all analyses for every analytical batch.				
Analytical Duplicate results were < 25% RPD.				
Matrix spike data were included for all pertinent analyses for every analytical batch, and recoveries were within 75-125%.				
Matrix spike additions were at 3-10x the native.				
Matrix spike duplicates were ≤ 25% RPD.				
Continuing calibration data were within QAPP defined acceptance criteria (80-120% of initial slope) for all analyses.				

Reviewer's Name (print): _____

Reviewer's Signature: _____

Reviewer's Title: _____

Date of Review: _____

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(10/2019)

APPENDIX D

MONTEREY COUNTY CONSOLIDATED CHEMISTRY LABORATORY

QA MANUAL AND STANDARD OPERATING PROCEDURES

Appendix D-1: QA Manual

Appendix D-2: Specific Conductance, based on SM 2510 B

Appendix D-3: pH, based on SM 4500-H B

Appendix D-4: Total Alkalinity, based on SM 2320 B

Appendix D-5: Metals, based on SM 3111 B

Appendix D-6: Anions, based on EPA 300.0

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ANALYTICAL PROCEDURES 10

ACQUISITION, REDUCTION AND VALIDATION OF REPORTING DATA.....11

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APPENDICES

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ORGANIZATION AND RESPONSIBILITY

On October 11, 1988, the Monterey County Board of Supervisors, in Resolution No. 88-508, authorized the Director of the County Health Department and the General Manager of Monterey County Flood Control and Water Conservation District (MCFC&WCD) to consolidate laboratory services for their respective programs into one facility. A Laboratory Steering Committee, comprised of representatives from both agencies, was established for the purpose of providing the planning, operation, and future development of the Consolidated Environmental Laboratory.

Each year the Steering Committee develops a Memorandum of Agreement (MOA) that describes and confirms the services to be provided by the Health Department to the Water Resources Agency (formerly the Flood Control and Water Conservation District) and defines the responsibilities of each party. In addition to providing laboratory support for the Health Department and the Water Resources Agency, the Consolidated Chemistry Laboratory provides analytical services to the Monterey Regional Water Pollution Control District, the County Department of Public Works and numerous water supply systems and wastewater treatment facilities.

The Consolidated Environmental Laboratory is accredited by the State Department of to perform tests in the following fields: 1) microbiology of drinking water and waste water; 2) inorganic chemistry and physical properties of drinking water; 3) analysis of toxic chemical elements in drinking water; 4) wastewater inorganic chemistry, nutrients and demand; and 5) toxic chemical elements in wastewater. A list of analyses and methods used in the laboratory is included in Appendix A.

The following is a brief description of the staff support for the Consolidated Chemistry Laboratory:

1. Director - Plans, organizes and controls laboratory operations. Coordinates laboratory interactions with other programs in the Health Department. Administers laboratory budget, billing and purchasing. Develops laboratory policy and procedures and supervises staff.

2. Public Health Chemist – Principal analyst. Performs complex organic and inorganic chemical analysis, evaluates and implements laboratory methods, develops and maintains quality assurance, reports results and maintains records, purchases equipment and supplies, provides technical consultation to Environmental Health and Water Resources Agency. Trains analysts and documents competency

3. Water Quality Specialist- Performs broad range of professional scientific work related to water quality and environmental issues; is proficient in

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performing water quality analyses and managing the laboratory water quality database. Interpret and explain regulatory guidelines to clients.

4. Public Health Microbiologists - Assist Public Health Chemist in performing microbiological analyses and performing quality control.

5. Laboratory Assistant - Prepares culture media and reagents, assists in the processing of specimens, performs low to moderately complex environmental analyses and clinical analyses where interpretation or medical judgement is not required.

5. Laboratory Helper - Washes and sterilizes glassware and supplies. Prepares and labels mailing containers and specimen collection kits. Accession laboratory specimens. Sterilizes and disposes infectious waste. Maintains stockroom.

6. Typist-Clerk II - Enters clients and laboratory results into computer. Prints reports/forms. Prepares billing statements; receives and accounts for payments. Distributes laboratory results, and maintains laboratory files.

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QUALITY ASSURANCE OJECTIVES FOR MEASUREMENT OF DATA

Quality Assurance (QA) includes all aspects of laboratory operation that affect the accuracy and reliability of sample test results. In addition to quality control of the analytical test process, quality assurance practices include: 1) proper sample collection, receiving and holding, 2) proper maintenance of equipment, 3) accurate data reduction, validation and reporting; and, 4) periodic performance and systems audits.

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(10/2019)

CUSTODY, HOLDING AND DISPOSAL OF SAMPLES

Quality assurance includes proper labeling of samples, proper completion of the chain of custody/analysis request form, proper collection, preservation and storage of samples, proper accessioning of samples, and proper disposal of the sample.

1) Sample Collection/Labeling. Sample collection is a coordinated effort between the client and the laboratory. The laboratory will provide clients with appropriate sample containers and sample collection/preservation instructions. The laboratory will also request duplicates and blanks according to client's sample plan requirements. All samples submitted for testing should be appropriately labeled. Sample containers provided by our laboratory have a suitable label which should be filled out at the time of sampling by the sample collector. The following information must be provided with all samples:

   a) Sample identification - submitters identification of sample (e.g. well number)

   b) Location - an address or brief description of the place the sample was taken.

   c) Time and date taken.

   d) Name of sample collector.

   e) Any preservatives

2) Chain of Custody/Analysis Request Form. A Chain of Custody/Analysis Request form should accompany all samples (see Appendix B). The Chain of Custody/Analysis Request form must include the following information: submitter name and address; sample identification; location of sample collection; date & time of collection; sample type; analysis to be performed; signatures of persons involved in the collection and chain of possession; and inclusive dates of possession.

3) Sample Receiving. Laboratory personnel receiving samples should assure that samples are properly collected, labeled, and the Custody/Analysis Request form has been completed:

   a) The laboratory assistant receiving the specimen must sign and date the Custody/Analysis Request form. Make sure that any special requests made by the client are recorded under the comments section of the form

   b) Assign each sample a unique laboratory identification number. Place

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preprinted lab number on analysis request form and sample container. When a sample is collected in multiple containers for different analyses, each container should receive the same laboratory number. (Exception: sample containers for analytes requiring a rapid turnaround time (e.g. coliforms) may receive separate number to expedite reporting).

c) Check that the samples meet the criteria described in Table 1006:I Summary of Special Sampling or Handling Requirements in 18th ed. of *Standard Methods for the Examination of Water and Wastewater* (Appendix C)

   i) Samples should be collected in a suitable container; samples collected in bottles of unknown origin or questionable cleanliness should be brought to the attention of the Water Quality Specialist or the Public Health Chemist.

   ii) Samples should be adequately labeled

   iii) Samples should be checked for proper preservative, holding time, and holding temperature.

   iv) Samples should be adequately sealed. Notify public health chemist if there is evidence of leakage. Verify that adequate sample volume exists to perform requested analysis.

d) NOTE: Samples that are not properly identified or are otherwise unsuitable for testing (e.g. improperly preserved or exceeding holding/ transport time) are recorded on the "Sample Invalidation Log" and the Water Quality Specialist or Public Health Chemist notifies the client. Samples not meeting collection/preservation criteria may be tested only if resampling is impossible; results from such samples must be qualified on the laboratory report by comments describing sample deficiency.

4) When the sample meets criteria for acceptance by the laboratory, required preservatives are added immediately and the sample is stored under conditions specified by the analytical method to be used. For samples requiring thermal preservation, a laboratory refrigerator and freezer is available. The temperature is maintained at 4 degrees and below -10°C respectively. Temperatures are monitored each day.

5) Chain of Custody/Analysis Request forms are given to the clerk to enter into a password protected computer laboratory information management system. Refer to "Water Sample Entry" in Clerical Manual for instructions on sample log-in.

6) Disposal of samples: Upon completion of all analyses, any remaining

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sample will be stored for at least one month prior to disposal. Chain-of-Custody form, worksheets and lab reports are retained for three years. NOTE: Longer retention of samples or data may be required when legal action is probable. The samples and any associated extracts or digests are disposed of following recommendations found in the book, *Prudent Practices for Disposal of Chemicals from Laboratories*, National Academy Press, Washington, D.C. 1983.

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CALIBRATION PROCEDURES AND FREQUENCY

Calibration is the process for determining the correctness of the assigned values of the physical standards used or the scales of the measuring instruments. Calibration accuracy is critically dependent on the reliability of the standards used for the required comparisons. Only the highest quality chemicals are used to provide necessary standard solutions, and due care is exercised in their preparation. The concentrations of the calibration standards bracket the expected concentration of the analyte in the samples. No data is reported beyond the range of calibration of the methodology. The calibration data, when plotted graphically, is referred to as a calibration curve. The calibration must be done under the same instrumental and chemical conditions as those that will exist during the measurement process. The frequency of calibration depends on the accuracy requirements of the investigation and the stability of the instrument used for the measurements:

At a minimum, three different dilutions of the standard will be measured when an analysis is initiated. Correlation coefficient must be > 0.995. Reportable analytical results are those within the range of the standard dilutions used. Do not report values above the highest standard. The lowest reportable value is the Method Detection Limit (MDL), providing that the lowest calibration standard is less than 10 times the MDL.

1) Atomic Absorption Spectrophotometers - Two approaches are used to calibrate atomic absorption spectrophotometers. These methods are direct comparison and standard additions.

   a) Direct comparison is the simple approach, and can be used with many instruments to give a direct readout of the concentration of an element in an unknown sample. To obtain good precision (e.g., 1-2% coefficient of variation), the absorbance levels measured must be about 0.1 to 0.6 units. Standard and sample solutions should be similar in bulk matrix constituents, particularly acid and salt content. Interference suppressants are used in all solutions when required. A number of standards (usually three to five in increasing concentration) as well as a blank, are prepared to cover the concentration range. A volume of type II reagent water with the same amounts of acids as the samples and standards) will be used for calibration blank. These solutions are run in absorbance to check linearity of the calibration curve.

   b) The method of standard additions is used when samples contains severe matrix interference. In this case it is possible to add small amounts of conventional standard solutions, in increasing amounts, to aliquots of each sample. A calibration graph can then be constructed. This method will often be used in work with the graphite furnace.

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2) UV-VIS Spectrophotometer - The calibration procedure for the UV-VIS spectrophotometer is similar to that for the A.A. spectrophotometers. An integration interval is not required as the signal is very stable. It is important to use blanks and allow at least 1/2 hour warm up time.

3) PH Meters - The proper calibration of pH meters requires the use of two buffer solutions and a thermometer. The two buffer solutions must cover the expected range of samples to be tested. A third buffer is used to confirm calibration. The pH meter should be calibrated each day. The temperature of the buffers must be entered into the meter.

4) Conductivity Meter - The conductivity meter does not require frequent calibration but should be checked against a known standard each day of use. Recalibrate when there is significant deviation with the value of the standard.

5) Ion Chromatograph- Calibration of the Ion Chromatograph is performed at least once each year and whenever: 1) Controls are out of range; or, 2) the column, suppressor or detector is changed.

6) Inductively Coupled Plasma/Mass Spectrometer – Calibration of the ICP-MS is performed every day of analysis and whenever controls are out of range. See the SOP for more information.

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ANALYTICAL PROCEDURES

The laboratory employs only methods approved by Environmental Laboratory Accreditation Program. Analysts must conduct sufficient preliminary tests using the methodology and typical samples to demonstrate competence in the use of the measurement procedure.

Each time an analytical procedure is performed controls are included and duplicate samples and known additions are tested to insure accuracy and precision. Results are not reported unless all controls are within acceptance limits referenced in Standard Methods 18th Edition, 1992.

To monitor reliability of analytical measurements, data is periodically obtained on detection limits, accuracy, precision and recovery.

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ACQUISITION, REDUCTION, VALIDATION OF REPORTING DATA

The analytical chemist is responsible for describing and reporting the data in an appropriate manner. In order to insure the accurate transcription, calculation and reporting of analytical data, the chemist will adhere to the following quality assurance procedures.

1) Use documented procedures and record all significant experimental details in such a way that the measurements could be reproduced by a competent analyst at a later date.

2) All measurements are made so that results are representative of the matrix (soil, water, etc.) and conditions being measured.

3) Report data only to the number of significant figures consistent with their limits of uncertainty.

4) Report data with the proper units of concentration. Units should be chosen which clearly indicate whether the concentration is in terms of weight by weight, weight by volume or volume by volume. Unless otherwise specified, all data are calculated and reported in standard units to allow comparison with data reported by other laboratories.

5) The analytical methodology used will be cited. The raw data for each sample, along with reagent blanks, control, and spiked samples will be suitably identified if included in the report. If average values are reported, an expression of the precision, including the number of measurements, must be included.

6) The report should include date and place of sampling, sampling point, the name of the sample collector, identification as to type of sample, date and time of submittal to the lab, date of analysis, name of the analyst, and the result. Any conditions which may effect the interpretation of the data should be noted in the report.. All results will be reviewed by a Water Quality Specialist or Public Health Chemist before a final report is released.

7) Laboratory records will be retained in a permanent file for three years.

8) Retain samples for one month after issuing final report and retain data and documentary evidence for three years.

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INTERNAL QUALITY CONTROL

Quality Control (QC) may be defined as those measures undertaken in the laboratory to maintain the analytical testing process within acceptable limits of accuracy and precision.
The Quality Control Program consists of the following elements: documentation of operator competence, recovery of known additions, analysis of externally supplied standards, analysis of method blanks, and testing of replicate samples:

1) Operator competence The principal analyst is responsible for: 1) developing a standardized training syllabus for the methods employed in the laboratory; 2) assuring that test personnel are adequately trained; 3) assessing the competency of test personnel, and 4) maintaining documentation of training and competency of all test personnel.

   a) Before test personnel are permitted to do reportable work , competency in performing the analysis is to be demonstrated. Commonly, the analyst performs replicate analysis under the supervision of the principal analyst. General limits for acceptable work are found in Standard Methods 18th Edition, 1992 in Table 1020 :I.

   b) After initial demonstration of competency, the principal analyst will assure test personnel maintain competency through testing internal or external proficiency test samples at least once each year.

2) With each batch of samples tested, controls will be tested to verify the accuracy of results as described below. Controls used with each method are outlined in Appendix D.

   a) Recovery of known additions as part of all regular analytical protocols except titrimetric and gravimetric methods. Use known additions to verify the absence of matrix effects. Spiked samples shall be analyzed with a minimum frequency of ten percent of the samples per matrix per batch of samples. Spike recovery must be between 80-120% for potable water (75-125% for waste water). When a spike sample fails to meet this criteria, retest all samples following the last acceptable spike sample. Spike recovery calculated as % of the known addition recovered.

   b) Analyze control standards with a minimum frequency of ten percent of the samples per matrix, per batch of samples. If there are less than 10 samples in a batch, at least one per matrix per batch must be analyzed. The concentration of the sample shall be within the working range of the method. Sources of these samples include but are not limited to: performance evaluation samples from the EPA, commercially available standards, or standards prepared in-house but from sources different

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from calibration standard. Control standards must be within the published acceptance range (for external controls). If the control standard does not have a published acceptance range, recovery of the control should be within 10% of the known value. When a control standard fails to meet this criteria, retest all samples following the last acceptable control.

c) Method blanks will be analyzed with each batch of samples. The use of method blanks provides a measurement of laboratory contamination. Blanks cannot exceed the minimum detection level. See Appendix A.

d) Replicate samples will be analyzed with a minimum frequency of ten percent of samples per matrix, per batch of samples for drinking water. For wastewater the requirement is 5%. If there are less than ten samples per batch, at least one sample per matrix per batch must be analyzed. If the analyte is not detected, replicate matrix spike samples will be analyzed. The percent difference between replicate samples must be within 20% for potable water (25% for wastewater). When a replicate sample fails to meet this criteria, retest all samples following the last acceptable replicates. Duplicate % difference calculated as the difference as a percent of the mean. [100(X1-X2)/avg].

e) In addition to the control standards tested with each run, an external reference standard for each analyte will be tested at least once each quarter.

All of the quality assurance control procedures will be followed in the laboratory. All documentation for these checks should be available for inspection by laboratory management.

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PREVENTIVE MAINTENANCE

As part of the QA plan, the laboratory has a comprehensive preventive maintenance program. Balances, spectrophotometers, and other instruments undergo routine maintenance and accuracy checks by a manufacturer's representative or by laboratory personnel as described below. All preventive maintenance performed in-house is documented on preventive maintenance forms. Instrument s which undergo routine professional maintenance have labels affixed to indicate date of last servicing. Manufacturer's instructions and service manuals are readily accessible.

Adequate spare parts are kept on hand to perform routine maintenance and minimize downtime. The spectrophotometers have maintenance contracts that provide for immediate servicing in the event of malfunction. Equipment records documenting preventive maintenance and emergency servicing/repairs are kept for a minimum of three years.

1) Thermometer/temperature-reading instruments: Accuracy of thermometers or recording instruments are checked annually against a certified National Bureau of Standards (NBS) thermometer or one traceable to NBS and conforming to NBS specifications. All thermometers a relabeled with date calibrated and correction factor.

2) Balance: Balance accuracy is verified each week using ASTM type 1 reference weights. Accuracy checks are documented on preventive maintenance chart. Balances are serviced and certified annually through a maintenance contract. Type 1 weights are re-certified at least every five years.

3) pH meter: pH meters are standardized with at least two NIST traceable standard buffers (pH 4.0, 7.0, or 10.0) and compensated for temperature before each series of tests. A third buffer is used to confirm calibration. Date buffer solutions when opened and discard buffer after expiration date on bottle. Buffers prepared from powders are replaced after four weeks.

4) Water deionization unit: Conductivity of the RO and Nanopure water is checked each month. A heterotrophic plate count on Nanopure water is also performed monthly. Filters are changed as indicated by conductivity readings and heterotrophic plate count. Records are maintained on preventive maintenance chart. Water is tested annually for bacteriologic quality and heavy metals.

5) Autoclave: Autoclave charts are used to document date, time, temperature and contents of each load. Chem-di indicators and heat sensitive tape are used with each load to identify materials that have been autoclaved; results are recorded on autoclave chart. Autoclave performance is

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checked each month with biological indicator (e.g. spore suspension). Autoclaves are serviced quarterly under maintenance contract. The accuracy of autoclave recording thermometer is checked annually. The autoclave operating temperature is monitored on a weekly basis.

6) Refrigerator: Temperatures are recorded daily and units defrosted and cleaned as needed. All media and reagents stored in the refrigerator are labeled.

7) Freezer: Temperatures are recorded daily. Identify and date materials stored. Defrost and clean semiannually; discard outdated materials.

8) Ultraviolet sterilization lamps: Unit is cleaned monthly by wiping lamps with a soft cloth moistened with ethanol. Test lamps quarterly with UV light meter and replace if they emit less than 70 % of initial output or if agar spread plates containing 200 to 250 microorganisms, exposed to the light for 2 minutes, do not show a count reduction of 99%.

9) Water bath: Fecal coliform water bath is checked twice daily. All other water baths are checked each day of use.

10) Incubator: Check and record temperature twice daily (morning and afternoon) on the shelf areas in use. Locate incubator where room temperature is in the range of 16 to 27O C.

11) Fume hoods/Biological Safety Cabinets: Fume hoods are checked once each month using a velometer; readings are recorded on preventive maintenance chart. Hoods and safety cabinets are certified annually through service contract.

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PERFORMANCE AND SYSTEMS AUDITS

Corrective action is required when data is outside of predetermined limits for acceptability. The corrective actions can be triggered by the following quality assessment activities: Control Chart analysis; proficiency evaluation testing; and QA audits.

1) CONTROL CHART ANALYSIS:

The laboratory's quality assessment techniques will be used to maintain the precision and accuracy of all laboratory analyses within a state of statistical control. Precision and accuracy measurements are the best way to assess analytical performance. Precision is the degree of reproducibility of a particular analytical procedure. Accuracy is a measure of the agreement between an experimental determination and the true value.

a) PRECISION - Assess precision by replicate analysis, by repeated analysis of a stable standard, or by analysis of known additions to samples. Precision is specified by the standard deviation of the results. The formula for determining standard deviation (SD) is:

$$SD = \sqrt{\Sigma (X1-X)^2/(N-1)}$$

X1 is the value of the individual measurements; X is the mean of all measurements for a given sample and N is the number of measurements.

The purpose of determining precision is to establish the typical variance of the method in the absence of any matrix influence. In the course of determining precision, there are two cases that indicate there is a problem with the precision data:

i) The measured values show wide variation from one to another for a given day.

ii) The measured values show little variance from one to another for a given day, but the mean and standard deviation show wide variation from one day to another.

If either of the above occurs, factors such as sample homogeneity, instrument calibration, or analyst error should be checked, documented, and corrected. The precision measurements should then be repeated.

b) ACCURACY - The best method to determine accuracy is to spike an alequot of reagent water with a known amount of the constituent being measured and analyze the sample. The amount spiked should be at least five to ten times greater than the analytical detection limit.

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To evaluate the data accuracy, the percent recovery of the spike must be determined. The formula for determining percent recovery is:

$$\% \text{ recovery} = [100(S - S1) \div S2]$$

Where S is the concentration of the spiked sample; S1 is the concentration of the unspiked sample; S2 is the concentration of the spike added to the sample.

If the percent recovery deviates significantly from 100% and the method has not demonstrated significant bias, the problem must be detected and corrected prior to continuing the analysis. Sources of this problem include incorrect standard or spike solution concentration or a problem in the procedural detection system.

Precision, accuracy, and detection limits for all methods used in the laboratory is comparable to values referenced in Standard Methods 18th Edition, 1992 and EPA Methods for Chemical Analysis of Water and Wastes, March 1983.

2) PERFORMANCE EVALUATION SAMPLES: The laboratory director is responsible for enrolling the laboratory in ELAP approved proficiency testing program(s) and assuring that proficiency testing is performed for all regulated tests. The principal analyst (Public Health Chemist) will conduct and document internal proficiency testing at least once a year for tests where proficiency testing is not available. Proficiency test samples are treated in the same manner as routine samples (ie. tested the same number of times, tested using personnel who routinely perform testing, tested using routine methods and tested during patient testing).

3) QUALITY ASSURANCE AUDIT: The quality assurance program will be audited quarterly and any deviations from the program will signal corrective action to be taken. Quality assurance audit will be documented in a written report. The audit will include the following aspect:

   a) Competency of test personnel must be evaluated annually and be documented

   b) Evidence of the systematic use of control samples, replicate measurements and reference materials all in conjunction with control charts.

   c) Proper labeling of reagents and samples.

   d) Use of approved methods.

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e) Results on blind samples.

f) Acceptable safety equipment and procedures.

g) Quality assurance reports generated on a regular basis.

h) Documentation on equipment performance and maintenance.

i) Training records.

j) All relevant files accessible and organized.

k) Laboratory personnel following good laboratory practices.

l) Laboratory personnel following good measurement practices

The Public Health Chemist will be responsible for initiating and documenting any corrective action necessary. Corrective action will be documented on the appropriate control chart, performance evaluation report, or QA audit report. No data shall be reported until the cause of the problem is located and corrected or the laboratory demonstrates the cause was a random event and no longer affects data. Although the elimination of events requiring corrective action may not be achieved, a reduction in the repetition of these events is the objective of this program.

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REFERENCES FOR QUALITY ASSURANCE DOCUMENT

1) Standard Method for the Examination of Water and Wastewater, 18th edition, 1992.

2) Handbook for Analytical Quality Control in Water and Wastewater Laboratories. EPA-600/4-79-019, March 1979, USEPA.

3) Manuals for the Certification of Laboratories Analyzing Drinking Water Criteria and Procedures/Quality Assurance. EPA QAMS-005/80, Interim Guidelines, EPA-570/9-82-009, USEPA.

4) Methods for Chemical Analysis for Water and Waste. EPA-600/4-79-020, March 1983.

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(10/2019)

Written by: Gerry Guibert & David Holland

Date: May 1993

Revised: January 1999
Revised: September 21, 2004

Approved by: _____

(Laboratory Director's Signature)

Appendix A

Monterey County
Consolidated Chemistry Laboratory

ANALYTICAL METHODS FOR WATER ANALYSIS

PARAMETER	HOLD TIMES	METHOD REFERENCE	MDL	UNITS
Free Chlorine	.25 h; ASAP	SM 4500-Cl G	0.02	mg/L
Total Chlorine	.25 h; ASAP	SM 4500-Cl G	0.05	mg/L
Enterococcus	8 h	IDEXX	1/100 ml	
Heterotrophic Plate Count	8 h	SM 9215 B	1	CFU
E. coli – MPN	6 h waste 8 h source 30 h potable	SM 9221 B	2/100 ml	
Fecal Coliform – MPN	6 h waste 8 h source 30 h potable	SM 9221 B	1/100 ml	
Total Coliform – MPN	6 h waste 8 h source 30 h potable	SM 9221 B	2/100 ml	
Total Coliform – Quantitray	6 h waste 8 h source 30 h potable	SM 9223	1/100 ml	
E. coli – Presence/Absence	30 h potable	SM 9223	1/100 ml	
Total Coliform – P/A	30 h potable	SM 9223	1/100 ml	
pH	.25 h; ASAP	SM4500H B		pH units
Bicarbonate	ASAP (with pH)	SM 2320 B	10	mg/L
Calcium Carbonate	ASAP (with pH)	SM 2320 B	1	mg/L
Carbonate	ASAP (with pH)	SM 2320 B	1	mg/L
Solids	24 h	SM 2540 F	0.1	mL/L
Color Determination	48 h	SM 2120 B	2	CU
Odor	NS; 48 h (rec 6h)	SM 2150 B	1	TON
Turbidity	48 h	SM 2130 B	0.05	NTU
Nitrate	48 h	EPA 300.0	1	mg/L
Nitrite as (N)	48 h	SM 4500 NO2-B	10	ug/L
Total Dissolved Solids	7 d	SM 2540 C	5	mg/L
Total Suspended Solids	7 d	SM 2540 D	5	mg/L
Alkalinity	14 d	SM 2320 B	1.0	mg/L, CaCO3
Bromide	28 d	EPA 300.0	1	mg/L
Chloride	28 d	EPA 300.0	1	mg/L
Fluoride	28 d	EPA 300.0	0.02	mg/L
Sulfate	28 d	EPA 300.0	1	mg/L
Conductivity	28 d	SM 2510 B	1	umhos at 25C
Ammonia (N)	28 d	SM 4500 NH3 F	0.05	mg/L
Orthophosphate	NS; 28 d	SM 4500 P E	0.03	mg/L
Total Phosphorus	28 d	SM 4500 P E	0.03	mg/L

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PARAMETER	HOLD TIMES	METHOD REFERENCE	MDL	UNITS
Aluminum	6 months	EPA 200.8	5	ug/L
Antimony	6 months	EPA 200.8	0.5	ug/L
Arsenic	6 months	EPA 200.8	1	ug/L
Barium	6 months	EPA 200.8	0.5	ug/L
Beryllium	6 months	EPA 200.8	0.5	ug/L
Cadmium	6 months	EPA 200.8	0.5	ug/L
Chromium	6 months	EPA 200.8	5	ug/L
Copper	6 months	EPA 200.8	0.5	ug/L
Iron	6 months	SM 3111B	100	ug/L
Lead	6 months	EPA 200.8	0.5	ug/L
Manganese	6 months	EPA 200.8	0.5	ug/L
Mercury	6 months	EPA 200.8	0.25	ug/L
Nickel	6 months	EPA 200.8	0.5	ug/L
Selenium	6 months	EPA 200.8	5	ug/L
Silver	6 months	EPA 200.8	5	ug/L
Thallium	6 months	EPA 200.8	0.5	ug/L
Zinc	6 months	EPA 200.8	5	ug/L
Calcium	6 months	SM 3111B	1.0	mg/L
Magnesium	6 months	SM 3111B	0.1	mg/L
Potassium	6 months	SM 3111B	0.1	mg/L
Sodium	6 months	SM 3111B	0.1	mg/L
Hardness as CaCO3	6 months	SM 2340 B	1.0	mg/L
Boron	6 months	SM 4500 B B	0.1	mg/L

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Appendix B

ENVIRONMENTAL ANALYSIS REQUEST FORM

MONTEREY COUNTY CONSOLIDATED CHEMISTRY LABORATORY
1270 NATIVIDAD ROAD, SALINAS, CALIFORNIA 93906 Phone (831) 755-4516

Shaded areas for laboratory use only

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Chain of Custody:

Collected by (Print & sign):	Received by:	Date & Time:
Relinquished by:	Received for Laboratory:	Date & Time:

Client Name:	Report Attention:	
Address:	Copy to:	
City, State, Zip:	Phone:	Fax:

Laboratory Number	Sample ID or System #	Sample Site or Description	Collection Date & Time	Matrix(1) 1-Routine 2-Repeat 3-Replacement	No. of Containers	Coliform	MMO..... ☐ Quanti..... ☐ Low-D..... ☐	Nitrate					

ANALYSES REQUESTED

(1) **D**=Drinking Water (Specify as routine, repeat or replacement) **W**=Wastewater (Specify as grab or composite) **O**=Other (identify)

[ ] Payment received with delivery Amount: _____

Check: _____ Initials: _____

Receipt #: _____ Date: _____

Sample comments (irregularities/preservation, billing information if different than reporting):

SPECIFIC CONDUCTANCE
EPA 120.1/SM 2510 B
umhos at 25°C

Scope and Application:
This method is applicable to drinking, surface and saline waters, domestic and industrial wastes and acid rain.

Summary of Method:
The specific conductance of a sample is measured by use of a self-contained conductivity meter, the YSI Model 32. The conductivity meter is used in the temperature compensated mode.

Sample Criteria & Acceptability:
A minimum of 100 ml sample should be submitted in a clean container provided by the laboratory. Samples can be stored for up to 28 days at 4oC. The samples must be brought to room temperature before testing. If the sample does not meet the above criteria, document it on the worksheet but perform the test.

Reagents:
0.02 Molar Standard Potassium Chloride Solution:

1. Dry 0.85 g of Reagent Grade Potassium Chloride (KCl) for 4 hours at 105°C. Use immediately or store in a desiccator until use.
2. Dissolve 0.7456g of pre-dried potassium chloride in a 1 liter Class A volumetric flask using deionized water.
3. Label the flask with Potassium Standard Solution, 0.7456 g KCl/L, date made, outdate of 3 months, and initial.
4. Alternately, order two 500 ml containers of the Traceable Conductivity Calibration Standard near the 1414 micromho/cm range; from Fisher Scientific, Cat No. 09-328-11.

Control

1. Check deionized water. It should read less than 1 umho. If the reading is higher, clean cell and repeat reading of deionized water. If reading is still high, notify the Chemist.
2. Use current Quality Control sample with each run. The control must be in range before proceeding with specimens. The 0.01 M KCl can be used as control.

Conductance Meter Maintenance:

1. Store cell in deionized water. If the cell has been stored dry, soak in deionized water for 24 hours.
2. Check the platinum black coating on the electrode. If the coating appears thin or if it is flaking off the electrode, the cell should be cleaned and the electrodes replatinized. See "Instruction Manual YSI Model 32 Conductance Meter" pages 11 and 12 for instructions.
3. The electrode should be cleaned and replatinized every four months. Record the preventative maintenance on the "PM Worksheet".

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Conductance Meter Calibration Check:

Instrument must be standardized with KCl solution before daily use.

1. Pour 50 ml of the standard potassium chloride solution into a 250 ml beaker. Alternately, immerse the conductivity cell and thermometer in the Rinse Bottle, then transfer to the Read Bottle for actual reading
2. Immerse conductivity cell in sample. The electrodes must be submerged and the electrode chamber must be free of trapped air. Tap the cell to remove any bubbles, and dip it two or three times to assure proper wetting.
3. Rotate the Range Switch to the lowest range position that gives a reading (within range) on the display. An over-range value is indicated by a "1" followed by blanks. An under-range value is indicated by a reading followed by a small letter "u". Readings may be in error when operating in the under range conditions. On the 0.1 – 2 micromho range; allow extra time to stabilize.
4. The conductance value of the solution is displayed on the meter. The units in which it is to be read are determined by the Range Switch, either in mU or in uU (or milli and micro siemens).

   2 uU, 20 uU, 200 uU reading = final result
   2 mU, 20 mU, 200 mU readings x 1000 = final result

5. Use the table below to check accuracy of cell constant:

Conductivity of 0.01 M KCl	
Temperature in Centigrade	Micro-omhos/cm
21	1305
22	1332
23	1359
24	1386
25	1413
26	1441
27	1468
28	1496

6. If the standard is within range, rinse the cell three times with deionized water, and start testing unknowns as described in steps 2-4.

Reporting:

Report results to three significant figures. Report in units of micromhos per centimeter at 25 ^{o}C

References:

1. Instruction Manual YSI Model 32 Conductance Meter", Item 060818, PN A32018 R, October 88 EP
2. Methods for Chemical Analysis of Water and Wastes", EPA- 600: 4-79-020, March 1983, pages 120.1-1 to 120.1-3.
3. "Standard Methods for the Examination of Water and Wastewater", 18th Edition, 1992.

Written by: David Perez, Date: February 1993
Revised: January 12, 2007

Approved by:_____
Chemist

UNDER REVISION (10/2019)

pH
SM 4500-H B
Electrometric

UNDER REVISION (10/2019)

Scope and Application
Application to drinking, surface, ground and saline waters as well as acid rain, and wastewater (domestic and industrial.

Principle of Operation
pH is defined as the negative logarithm of the hydrogen ion concentration in moles per liter. The pH scale goes from zero to fourteen with a value of seven units to be considered neutral. Values below seven are acid; values above seven are basic. It is important to note that a one-unit change in pH represents a ten-fold change in the concentration of the hydrogen ion.

pH has a great impact on almost all biological and chemical processes used for water and wastewater treatment, and proper measurement of this value is critical. pH is measured using a pH meter consisting of a potentiometer, glass pH electrode, reference electrode and temperature compensating device. When calibrating the instrument, use two buffers that bracket the expected pH value for greatest accuracy.

Specimen collection and Handling
Collect sample in plastic or glass container. Test sample immediately upon receiving and/or within two hours after collection.

Instrument Calibration:
Two buffer calibration:

1. Fill a 50 ml beaker with up to 30 ml of pH 7 buffer. Add a stir bar and set the knob on the magnetic stirrer to the second line on the dial (slow spin). Place the electrode in the pH 7 buffer; make sure that the reference electrode is filled with KCl and is open. Allow the electrode to equilibrate for 5 minutes.

2. Release Standby button and press the pH button. Measure the temperature of the buffer solution and set the temperature control. Turn the large slope knob to 100 and the inner know fully clockwise.

3. Adjust the calibration control until the readout displays 7.00. Press the mv button and record the mv reading on the worksheet. Remove electrodes from the buffer and rinse with deionized water.

4. Fill a 50 ml beaker with up to 30 ml of pH 4 buffer. Add a stir bar and set the knob n the magnetic stirrer to the second line on the dial (slow spin). Place the electrode in the pH 4 buffer and allow the electrode to equilibrate for 5 minutes. Press the pH button.

5. Adjust the slope knob until the readout displays 4.00. Press the mv button and record the mv reading on the worksheet. Remove electrodes from the buffer and rinse with deionized water.

6. Fill a 50 ml beaker with up to 30 ml of pH 6.86 buffer. Add a stir bar and set the knob n the magnetic stirrer to the second line on the dial (slow spin). Place the electrode in the pH 6.86 buffer and allow the electrode to equilibrate for 5 minutes. Press the pH button and record the result on the worksheet and quality control graph. PH should be 6.86 ± 0.1; notify chemist if out of range.

7. Rinse the electrodes with deionized water.

8. Record mv readings of calibration buffers. Calculate change in millivolts and divide by 3. The result should be 58 ± 2 mv.

9. If the slope is within limits, begin testing unknowns. If the slope is out of range, re-calibrate the pH meter. If the second calibration slope is out of range, notify the chemist.

Controls

1. Run every tenth specimen in duplicate. The duplicates should be within 20% of each other.

2. Check the 6.86 control buffer after every tenth specimen. Record the results on the worksheet and quality control chart.

Procedure

Once the pH meter has been calibrated, the unknown samples can be tested.

1. Pour 30 ml of unknown (or 50 ml of unknown if also testing for alkalinity) into a 150 ml beaker containing a small stir bar. Start the stirrer. Keep the automatic stirrer at a constant moderate rate (The speed is marked on the dial by a pen marking).
2. Allow the display to stabilize, and record the results on the worksheet.
3. Rinse the electrode with deionized water between specimens. Blot dry with a 'kimwipe'. Do not rub the electrode; the static electricity can alter readings.

Reporting

Report the result to the nearest tenth (0.1).

References:

1. "Method for Chemical analysis of Water and Wastes", EPA 600/4-79-020, Revised March 1983.
2. Standard Methods for the Examination of Water and Wastewater 18th edition 1992

UNDER REVISION
(10/2019)

Written by: David Perez
Date: December 1994

Approved by: _____
Chemist

Total Alkalinity
SM 2320 B
Titration

Principle
Total alkalinity is defined as the acid-neutralizing capability of water. It is reported as due to bicarbonate (HCO3), carbonate (CO3), and hydroxide (OH). Unaltered sample is titrated potentiometrically to pH 8.3 endpoint for "carbonate" alkalinity and 4.5 endpoint for "bicarbonate" alkalinity.
Note: Samples with a pH less than 8.3 (i.e. most drinking water samples) are reported as having non-detectable hydroxide and carbonate alkalinity; for these samples total alkalinity is due entirely to the bicarbonate content of the water. Bicarbonate alkalinity (as HCO3) can be calculated from total alkalinity (as CaCO3) by multiplying by a factor of 1.22.
Applicable to drinking and surface waters, domestic and industrial wastes, and saline waters.

Sample Criteria & Acceptability
Samples should be submitted in clean containers provided by the laboratory. A minimum of 100ml of sample should be submitted for testing. Samples, which cannot be tested within 24 hours of collection, should be stored at 4°C and tested within 14 days. If any sample does not meet the above criteria, document it on the worksheet but perform the test.

Equipment
1. pH meter that can read to 0.05 pH units.
2. Two 1,000 ml Class A volumetric flasks.
3. Magnetic stirrer and magnetic stir bars.
4. Two 100 mL beakers.
5. One 250 mL flask
6. One 50 mL graduated cylinder

Reagents
The day before preparing standardize sulfuric acid, dry 0.1 g of Tris Buffer for at least 3 hours at 103 C (overnight is acceptable). After drying, immediately weigh out the Tris buffer. If that is not possible, store the reagent in the desiccators until used.
1. Standardized 0.02 N H_2SO_4 (sulfuric acid) + 0.004 units:

   The concentrated H_2SO_4 and stock 1.0 N H2SO4 may be found in acid cabinet below hood.
   a. Prepare a 1.0 N H H_2SO_4 Stock Solution: Fill a 1,000 ml Class A volumetric flask three quarters full with deionized water. Carefully add 28.0 mL of concentrated H_2SO_4 using a 25 mL and 3 mL Class A volumetric pipette. Fill to the mark with deionized water and mix. Transfer to plastic bottle and label as 1.0 N H_2SO_4 Stock Solution, date made, outdate of 1 year, and initial. Cap tightly.

   b. Prepare a standardized 0.02 N H_2SO_4.
      1. Fill a 1,000 mL Class A volumetric flask three quarters full with deionized water. Carefully add 20.0 mL of the Stock H_2SO_4 using a 20 mL Class A pipette. Fill to mark and mix thoroughly.
      2. Weigh out between 0.0700 to 0.0800 g of Tris buffer using the analytical balance. Record the weight of the Tris Buffer to four places in the "Standard & Reagent Preparation" notebook. Add the buffer to 250 mL flask containing 25 mL of deionized water and stir bar; mix.

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3. Add 3 drops of Hach Brom Cresol Green-Methyl Red indicator solution (Hach cat. number 451) to the Tris buffer solution.
4. Fill the titrating buret with the 0.02 N H_2SO_4 solution. Titrate the solution until a stable pink color is reached. Record the volume of reagent used.
5. Calculations:
   Normality of H_2SO_4 = Wt of Tris Buffer (g) ÷ (0.121137 g/meq Tris X mL of 0.02 N H_2SO_4 used)
   Example:
   0.0879 g Tris Buffer ÷ (0.121137 g/meq Tris X 35.7 ml H_2SO_4) = 0.0203 N H H_2SO_4
6. Transfer the 0.02 N H_2SO_4 to a one liter plastic bottle. Record the normality on the bottle, date made, outdate of 3 months, and initial. Store at room temperature.

2. Alternatively, order 0.02 N H_2SO_4, already prepared and standardized from a vendor such as Fisher Scientific. Record lot on QC worksheet.

Controls

1. Run deionized water as blank. Value of blank should be less than 2 mg/L of calcium carbonate (approximately 0.1 mL of H_2SO_4).

2. Use one quality control standard. This is a solution of sodium bicarbonate (100 mg/l). Run once with each set of samples and record results on control chart. Consult chemist if out of control situation exists.

3. Run every 10th specimen in duplicate. Calculate the relative standard deviation (RSD) of the replicates using the following formula: RSD=SD ÷ mean x 100. The RSD should be less than 10% If the replicates are outside of this range, repeat the specimen a third time. Check with the chemist for instructions.

4. Each quarter an external reference sample is to be analyzed. In the case of results exceeding acceptance values, document corrective action. Place any corrective action records in proficiency file

Procedure:

If applicable, standardize the pH meter each day of use (see supplemental procedure). Record slope with offset on worksheet.

Run the blank and control first. If the control is within range (range found in the "QC Inorganic True Value" binder), run the samples. Repeat the control if it is out of range. Notify the chemist if the control is out of range a second time.

1. Add 50 mL of control or sample to a 100 ml beaker containing a magnetic stir bar. Set magnetic stirrer at low speed.

2. Carefully lower pH probe into the solution. **If the pH is above 8.3 consult principal analyst!**

3. Fill the titrating buret to the zero mark with the standardized H2SO4. Carefully add the H2SO4 to the sample until a pH of 4.5 ± 0.05 is reached.

4. Record the volume of H_2SO_4 added to the sample, to the nearest tenth, on the chemistry worksheet.

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5. Rinse the pH electrode with deionized water. Measure out the next sample, refill the buret, and titrate the next specimen.

Calculations:

Use the following formula to calculate the alkalinity as mg/L of calcium carbonate.

Exception: For alkalinity below 20 mg/L use low alkalinity calculation procedure (refer to SM2320B part 5)

mg/L = (mL of H_2SO_4 – 0.1) X normality of H_2SO_4 X (50,000 ÷ ml of sample)

Example (for 50 ml sample):

(28.6 mL – 0.1) X 0.02 X (50,000÷50ml) = 570 mg/L of Calcium Carbonate

or

(28.6 ml – 0.1 ml) X (20) = 570 mg/L of Calcium Carbonate

Reporting

Report in **whole** numbers; round off to 3 significant figures. Examples:
2,902.5 = 2,900; 1,125.9 = 1,130; 23.65 = 24

References

Standard Methods for the Examination of Water and Wastewater 18th edition 1992

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Written by: David Perez
Date: January 1993
Revised by: G. R. Guibert
Date: August, 1998

Approved by: _____
Principal Analyst

Varian Flame AA Procedure
SM 3111B
For Ca, Mg, Na, K and Fe

Principle:
In flame atomic absorption spectrometry, a sample is aspirated into a flame and atomized. A light beam is directed through the flame, into a monochrometer and into a detector that measures the amount of light absorbed. Because each metal has its own characteristic absorption wavelength, a source lamp composed of that element is used. The amount of energy absorbed in the flame is proportional to the concentration of the element in the sample.

Sample Collection/Handling:
Use metal free collection bottle to collect sample. Collect one liter of sample. Smaller volumes (not less than 200 ml) can be used if necessary. On collection, acidify samples to pH <2 with 1:1 nitric acid, usually 3ml per liter. If samples are not acidified at time of collection, add acid upon receipt in lab and hold for minimum of 16 hours before analysis.[40 CFR 141.23(K)].

Sample Preparation:
Samples containing particulate or organic material require pretreatment before analysis. Samples with a turbidity <1 NTU, no odor and single phase may be analyzed directly. Digest all other samples before determining total metals.

Digestion Procedure for total metals:
Drinking water samples with turbidity >1 NTU can be analyzed following digestion with nitric acid. See procedure SM 3030E (Nitric Acid Digestion). Wastewater samples are better digested using method SM 3030F part b (Nitric Acid-Hydrochloric Acid Digestion). Report as total recoverable metal.

Sample criteria:
Except as noted, specimens that do not meet the criteria below should be immediately reported as "no test" with an explanatory note:

1. Samples submitted in improper collection container.
2. Sample inadequately identified. (Sample has no identification, or cannot be matched to a laboratory request form).
3. Sample quantity insufficient
4. Sample container broken or leaked in transit.

Special Instructions:
All glassware and pipettes used in this procedure must be cleaned using glassware-cleaning procedure. See document in kitchen.

Reagents:

1. Nitric Acid (HNO3). Use high purity nitric acid 1+1.
2. Lanthanum solution (1.11%): Dissolve 58.65 g lanthanum oxide in 250 ml of conc HCL. Add slowly with stirring until dissolved and dilute to about 900 ml. Allow to cool for a few hours then dilute to final 1000 ml volume. Used for Ca, Mg, Na, and K analysis.
3. Calcium solution: Dissolve 630 mg calcium carbonate, CACO3, in 50 ml of 1+5 HCL. If necessary, boil gently to obtain complete solution. Cool and dilute to 1000 mL with water. Used for Fe analysis.
4. Standard Metal solutions: Standard metal solutions are prepared from 1000 mg/l AA or ICP-MS standards purchased from Ricca Chemical company, Spex Certiprep, LabChem, Fisher Scientific or VWR. A standard from EM scientific (ICP Multi-element Standard) is very convenient for calibration standards.
5. Deionized Water from Millipore system – metal free water.

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Instrument Set-up:
Use the Varian Spectra 300AA operating in the flame mode with Air Acetylene burner.

1. Turn on exhaust hood. Switch is located in the corner by the Chemistry room refrigerator. Note: Turn switch until it clicks on. If you continue turning the switch after it clicks, the airflow will be reduced.

2. Turn on "Acetylene" gas cylinder located outside in the "Safety Storage" shed. The correct door housing the tank is labeled "Acetylene". Pressure should be set at 8-9 PSI.
   Note: The cylinder valve is opened by turning the handle only 1/4 turn counterclockwise. Replace cylinder when pressure in tank drops below 100 psi. This prevents acetone from entering instrument.

3. Check the Varian Spectra AA 300A unit to see if the burner is installed.

4. Check to see if the cathode lamp required is in the correct socket position, and it is lined up in the "Operating Lamp"
   Note: Lamps are stored in the top drawer located directly across from the GTA 96 Graphite Tube Atomizer (next to hood).

5. Turn on the equipment in the following order (allow a 20 minute warm-up period):
   Note: If the computer is already on, turn it off.
   a. Spectra AA 300A: switch located on lower right front of instrument.
   b. IBM PC and Printer: Turn surge suppressor on (power supply); hit reset button.

Once the unit has been set-up, program the machine for testing by:

1. Start at the "C:" prompt. Press "M" and "Enter".

2. Press "Spectra Flame"

3. Press "Index" (F10). Enter number 10, "Sequence Selection", press "Enter" key.

4. Select element to be tested

5. Press "Sequence Control" (F6). Enter number of samples to be tested.

6. Press "Index" (F10), enter number 6, "Optimization", press "Enter" key.

7. The Screen will display two signal bar graphs. Check the previous week worksheet for the "Photomultiplier voltage" reading.

8. Maximize the lamp signal of the Cathode tube using the two thumbscrews located on the back of the lamp socket (see figure 5.8).
   a. Watch the bar graph as you turn one thumbscrew. Once the value reaches .9 or greater press "Rescale" (F1).
   b. Check the Photomutiplier Voltage display on the screen, after rescaling. If the voltage is higher than the preceding week, continue adjusting and rescaling until the proper voltage is reached. If you are unable to reach the proper voltage, try adjusting the second screw.
   c. Note: Normally the voltage stays the same from week to week, but as the lamp nears the end of its usefulness, the voltage reading will go up. If a new lamp is installed, the starting voltage may be different than the previous lamp. Record millivolt reading on worksheet.

9. After adjusting for maximum signal, hit "Rescale" (F1). The photomultiplier voltage will be displayed. If the reading matches the previous week, record the voltage on the new worksheet. If it is out of range, readjust lamps. If voltage is still out of range, notify Chemist.

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10. Press "Index" (F10) key and select "Standards" (number 7). Verify that the values of the standards are correct (see previous worksheet for standard values). To select a value to change, use the up and down arrows. Enter the correct value with the keyboard.

11. Check to see that drain hose, located below the Spectra 300A, is inserted into the drain bottle. (empty after each use).

12. Press "Index" key, enter number 18 (Signal Graphics), and press "Enter".

13. Press "Shift" and "Instrument Zero" (F10).

14. Light burner by pressing ignite button. Aspirate DI water for about 10 minutes. This will allow burner temperature to stabilize.

Standard and Sample Preparation:
Required sample preparation depends on the metal form being measured.

Procedure for Ca, Mg, Na, and K
1. Label the 10 ml beakers with the standard value; label the sample beakers with the last three numbers of the tiny tab number. Using the adjustable pipette, pipette 1.0 ml of sample or standard into each disposable beakers.

2. Add 9.0 ml of 1.11% lanthanum to each sample or standard using the adjustable pipette.

3. Repeat the process once again by diluting 1 ml of the diluted sample to 10 ml with the 1.11% Lanthanum. The samples have now been diluted 1:10 and 1:100. Alternatively use proportionally smaller volumes (i.e. .5 ml sample and 4.5 ml of 1.11% lanthanum).

4. The standards are prepared from stock solutions that when diluted 1:10 will give the necessary concentrations for calibration. The stock solutions are prepared from 1000 ppm standard metal solutions purchased from Ricca Chemical Co. Record dates of preparation and expiration (3 months) in sample prep manual.

5. The final concentration of calibration standards will be,

    1. Ca: 1.00, 3.00, 5.00 and 10.00 mg/l
    2. Mg 0.10, 0.50, 1.00 and 1.50 mg/l
    3. Na 0.10, 0.50, 1.00, 1.50 and 2.50 mg/l
    4. K 0.10, 0.50, 1.00, 1.50 and 2.50 mg/l

6. Set report format: Go back to index by pressing the "Index" (F10) key, then select the "Report Format" (number 13). Here you can enter the name of the operator, batch name, and date. No other changes are usually necessary.

7. Start program: Press the "Start" (F11). The screen will show the message "Select Lamp 3"; press "Start" (F11). The program will now run to completion.

8. Calibration of other Metals besides Fe/Mn: The other metals tested by flame AA does not require an ionization suppressor and can be directly aspirated. See specific method on computer for required calibration standards.

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Standard and Sample Preparation: Procedure for Fe:

1. Label the sample beakers with the last three numbers of the tiny tab number. Using the adjustable pipette, pipette 1.0 ml of Ca solution into each disposable beakers.

2. Add 4.0 ml of sample to each beaker using the adjustable pipette.

3. The standards are prepared from 1000 ppm standard metal solutions purchased from LabChem or Spex Certiprep. Add 20 ml Ca solution and 1 ml conc HNO3 to each 100 ml of standard prepared. Record dates of preparation and expiration (3 months) in sample prep manual.

4. The final concentration of Fe calibration standards will be: 0.3, 0.5, 1.0, and 3.00 mg/l

5. Set report format: Go back to index by pressing the "Index" (F10) key, then select the "Report Format" (number 13). Here you can enter the name of the operator, batch name, and date. No other changes are usually necessary.

6. Start program: Press the "Start" (F11). The screen will show the message "Select Lamp 3"; press "Start" (F11). The program will now run to completion.

Quality Control:

1. Analyze a Blank after every 10 samples to verify baseline stability. Rezero when necessary.
2. Duplicate Spikes - replicate spikes are to be performed on 10% of samples. Recovery of spike in drinking water should be between 80% and 120% with a precision of 20%. Recovery of spike in wastewater should be between 75-125% with a precision of 25%. Spike level should not exceed MCL for analyte. Spiking solutions are available from Cresent Chemical Co.or SPEX.
3. External Reference Sample - Analyze a known reference sample after initial calibration and after every ten samples to confirm the test is in control.
4. See Table 3111:III in Standard Methods for recommended concentrations of standards to be run, limits of acceptability, and reported single operator precision data.
5. Analyze External Reference Sample on quarterly basis. Solutions available from APG, ERA or SPEX.

CRITERIA FOR ACCEPTABILITY OF RUN

1. Recoveries of spikes and controls are within acceptable range.
2. Blank values below detection levels.
3. Acceptable levels of precision.

NOTE: If any of the acceptance criteria are not met, the analyst must stop the run, correct the problem and and retest the samples.

OUT OF CONTROL PLAN

No sample should be reported until the all acceptance criteria have met. Or the out-of-control condition has been corrected and any problems or departure from protocol identified.

Trouble Shooting:

1. PROBLEM - poor precision,
   Check alignment of hollow cathode lamp. Check that capillary hose is not clogged. Make sure burner is clean and flame appears smooth and even. Replace pinched or crimped capillary tubing.

2. PROBLEM - error message
   Refer to instrument service manual

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3. PROBLEM - Contamination

Check supplies associated with sample collection for contamination. Check rinse water, sample diluent, pipettes, sample cups. Make sure work area is free from dust.

Shutdown Procedure:

Turn off acetylene, IBM PC,and AA300, and exhaust hood, in that order.

Calculations:

The results will be printed and should be recorded on a worksheet. The dilution factor must be shown and considered in the calculations.

Reporting:

1. The data from the printout should be transferred to the worksheet. Verify that controls were within acceptable range and that duplicates are within range.

2. The lab clerk enters the results into the computer. Results are reported in units and number of significant figures consistent with MDL of method.

References:

1. "Analytical Methods for Flame Atomic Absorption Spectrometry" Varian Techtron Pty, Limited, 1989.

2."Standard Methods for the Examination of Water and Wastewater"
18th Edition 1992 by APHA, AWWA, and the WEF.

UNDER REVISION
(10/2019)

Written by: David Holland
Date: January 1999

Approved by:_____
Laboratory Director

DETERMINATION OF INORGANIC ANIONS
BY ION CHROMATOGRAPHY (EPA METHOD 300.0)
USING THE DIONEX DX-80 ION ANALYZER

UNDER REVISION
(10/2019)

PRINCIPLE

This method determines the following inorganic anions: fluoride, chloride, nitrite, bromide, nitrate, phosphate and sulfate.

A small volume of sample (approx. 1 ml) is loaded into the ion chromatograph. The injection valve injects 10 ul of the sample into the flow of eluent. The eluent (a NaHCO3 - Na2CO3 solution) flows continuously through the IC and serves as a carrier for the 10 ul of sample and facilitates in the separation process.

The anions of interest are separated using suppressed conductivity detection, and are identified and quantified by comparing data to those obtain from a standard solution. The major parts of the system are the liquid eluent, high pressure pump, sample injector, guard column, the separator column, the chemical suppressor and the conductivity detector. The guard column protects the separator column, which separates the anions based on their size and charge. The function of the suppressor is to chemically reduce the background conductivity of the electrolytes in the eluent, and to convert the sample anions into a more conductive form. The detector then detects the conductivity of the solution, which varies depending on the concentrations of the anions (higher conductivity indicates a greater concentration of the anion).

SAMPLE CRITERIA

The holding times for drinking water samples are as follows:

Fl^-	28 days
Cl^-	28 days
NO_2^-	48 hours
NO_3^-	48 hours
SO_4^-	28 days
Br^-	28 days

Samples submitted for IC testing routinely should be run within 48 hours of collection, especially for nitrite and nitrate. If testing needs to be delayed, the sample can be preserved with sulfuric acid; preserved samples can be held for up to 28 days and the nitrate results reported as combined Nitrate/Nitrite. Any samples not tested within specified holding times should be identified on the worksheet.

Samples bottles dedicated for IC testing only are placed on the IC bench. As soon as a sample is setup, place it on the white tray for easier storage. After 6 weeks the containers should be emptied and discarded. Nondedicated samples (i.e. those also submitted for additional testing) should be returned to the designated cart after IC testing.

QUALITY ASSURANCE

Operator competency - Ion chromatography may be performed only by analysts who have been trained and who have demonstrated competency with the procedure. One check consists of preparing the calibration standards and calibrating the I.C. An r-value of 0.995 or higher (correlation coefficient of 99.95%) in the linear fit type must be attained for each analyte of interest. Another way to demonstrate competence is to run a minimum of four replicate analyses of an independently prepared sample. Each analyte of interest in the sample should have a known concentration between 5 and 50 times the MDL.

Blank - A blank consisting of nanopure water should be included at the beginning of each run. The results for the blank must be below the MDL for each analyte.

Control standard(s) - Controls representing two concentration levels for each analyte (ICMIX HIGH & ICMIX LOW) must be analyzed as described below. The source of the analytes used to prepare these controls must be different from the source used to prepare the calibration standards. An ICMIX HIGH stock solution of the 7 anions with the following final concentrations:

Anion	*Final Conc*	*Preparation in 500 ml volumetric flask*
Fl^-	20 ppm	10 ml of 1000 ppm Fl std
Cl^-	100 ppm	50 ml of 1000 ppm Cl std
NO2	65.5 ppm	10 ml of 1000 ppm NO2-N std
Br^-	20 ppm	10 ml of 1000 ppm Br std
NO3	100 ppm	50 ml of 1000 ppm NO3 std
PO4	100 ppm	50 ml of 1000 ppm PO4 std
SO4	100 ppm	50 ml of 1000 ppm SO4 std

should be kept on hand. Use this undiluted at the beginning of the run and after every tenth sample. Each week, prepare an ICMIX LOW solution from the ICMIX HIGH solution as follows: Using a 100 ml volumetric flask add 1 ml if ICMIX HIGH using the 1 ml volumetric pipet and fill to mark with nanopure water. Record date made in the IC logbook under Quality Control. Run the IC LOW at the beginning of the days run and after every 10^{th} sample after the IC HIGH. The percent recovery for each anion should be between 90 and 110%.

Duplicate spikes – Duplicate spikes should be run after every tenth sample. The spike should not be less than four times the MDL, and it should increase each anion concentration by more than 25% of the background value. A suitable spike can be prepared by adding one part ICMIX HIGH to three parts sample. The average percent recovery for each anion should be between 80 and 120%. The duplicate spikes should be within 10% of each other. Record average percent recovery of spikes and duplicate percent difference on worksheets. Note: if the concentration of the spike is less than 25% of the background concentration, the spike recovery should not be calculated.

If any of the above control criteria are not met, do not report sample results until the problem has been resolved.

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External controls & chart analysis - In addition to the control standards tested with each batch of samples, an external reference standard (i.e. SPEX IC standard or WS proficiency sample) should be tested on a quarterly basis; however we like to run one at the end of each run.

CALIBRATION FOR GOUNDWATER (DRINKING WATER AND MONITORING WELLS):

Calibration for groundwater samples is described below. Calibration should be performed whenever: 1) controls are out of range; 2) a new batch/lot of eluent/regenerant is made or 3) when a column, suppressor or detector is changed.

1. Prepare 1/10, 1/100, 1/1000 dilutions of the calibration standard ordered from Dionex, which contains 20 mg/l fluoride, 100mg/l chloride, 100 mg/L nitrite, 100 mg/L bromide, l00 mg/l nitrate, 200 mg/L phosphate and 100 mg/l sulfate.

2. Run calibration standards beginning with the highest dilution (1/1000) first.

3. Create calibration sequence: File – New – Sequence – Standards – Next. Skip section on Choosing Timebase – name the sequence *calibMMDDYEAR* and initials – Next – Done.

4. Add sequence to batch file before starting

5. After all four calibration standards have been ran, check the calibration curve.

   a) Double click on any of the calibration standards (Cal Std 1). You will get a chromatograph

   b) Click on Calibration Plot icon, upper right corner or click on VIEW – Calibration Plot. You will see a graph of the first analyte along with the correlation coefficient percentage for each analyte. Only anaytes with percentage of 99.5 or greater are acceptable. Generally try for a 99.98% for an average of all seven analytes to pass quality control checks. Scc the principle analyst if the result is a lesser value.

   c) The mean retention times and detection range are automatic on the DX-80 Ion Analyzer and can not be changed or edited.

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PREPARE MDL STUDY

The Method Detection Limit is the lowest concentration of a substance that can be identified with accuracy and confidence by a certain method or analysis.

1) Prepare a Cal Std 1 level each analyte separately using the secondary standards (not Dionex mix)
2) Make seven replicates of this dilution and run through the Ion Analyzer under the Unknown Method.
3) Collect data and calculate the standard deviation for the seven replicates. Multiply the standard deviation values by 3.143. This number will be the Method Detection Limit.

GENERATE BACKLOG REPORT:

1) On a network computer – not the Instrument computer. Double click on LABWORKS icon. Enter password. Click on OK. Click on backlog. Click on analysis code. Click on OK. Type in #ICANION. Click on OK. Click on display report. Click on print. Click on exit until you are out.

2) Check the clipboard to see if a worksheet has been initiated listing samples that need repeat testing; if so, append worksheet with samples on backlog report.
   a) Account for all specimens on backlog report
      i) Samples may have been tested in a previous run but not recorded. Record these results and give to the clerk.
      ii) If a sample appears on the backlog but needs to be tested by a different method (i.e. wastewater), inform the clerk so that the analysis ordered can be modified.
   b) Include any "new" samples on the I.C. bench that have not yet been entered into the computer.

SAMPLE PREPARATION

Groundwater (drinking water and monitoring wells) should be filtered through 0.45 um membrane filters before injection:

1) Rinse the syringe once with the sample water. Then fill syringe with about 10 ml of sample water.
2) Filter a minimum of 2 ml of sample through the 0.45 membrane into a labeled autosampler vial discarding the first few drops.
3) Place autosampler cap on vial and press down using the provided tool. Make sure the cap goes in straight and remove any air bubbles seen in the vial (invert or knock gently).
4) Place sample in autosampler rack. The order in the rack must match that on the schedule. Note: If you suspect the result of a sample to be above that of the calibration standard for an analyte, make an appropriate dilution. Check by measuring conductivity – anything greater than 700 uS will need to be diluted.
5) Include duplicate spikes for every 10th sample. Add 1 part ICMIX high to 3 parts filtered sample. Then IC HIGH, LRB, IC LOW. The laboratory reagent blank (LRB) is necessary to minimize carry over as the IC low is 100 times less than the High. Double check any samples where analyte concentrations are low after a high sample to verify analyte is even detected.

Samples which may contain high concentrations of chloride or organic contaminants (Carmel Area Wastewater District and ESF), are run on the DX-100 and require additional filtering through Dionex OnGuard P, Dionex OnGuard Ag, and Dionex OnGuard H filters before injection. See supplemental procedures.

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SYSTEM START-UP:

1) Ensure the **eluent** bottle is at least ¼ full. If it is less, depending on size of run, prepare new eluent (and regenerant):
   a) Prepare 2 liters of a final eluent concentration of 8.0 mM Sodium Carbonate and 1.0 mM Sodium Bicarbonate by diluting one Dionex AS 14A Eluent Concentrate bottle (P/N 057060) into two 1L-volumetric flasks. Bring each to volume (1000 ml) with nanopure water. Makes 2 liters.
   b) Use the designated filter/vacuum flask, a filter funnel, a clean 0.45um membrane filter, and a large magnetic stir bar to degas the eluent. Pour the eluent into the filter funnel and turn on the vacuum. Set the magnetic sticker at medium to high speed. Once all the eluent has been filtered, keep the vacuum and magnetic stirrer on for 15-20 minutes, allowing the eluent to degas.
   c) Turn off the magnetic stirrer and the vacuum. Remove the filter funnel. Carefully decant the degassed eluent into the eluent bottle, without aerating. Make sure the cap is on tightly, and the tubes are securely attached.

2) Whenever new eluent is prepared, new **regenerant** must also be made.
   a) Prepare 2 liters of a final anion regenerant concentration of 72 mN Sulfuric Acid by adding one Dionex Anion Regenerant Concentrate bottle (P/N 057559) to two liters of nanopure water.
   b) Mix in the regenerant in the designated filter flask using the stir bar and degas for 15-20 minutes.
   c) Turn off the magnetic stirrer and the vacuum. Remove the filter funnel. Carefully decant the degassed regenerant into the REGEN bottle, without aerating. Make sure the cap is on tightly, and the tubes are securely attached.

DX-80 OPERATION

1) Turn on nitrogen gas cylinder (main knob only), autosampler (rear right hand corner), ion analyzer (rear panel right hand side) and computer.

2) Double click on Peaknet to open computer program. **File – Panels\Dionex DX-80 System** for the Control Panel.

3) Under the DX-80 Status click on **CONNECT** to connect analyzer to computer

4) Turn on the pump by clicking the **ON** button on the DX-80 Control Panel. **Prime** the pump by turning the pump head waste valve knob counter clockwise and leaving it open for about 5 seconds. Close the pump valve knob by turning clockwise until secure. After changing to new eluent, it is a good idea to leave pump valve open until all air bubbles have been purged – look for the air bubbles coming out the eluent bottle until it reaches the waste line at the pump. This will allow any air bubbles to be pumped to waste instead of through the columns.
5) Allow the system to **equilibrate** for 30 minutes minimum, generally one hour if new eluent is used. Once ready, the **operating pressure** should be 2000+- 300 psi (usu 2100

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psi); and the operating **total conductivity** background should be < 30 uS (usually 25.00uS). You can offset the background and zero the reading by clicking the Autozero button on the Control Panel.

6) To begin a run, create a sequence worksheet by clicking on **File – New – Sequence**. (May have to do this twice if worksheet is not already open.)
   a. It will then prompt you to choose Standard or Unknowns. Choose **Unknowns - Next**
   b. Skip **next** screen where it prompts you to specify timebase,
   c. **Estimate** number of unknowns (you can always add or delete samples from sequence when done.
   d. Fill out file name you wish to save the file We save under ***MMDDYEAR*** and **initials**: (*05052002tl)* and press **enter**.
   e. Press **Done** when prompted to exit wizard.
   f. A worksheet will appear where sample identifications can be added after the calibration data (line #5). Follow printed worksheet – first include a *blank, ic low, ic high, lrb*, then the samples. Note for the first set, the lrb is listed as a sample. *Duplicate spikes* are required for every 10th sample or a minimum of 10% of samples. Finish off sequence with a known quality control standard, usually a proficiency standard such as *WS 60* or Ultra QC and another blank (LRB).
   g. Change *dilution factor* if sample was diluted; default is one. Save by pressing the SAVE icon (floppy disk).

7) To start the run – click on **Batch – Edit – Add** – double click on the newly created sequence, or the one you want run – then **Start** to begin.

8) Make sure autosampler vials are in order and the green light is on 'Run' not 'Hold'.

9) Record date, total conductivity and pressure in the log notebook at which the run has started.

10) During or after the run, verify that the blank and QCs (IC HIGH, IC LOW, IC CHECK) are within range. If not stop the run by clicking on **Batch – Stop - after current sample**, and notify principal analyst to investigate and solve the problem before resuming the run.

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REPORTING RESULTS

1) When run is complete the analyst performing the run is responsible for recording and reporting results. Review each chromatogram to verify that the peaks were properly identified. Retention times may shift if there was a sudden change in pressure. Changes to the peak name can be made by a right click on the peak and choosing the correct analyte then save.

2) The results are found on the worksheet next to the sample ID and can be exported to an excel file for accuracy calculation:
   a) Click on any sample cell – i.e. ic low, cell will be outlined.

b) Click on **File – Batch Report – Export** (unclick the Printout option- computer is not connected to any printer) – **Excel file format**
c) For sheets to be exported, choose only " **Summary – INJ vs. Area, Ht, Amt**." Unclick the Integration, Calibration, Peak analysis, Summary-INJ vs. Anion, and Audit Trail options as they are extra and rarely needed for our purpose.
d) Click on **Finish** then **OK** on batch menu. Status will appear and when transfer is complete, press **OK** to exit.

3) To copy exported file onto a floppy, right click on Start icon on lower left screen and choose EXPLORE for Windows Explorer. Under **C:\Chromel\Export** folders are the files just exported. Highlight the correct sequence and drag to **A:** drive to copy file. (Make sure you have a floppy disk inserted).

4) Open exported file under an EXCEL program – the instrument computer does not have one so use a network computer. You will see three types of charts: first- Sample vs. Area, second - Sample vs. Height, and third - Sample vs. Amount. Copy all of the **Sample vs. Amount** table to an old/previous excel file.

5) The Excel Results worksheet is permanently saved under **G:\Laboratory\Data\Water\IC Data\2002** under the correct month. It is also saved in Tess' computer under **C:\My Documents\IC Data** and correct year and month. Easiest way to create the worksheet is to open a previously saved file (of the same year and month) and then cut and paste the data. There are two worksheets in each file, one for the complete results, the other for the raw data (the Sample vs Amount table exported from peaknet).
a) Before any changes are made, save the file under a new name: MMDDYY and initials
b) On RAW worksheet, delete old table and replace with recently ran sequence data. Add a column between Sample ID and Fluoride Amount for the dilution factor.
c) Change Date Analyzed and Analyst if applicable. Calibrations are generally done once a month with the most recent noted under Date of Calibration – change if necessary.
d) **Copy** and paste data results from raw worksheet onto Results worksheet under correct sample name. Use the **Paste Special option – Values** - to retain similar fonts on results worksheet. **% Recoveries** will be automatically calculated as will **% Differences**, and **Averages** for the duplicate spikes but references to certain cells may need to be changed for the correct result.
e) Verify that all QC are accurate before entering into labworks.

6) For drinking water, results should be recorded as ND – Not Detected for levels below DLR (Detection Limit for Reporting) as follows:
a) Fluoride 0.1 mg/L
b) Nitrate 2.0 mg/L
c) Sulfate 0.5 mg/L
d) Bromide 0.1 mg/L
e) Chloride, Nitrite, Phosphate 1.0 mg/L

f) Any samples with readings above the calibration range (20 mg/L fluoride, 100 mg/l chloride, nitrite, bromide, nitrate, sulfate, and 200 mg/l phosphate) needs to be diluted and

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repeated in the next run. List these samples on a new worksheet with the appropriate dilution and place the worksheet on the clipboard.

7) Do not report results if control/spike values do not fall within limits (refer to section on quality control). If controls, spikes, etc. are out of range, notify the principal analyst. If controls are within limits, date and initial the worksheet and give the worksheet to the clerk for data entry. When the worksheet and backlog are returned place them in the binder.

SHUT DOWN

After the run is complete the Ion Analyzer can be shut down. The IC should be shut down on weekends if the system is not in operation on Friday night so as not to damage the suppressor unit:

1) On the Control Panel screen of Peaknet - turn **OFF** pump and **DISCONNECT** DX-80
2) Close Peaknet.
3) Turn off DX-80, autosampler and close nitrogen cylinder valve.

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PREVENTIVE MAINTENANCE:

1) Each quarter, replace the bed supports on guard column
2) Maintain the following spare parts. These items are considered consumables:
   a) Anion Refill Kit (Part No. 057069) contains 4 bottles each of AS14A eluent and anion regenerant concentrate.
   b) AS14A anion separator column, 3 mm (Part No. 056901)
   c) AS14G anion guard column (Part No. 056899)
   d) AMMS III suppressor (Part No. 056751)
   e) DS5 Detection Stabilizer (Part No. 057290T)

DOS AND DON'TS

* Try to make additions, changes, and deletions to the sequence during the middle of a run and then save immediately. If the changes are not saved immediately, the program may get confused on which sequence to use and will freeze. If this happens, wait until the current sample is completed, turn off all equipment and wait for about 15 minutes before restarting.

* Be gentle when loading samples onto the autosampler, especially the first rack. If racks are installed too roughly, conveyor belt may get stuck and samples will not be injected in the proper sequence.

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REFERENCES:

1) DX-80 Ion Chromatograph with SRS Control Operator's Manual, Dionex Corporation, 2002.
2) Methods for the Determination of Inorganic Substances in Environmental Samples, Method Number 300.0, Determination of Inorganic Anions by Ion Chromatography, John D. Pfaff, U.S. Environmental Protection Agency, 1993.
3) Standard Methods, 18th Edition, 1992. Part 4110.

Originally written by: Johanna Rosen for DX-100
Date: 12-96
Updated by: Theresa Lam for DX-80 Ion Analyzer
Date: 05-02

Approved by: _____
(Lab Director's signature)

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(10/2019)

APPENDIX 5.C – CHLORIDE DATA CONTOURING PROTOCOLS

CONTOURING PROTOCOLS

FOR CHLORIDE ISOCONTOUR MAPS

WATER RESOURCES AGENCY

MEMORANDUM

Monterey County

DATE: April 17, 2018

FROM: Sean Noble

TO: Water Quality

SUBJECT: How to Contour SWI in ArcGIS

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Background

The purpose of this memo is to describe the process of creating the initial seawater intrusion contours using ArcGIS. This is an attempt to standardize the process. Contours are based on chloride (Cl) data sampled from coastal wells in the Pressure 400-Foot and Pressure 180-Foot Aquifers. This data for comes from three primary sources. First, coastal wells are sampled twice each summer by Agency staff. Second, monitoring wells are sampled once each summer, using a portable pump. Finally, data from outside sources are pulled in to supplement the data and create better geospatial coverage. Historically contours are generated on every odd year, using even year data to fill any data gaps. Data is used to create contours that are then added to the historical seawater intrusion maps. The maps are as follows:

P180 Sea Water Intrusion Map
P400 Sea Water Intrusion Map

(In the future the deep aquifer may be added to the process)

After reviewing all the data and uploading it to the WRAIMS database, we are ready to move on to ArcGIS.

**** The 2017 year Pressure 400 will be used as an example ****

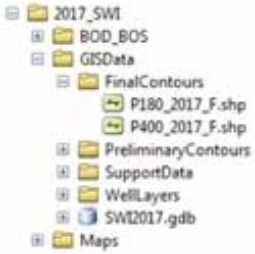
ArcCatalog

Open ArcCatalog and navigate to R:\Workspace\Common\WaterQuality\SWI. Notice that the folders are labeled by year with the exception of the CommonDirectories. This folder stores GIS data that can be used for any year that is contoured. It contains commonly used boundaries, databases, and layers.

In ArcCatalog copy/paste folder of the last year contoured (2015_SWI) and rename current year (2017_SWI).

This will be the naming convention for naming files:

Aquifer_Year _Version(if applicable), examples:



Within each year there are two main folders:

GISData

FinalContours, storage of approved shapefiles
PreliminaryContours – primary exported contour shapefiles
SupportData – secondary export shapefiles, database tables, and imagery

Maps

Stores final project maps and products

ArcMap

Step 1 – Project Formatting

Rename the ArcMap contour projects stored in the Maps folder:
R:\Workspace\Common\WaterQuality\SWI\2017_SWI\Maps**P400_2015.mxd** ->
R:\Workspace\Common\WaterQuality\SWI\2017_SWI\Maps**P400_2017.mxd**
By using the previous project, all of the background shapefiles can stay and be reused for the new project.

Step 2 – Database Formatting

Navigate to:
R:\Workspace\Common\WaterQuality\SWI\CommonDirectories\Databases
And open the **SWIContours (Current).mdb** database
First, make sure that all relevant data has been reviewed and loaded to WRAIMS. Open the **_Contouring_Start_** table and edit the year to the year being contoured.

Run the macro: **SWI_ContourTables**

The macro SWI_ContourTables runs four make table queries to produce these tables:

SWI180_ALL
SWI400_ALL
SWI_180_CONTOUR_WELLS

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SWI_400_CONTOUR_WELLS

The '…_ALL' tables include all wells that are in the Monthly Water Quality program and in the appropriate aquifers. Some wells have the aquifer designation PRESSURE BOTH. These well are included in both '…_ALL' tables, but are not included in the contouring. The '…_CONTOUR_WELLS' tables are a subsection of the '…_ALL' tables and only include wells to be used in contouring for the respective aquifers.

If certain wells need to be excluded, modify the **tblExcludedWells** table. Wells are excluded based on facility code and aquifer (180 or 400), so make sure both of those fields are filled out correctly. This table is used dictate which wells are excluded and to document which wells have been excluded and why. It should be kept updated as changes to the dataset are made. After adding new wells to tblExcludedWells, rerun the macros to update the tables.

The **ExternalData** table can be used to add data that is not stored in WRAIMS but has been approved to be used for contouring. In the 2017 example, the data from the Monterey Peninsula Water Supply Project monitoring wells was added this way. Only wells with a FACILITY_CODE and in the WellsAll GIS layer can be utilized in this manner (R:\Workspace\Common\MapElements\WellsAll.lyr).

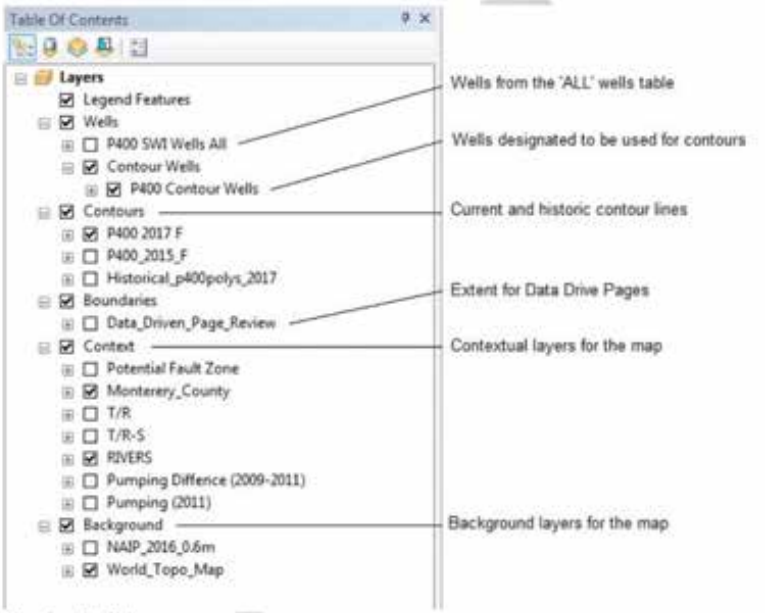
The tables include both present and past measurements and automatically include data from the previous year if the current year is missing data.

Field Name	Description
FACILITY_CODE	Facility Code of the well
FACILITY_NAME	State Well ID based on township and range
BASIN_NAME	Aquifer designation
ContourValue	Value used to contour as a year average of all samples taken during the most recent year
ContourValYr	Year that the value used to contour was sampled
ConYrCl	Contour year average of Cl data
ConYrStDev	Contour year standard deviation of Cl data
1yrBackCl	Previous year average of Cl data (2016)
1YrStDev	Previous year standard deviation of Cl data (2016)
2yrBackCl	Two years prior average of Cl data (2015)
2YrStDev	Two years prior standard deviation of Cl data (2015)
3yrBackCl	Three years prior average of Cl data (2014)
3YrStDev	Three years prior standard deviation of Cl data (2014)
PERF_START	Start of recorded perforation in well casing
PERF_END	End of recorded perforation in well casing
Use	Abbreviation of the wells primary uses
WATER_USE_DESCRIPTION	Description of the wells primary uses
FACILITY_STATUS_NAME	The status of the well

https://cloudshare.elmontgomery.com/s/Cm8HHen2GXgbY5g#pdfviewer 154/226

Step 3 – Data Labeling & Symbology

In ArcGIS:
All of the well layers in the ArcMap projects should automatically update to the 'Current' database values. The projects should be laid out in similar formats as demonstrated below. Compare the values and dates of various wells with recorded values in WRAIMS to ensure the correct data is being used.



Step 4 – Draft 1

To generate profiles run the tool
ArcToolbox -> SWIContouringTools -> SWI_Spline_Coastal_Contouring

And fill out the fields

Contour Wells:	Wells\Contour Wells\P180 Contour Wells
Z value field:	SWI_400_CONTOUR_WELLS.ContourValue
Spline type:	TENSION
Number of points:	4
Weight:	0.01

Contour Output:
R:\Workspace\Common\WaterQuality\SWI\2017_SWI\GISData\PreliminaryContours\p400_2017_v1.shp

In Layout view change any labels and titles to match the current year and draft, and make any appropriate changes to the legends.

Export to PDF, R:\Workspace\Common\WaterQuality\SWI\2017_SWI\GISData\PreliminaryContours\p400_2017_V1.pdf. From PDF, print to 11x17 and review. If all the data is there and the labels and symbology are correct then Print to Plotter, 30x30.

Steps Summary

Version 1 is the computers attempt to contour the data based on all the data that has been collected and reviewed for the appropriate aquifer. The next set of versions are created through careful examination of the data to establish what wells will be excluded from the contouring. Use past exclusion to help with wells with ambiguous aquifer designations and refer to well logs, well measurement histories, piper diagrams, and sample notes for wells that don't seem to fit the general trend. Once the list of wells to exclude is agreed upon, run the tool again. This process is iterated until **tblExcludedWells** is agreed to be final by the project supervisor. The next step is to generate the last set of computer generated lines (AT_2017_F) and edit them to match previous contours and represent the general trend of seawater intrusion.

Editing Contour Lines

The computer generated AT_2017_F needs to stay intact incase it has to be referenced at some point. The first thing to do is copy/paste AT_2017_F into the R:\Workspace\Common\WaterQuality\SWI\2017_SWI\GISData\FinalContours folder (this will be the version you edit). In ArcGIS:

Right click on the layer you wish to edit
Go to **Edit Features**
Click **Start Editing**

It sometimes makes editing easier to make the edited layer the only selectable layer.

Right click on layer
Go to **Selection**
Click on **Make This The Only Selectable Layer**

Double-click on the contour line you wish to modify. Many vertices will appear on the line as boxes. These are the points to drag in order to modify the line. When adding lines remember to edit the attribute table to add the appropriate contour value. Due to the limited data the contours will have to be heavily edited to achieve a general representation of sea water intrusion into the aquifers. As a general rule, lines will not recede approved by the project lead. Unless otherwise

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directed, lines that are seaward of past contours will default to the furthest inland historical extent (use the historical contour lines). Judgement will have to be used to decide how to alter lines to represent general seawater intrusion: work with the project lead on hand kriging and editing.

Final Clean Up

Once the list of excluded wells has been finalized copy the "Current" database and rename it with the contour year. This creates a backup and documents which wells were used and what values. Similarly, ensure that all shape files are in the correct places and properly labeled, especially the final contours.

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APPENDIX 5.D – INDUCTION LOGGING

APPENDIX D
INDUCTION LOGGING

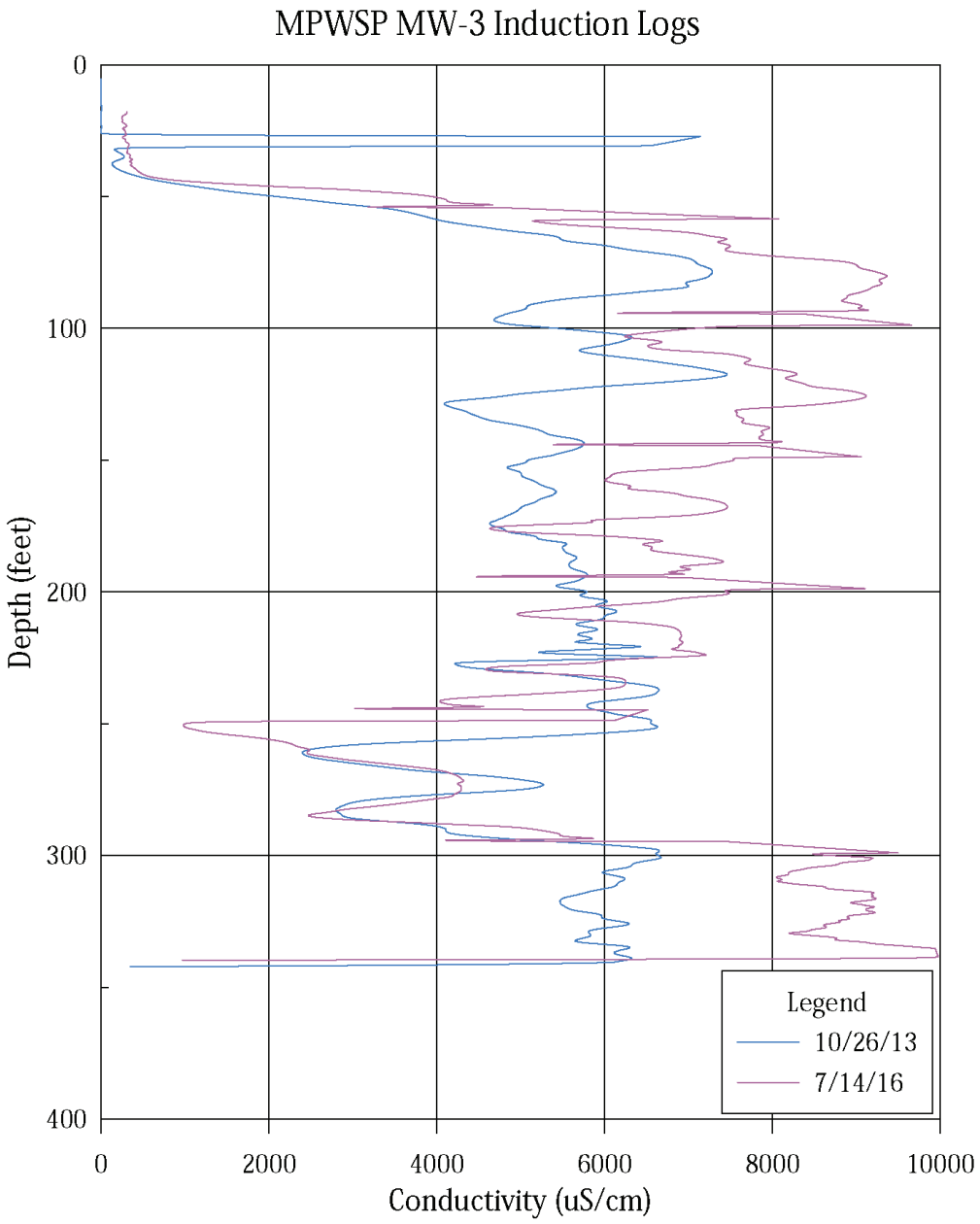
This appendix is presented to provide additional background on induction logging and its application in detecting changes in groundwater quality. The following are presented:

1. Two to three sets of induction logs were performed on some the MPWSP monitoring wells. These are presented with explanations of the measured changes visible in the results.

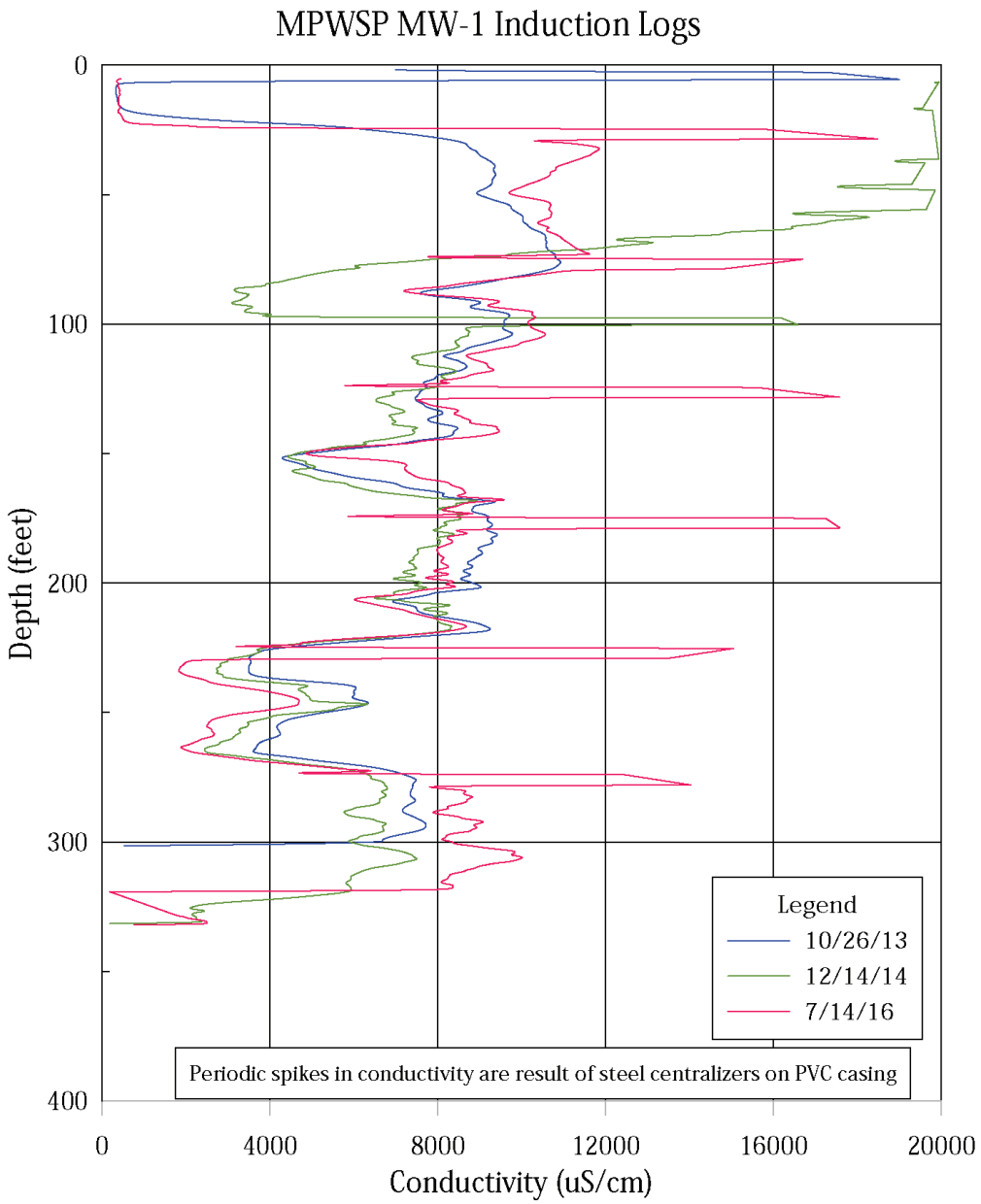
2. The cumulative results of the on-going induction logging program of the Seaside Basin Watermaster's four Sentinel Wells located in coastal Fort Ord. This program court-ordered involves semi-annual induction logging for purposes of detecting seawater intrusion. The Sentinel Wells are approximately 1,500 feet deep and the logging program is designed to detect changes in water quality throughout the entire thickness of sediments. To date, intrusion has only been detected in the shallow-most sediments which have been documented as intruded for decades.

3. Excerpts from the USGS Water Supply Paper (*Keys, W.S., 1990, Borehole geophysics applied to ground-water investigations: U.S. Geological Survey Techniques of Water-Resources Investigation)* explaining induction logging.

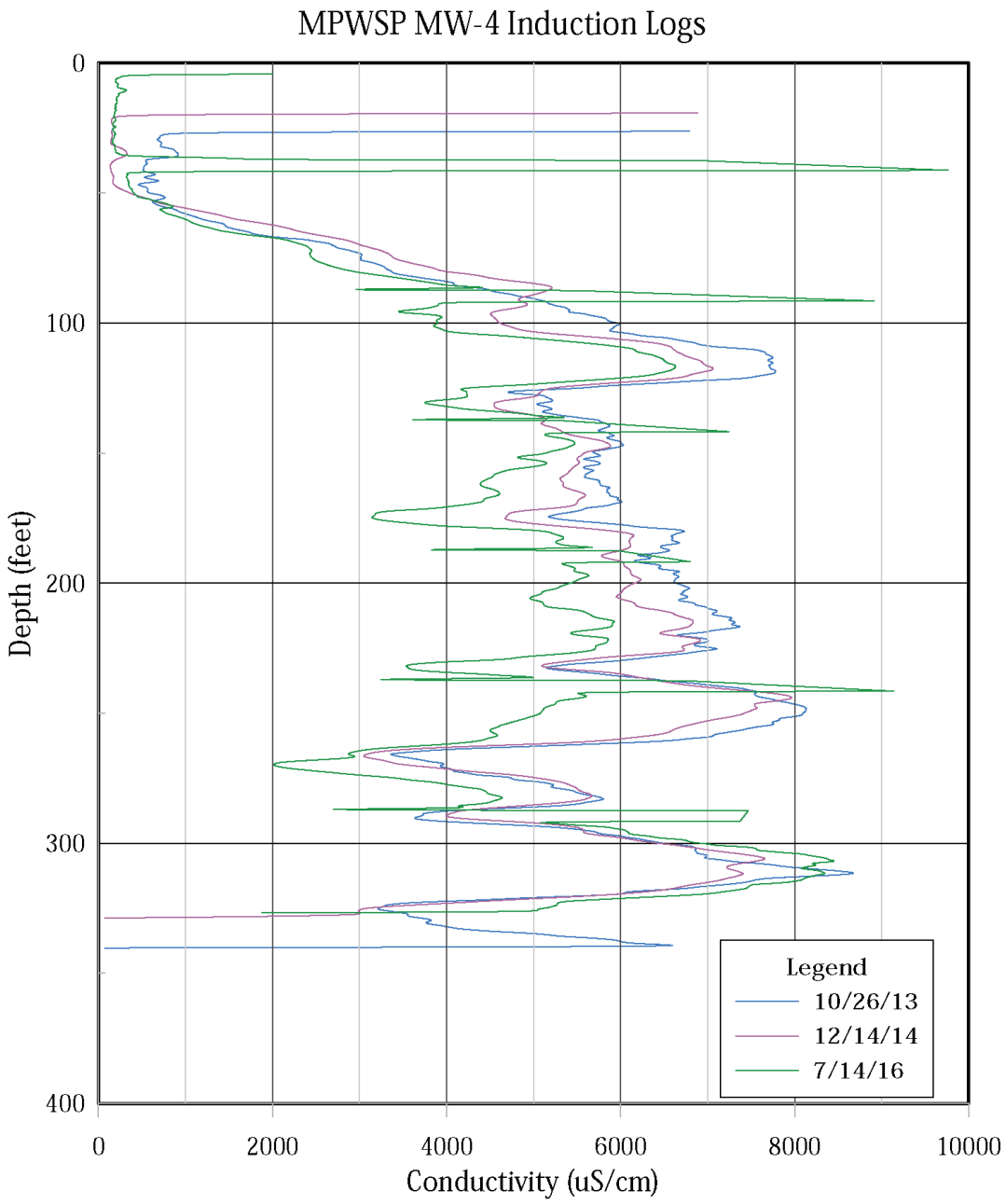
4. A recent paper from Ground Water Magazine detailing the use of induction logging in the Stockton Area. *Electromagnetic-Induction Logging to Monitor Changing Chloride Concentrations, Loren Metzer and John Izbicki, Ground Water Volume 51, Issue 1, p. 108-121*



Explanation: In general, groundwater conductivity increased throughout the entire depth of the well in the period between logging. In the upper portions above 290 feet, the increase is interpreted to be induced flow of seawater as it circles around in the capture zone of the well. Below 290 feet, the increase is due to continued seawater intrusion in the 400-foot aquifer.

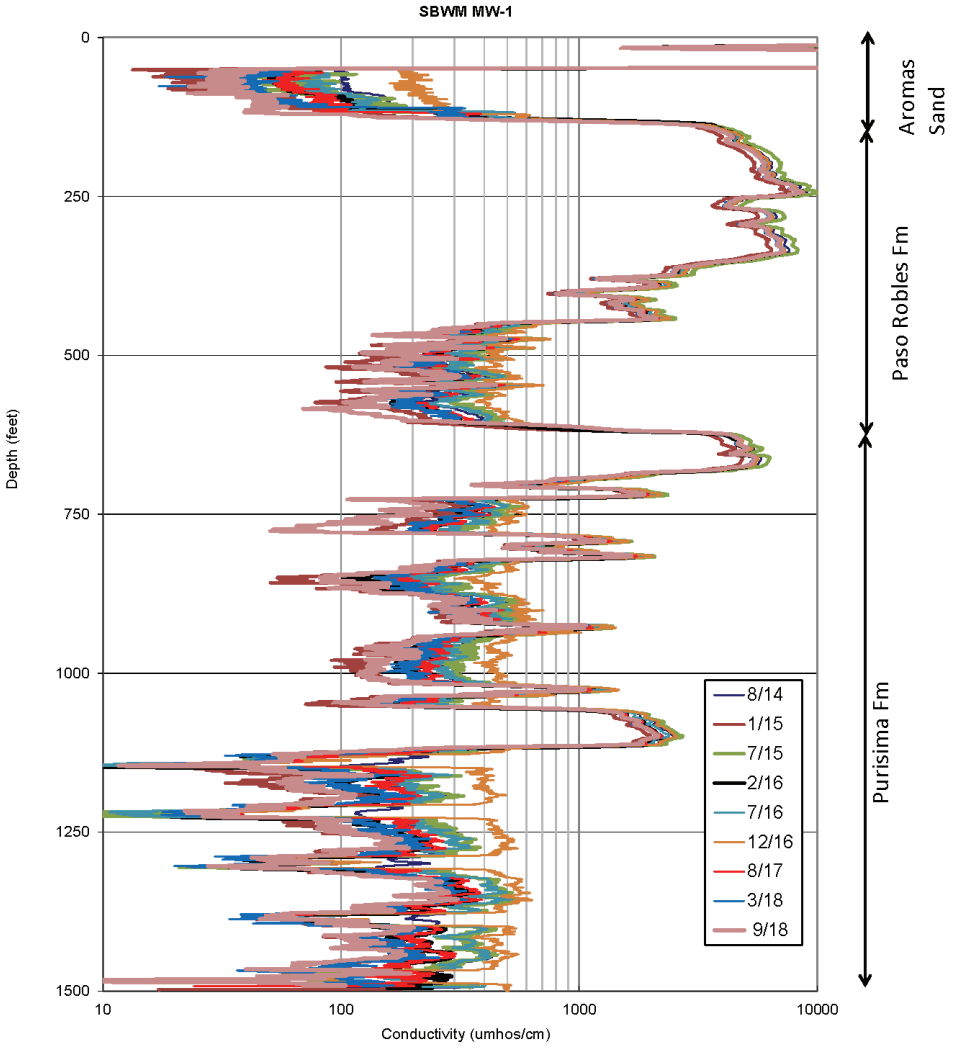


Explanation: Most obvious is the large increase in conductivity of the 12/14/14 log above 100 feet. This is interpreted as the result of very high surf which resulted in localized recharge of ocean water to the shallow zone near this well. Below this depth, and above 270 feet, groundwater condutivities are relatively unchanged. Below 270 feet, evidence of increasing intrusion of the 400-foot aquifer is apparent in the increasing conductivity.

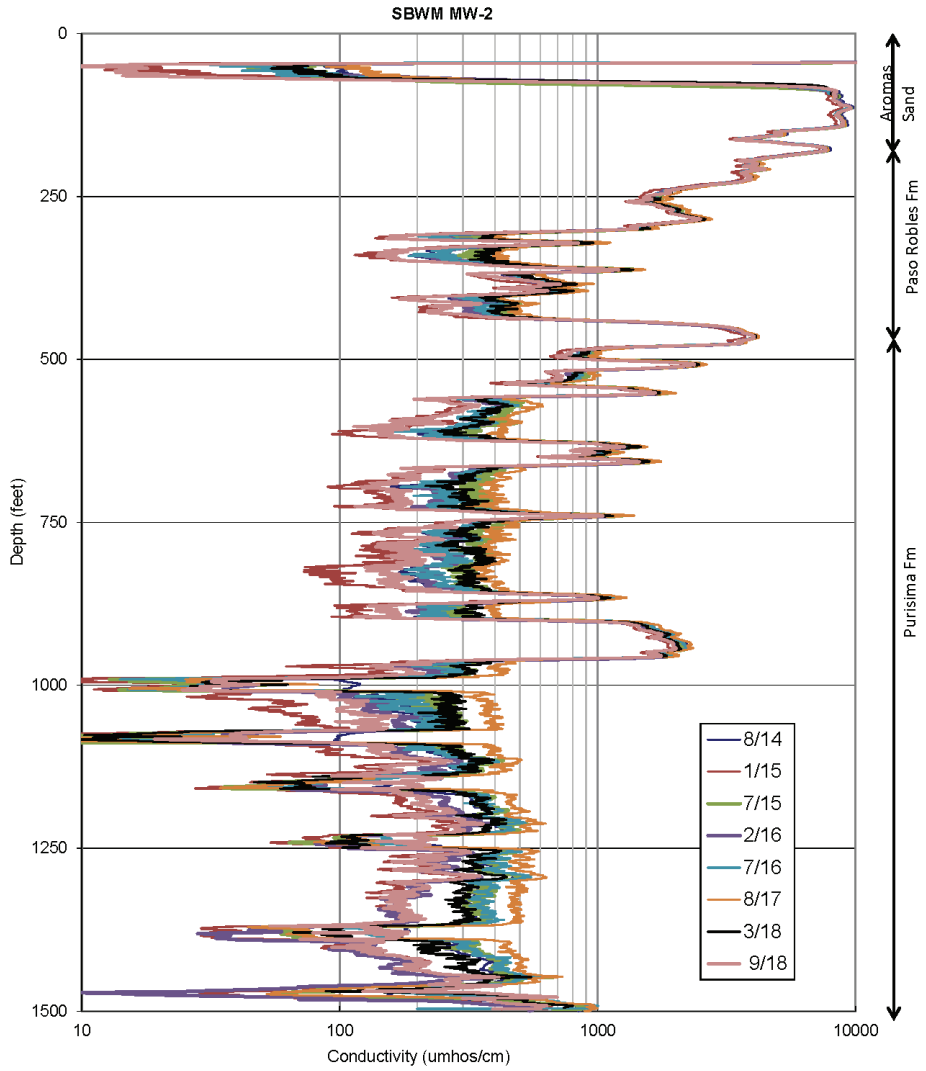


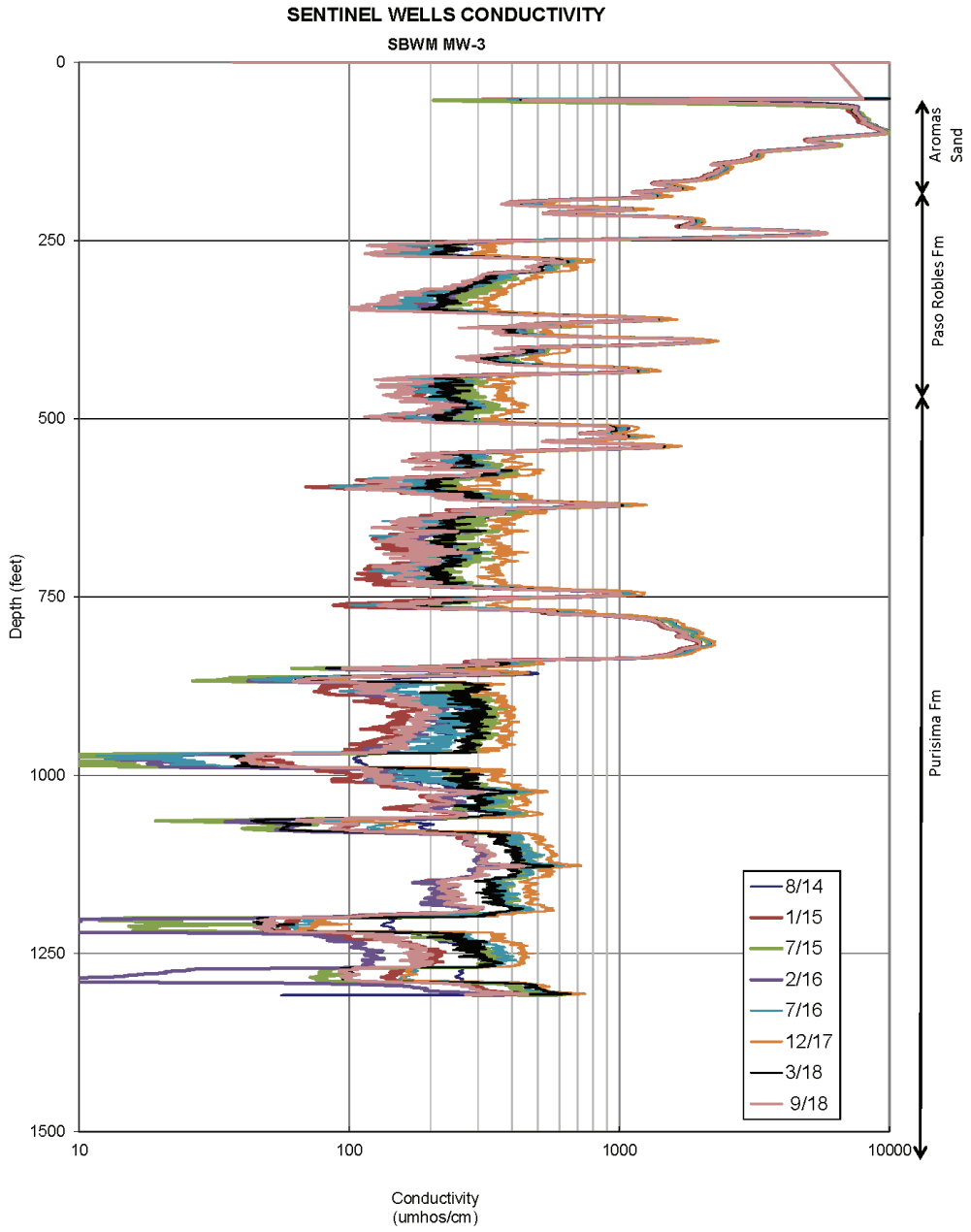
Explanation: In general, groundwater quality is relatively unchanged throughout the thickness of the aquifer system. If, anything the most recent log reveals groundwater quality to be slightly fresher.

SENTINEL WELLS CONDUCTIVITY

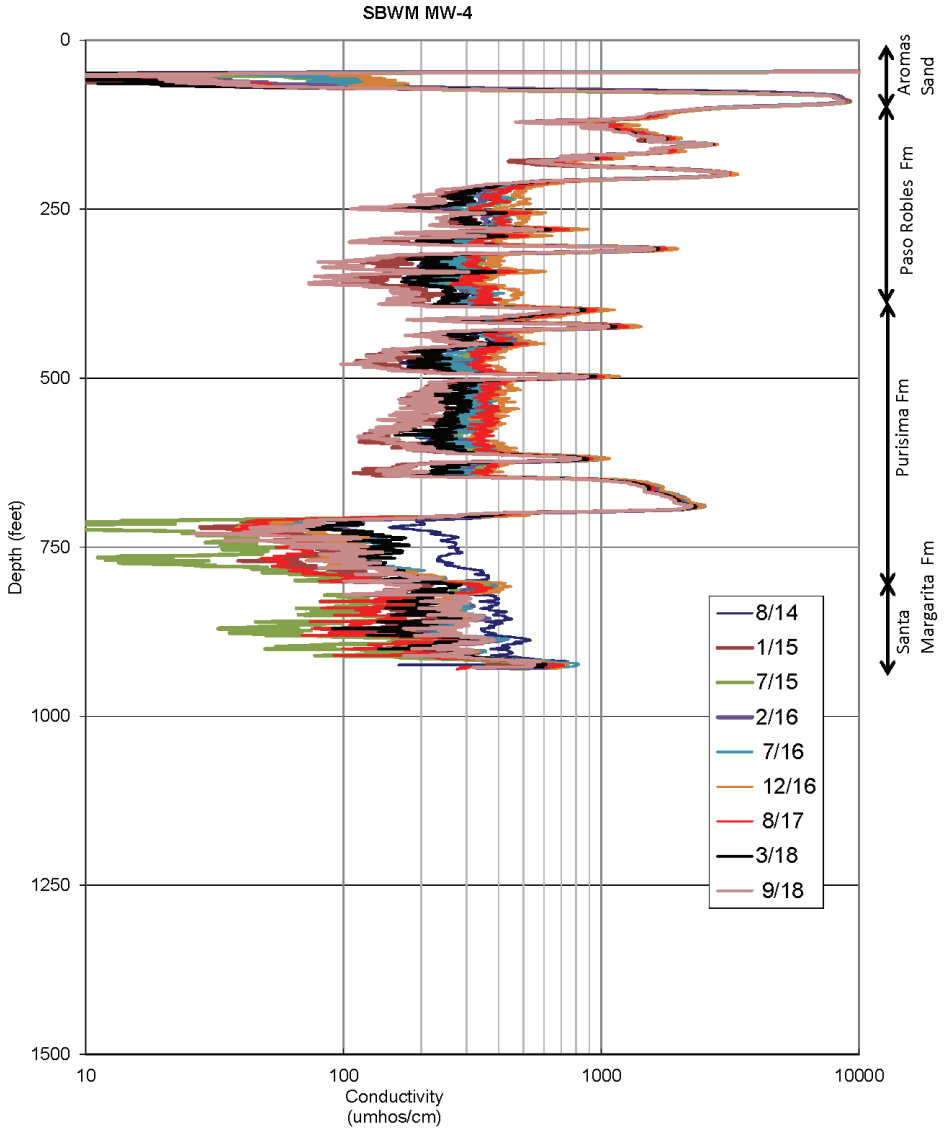


SENTINEL WELLS CONDUCTIVITY




SENTINEL WELLS CONDUCTIVITY
SBWM MW-3
Depth (feet)
0
250
500
750
1000
1250
1500
10
100
1000
10000
Conductivity
(umhos/cm)
Aromas Sand
Paso Robles Fm
Purisima Fm
8/14
1/15
7/15
2/16
7/16
12/17
3/18
9/18

SENTINEL WELLS CONDUCTIVITY



Link back to USGS publications

Techniques of Water-Resources Investigations
of the United States Geological Survey

Chapter E2

BOREHOLE GEOPHYSICS APPLIED TO GROUND-WATER INVESTIGATIONS

By W. Scott Keys

Book 2
COLLECTION OF ENVIRONMENTAL DATA

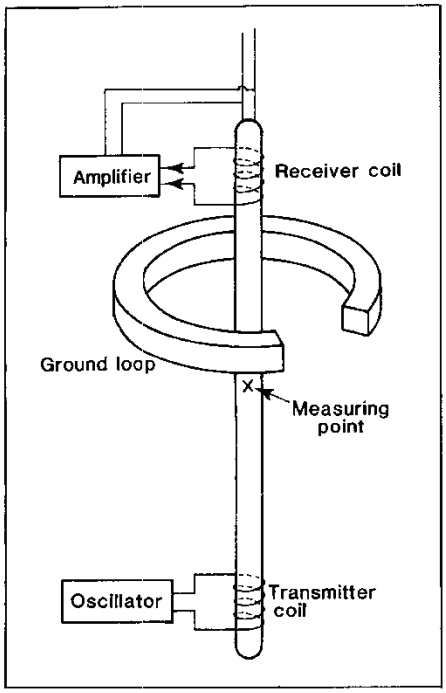


Figure 39.—System for making induction logs.

used widely in ground-water hydrology, but the equipment is still available through oil-well logging-service companies.

Induction logging

Induction-logging systems originally were designed to solve the problem of measuring resistivity in oil-based drilling mud, where no conductive medium is present between the probe and the formation. A basic induction-logging system is illustrated in figure 39. A simple version of an induction probe contains two coils, one for transmitting an alternating current into the surrounding rocks and the other for receiving the returning signal. The transmitted alternating current, at about 20,000 cycles per second (20 kHz), induces the flow of eddy currents (a ground loop) in conductive rocks penetrated by the borehole. These eddy currents set up secondary magnetic fields that induce a voltage in the receiving coil. That signal is amplified and converted to direct current before being transmitted up the cable. The magnitude of the received current is proportional to the electrical conductivity of the rocks. Induction logs measure electrical conductivity, which is the reciprocal of resistivity. Additional coils usually are included to focus the current in a manner similar to that used in the guard type of focused-resistivity systems.

Induction-logging systems provide resistivity measurements regardless of whether the well contains oil-based mud or is filled with air or fresh mud. The measurement of electrical conductivity usually is inverted to provide curves of both resistivity and electrical conductivity. The unit of measurement for conductivity is the mho-meter; however, induction logs are calibrated in millimho-meters. Calibration is checked by suspending the probe in air, where humidity is minimal, in order to obtain zero electrical conductivity. A copper hoop is suspended around the probe while it is in the air to simulate known resistivity values. It is also possible to suspend the probe in a lake or other body of water that is large enough to be infinite with respect to probe response. The electrical conductivity of the water can be measured with a conductivity cell.

The volume of investigation of an induction probe is a function of coil spacing, which varies among the probes provided by different service companies. For most probes, the diameter of material investigated is 40 to 60 in. For some probes, the signal produced by material closer than 30 in is small, and borehole diameter and properties of the invaded zone have little effect on measured resistivities. Although induction probes are not greatly affected by changes in borehole diameter, they are affected by eccentricity, so they usually are centralized. Vertical resolution of the logs is good for beds that are more than 6 ft thick.

The application of induction logs in ground-water hydrology is limited because the probe is most responsive to small changes in resistivity when background resistivity is minimal. The dual induction log configuration where the probe measures resistivity uses two different volumes of investigation is one of the most common electric logs used in the petroleum exploration industry. The ratio of Rm to Rw usually determines the applicability of induction probes. If the value of Rw exceeds 5 times Rm, which is common in wells containing freshwater, resistivity values on an induction log depart substantially from Rt.

Microresistivity logging

A large number of microresistivity probes is available, but all have short electrode spacing, and thus a shallow depth of investigation. They are of two general types: nonfocused and focused. Both types incorporate pads or some kind of contact electrodes to decrease the effect of the borehole fluid.

ground water

Electromagnetic-Induction Logging to Monitor Changing Chloride Concentrations

by Loren F. Metzger[1] and John A. Izbicki[2]

Abstract

Water from the San Joaquin Delta, having chloride concentrations up to 3590 mg/L, has intruded fresh water aquifers underlying Stockton, California. Changes in chloride concentrations at depth within these aquifers were evaluated using sequential electromagnetic (EM) induction logs collected during 2004 through 2007 at seven multiple-well sites as deep as 268 m. Sequential EM logging is useful for identifying changes in groundwater quality through polyvinyl chloride-cased wells in intervals not screened by wells. These unscreened intervals represent more than 90% of the aquifer at the sites studied. Sequential EM logging suggested degrading groundwater quality in numerous thin intervals, typically between 1 and 7 m in thickness, especially in the northern part of the study area. Some of these intervals were unscreened by wells, and would not have been identified by traditional groundwater sample collection. Sequential logging also identified intervals with improving water quality—possibly due to groundwater management practices that have limited pumping and promoted artificial recharge. EM resistivity was correlated with chloride concentrations in sampled wells and in water from core material. Natural gamma log data were used to account for the effect of aquifer lithology on EM resistivity. Results of this study show that a sequential EM logging is useful for identifying and monitoring the movement of high-chloride water, having lower salinities and chloride concentrations than sea water, in aquifer intervals not screened by wells, and that increases in chloride in water from wells in the area are consistent with high-chloride water originating from the San Joaquin Delta rather than from the underlying saline aquifer.

Introduction

Chloride concentrations in water from wells in the Stockton area of the Eastern San Joaquin Groundwater Subbasin, California, 130 km east of San Francisco (Figure 1), have increased as a result of groundwater pumping and subsequent declines in groundwater levels (Izbicki et al. 2006). The concentration of chloride in some wells has exceeded the U.S. Environmental Protection Agency Secondary Maximum Contaminant Level (SMCL) of 250 mg/L, and some public-supply wells have been removed from service due to high-chloride concentrations. Potential sources of high-chloride water to wells in the subbasin include: (1) high-chloride surface water from the San Joaquin Delta, (2) saline aquifers that underlie fresh water aquifers, (3) soluble salts emplaced in delta sediments by the evaporation of groundwater discharge from fresh water and saline aquifers along the delta margin, and (4) irrigation return water (Izbicki et al. 2006).

Sequential electromagnetic (EM) induction logging was performed to identify the sources and assess the spatial and vertical distribution of high-chloride water in the Eastern San Joaquin Groundwater Subbasin near the San Joaquin Delta. The EM logs were collected between spring 2004 and fall 2007 in polyvinyl chloride (PVC)-cased monitoring wells installed as part of this

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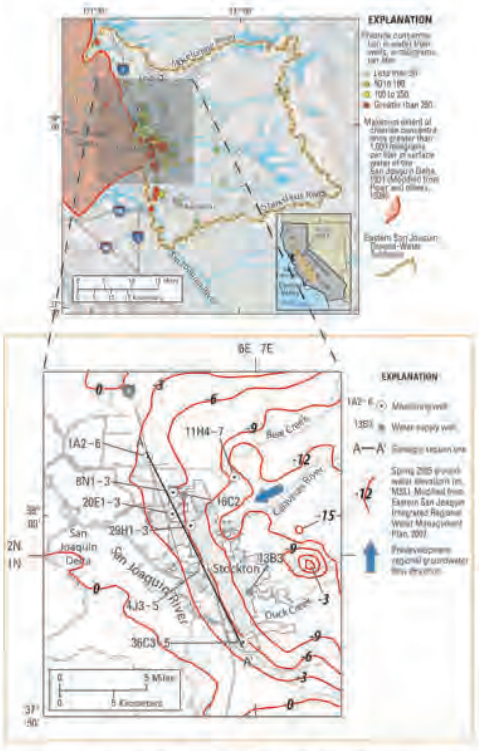


Figure 1. Location of the study area in the Eastern San Joaquin Groundwater Subbasin, near Stockton, California.

study (Clark et al. in review) and during previous work (California Department of Water Resources 2003). EM logs collected from PVC-cased wells provide an opportunity to supplement traditional hydrologic data collected from wells by assessing changes in groundwater quality in intervals not screened by wells. The monitoring wells installed for this study consisted of multiple wells installed in a single borehole. The individual wells were perforated over small intervals to provide depth-dependent data; as a consequence of this design, large portions of the aquifer system are not sampled by wells. For example, the multiple-well site 2N/5E-1A2-6, drilled to a depth of more than 300 m below land surface (bls), contains five wells in a single borehole having a combined screen length of 27 m. This multiple-well site samples less than 10% of the aquifer, leaving groundwater quality in more than 90% of the aquifer unmeasured. Although much of the unmeasured aquifer was composed of fine-grained deposits that were less suitable for well installation, the wells at the site may not adequately monitor groundwater quality in all the intervals contributing to the increasing chloride concentrations in production wells in the subbasin. Collection of sequential EM logs, in conjunction with conventional water quality sampling from wells, provides a way to evaluate the vertical distribution of groundwater quality throughout the entire aquifer encountered by the deepest PVC-cased monitoring well at each site.

The basis for EM logging is the relationship between geologic materials, fluid conductivity, and electrical resistivity (Archie 1942; McNeil 1980; Biella et al. 1983; Kwader 1985). EM probes are more sensitive when bulk aquifer resistivity is low and less sensitive when the aquifer resistivity is high; therefore, EM logging is best suited for use in aquifers intruded by sea water or other strong brines that provide a large resistivity contrast with aquifer materials (Keys 1990). The tool sensitivity was initially believed to limit the practical application of EM tools for field studies. In most cases, the EM properties of the aquifer materials are unknown or uncertain; however, aquifer lithology remains constant through time (neglecting possible changes caused by subsidence). Therefore, changes in bulk EM resistivity measured during sequential EM logging of wells can only be caused by changes in groundwater quality (Williams et al. 1993). Collection of sequential EM logs in a well over time eliminates the uncertainty associated with the estimation of the EM properties of aquifer materials and can provide an estimate of the relative changes in groundwater quality with time.

One of the first applications of EM logs from PVC-cased boreholes was by Stewart and Hermeston (1990) in the upper Floridian Aquifer along the central west coast of Florida. Stewart and Hermeston (1990) demonstrated that EM logs could be used to estimate pore-fluid conductivity and the extent of sea water intrusion in karstic aquifers. They also demonstrated that EM logs could be reproduced with the high degree of precision needed to allow direct comparison of changes in pore-fluid composition through time (Stewart 1999). The approach was combined with a wide range of advanced borehole geophysical methods and extended to determining the extent and movement of sea water intrusion in marine deposits underlying Long Island (Stumm 1993, 2001), and for saline water in Florida (Paillet et al. 1999). Hanson (2003) and Land et al. (2004) combined the approach with geochemical data and extended the technique to alluvial aquifers impacted by sea water intrusion in central and southern California. In the California studies, predictive relations were developed between measured bulk EM resistivity from boreholes and pore-fluid conductance in water from observation wells. Land et al. (2004) used this relation to determine the extent of the sea water intrusion front and the presence of fresh water injected by wells used to form a barrier to control the landward movement of sea water.

Most of the published applications of EM logs involve estimating changes in water quality resulting from the direct movement of sea water into fresh water aquifers. Sea water is highly saline, having a chloride concentration of 19,000 mg/L, and provides a large resistivity contrast with native fresh water. In contrast, alluvial deposits in the Eastern San Joaquin Groundwater Subbasin are not directly connected to the ocean. The principal sources of high-chloride water in the subbasin include lateral movement of saline water from delta deposits along the

San Joaquin River, or upward migration of saline water from the underlying saline aquifers. The chloride concentrations of these sources are less than sea water, typically about 3000 mg/L (Izbicki et al. 2006). Movement of groundwater through alluvial deposits, such as those found in the study area, occurs through coarse-grained sands and gravels deposited by streams and rivers. As a consequence, specific depth intervals having high-chloride water may be difficult to identify. Because the resistivity contrast between high-chloride water from the San Joaquin Delta and other sources, and that of the native fresh water is much less than the contrast between fresh water and sea water, conventional analysis of EM borehole logs needs to be refined to understand the distribution and movement of high-chloride water to wells in this setting.

Purpose and Scope

The purpose of this study is to relate changes in the bulk EM properties of formation materials and pore fluids to changes in chloride concentrations in selected wells in the Eastern San Joaquin Groundwater Subbasin, near Stockton California. The scope of the study included collection of EM induction logs and water quality data from seven multiple-well monitoring sites in the Stockton area during July 2004 through September 2007.

Hydrogeology

The Eastern San Joaquin Groundwater Subbasin is about 2860 km^2 (California Department of Water Resources 2006) and is part of the larger San Joaquin Groundwater Basin that forms the southern two-thirds of the Central Valley of California. The climate is characterized by hot, dry summers, and cool, moist winters. Average annual precipitation in Stockton averages about 350 mm and falls primarily during the November through March rainy season (National Climatic Data Center 2007). During the years of this study, 2004 through 2007, annual precipitation was close to average with the exception of 2007 when only 60% of normal precipitation was recorded. Precipitation is greater in the Sierra Nevada to the east of the study area. Runoff from the Sierra Nevada, primarily as snowmelt, sustains flows in the Mokelumne and Stanislaus Rivers that bound the study area to the north and south, respectively. The San Joaquin River, which drains the San Joaquin Valley to the south, bounds the study area to the west, and the foothills of the Sierra Nevada bound the study area to the east (Figure 1).

The Eastern Jan Joaquin Groundwater Subbasin is underlain by 150 to 300 m of consolidated, partly consolidated, and unconsolidated sedimentary deposits that form the principal fresh water aquifer system (California Department of Water Resources 1967). These deposits consist of alluvial-fan deposits eroded from the Sierra Nevada and its foothills, and delta deposits along the San Joaquin River. The alluvial-fan deposits are pumped extensively for water supply. Volcanic deposits underlie the sedimentary deposits throughout the subbasin and separate the fresh water aquifer from underlying marine deposits. The volcanic deposits consist of andesitic tuffs and lahars (Curtis 1954) blanketed by a layer of alluvium eroded from these deposits (California Department of Water Resources 1967) that are collectively known as the Mehrten Formation. The underlying marine deposits contain fresh water near the mountain front, but contain saline water in most parts of the subbasin.

Prior to the development of groundwater for agriculture during the later half of the 19th century, regional groundwater flow was generally from northeast to southwest (Figure 1). Under steady-state conditions, groundwater flowed from recharge areas along the margin of the San Joaquin Valley toward topographically low areas along the San Joaquin River and the delta (Williamson et al. 1989). As a result of groundwater development, pumping in excess of recharge led to the formation of a cone of depression centered to the east of Stockton (Figure 1). Present-day groundwater-level elevations in much of the study area are below sea-level and groundwater flow is from the delta toward Stockton (Northeast San Joaquin County Groundwater Banking Authority 2007).

Groundwater recharge to the subbasin is estimated to average about 111×10^7 m^3/year (CDM Inc. 2001). Pumping for municipal and agriculture supplies in 2000 was estimated to exceed recharge by 18.5×10^7 m^3/year (CDM Inc. 2001). In 2000, the subbasin had a population of about 580,000 (CDM Inc. 2001) and the population is expected to increase to more than 1.2 million by 2040 (CDM Inc. 2001). Pumping is expected to increase with increasing population, potentially resulting in greater overdraft.

Chloride concentrations have increased in a number of water-supply wells in the Stockton area. For example, chloride concentrations in water from water-supply well 1N/6E-13B3, located about 3 km north of multiple-well site (1N/6E-36C3-5) have increased from 26 mg/L in 1970 to 567 mg/L as of 2006, more than two times the 250-mg/L SMCL for chloride (U.S. EPA 2008). In comparison, chloride concentrations in other public-supply wells, such as 2N/6E-16C2, have increased, but at a slower rate—from 32 to 64 mg/L in the same time period (Figure 2).

Under predevelopment conditions, prior to the construction of reservoirs on rivers tributary to the San Joaquin River Delta, sea water intruded the delta during low-flow periods resulting in chloride concentrations as high as 1000 mg/L in the San Joaquin River near Stockton (Piper et al. 1939). Under present-day conditions, surface flows are managed to prevent the inland movement of sea water and to protect fresh water resources in the delta. However, high-chloride water trapped in delta sediments may intrude fresh water aquifers. Constituents dissolved within this water may retain a chemical composition consistent with a sea water origin (Izbicki et al. 2006). High-chloride water may also originate from soluble salts emplaced in delta sediments from evaporation of groundwater discharge along the delta margin (Izbicki et al. 2006). Constituents dissolved within this

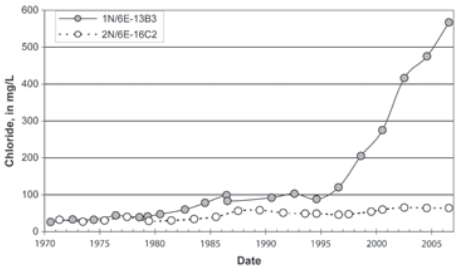


Figure 2. Chloride concentrations in samples from wells 1N/6E-13B3 and 2N/6E-16C2, Stockton, California, 1970 through 2007.

water would have a chemical composition different from sea water. Water from deeper aquifers that underlie fresh water aquifers pumped for supply also has a markedly different chemical composition and may contribute high-chloride water to wells in different parts of the subbasin (Izbicki et al. 2006). In addition, irrigation return may increase chloride concentrations near the water table. To further complicate the issue, multiple sources of high-chloride water may occur at the same location but at different depths within the aquifer (Izbicki et al. 2006).

Approach

Sequential EM logs were collected from the deepest accessible well at seven multiple-well sites in the study area between July 2004 and October 2007 (Table 1). EM log data were compared with lithologic and geophysical data collected from the wells during test drilling. EM log data were also compared with chloride and specific conductance data collected concurrently with EM logging from each well at all seven sites during the study period. In addition, EM log data were compared with chloride

Table 1
Well Construction Data and Dates of EM Induction Log Collection for Selected Multiple-Well Sites, Near Stockton, California

Site[1]	State Well Number	Local Name	Date Drilled	Depth Cased (m)	Screened Interval Depths (m)	Available EM Induction Data
Victory	1N/6E-4J3	STK4-1	9/16/2005	170.7	164.6–170.7	9/13/2005, 1/26/2006, 3/30/2007, 9/24/2007
	1N/6E-4J4	STK4-2		109.7	103.6–109.7	
	1N/6E-4J5	STK4-3		67.1	61.0–67.1	
Sperry	1N/6E-36C3	MW-1	5/10/2002	141.7	134.1–140.2	5/6/2002, 7/15/2004, 1/26/2006, 3/29/2007, 9/24/2007
	1N/6E-36C4	MW-2	5/15/2002	96.6	79.9–86.0, 92.0–95.1	
	1N/6E-36C5	MW-3	5/16/2002	39.3	34.7–37.8	
Oak Grove	2N/5E-1A2	STK1-1	5/6/2005	268.2	262.1–268.2	5/3/2005, 1/24/2006, 4/10/2007, 9/25/2007
	2N/5E-1A3	STK1-2		164.6	158.5–164.6	
	2N/5E-1A4	STK1-3		115.8	109.7–115.8	
	2N/5E-1A5	STK1-4		73.2	67.1–73.2	
	2N/5E-1A6	STK1-5		20.7	17.7–20.7	
Sandman	2N/6E-8N1	STK5-1	5/16/2006	176.8	170.7–176.8	5/13/2006, 7/13/2006, 4/11/2007, 5/24/2007, 9/26/2007
	2N/6E-8N2	STK5-2		131.1	125.0–131.1	
	2N/6E-8N3	STK5-3		70.1	64.0–70.1	
Morada	2N/6E-11H4	STK2-1	5/16/2005	193.6	187.4–193.6	5/13/2005, 1/23/2006, 4/10/2007, 9/26/2007
	2N/6E-11H5	STK2-2		164.6	158.5–164.6	
	2N/6E-11H6	STK2-3		91.4	85.3–91.4	
	2N/6E-11H7	STK2-4		67.1	61.0–67.1	
Swenson	2N/6E-20E1	MW-1	5/23/2002	154.5	146.9–153.1	5/20/2002, 7/15/2004, 1/24/2006, 3/28/2007, 9/25/2007
	2N/6E-20E2	MW-2	5/29/2002	97.2	89.6–95.7	
	2N/6E-20E3	MW-3	5/29/2002	63.7	59.1–62.2	
Atherton	2N/6E-29H1	STK6-1	5/26/2006	170.7	164.6–170.7	5/22/2006, 6/20/2006, 4/11/2007, 9/26/2007
	2N/6E-29H2	STK6-2		143.3	137.2–143.3	
	2N/6E-29H3	STK6-3		79.3	73.2–79.2	

[1]The EM-induction logs were generally collected from the deepest well at each multiple-well site.

and specific conductance data from water extracted from core samples collected at the time of drilling by pressure extractions. A statistical relation between EM resistivity and chloride concentration of water from wells and extracted from core material was developed and used to estimate chloride concentrations at multiple-well sites in intervals not screened by wells.

Electromagnetic Induction Log Collection

Electromagnetic induction logs were collected using a Century model 9511 tool (Century Geophysical Corporation, Tulsa, Oklahoma). The tool uses an EM field to induce an electrical current in the surrounding formation (Johnson and Williams 2003). The induced current sets up a secondary magnetic field that is measured, amplified, and then transmitted to the surface as a direct current. The magnitude of the direct current is proportional to the electrical conductivity of the formation, which is a function of lithology and pore-fluid conductivity (Keys 1990; Paillet et al. 1999). The volume of the material measured by a typical EM logging tool is a donut-shaped torus (Geonics, Inc. 2005; Century Geophysical Corp. 2008). The size of the torus is dependent upon the coil spacing within the tool. The inner and outer diameters of the torus measured by the Century 9511 tool range approximately from 46 to 127 cm, respectively (Century Geophysical Corp. 2008). As a consequence, the tool is relatively insensitive to borehole fill material adjacent to the well (McNeill et al. 1990).

Additional measured parameters include fluid conductivity in mmho/m, corrected for temperature and skin effects, and natural gamma in API (American Petroleum Institute) units. Resistivity (ohm-m) is automatically calculated from measured conductivity. Because aquifer lithology remains constant, repeat EM logs collected from a PVC-cased well can be used to measure changes in pore-fluid conductivity with time. The range of conductivity that can be measured is 0 to 1000 mmho/m (resistivity 500 to 1 ohm-m) with an accuracy of ±5 mmho/m over the entire range (B. Petersen, Century Geophysical Corporation, oral communication, 2008).

Electromagnetic induction measurements may be affected by borehole size (including wash-outs during drilling that increase borehole diameter), metallic minerals, and well construction components such as centralizers (Century Geophysical Corp. 2008). Metal centralizers installed at 9- to 18-m intervals during construction of wells 1N/6E-36C3 and 2N/6E-20E1 created interference over approximately 15% of the depth of each well, including the bottom 9 and 6 m, respectively. These intervals of poor-quality data were omitted prior to data processing and analysis of the EM logs.

Calibration and operation of the EM tool was carried out according to the manufacturer's guidelines in an effort to ensure repeatability between sequential logs at each site. Calibration was checked at each site prior to logging by using a two-point calibration technique. Suspending the tool in air upside down, induction values were alternately checked using free air as a zero value and a calibration-ring sleeve, placed over the bottom end of the inverted tool. The calibration ring is manufactured to have a value of 705 mmho/m. Tool adjustment is required if the induction values exceed 10% of the factory calibration (Century Geophysical Corp. 2008). At sites where signal interference from nearby cultural artifacts (overhead power lines, metal fences, underground utilities) made recalibration difficult or impossible, the existing calibration values from previous logs were retained.

Wells were logged in the upward direction, to maintain tension on the draw-works cable, at a speed of about 6 m/min. The deepest well at each of the multiple-well sites was logged three to four times during the course of the study (Table 1), with the exception of multiple-well site 2N/6E-8N1-3, where an obstruction in the well necessitated the use of the second deepest well (2N/6E-8N2) for logging in May and September 2007.

Duplicate logs were collected from well 1N/6E-4J3 in 2006 and from wells 1N/6E-36C3, 2N/6E-8N1, 2N/6E-8N2, and 2N/6E-20E1 in 2007 to verify the repeatability of measurements. The precision of these duplicate logs as indicated by R^2 and coefficient of variance ranged from 0.993 to 0.997 and from 2.32 to 4.46, respectively. As an example, duplicate logs for well 1N/6E-36C3 (Figure 3) indicate good agreement with an R^2 value of 0.996 and a coefficient of variance of 2.86. The logs show higher variability at higher resistivity and less variability (greater precision) at lower resistivity (Figure 3), typical of EM induction logs data described by Keys (1990). However, the variability at higher resistivity is not so great as to preclude the use of the EM tool in the study area.

Results

Electromagnetic resistivity in logged wells ranged from 2.5 to 50 ohm-m. In general, EM resistivity was lower in fine-grained deposits and higher in coarser-grained deposits consistent with the properties of these materials (McNeil 1980; Biella et al. 1983; Kwader 1985; McNeil et al. 1990). Regardless of lithology, EM

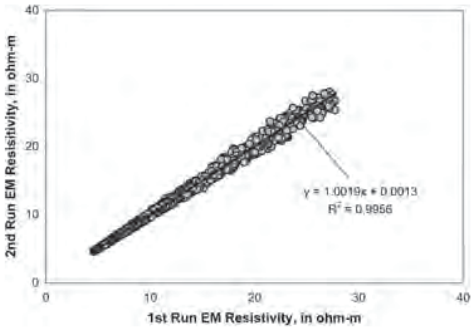


Figure 3. Electromagnetic resistivity data for duplicate logs from well 1N/6E-36C3, Stockton, California, March 2007.

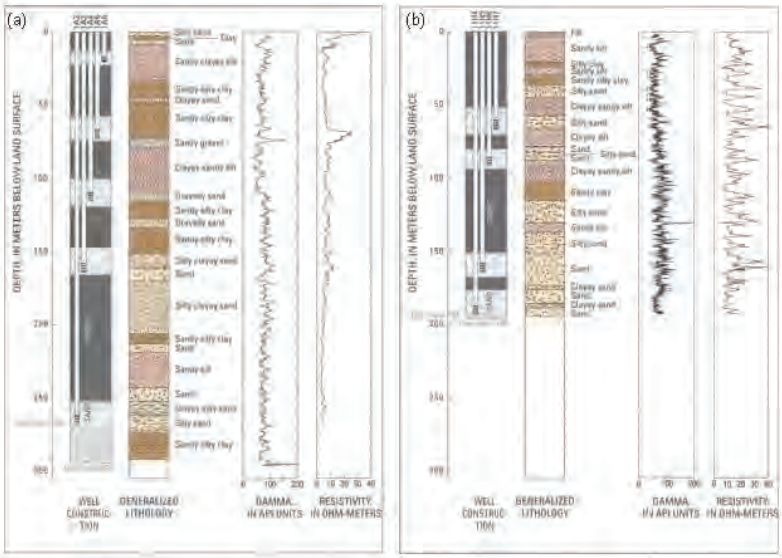


Figure 4. Well construction, generalized lithology, natural gamma, and EM resistivity logs (September 2007) for multiple-well sites (a) 2N/5E-1A2-6 and (b) 2N/6E-11H4-7, near Stockton, California.

resistivity was less in multiple-well site 2N/5E-1A2-6 closest to the delta and higher in multiple-well site 2N/6E-11H4-7 farthest from the delta (Figure 4). EM logs and dates of collection are listed in Table 1.

Chloride concentrations in 24 wells sampled between April 2004 and March 2007 ranged from 4 to 2050 mg/L (Table 2). The highest chloride concentrations were in water from wells at multiple-well site 2N/5E-1A2-6 closest to the San Joaquin Delta. The lowest chloride concentrations were in water from wells at multiple-well site 2N/6E-11H4-7. During the study period, samples from 9 of 24 wells showed increasing chloride concentrations, 12 wells showed decreasing chloride concentrations, and 3 wells showed almost no change (Table 2). The comparatively large number of wells with no change, or decreased chloride concentrations, may result from groundwater management practices, including pumping restrictions and artificial recharge, intended to control the movement of high-chloride water from the delta.

Chloride concentrations in eight samples of water pressure-extracted from core material using methods described by Manheim et al. (1994) ranged from 28 to 3590 mg/L (Table 3). The highest chloride concentrations were in core material collected from multiple-well site 2N/5E-1A2-6 and from an adjacent test boring drilled in July 2007 after installation of the original site. Core material was collected from finer-grained deposits rather than from the sand and gravel layers screened by wells, and provided for the range in geologic materials necessary for incorporating lithology into equations relating EM resistivity to chloride concentrations and specific conductivity of groundwater.

Discussion

EM logs were analyzed to determine depth intervals within the aquifer where changes in water quality occurred by comparing logs collected from the same well at different times. For these logs, the percent change between measurements for data collected at the same depth was calculated and plotted as a function of well depth. A percent change greater than ±1 standard deviation was used to identify depth intervals where the EM resistivity increased or decreased between collections of the logs. This approach is illustrated for data from well 2N/5E-1A2 (Figure 5).

Changes in EM resistivity identified within wells in the study area occurred in thin intervals, ranging from 1 to 7 m in thickness (Table 4). Lithologic data collected during drilling show that these intervals were generally coarser grained, and presumably have higher hydraulic conductivities than the surrounding finer-grained zones. Changes in EM resistivity, and therefore changes in groundwater quality, were measured both in intervals sampled by wells and in intervals not sampled by wells (Table 4). The unsampled intervals represent as much as 90% of the alluvial deposits encountered at each site.

Multiple-well sites 2N/5E-1A2-6 and 2N/6E-8N1-3 (Table 4) had the greatest number of depth intervals with decreasing EM resistivity during 2004 through 2007. These sites are closer to the San Joaquin Delta (Figure 1). Production wells located east of these monitoring wells may be inducing the lateral movement of high-chloride water from the delta. In contrast, depth intervals showing increasing resistivity (freshening water quality) occurred at one or more depth intervals at all seven multiple-well

Table 2
Chloride Concentrations in Water from Wells at Selected Multiple-Well Sites, Stockton, California, 2004 to 2007

Site	State Well Number	Screened Interval (m blsd)	Chloride (mg/L)								Overall Chloride Change (%)
			Spring 2004	Spring 2005	Winter 2006	Spring 2006	Summer 2006	Winter 2007	Spring 2007	Fall 2007	
Victory	1N/6E-4J3	164.6–170.7	—	—	292	—	310	—	305	311	6.5
	1N/6E-4J4	103.6–109.7	—	—	506	—	487	—	367	340	–32.8
	1N/6E-4J5	61.0–67.1	—	—	123	—	63.0	—	60.2	62.4	–49.3
Sperry	1N/6E-36C3	134.1–140.2	165	—	—	—	—	—	111	163	–1.2
	1N/6E-36C4	79.9–95.1[1]	22.4	—	—	—	—	—	22.4	20.8	–7.4
	1N/6E-36C5	34.7–37.8	20.2	—	—	—	—	—	18.0	18.2	–9.9
Oak Grove	2N/5E-1A2	262.1–268.2	—	1730	—	—	1820	—	1820	1940	12.1
	2N/5E-1A3	158.5–164.6	—	626	—	—	580	—	591	596	–4.8
	2N/5E-1A4	109.7–115.8	—	962	—	—	932	—	929	962	0.0
	2N/5E-1A5	67.1–73.2	—	547	—	—	551	—	538	627	14.6
	2N/5E-1A6	17.7–20.7	—	1840	—	—	1900	—	1970	2050	11.4
Sandman	2N/6E-8N1	170.7–176.8	—	—	—	—	112	—	158	112	0.0
	2N/6E-8N2	125.0–131.1	—	—	—	—	37.7	—	34.6	34.5	–8.5
	2N/6E-8N3	64.0–70.1	—	—	—	—	19.9	—	19.1	18.1	–9.0
Morada	2N/6E-11B4	187.5–193.6	—	10.0	—	11[2]	11[2]	12[2]	12[2]	—	20
	2N/6E-11B5	158.5–164.6	—	5.6	—	6[2]	5[2]	5[2]	5[2]	—	–11
	2N/6E-11B6	85.4–91.5	—	8.8	—	9[2]	7[2]	8[2]	9[2]	—	2
	2N/6E-11H7	61.0–67.1	—	3.9	—	5[2]	5[2]	5[2]	5[2]	—	28
Swenson	2N/6E-20E1	146.9–153.0	60.4	—	—	—	—	—	60.0	59.9	–0.8
	2N/6E-20E2	89.6–95.7	28.9	—	—	—	—	—	27.2	25.8	–10.7
	2N/6E-20E3	59.1–62.2	10.0	—	—	—	—	—	9.5	10.7	7.0
Atherton	2N/6E-29H1	164.6–170.7					38.1			38.5	1.0
	2N/6E-29H2	137.2–143.3					13.5			12.7	5.9
	2N/6E-29H3	73.2–79.2					5.6			5.4	3.6

Note: blsd = below land-surface datum.
[1]Two separate screens at 79.9–86.0 and 92.0–95.1 m.
[2]Samples collected and analyzed by California Department of Water Resources (CADWR).

Table 3
Chloride Concentrations in Water Pressure Extracted from Core Material Collected During Drilling, Near Stockton, California, April 2005–July 2006

Site	State Well Number	Chloride (mg/L)		
		Core Sample Depth[1] (m blsd)	Spring 2005	Summer 2006
Oak Grove	2N/5E-1A2-6	15.2	—	3590, 1120[2]
		15.7	—	2400
		22.9	1270	—
		294.4	490	—
Sandman	2N/6E-8N1-3	16.9	—	51.4
		186.8	—	142
Atherton	2N/6E-29H1-3	18.9	—	28.1
		188.4	—	47.2

Notes: mg/L, milligrams per liter; blsd, below land-surface datum.
[1]Depths listed represent bottom of generally less than 1 m cores.
[2]Second sample.

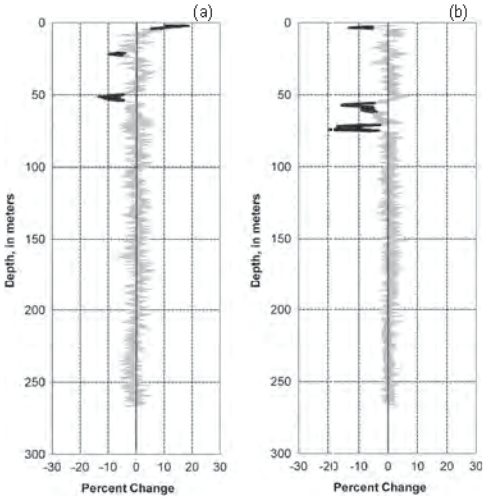


Figure 5. Percent change in electromagnetic resistivity with depth for (a) January 2006 to April 2007 and (b) April 2007 to September 2007 from well 2N/5E-1A2, near Stockton, California. Highlighted depth intervals show change greater than 1 standard deviation.

sites (Table 4). The greatest number of depth intervals with increasing resistivity was at multiple-well site 2N/6E-29H1-3. Increasing resistivity at this site may be related to infiltration of water from several nearby unlined man-made lakes. Alternatively, groundwater management and a reduction in pumping in recent years (CDM Inc. 2001) and increased groundwater recharge (O'Leary 2011) could be another explanation for the increasing EM resistivity and improving water quality at some depths in aquifers underling the study area.

Increases in EM resistivity were present at relatively shallow depths less than 30 m bls at multiple-well sites 2N/5E-1A2-6, 2N/6E-11H4-7, and 2N/6E-20E1-3. These increases reflect seasonal water-level fluctuations rather than changes in groundwater quality. Depth to water at these sites during the course of this study generally ranged from 3 to 25 m bls (Table 4).

No changes were identified in the EM resistivity on the basis of sequential logs below approximately 150 m bls. Most production wells in the area are screened above 150 m bls, and well-bore flow data show that most of water enters these wells at the shallower depths perforated by the wells (Clark et al. in review). These results are consistent with increases in chloride in water from wells originating from the San Joaquin Delta rather than underlying saline aquifer. However, with the exception of well 2N/5E-1A2, none of the other EM-logged wells are greater than 180 m deep, and additional well drilling and monitoring well installation at greater depths would be needed to evaluate changes in EM resistivity and pore-fluid resistivity at these depths.

Comparison Between EM Resistivity, Chloride, and Specific Conductance

Comparison of EM resistivity data with chloride data from monitoring wells showed lower resistivity at depths where higher chloride concentrations were measured. However, data from multiple-well site 2N/5E-1A2-6 collected between spring and fall 2007 (Figure 6) show that the percent change in chloride concentration, rather than the absolute magnitude of the change, creates larger differences in EM resistivity (and conductivity not shown in Figure 6) between the two logs. In this example, the increase in chloride concentration, about 80 mg/L, was similar for each well; however, the percent change in chloride concentration was 4% for well 1A6 and 17% for well 1A5. (Additionally, the EM log data for the interval sampled by well 1A5 show a decrease in resistivity in only the bottom half of the well screen, indicating that high-chloride water was moving through the aquifer in an interval thinner than the 6-m long well screen.) Data

Table 4
Depth Intervals Showing a Net Decrease in Electromagnetic Resistivity Associated with Poorer Water Quality (bold) or a Net Increase in Electromagnetic Resistivity Associated with Improving Water Quality (*italic*), Based on Sequential Electromagnetic Induction Logging at Multiple-Well Monitoring Sites Near Stockton, California 2004–2007

	Oak Grove 2N/5E-1A2-6	Sandman 2N/6E-8N1-3	Morada 2N/6E-11H4-7	Swenson 2N/6E-20E1-3	Atherton 2N/6E-29H1-3	Victory 1N/6E-4J3-5	Sperry 1N/6E-36C3-5
	1.8–4.3	**8.5–10.7**	*11.6–17.4*	*24.1–26.5*	**7.9–14.6**	*63.7–67.1*	**12.2–14.6**
	49.6–54.1	**21.3–24.4**	**18.0–19.8**	*67.1–68.9*	**17.7–18.9**	*104.5–107.3*	**31.7–37.8**
	55.6–61.9	**58.5–59.7**	*43.3–45.4*	*91.7–93.6*	*73.5–75.6*	**116.1–118.0**	*80.8–83.8*
	70.8–75.3	**62.8–70.1**	*110.4–112.5*	**106.7–111.0**	*89.0–91.4*		*84.7–86.6*
		76.5–80.8		**124.1–126.2**	*95.1–96.0*		*92.0–95.4*
		93.9–99.1			*103.6–104.9*		
		110.6–113.4			*126.5–128.3*		
					136.2–142.6		
Total well depth (m)	268.2	176.8	193.6	154.5	170.7	170.7	141.7
Depth-to-water range (m)	3.4–10.0[1]	6.7–11.3[2]	17.1–24.7[3]	6.7–8.8[4]	7.0–11.3[2]	3.0–10.0[5]	9.1–12.5[4]

[1]Overall range for all piezometers based on continuous recording water-level transducers, April 2006 through 2007.
[2]Overall range for all piezometers based on continuous recording water-level transducers, December 2006 through February 2008
[3]Overall range for all piezometers based on continuous recording water-level transducers, January 2006 through 2007.
[4]Overall range for all piezometers based on periodic water-level measurements.
[5]Overall range for all piezometers based on continuous recording water-level transducers, March 2006 through 2007.

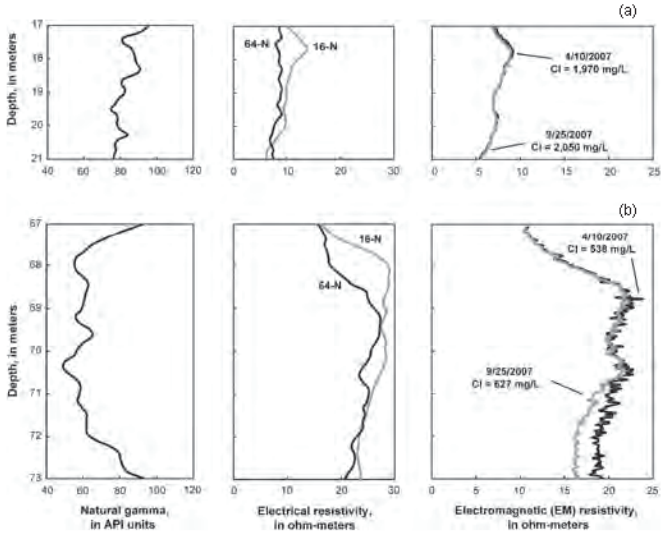


Figure 6. Comparison of natural gamma, electrical resistivity, and electromagnetic resistivity (EM) logs collected April 2007 and September 2007 from (a) well 2N/5E-1A6 and (b) well 2N/5E-1A5, near Stockton, California.

collected as part of this study suggest that a 10 to 15% change in chloride concentration is required to produce a measurable change in EM resistivity (or its inverse conductivity).

A least-squares regression equation was developed to relate changes in EM resistivity to changes in the chloride concentration in water from wells:

$$\text{Log}_{10}\ \text{Cl} = 4.36 - 2.12\ \text{log}_{10}\ \text{EM} \qquad (1)$$

where Cl is the chloride concentration in water from screened intervals of wells near the time of the EM log

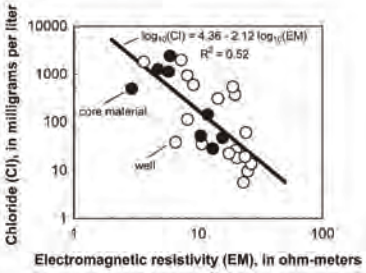


Figure 7. Chloride concentrations in water from monitoring wells (open circles) and water pressure extracted from core material (solid circles) as a function of electromagnetic-log resistivity in wells 2N/5E-1A2-5, 2N/6E-20E1, 1N/6E-4J3-5, and 1N/6E-36C3, near Stockton, California, 2004 through 2007.

and in core material at the time the multiple-well site was drilled in milligrams per liter, and EM is the average electromagnetic resistivity in ohm-meters over the screened interval of the sampled well, typically 6 m, or over the length of the sampled core, typically 0.75 m.

This equation was statistically significant on the basis of the F-test (Neter and Wasserman 1974) with the confidence criteria of $\alpha = 0.001$, and an R^2 of 0.52 (Figure 7).

Examination of the data in Figure 7 shows that the data are not randomly distributed about the regression line. Instead, the higher chloride values tend to plot above the regression line (have positive residuals), whereas the lower chloride values tend to plot below the regression line (have negative residuals). This distribution suggests that there may be additional explanatory variables to be considered that may further refine this relationship.

One variable considered was aquifer lithology, specifically the presence of clay within the deposits. For the purposes of this study, natural gamma was used as an indicator of the amount of clay in the aquifer (Paillet and Crowder 1996). Although not perfect, as the clay content of the materials increases, the natural gamma values increase. When natural gamma (gamma) was incorporated into the equation, the least-squares regression equation became:

$$\text{Log}_{10}\ \text{Cl} = 4.67 - 2.23\ \log_{10}\text{EM} - 0.005\ \text{gamma} \quad (2)$$

This equation was also statistically significant on the basis of the F-test (Neter and Wasserman 1974) with the confidence criteria of $\alpha = 0.001$, and an R^2 of 0.58. The inclusion of natural gamma was statistically significant in this equation on the basis of the F-test with the confidence criterion of $\alpha = 0.1$. When specific conductance was the predicted variable, the R^2 increased to 0.61.

Equation 2 was used to estimate pore-fluid concentrations in the aquifer at the multiple-well sites (Figure 8). The uncertainty associated with the predicted pore-fluid chloride concentrations was evaluated as the $\pm 2\sigma$ uncertainty associated with the gamma term that ranged from −0.01 to 0 (Figure 8). Given the comparatively low R^2 of 0.58 associated with the equation, calculated pore-fluid chloride concentrations are best interpreted in a relative sense rather than in terms of absolute numbers.

The calculated pore-fluid data show higher chloride concentrations in fine-grained materials than in the coarser-grained materials screened by wells. This is consistent with the hypothesis that much of the high-chloride water in the aquifer originated from salt-affected delta deposits. Equation 2 overpredicts chloride concentrations for the pore-fluids squeezed from core material that had chloride concentration less than 100 mg/L and underpredicts chloride concentrations for cores with chloride concentrations greater than 100 mg/L (Figures 7 and 8). However, the equation correctly estimated the low-chloride concentrations in water from multiple-well site 2N/6E-11H4-7 farthest from the delta.

Hydrogeologic Implications

Geologic section A-A′ shows multiple-well sites drilled as part of this study along a north-south section through the study area (Figures 1 and 9). Natural gamma logs are shown along with predicted (best solution) chloride concentrations in aquifer intervals not sampled by wells. Only about 10% of the aquifer at each multiple-well site was screened by wells leaving the bulk of groundwater in the aquifer unmeasured. Intervals having changing EM resistivity also are shown in Figure 9. An equal number of intervals (16) showed increasing resistivity (freshening water quality) and decreasing resistivity (degrading water quality). Only one-third (11) of the 33 depth intervals identified as having changing EM resistivity coincided either completely or partially with a screened interval.

Decreasing resistivity and predicted increases in chloride concentrations were more prevalent in the northern part of the study area (sites 2N/5E-1A2-6 and 2N/6E-8N1-3), especially between about 50 and 75 m bls (Figure 9). Decreasing resistivity at site 1A2-6 appears to be occurring in intervals already containing high-chloride water. However, decreasing resistivity and predicted increases in chloride concentrations also appear to be occurring in fresher intervals not previously impacted by high-chloride water from the San Joaquin Delta at site 8N1-3. The changes in resistivity and predicted changes in chloride concentrations may be the result of pumping by public-supply wells to the east of these sites.

Increasing EM resistivity and predicted decreases in chloride concentrations at other sites may represent improvements in water quality resulting from management efforts to reduce groundwater overdraft, raise water levels, and reduce the invasion of high-chloride water. However, the intervals interpreted as having decreasing chloride concentrations are primarily in multiple-well sites located near recreational lakes and stormwater detention ponds (multiple-well sites 2N/6E-29H1-3 and 1N/6E-36C3-5, respectively) and may result from local sources of recharge. For example, O'Leary et al. (2011) showed water from a stormflow detention pond used for groundwater recharge in the study area moved as deep as 100 m

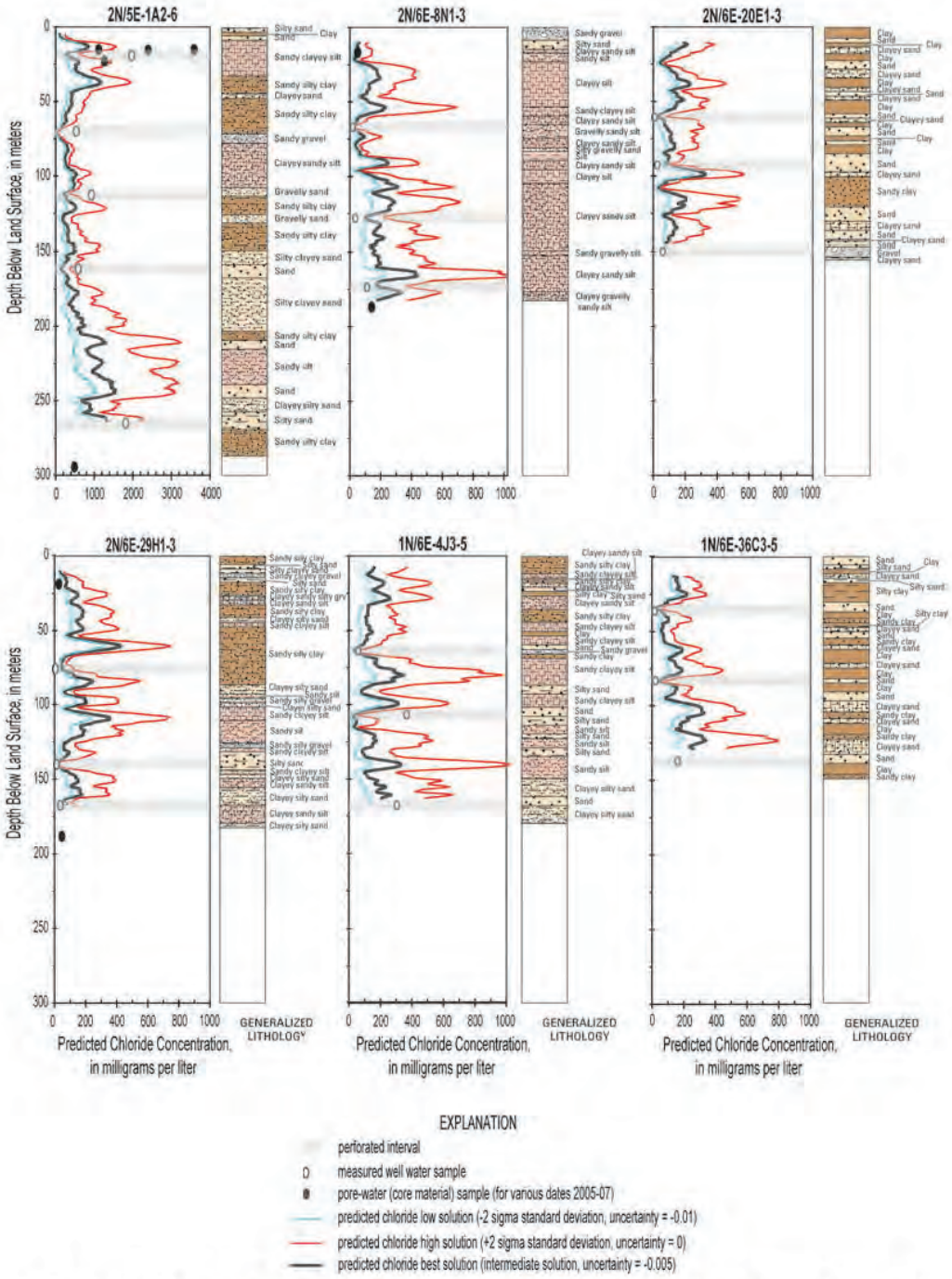


Figure 8. Predicted vs. measured chloride concentrations for selected multiple-well sites, near Stockton, California, spring 2007.

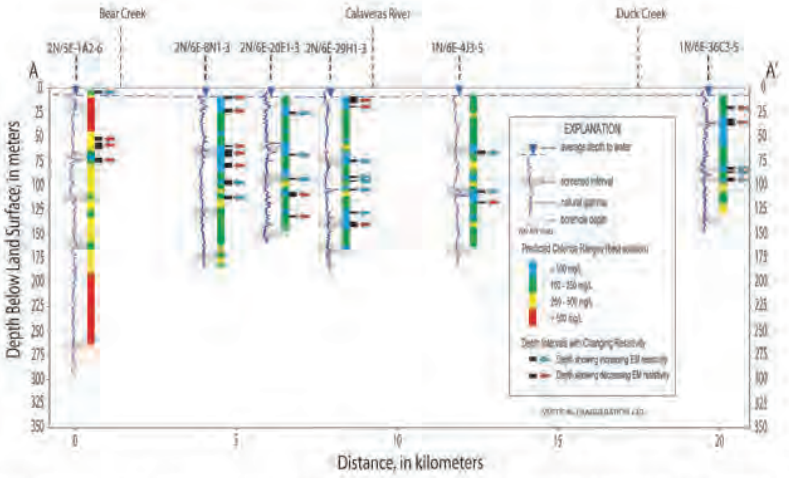


Figure 9. Natural gamma, predicted chloride concentrations, and intervals having changing EM resistivity for selected multiple-well sites along geologic section A-A′ near Stockton, California.

bls within several months of application of sulfur hexafluoride tracer.

Intervals showing decreasing EM resistivity and increasing chloride concentrations are thin, coarser-grained deposits that do not appear to be related to regional changes in subsurface geology or associated basal gravel units that are conduits for sea water intrusion in coastal California aquifers (Nishikawa 1997). These thin, coarse-grained layers may be lenticular stream channel deposits, similar to those described by Burow et al. (2004) in the Modesto area to the south of the study area. Such thin, lenticular units would be difficult to identify using any technique that does not provide continuous data throughout available boreholes. The source of the high-chloride water appears to be saline water trapped within finer-grained deposits associated with the San Joaquin Delta, rather than deeper saline groundwater that underlies fresh water aquifers. Saline water mobilized from fine-grained deposits has been identified as a source of high-chloride water to fresh-water aquifers elsewhere in California (Izbicki 1996; Izbicki et al. 2003). Additional deep monitoring sites may need to be constructed to assess contributions from deeper sources.

Summary and Conclusions

Previous studies have used EM logging to assess the movement of sea water into fresh water aquifers. The Eastern San Joaquin Groundwater Subbasin is not affected by sea water intrusion directly from the ocean, but rather by the movement of saline water from the San Joaquin Delta and underlying saline aquifers. The area provided a setting for testing EM logging techniques to assess changes in pore-fluid composition under lower salinity conditions than those evaluated in most previous studies.

Results of this study suggest that sequential EM logging may be a useful screening tool for detecting the early onset of increasing chloride concentrations. This is because changes in logs collected sequentially through time show small magnitude changes in 1- to 7-m-thick thin aquifer layers that are associated with increasing chloride concentrations. The data show that EM induction logs can be used to identify brine invasion before concentrations reach levels of concern for groundwater management. The results of this study also suggest that this technique can be used to identify the movement of brines having lower salinities and chloride concentrations than sea water. These data may serve as an early warning monitoring technique that is useful for detecting the initial changes in groundwater quality resulting from brine invasion or from sea water intrusion.

Sequential EM logging is uniquely suited for monitoring the unscreened portion of wells within an aquifer. In this study, approximately 90% of the aquifer at each multiple-well site was unscreened. EM logging can provide a continuous profile of changes in groundwater quality within an aquifer penetrated by a PVC-cased well, thereby permitting the identification of zones of poor-quality water that may otherwise be missed by traditional water quality sampling from wells.

At present, EM logs are best used qualitatively to compare sequential changes in groundwater quality at a single well location through time. However, an equation relating chloride concentration with EM resistivity and natural gamma (as a surrogate for aquifer lithology) enabled the estimation of chloride concentrations within the aquifer. The inclusion of natural gamma in the regression equation was possible because chloride concentrations in water from pressure extracts from fine-grained core material composed of silts and clays were available.

Chloride concentrations in water from wells are typically from coarser-grained sands and gravels that yield water to wells and the pressure-extract data were from finer-grained intervals not normally screened by wells.

The comparatively low R^2 of the equations presented in this study limits their use for quantitative analysis. However, improvements in study design that result in improved data collection and analysis may result in increased predictive power and increasing the quantitative analysis of EM log data in settings where sufficient data are available.

Improvements in study design for EM data collection and interpretation include the following. First, monitoring wells can be constructed with at least 3 m of blank casing between the end of the well casing and the bottom of the well screen to facilitate access for the EM induction tool through the entire screened interval of the well. Second, water sampling and induction logging should be carried out at the same time to minimize variability in the data and improve the relation between measured chloride concentrations and EM resistivity. Finally, scheduling for sampling and sequential logging should also take into consideration the time of year and factors such as groundwater pumping cycles, to enable long-term trends to be distinguished from seasonal variations in chloride concentrations and EM resistivity.

Acknowledgments

This study is part of larger study to quantify the sources, areal extent, and vertical distribution of high-chloride water to wells in the Eastern San Joaquin Groundwater Subbasin. Funding was provided cooperatively by the Northeastern San Joaquin Groundwater Banking Authority and the California Department of Water Resources. The authors thank local agencies for access to wells for sample collection and EM logging. The authors also thank Brandon Nakagawa of the Northeastern San Joaquin Groundwater Banking Authority, Anthony Tovar of the City of Stockton, and Tanya Meeth of the California Department of Water Resources for logistical and technical support during this study. The authors also thank the cooperators, U.S. Geological Survey, and journal reviewers for their comments and assistance in the preparation of the manuscript, especially Dr. Fred Paillet for his comments during review.

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