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Operable Unit Carbon Tetrachloride Plume Upper 180-Foot Aquifer Remedial Design Addendum
Former Fort Ord, California

Prepared for:

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On behalf of:

U.S. Department of the Army
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Acronyms and Abbreviations

°C	degrees Celsius
ACL	Aquifer Cleanup Level
Ahtna	Ahtna Global, LLC.
Army	U.S. Department of the Army
ASTM	ASTM International (formerly American Standards of Testing and Materials)
bgs	below ground surface
COC	chemical of concern
DO	dissolved oxygen
EPA	U.S. Environmental Protection Agency
EW	extraction well
FO-SVA	Fort Ord Salinas Valley Aquitard
FONR	Fort Ord Natural Reserve
FS	Feasibility Study
GAC	granular activated carbon
gpm	gallons per minute
GWMP	groundwater monitoring program
GWTP	groundwater treatment plant
GWTS	groundwater treatment system
HDPE	high density polyethylene
HHRA	Human Health Risk Assessment
HLA	Harding Lawson Associates
IW	injection well
MACTEC	MACTEC Engineering and Consulting, Inc.
µmhos/cm	micromhos per centimeter
msl	mean sea level
NTU	nephelometric turbidity units
O&M	operations and maintenance
ORP	oxidation-reduction potential
OU2	Operable Unit 2
OUCTP	Operable Unit Carbon Tetrachloride Plume
PLC	programmable logic controller
psi	pounds per square inch
PVC	polyvinyl chloride
QAPP	Quality Assurance Project Plan
RAWP	Remedial Action Work Plan
RD	Remedial Design
ROD	Record of Decision
RI	Remedial Investigation
SAP	Sample and Analysis Plan
SCADA	supervisory control and data acquisition

SIM	selected ion monitoring
Sites 2/12	Sites 2 and 12
TCE	trichloroethene
USACE	U.S. Army Corps of Engineers
VFD	variable frequency drive
VOC	volatile organic compound

1.0 Introduction

Ahtna Global, LLC (Ahtna) has prepared this Operable Unit Carbon Tetrachloride Plume (OUCTP) Upper 180-Foot Aquifer Remedial Design (RD) Addendum to the *Final Operable Unit Carbon Tetrachloride Plume Upper 180-Foot Aquifer Remedial Design* (OUCTP RD; Shaw, 2010) on behalf of the U.S. Army Corps of Engineers (USACE) Sacramento District, per Contract W91238-19-C-0027. This RD Addendum addresses the remediation of groundwater within the OUCTP in the Upper 180-Foot Aquifer at the former Fort Ord, California (Figure 1).

A Remedial Investigation (RI) was conducted in the vicinity of Lexington Court (Abrams Housing Development) to define the nature and extent of volatile organic compounds (VOCs) in groundwater from an undocumented release of carbon tetrachloride from a former storage area/training facility (MACTEC Engineering and Consulting, Inc. [MACTEC], 2006).

A Human Health Risk Assessment (HHRA) was conducted to evaluate the risk associated with VOCs detected in groundwater. Remedial alternatives for contaminated groundwater within the OUCTP were developed as part of the *Final Operable Unit Carbon Tetrachloride Plume Groundwater Remedial Investigation/Feasibility Study, Former Fort Ord, California* (OUCTP RI/FS; MACTEC, 2006) and the selected remedy was identified in the *Record of Decision Operable Unit Carbon Tetrachloride Plume, Former Fort Ord California* (OUCTP ROD; Army, 2008). The RD presented in this RD Addendum addresses the remediation of the Upper 180-Foot Aquifer within OUCTP. The RDs for the other aquifers within the OUCTP are presented in the OUCTP Remedial Action Work Plan (RAWP; Shaw, 2009).

The carbon tetrachloride plume at the former Fort Ord is believed to result from routine maintenance operations conducted prior to the facility's closure. Carbon tetrachloride is present in groundwater within three aquifer units at OUCTP: the shallow A-Aquifer, the Upper 180-Foot Aquifer, and the Lower 180-Foot Aquifer. The aquifers are impacted primarily by carbon tetrachloride, with the shallow A-Aquifer representing the largest area of groundwater impact. The underlying Upper 180-Foot Aquifer and Lower 180-Foot Aquifer are impacted to a lesser extent (Figure 2 and Figure 3). A complete list of the chemicals of concern (COCs) and aquifer cleanup levels (ACLs) is provided in Table 1.

The remediation of the Upper 180-Foot Aquifer utilizes groundwater extraction and aboveground treatment to minimize further migration of the OUCTP from the Upper 180-Foot Aquifer to the Lower 180-Foot Aquifer and provides contaminant mass reduction in the aquifer. The OUCTP remedy for the Upper 180-Foot Aquifer will be expanded with one additional extraction well (EW-OU2-13-180), which will be connected to the existing groundwater extraction pipeline that conveys water to the OU2 groundwater treatment plant (GWTP). At the OU2 GWTP, the groundwater is treated through liquid-phase granular activated carbon (GAC) to remove the contaminants before the treated water is reinjected into the subsurface through existing aquifer recharge structures. Groundwater capture modeling was conducted as part of this RD Addendum to evaluate the proposed location and operating conditions for extraction well EW-OU2-13-180 to optimize capture of the OUCTP in the Upper 180-Foot Aquifer.

New extraction well EW-OU2-13-180 will be installed to improve plume capture and contaminant mass removal, with the primary purpose of preventing migration of carbon tetrachloride (CT) from the Upper 180-Foot Aquifer to the Lower 180-Foot Aquifer and downgradient drinking water supply wells. An extraction well in other locations, while potentially removing additional contaminant mass in the near term, would not meet this objective. The proposed location for EW-OU2-13-180 at the upgradient edge of the discontinuity in the Intermediate 180-Foot Aquitard accomplishes this. Additionally, currently declining CT concentration trends in the Upper 180-Foot Aquifer indicate upgradient CT mass is becoming depleted, potentially mitigating the need for additional groundwater extraction in the area of multiport well MP-BW-46-170 (Figure 2). Analysis of whether additional extraction wells or other actions are necessary is not appropriate at this time because, as stated in Section 3.2 of the OUCTP Fourth Quarter 2021 through Third Quarter 2022 Groundwater Monitoring Report (Ahtna, 2023b), progress toward achieving long-term remedy goals should be assessed after implementation of additional groundwater extraction to improve hydraulic control and containment of the OUCTP in the Upper 180-Foot Aquifer.

This RD Addendum presents the basis for the design and the specific requirements for implementation of groundwater extraction from the Upper 180-Foot Aquifer of the OUCTP and treatment within the OU2 GWTP. In addition, this RD Addendum presents a general description of the Upper 180-Foot Aquifer hydrogeology and contaminant distribution.

1.1 Hydrogeology Design Considerations

The information presented in this section outlines the hydrogeologic considerations for the design for expanding the groundwater extraction and treatment remedial action within the Upper 180-Foot Aquifer at OUCTP. The siting and installation of new extraction well EW-OU2-13-180, designed to improve plume capture and contaminant mass removal, were based on hydrogeologic factors outlined below.

The interpretation of the lithologic sequence and associated hydrogeologic characteristics within the area of OUCTP provides a framework necessary to understand groundwater flow. Knowledge of the flow of groundwater provides insight into potential pathways for the migration of carbon tetrachloride and provides the basis for placement of extraction well EW-OU2-13-180 at an optimum location and appropriate depth to remove contaminated groundwater from the Upper 180-Foot Aquifer. The remediation of the Upper 180-Foot Aquifer is designed to minimize the migration of contaminants into the underlying aquifers and, therefore, reduce potential adverse impact to water producing zones.

Previous investigations provide the basic stratigraphic sequence and present a general interpretation of the OUCTP hydrogeology. Early investigations of the general area include the *Final Fort Ord Landfills, Preliminary Hydrologic Investigation* (HLA, 1990), the *Final Remedial Investigation Report, Remedial Investigation/Feasibility Study, Fort Ord Landfills* (Dames and Moore, 1993), and *Final Basewide Remedial Investigation/Feasibility Study, Fort Ord, California, Volume II – Remedial Investigation, Basewide Hydrogeologic Characterization* (HLA, 1995). Investigations addressing the hydrogeology of the OUCTP were discussed in the OUCTP RI/FS (MACTEC, 2006).

Geologic units of interest within the OUCTP area include the aquifers within the dune sands, valley fill deposits, and the Aromas Sand/Paso Robles Formation. The A-Aquifer is located within the recent dune sands and is perched above the regional Fort Ord - Salinas Valley Aquitard (FO-SVA). Below the FO-SVA, the valley fill deposits contain both the Upper and Lower 180-Foot Aquifers, and portions of the 400-Foot Aquifer (locally). The Aromas Sand and Paso Robles Formation contain the majority of the 400-Foot Aquifer and the deep aquifer units.

The 180-Foot Aquifer in the former Fort Ord area is typically subdivided into the Upper and Lower 180-Foot Aquifers. The Upper 180-Foot Aquifer is the primary focus of this RD. The early studies of the area (HLA, 1990 and Dames and Moore, 1993) did not differentiate between the Upper and Lower 180-Foot Aquifers. Regional groundwater studies such as the U.S. Geological Survey publication *Ground-Water Quality Data in the Monterey Bay and Salinas Basins, California 2005* (USGS, 2011) generally discuss the 180-Foot Aquifer as a single unit. Data collected as part of the site investigation activities indicate the presence of the Intermediate 180-Foot Aquitard that isolates the Upper and Lower 180-Foot Aquifers throughout most of the former Fort Ord area.

The presence of carbon tetrachloride in the Upper 180-Foot Aquifer and the Lower 180-Foot Aquifer (Figures 2, 3, and 4) indicates that hydraulic intercommunication occurred between what are otherwise believed to be vertically isolated aquifers. The carbon tetrachloride plume migrated from the A-Aquifer into the Upper 180-Foot Aquifer through two known vertical conduits through the FO-SVA, creating two distinct parallel plumes. These vertical conduits (wells installed with inadequate sanitary seals) were decommissioned in 1999 and 2005. The two parallel plumes commingled and continued to migrate southeastward toward a natural vertical conduit (a discontinuity in the Intermediate 180-Foot Aquitard). Since implementation of the remedy for OUCTP in the Upper 180-Foot Aquifer in 2011, the single commingled plume has become two distinct plumes (Ahtna, 2023b). The migration of carbon tetrachloride vertically between aquifers and laterally within aquifers is dependent on both the flow properties of the aquifer and the hydrologic gradient. The flow properties of the aquifer units reflect the lithologic composition of the units. The lithologic composition and variability of the aquifer lithologies are discussed below.

1.1.1 Lithologic Description of Remediation Area

A general description of the hydrogeology in the area of the OUCTP is included in Section 3.0 of the OUCTP RAWP (Shaw, 2009). The hydrogeology of the overlying A-Aquifer and underlying Upper and Lower 180-Foot Aquifers is presented in more detail in Appendix A and Appendix C of the OUCTP RAWP, respectively. The design for groundwater extraction and treatment within the Upper 180-Foot Aquifer required the evaluation of the lithology and hydrogeologic character of the aquifer and the intercommunication between the aquifers. The geologic units directly influencing groundwater flow within the Upper 180-Foot Aquifer include the FO-SVA, the Upper 180-Foot Aquifer, the Intermediate 180-Foot Aquitard, and the Lower 180-Foot Aquifer. Cross sections were constructed to assist in the evaluation of lithology on flow within the OUCTP, specifically between the Upper 180-Foot Aquifer and the Lower 180-Foot Aquifer. The cross-section locations are presented on Figure 4. The cross sections are presented on Figure 5 (Cross Section A-A’) and Figure 6 (Cross Section B-B’).

1.1.1.1 FO-SVA

The FO-SVA separates the overlying A-Aquifer from the Upper 180-Foot Aquifer (hydrologically) over the area of the OUCTP (Figure 5 and Figure 6). The FO-SVA is a thick, dense clay unit deposited in a marine environment and contains significant organic content, occasionally in the form of peat lenses. Even though the FO-SVA represents a significant aquitard that is capable of restricting vertical flow from the A-Aquifer, intercommunication between the aquifers is indicated by the presence of carbon tetrachloride in the Upper and Lower 180-Foot Aquifers. The carbon tetrachloride, which originated in the A-Aquifer, has migrated along with groundwater into the underlying Upper 180-Foot Aquifer as discussed in Section 1.1.2.

1.1.1.2 Upper 180-Foot Aquifer

The Upper 180-Foot Aquifer underlies the relatively impermeable FO-SVA and represents the upper lithologic sequence of the generalized 180-Foot Aquifer. The upper contact of the Upper 180-Foot Aquifer occurs at depths ranging from approximately 140 to 200 feet below ground surface (bgs) which correspond to elevations of 20 to 180 feet below mean sea level (msl).

Depths mostly reflect variations in the area's surface topography. The cross sections (Figure 5 and Figure 6) illustrate the uniform contact surface between the FO-SVA and the Upper 180-Foot Aquifer. The thickness of the Upper 180-Foot Aquifer ranges from 50 feet near the western extent of cross section A-A' to over 120 feet near the eastern end (Figure 5). The variations in thickness of the aquifer are generally the result of variations in the elevation of the underlying Intermediate 180-Foot Aquitard. The lithology of the Upper 180-Foot Aquifer is relatively uniform across the OUCTP area as depicted in the cross sections. The unit is composed primarily of well to poorly graded sand deposited in relatively thick beds with single depositional units comprising a large proportion of the unit's thickness in some locations. Gravel content increases toward the base of the unit, although gravel stringers are present at shallow depths locally. Silts represent a larger proportion of the section to the southeast of the suspected area of vertical communication through the Intermediate 180-Foot Aquitard (Figure 5), where the thickness of the unit increases to greater than 100 feet.

1.1.1.3 Intermediate 180-Foot Aquitard

The Intermediate 180-Foot Aquitard underlies the Upper 180-Foot Aquifer and separates it from the Lower 180-Foot Aquifer within the OUCTP area. The contact between the Upper 180-Foot Aquifer and the underlying Intermediate 180-Foot Aquitard occurs at approximately between 70 and 100 feet below msl within the area (Figure 5 and Figure 6). This places the contact approximately between 200 and 290 feet bgs depending on ground surface elevation.

The Intermediate 180-Foot Aquitard consists of approximately 50 feet of interbedded clay and clayey sand layers, mixed occasionally with coarse gravel. The aquitard hydraulically isolates the Upper and Lower 180-Foot Aquifers, although the unit pinches out or contains more conductive lithologies in the southern portion of the OUCTP area. The pinch-out is suspected to represent an area of vertical communication between the Upper and Lower 180-Foot Aquifers. The OUCTP RI/FS (MACTEC, 2006) concluded that the Intermediate 180-Foot Aquitard pinches out locally and groundwater from the Upper 180-Foot Aquifer flows downward into the Lower 180-Foot Aquifer/400-Foot Aquifer in these locations. The area where the carbon tetrachloride plumes in the Upper 180-Foot Aquifer and the Lower 180-Foot Aquifer intersect (Figure 4) and the cross sections shown in Figures 5 and Figure 6 support the presence of a zone of vertical communication. The thin layers of the Intermediate 180-Foot Aquitard that are apparent in well MP-BW-42 and well MW-OU2-69-180L (below -70 feet msl) are not present in well MP-BW-49 (Figure 5). The area depicted on Figure 5 represents the bounds of an area of vertical communication that influences (promotes) the vertical migration of groundwater. The lack of continuity of the Intermediate 180-Foot Aquitard is important to vertical groundwater flow and the migration of contaminants in the groundwater.

1.1.1.4 Lower 180-Foot Aquifer

The Lower 180-Foot Aquifer consists of approximately 200 feet of coarse sand and gravel and, along with the 400-Foot Aquifer, is a significant source of potable water for the former Fort Ord and City of

Marina. Remedial actions for the Lower 180-Foot Aquifer are discussed in Appendix C of the OUCTP RAWP (Shaw, 2009).

1.1.2 Intercommunication Between Aquifers

Several wells had been installed within the area of the OUCTP near Reservation Road for municipal water supply and environmental investigations before the OUCTP was discovered. A limited number of these wells are believed to have been constructed through the aquitard units (the FO-SVA and/or the Intermediate 180-Foot Aquitard) without adequate annular seals (MACTEC, 2006). The lack of an adequate seal in the aquitard material at the well locations would allow groundwater to migrate between the aquifers. Basin-wide groundwater withdrawal from the deep aquifers has created hydrologic conditions that promote downward migration of groundwater. When these wells were discovered to be potential migration pathways for the OUCTP between the aquifers, the wells were removed and the conduits through the aquitards were filled with cement grout to seal them.

The wells suspected of being vertical migration pathways included water production wells FO-26, FO-27, and FO-28, located at the western Fort Ord boundary south of Reservation Road, which were shut down in 1991 due to concerns about saltwater intrusion and were decommissioned in 1999 (HLA, 1999). Monitoring well MW-B-13-180, where carbon tetrachloride was detected in September 1992 (HLA, 1994), was also suspected as a potential path of vertical migration and was monitored quarterly until it was decommissioned in 2005. A production well installed in 1996 at the Marina Mini-Storage location north of Reservation Road was also a suspected vertical migration route and was being monitored quarterly; however, carbon tetrachloride had not been detected above the ACL at the Mini-Storage well since 2015 and the well was removed from the groundwater monitoring program in 2021.

1.2 Operable Unit 2 Groundwater Extraction and Treatment System

The original OU2 groundwater treatment system (GWTS) commenced operations on October 23, 1995 and consisted of 13 A-Aquifer and two Upper 180-Foot Aquifer extraction wells, the OU2 GWTP, three Upper 180-Foot injection wells, five A-Aquifer infiltration wells, and interconnecting underground groundwater extraction and treated water conveyance pipelines. The OU2 GWTP consisted of two 20,000-pound liquid-phase GAC adsorption vessels; one backwash tank; a 10,000-gallon effluent tank; and ancillary pumps, piping, instrumentation, and system controls. In 1999, an 8-inch pipeline was installed between the OU2 GWTP and the Sites 2 and 12 (Sites 2/12) GWTP, allowing an average of 300 gallons per minute (gpm) of excess treated water from OU2 to be conveyed to Sites 2/12. The combined OU2 and Sites 2/12 treated water was then conveyed west of State Route 1 for aquifer recharge.

In 2001, the OU2 GWTS was upgraded to handle additional flow capacity. Three A-Aquifer and four Upper 180-Foot Aquifer wells were installed and connected to the existing groundwater extraction pipeline. The OU2 GWTP was expanded to include two additional 20,000-pound liquid-phase GAC adsorption vessels and one additional backwash tank. Two treated water infiltration galleries were installed and the five A-Aquifer infiltration wells were decommissioned. These changes roughly doubled the throughput capacity of the OU2 system and the treatment capacity of the GWTP following the installation of the additional GAC vessels exceeded 1,200 gpm.

In 2002, the dual contained pipeline running parallel to the former 12th Street was rerouted when 12th Street was realigned and upgraded into a four-lane street (Imjin Parkway). Although the nominal pipe size was the same for the new pipeline, switching from polyvinyl chloride (PVC) to high-density polyethylene (HDPE) resulted in a decrease of the nominal inside pipe diameter and, therefore, a reduced flow capacity for this section of pipeline.

In 2006 and 2007, a Phase II expansion was completed to address the capture and treatment of the eastern edge of the Upper 180-Foot Aquifer impacted by trichloroethene (TCE). The Phase II expansion included the installation of two Upper 180-Foot Aquifer extraction wells (EW-OU2-07-180 and EW-OU2-08-180), installation of approximately 3,600 feet of conveyance pipeline from the newly installed wells around an existing housing development to the existing extraction conveyance pipeline, relocating approximately 1,100 feet of existing extraction conveyance pipeline around an intersection to minimize proposed transit right-of-way issues, and installing an in-line booster pump at the OU2 GWTP to increase groundwater extraction capacity. Following the Phase II expansion, the OU2 system included 24 extraction wells, the OU2 GWTP, two infiltration galleries, three injection wells, and a treated water pipeline to the Sites 2/12 GWTP.

On October 12, 2018, the original OU2 GWTP located at 296 12th Street in Marina, California was shut down permanently to transition to the new OU2 GWTP located at the Fort Ord Landfills at 11000 Engineering Equipment Road in Marina, California. Full-time operation of the new OU2 GWTP began on November 30, 2018 and the OU2 groundwater remedy currently consists of the GWTP, seven extraction well networks (30 extraction wells total), four injection wells, and two infiltration galleries. Improvements included constructing:

- New extraction wells north of the Fort Ord Landfills.
- A new OU2 GWTP near the Fort Ord Landfills to replace the original GWTP, which was located near the western extraction well network.
- Two new injection wells southeast of the Fort Ord Landfills (IW-OU2-04-180 and IW-OU2-05-180).

The OU2 GWTP is currently operated in accordance with the *Final Operations and Maintenance Manual Revision 4, Operable Unit 2 Groundwater Treatment System, Former Fort Ord, California* (O&M Manual; Ahtna, 2022) at a nominal flowrate of approximately 1,000 gpm, which is well below the design average flowrate of 1,600 gpm. Sampling and analysis of groundwater are conducted to monitor remediation progress and support systems operations in accordance with the *Quality Assurance Project Plan, Former Fort Ord, California, Volume I, Appendix A, Final Revision 11, Groundwater Remedies and Monitoring at Sites 2 and 12, Operable Unit 2, and Operable Unit Carbon Tetrachloride Plume* (QAPP; Ahtna, 2023c).

1.3 Plume Capture Strategy

Contaminated groundwater within the OUCTP generally migrated from the source area in the A-Aquifer toward the northwest. A portion of the contaminated groundwater migrated downward through the FO-SVA at specific locations into the Upper 180-Foot Aquifer (see Section 1.1.2) creating two distinct parallel plumes. The two parallel plumes commingled starting in 2006 (MACTEC, 2007), but split into separate northern and southern plumes in 2016 (AEI, 2017), likely due to operation of extraction well EW-OU2-09-180 since 2011, which constitutes the remedy for OUCTP in the Upper 180-Foot Aquifer. However, groundwater monitoring data indicate that the plume continues to migrate southeast toward an area of vertical communication through the Intermediate 180-Foot Aquitard. Groundwater appears to be migrating downward into the Lower 180-Foot Aquifer at this location. Within the Lower 180-Foot

Aquifer, the contaminated groundwater migrates to the east in the direction of three municipal water production wells (FO-29, FO-30, and FO-31), which are owned and operated by the Marina Coast Water District. In September 2022, contaminated water from the OUCTP in the Upper 180-Foot Aquifer was approximately 3,000 feet from the nearest groundwater production well (FO-29), as shown on Figure 4.

The objective of the remedial action within the OUCTP Upper 180-Foot Aquifer is to minimize further impact to the Lower 180-Foot Aquifer by extracting groundwater from the downgradient edge of the plume in Upper 180-Foot Aquifer to remove contaminant mass and to capture the plume before it reaches the area of vertical communication through the Intermediate 180-Foot Aquitard. The OUCTP ROD (Army, 2008) assumes that existing extraction wells EW-OU2-07-180 and EW-OU2-08-180 would be pumped for capture of the majority of the Upper 180-Foot Aquifer plume in conjunction with potential future extraction wells. These wells were installed primarily as part of the OU2 remedy and not specifically to capture the OUCTP.

Since extraction wells EW-OU2-07-180 and EW-OU2-08-180 are located cross-gradient of the OUCTP in the Upper 180-Foot Aquifer and the edge of the area of vertical communication, they do not provide carbon tetrachloride mass removal nor do they capture the plume prior to it migrating through the Intermediate 180-Foot Aquitard. Therefore, as described in the OUCTP Upper 180-Foot Aquifer Remedial Action Construction Completion Report (Shaw, 2012), extraction well EW-OU2-09-180 was installed in the vicinity of monitoring wells MW-BW-56-180 and MW-OU2-64-180 (Figure 2), where some of the highest carbon tetrachloride concentrations had been measured in the Upper 180-Foot Aquifer, and has been in operation since September 2011. Extraction well EW-OU2-09-180 is installed with a screened interval within the Upper 180-Foot Aquifer to meet the objective of plume capture and is connected to the OU2 GWTS; however, carbon tetrachloride was not detected in this well until 2014. Since then, there have been several estimated detections at concentrations below the ACL, with the historical maximum of 0.21 J micrograms per liter (µg/L) detected in 2016, demonstrating the relative inefficiency of this extraction well over its lifespan.

Groundwater modeling shows extraction well EW-OU2-09-180 only partially captures the carbon tetrachloride plumes in the Upper 180-Foot Aquifer, and this partial capture may also only be seasonal due to changes in groundwater flow induced by downgradient agricultural supply wells. The simulated capture zone appears wide enough to encapsulate the southern part of the carbon tetrachloride plume located upgradient of EW-OU2-09-180, but the average annual flow direction may be somewhat offset from the long axis of the carbon tetrachloride plume in this area and the downgradient portion of the plume, located east of EW-OU2-09-180 and adjacent to the discontinuity in the Intermediate 180-Foot Aquitard, is not being captured (Ahtna, 2023a).

To capture the downgradient carbon tetrachloride plume in the Upper 180-Foot Aquifer before it enters the Lower 180-Foot Aquifer, an additional extraction well (EW-OU2-13-180) will be installed with a screened interval within the Upper 180-Foot Aquifer in the vicinity of monitoring wells MW-OU2-64-180 and MW-OU2-66-180 (Figure 4). This well will be connected by conveyance piping to the OU2 GWTP for groundwater treatment. Minor adjustment will be required in the operation of the OU2 GWTP to incorporate control of extraction well EW-OU2-13-180 and to balance flowrates from EW-OU2-13-180 with existing extraction flowrates.

A groundwater flow and transport simulation was developed to evaluate the proposed location and design flowrate for the proposed extraction well using the basewide numerical groundwater flow model (the "model"), which is used to simulate groundwater conditions beneath the former Fort Ord. The model was updated in January 2016 (USACE-HEC, 2016) to evaluate hydraulic capture of COCs by the A-Aquifer and Upper 180-Foot Aquifer extraction wells. The model was updated in 2017 to extend the model domain 400 feet vertically and 1,000 feet horizontally to the south. The model was further updated in 2018 to include a "wave-cut terrace" conceptualization to assist in the simulation of observed sharp drops in water levels in the A-Aquifer. Additionally, the number of homogeneous hydraulic conductivity zones was reduced based on limited field data and the concept of appropriate complexity. In the 2022 model update, several boundary conditions (recharge, river boundary, ocean boundary, etc.) were updated based on available data. The number of wells used for calibration was increased to include all applicable monitoring well data. This includes wells in the A-Aquifer, Upper and Lower 180-Foot Aquifers, and the 400-Foot Aquifer. Hydraulic conductivity values in geologic units were adjusted using both manual and automated parameter estimation techniques to obtain a reasonable model calibration. Additionally, pilot points were used in the A-Aquifer to capture the special variation of hydraulic conductivity in that model layer. More details about previous model updates and the 2022 model update are provided in Attachment A.

The model simulates backward-tracking groundwater flow paths induced by operation of extraction wells. The simulation was run using the first quarter of 2022 (average period) calibration parameters (Simulation 2a) and the third quarter of 2022 (dry period) calibration parameters (Simulation 2b). Additional simulations assuming a flowrate of 30 gpm were also performed using the first quarter of 2022 (average period) calibration parameters (Simulation 2a30) and the third quarter of 2022 (dry period) calibration parameters (Simulation 2b30). The details of the latest groundwater modeling effort in 2022 are presented in Attachment A and summarized below. The model will be refined and some adjustments may be made to the final system design, construction, and operation as data are collected from well installation and testing activities.

The RD modeling effort included a baseline particle-tracking simulation using the existing regional groundwater flow and transport model to evaluate the current groundwater flow regime. Particle tracking was conducted using backward particle tracks over a duration of 15 years with 18 particles evenly distributed at each cell containing an extraction well (Attachment A). The simulation indicated that the addition of extraction well EW-OU2-13-180 will enhance capture of the carbon tetrachloride plumes in the Upper 180-Foot Aquifer. However, the variations in the regional groundwater flow patterns during the dryer calibration period indicate that extent of capture may be variable due to changes in recharge and regional pumping. These model results are consistent with historical data collected in the field and the current understanding of OUCTP migration.

The proposed location for new extraction well EW-OU2-13-180 is approximately 841 feet east of extraction well EW-OU2-09-180 at the upgradient edge of the discontinuity in the Intermediate 180-Foot Aquitard (Figure 7). This location is in the vicinity of MW-OU2-64-180 where some of the highest carbon tetrachloride concentrations have been measured recently. Placement of the well in this area is expected to remove most of the carbon tetrachloride mass in the plume before it can migrate downward into the Lower 180-Foot Aquifer. Four model scenarios were developed to simulate groundwater plume capture under potential conditions within the new extraction well area. The model scenarios were developed to evaluate potential design and operating parameters based on previously observed site conditions. The four scenarios include:

1. New extraction well EW-OU2-13-180 with:
   a. Pumping at a flowrate of 60 gpm (based on performance of nearby extraction wells EW-OU2-08-180 and EW-OU2-09-180)
   b. Calibration parameters developed from evaluating available data for the first quarter of 2022 (average period)
2. New extraction well EW-OU2-13-180 with:
   a. Pumping at a flowrate of 30 gpm
   b. Calibration parameters developed from evaluating available data for the first quarter of 2022 (average period)
3. New extraction well EW-OU2-13-180 with:
   a. Pumping at a flowrate of 60 gpm
   b. Calibration parameters developed from evaluating available data for the third quarter of 2022 (dry period)
4. New extraction well EW-OU2-13-180 with:
   a. Pumping at a flowrate of 30 gpm
   b. Calibration parameters developed from evaluating available data for the third quarter of 2022 (dry period)

Scenario 1: Groundwater modeling indicates that an additional extraction well pumping at 60 gpm would remove most of the mass of carbon tetrachloride from the Upper 180-Foot Aquifer that is not captured by extraction well EW-OU2-09-180 and intercept the carbon tetrachloride before it could migrate downward to the Lower 180-Foot Aquifer. The modeled simulations also indicated that the capture zone of this well would also encompass most of the current plume extent east of extraction well EW-OU2-09-180 and a portion of the current plume extent northwest of extraction well EW-OU2-09-180 during the average period (Attachment B, Figure 1).

Scenario 2: This scenario assumes the flowrate for new extraction well EW-OU2-13-180 is 30 gpm due to limitations in OU2 GWTS capacities (e.g., pipeline back pressure due to operation of EW-OU2-09-180), the aquifer itself, or other factors. Groundwater modeling results are similar to Scenario 1, indicating the additional extraction well pumping at a reduced flow rate during the average period will still be effective in removing the mass of carbon tetrachloride from the Upper 180-Foot Aquifer and preventing carbon tetrachloride mass from entering the Lower 180-Foot Aquifer (Attachment B, Figure 2).

Scenario 3: This scenario assumes the flowrate for new extraction well EW-OU2-13-180 is 60 gpm. Groundwater modeling results indicate a reduced capture area for the southern carbon tetrachloride plume in the Upper 180-Foot Aquifer and no capture of the northern carbon tetrachloride plume in the Upper 180-Foot Aquifer during the dry period; however, continued operation new extraction well EW-OU2-13-180 will still remove carbon tetrachloride mass before it could migrate downward to the Lower 180-Foot Aquifer (Attachment B, Figure 3).

Scenario 4: This scenario assumes the flowrate for new extraction well EW-OU2-13-180 is 30 gpm due to limitations in OU2 GWTS capacities (e.g., pipeline back pressure due to operation of EW-OU2-09-180), the aquifer itself, or other factors. Groundwater modeling results are similar to Scenario 3, but new extraction well EW-OU2-13-180 operating at 30 gpm captures a smaller plume area and may not be as effective at preventing downward migration of the OUCTP to the Lower 180-Foot Aquifer (Attachment B, Figure 4).

The groundwater modeling results indicate the operational flowrate for new extraction well EW-OU2-13-180 should be 60 gpm or greater to most effectively capture the OUCTP in the Upper 180-Foot Aquifer and prevent migration of carbon tetrachloride to the Lower 180-Foot Aquifer. The modeling results also indicate lower flowrates will still effectively remove carbon tetrachloride mass before it can migrate to the Lower 180-Foot Aquifer.

The modeling results also indicate new extraction well EW-OU2-13-180 either only partially captures the northern carbon tetrachloride plume during the average period or does not capture the northern carbon tetrachloride plume during the dry period. However, data for OUCTP in the Upper 180-Foot Aquifer indicate the northern carbon tetrachloride plume is attenuating and will likely migrate into the capture area of new extraction well EW-OU2-13-180 at it moves toward the discontinuity in the Intermediate 180-Foot Aquitard (Ahtna, 2023b). Therefore, analysis of whether additional actions are necessary to address the northern carbon tetrachloride plume will be conducted after implementation of additional groundwater extraction to improve hydraulic control and containment of the OUCTP in the Upper 180-Foot Aquifer before it can migrate to the Lower 180-Foot Aquifer.

The final design and construction of the groundwater extraction and treatment system will depend on field and aquifer conditions encountered during the well installation and testing activities. The implementation strategy for the remedial action will include provisions for adapting the system design as required (e.g., an alternating pumping strategy or optimized flow rates for operating extraction wells in the Bunker Hill network).

Remedial action implementation will proceed as sequential activities that will include sufficient flexibility for site professionals to respond to field conditions. The hydraulic properties of the Upper 180-Foot Aquifer within the proposed extraction area and the ability of extraction well EW-OU2-13-180 to produce water will determine the final configuration of the system. The design and operation of the extraction and conveyance system will depend on extraction rates. The proposed sequence of implementation is as follows:

1. Installation of extraction well EW-OU2-13-180 with a screen interval based on the lithologic sequence encountered.
2. Well development and specific capacity testing to maximize and test well production.
3. Hydrogeologic testing to refine aquifer parameters for additional design.
4. Refinement of the groundwater model (if required).
5. Evaluation of the current design and making adjustments, as necessary, in planned GWTS operations.
6. Redesigning the system only if remediation cannot be achieved as specified in this RD Addendum.

The implementation of the remedial action will proceed through the sequence discussed above to the extent required to install and operate the groundwater extraction and treatment system. The steps required are dependent on each previous step. If installation of the one additional extraction well provides sufficient quantity of water and yields the desired effects upon the aquifer, no further well-performance testing work will be required and the remainder of the system will be installed as specified. If testing results indicate installation of the one additional extraction well cannot achieve remediation goals per this RD Addendum, further well-performance testing work may be conducted to collect additional data to support system redesign. General information regarding hydrogeologic testing is provided in Section 4.1.2 and a detailed description of testing procedures will be included in a forthcoming Remedial Action Work Plan (RAWP) and Quality Assurance Project Plan (QAPP).

1.4 Design Basis

The OUCTP ROD (Army, 2008) specifies groundwater extraction and treatment using the OU2 GWTP as the remedial action for the Upper 180-Foot Aquifer. Based on the results of the plume capture model, a single well can be used to extract groundwater from the downgradient edge of the OUCTP Upper 180-Foot Aquifer to minimize further migration into the Lower 180-Foot Aquifer. The proposed location of extraction well EW-OU2-13-180 is shown on the figures. Based on the plume capture model results, a design extraction flowrate of at least 60 gpm is desired for plume capture. Conveyance piping from extraction well EW-OU2-09-180 is located within approximately 841 feet of the proposed extraction well location and conveyance piping from proposed extraction well EW-OU2-13-180 could be connected to the existing conveyance pipeline near EW-OU2-09-180. The construction drawings included in Attachment C show the existing OU2 GWTS construction details.

An electrical panel located near existing extraction well EW-OU2-08-180 includes sufficient capacity for expansion to include power to proposed extraction well EW-OU2-13-180. The electrical equipment within the panel was originally designed for future expansion and includes a circuit breaker panel with spare slots, and a programmable logic controller (PLC) with spare input and output slots for the instrumentation required for the proposed extraction well. However, the DirectLOGIC 405 PLC at Bunker Hill is obsolete and should be upgraded to an Allen-Bradley MicroLogix 1400 PLC, or similar. The construction drawings included in Attachment C show the existing electrical details. The following sections provide details of the design considerations for extraction well EW-OU2-13-180 and incorporation of the proposed well into the existing OU2 GWTS.

1.4.1 Extraction Well

Extraction well EW-OU2-13-180 will be installed at the location shown on Figure 7 and screened across the Upper 180-Foot Aquifer. Based on historical data in the area, the Upper 180-Foot Aquifer spans approximately 150 to 220 feet bgs. This depth will be targeted for the screen interval for extraction well EW-OU2-13-180, but adjustments may be required in the field based on data collected during the boring construction.

Since several extraction wells have already been installed within the Upper 180-Foot Aquifer in the vicinity of the proposed extraction well, construction of the proposed well will use similar drilling methods and construction materials. The as-built construction drawings from extraction well EW-OU2-09-180 and boring logs monitoring wells MW-OU2-64-180 and MW-OU2-66-180 (Attachment D) will be used as the primary guidance for the design of proposed extraction well EW-OU2-13-180.

Extraction well EW-OU2-13-180 will be located within the Fort Ord Natural Reserve (FONR). Work within the FONR requires specific consideration to minimize impact to listed and endangered plants and animals. The specific requirements for working within the FONR as part of the OUCTP remedial action are addressed in Section 10 of the main OUCTP RAWP (Shaw, 2009).

1.4.2 Treatment Using Operable 2 Groundwater Treatment System

The OU2 GWTP is designed and operated to treat groundwater contaminated with VOCs (primarily TCE). Carbon tetrachloride is included as a COC for OU2 so operation of the system, including sample analysis and evaluation of discharge requirements and GAC changeout frequency, already includes considerations for the COCs found in the OUCTP Upper 180-Foot Aquifer.

Based on the original design, subsequent modifications, and recent operating conditions, the OU2 GWTP has sufficient capacity to accommodate the additional flow from proposed extraction well EW-OU2-13-180. In addition, as described above, the system was designed for future expansion in the area near existing extraction wells EW-OU2-07-180, EW-OU2-08-180 and EW-OU2-09-180. Other than upgrading the Bunker Hill PLC, adding proposed extraction well EW-OU2-13-180 to the existing GWTS should require only minor modification in the system control parameters and balancing of the additional extraction flow with the current extraction flowrates. This balancing of flowrates is common during the normal operation of the OU2 GWTS.

2.0 Remedial Approach

The remediation of the OUCTP Upper 180-Foot Aquifer will be achieved through the application of groundwater extraction and treatment. The groundwater extraction will be achieved from one existing extraction well (EW-OU2-09-180) and one new extraction well (EW-OU2-13-180) located near the downgradient edge of the plume within the Upper 180-Foot Aquifer. The groundwater model will be updated based on data collected during hydrogeologic testing conducted following well installation and start-up activities. The model updates will be used to optimize system operating parameters.

Monitoring will be conducted before, during, and following operation of extraction well EW-OU2-13-180 to optimize GWTS operations, evaluate GWTS effectiveness, overall plume remediation, and plume capture, and support site closure. Monitoring will include sampling and analysis at the GWTP, the extraction wells, and surrounding monitoring wells. Monitoring will also include process measurements and water level measurements to evaluate system operations and plume capture.

The following sections describe the extraction and treatment requirements to achieve remediation. Monitoring requirements are addressed in Section 5.0.

2.1 Extraction Requirements

Extraction well EW-OU2-13-180 will be installed in the location shown on Figure 7 and will be designed to optimize groundwater recovery. A downhole submersible pump of sufficient capacity will be installed in the well to pump groundwater at the design flowrate from the extraction well to the OU2 GWTP through new and existing conveyance piping. The pump will be controlled by a downhole pressure transducer and variable frequency drive (VFD) to minimize cycling.

The extracted groundwater flowrate will be measured and controlled at the wellhead before it enters the groundwater extraction conveyance piping. A flowmeter will be installed at the wellhead to measure instantaneous and cumulative flow from the well. The wellhead piping will also include a pressure switch to shut off the pump if a blockage occurs in the conveyance pipeline resulting in excess pressure in the well pipeline. A globe valve will be installed in the wellhead piping to control the extraction flowrate. A check valve and gate valve will also be installed in the wellhead piping to ensure that untreated water from the main extraction conveyance pipeline does not back up into the extraction well. Components at the wellhead will be installed in a concrete vault for security and to provide secondary containment in case of a leak in the process piping. The vault will be traffic rated and include a lockable lid. The vault will also include a sump to collect water and level switch to notify the operator of a leak in the system piping and shut off the extraction pump to minimize the release of contaminated groundwater in the event of a leak.

Conveyance piping between extraction well EW-OU2-13-180 and existing groundwater extraction piping will be double-contained to minimize the potential for a release if the conveyance pipe were to leak. The conveyance pipe will be sufficiently sized for the pump design capacity and to minimize friction loss. High-point, low-point, and leak detection vaults will be placed along of the length of the new conveyance piping as required. At the location that the well conveyance piping ties into the existing extraction conveyance pipeline, an isolation valve will be installed to allow for extraction well EW-OU2-13-180 to be isolated from the rest of the OU2 GWTS. Power and control for the system will come from the panel located near extraction well EW-OU2-08-180. Control for proposed extraction well EW-OU2-13-180 will be incorporated into the overall control for the existing GWTS.

2.2 Treatment Requirements

Contaminated groundwater from new extraction well EW-OU2-13-180 will be mixed with contaminated groundwater from the existing OU2 extraction wells in the extraction conveyance pipeline. The mixed groundwater will be treated through liquid-phase GAC at the OU2 GWTP. Since carbon tetrachloride is already a COC for the OU2 system, no additional treatment or monitoring requirements are necessary. Because higher concentrations of carbon tetrachloride may be delivered to the GWTP relative to current levels, breakthrough of carbon tetrachloride in the GAC vessels will be monitored to ensure it does not drive GAC usage or reduce time between GAC changeouts.

3.0 System Components

The remedial system components for the OUCTP Upper 180-Foot Aquifer consist of an extraction well and mechanical equipment (pump, piping, instrumentation, and controls) to extract groundwater and convey it to the OU2 GWTP. Installation of extraction well EW-OU2-13-180 and conveyance piping will be conducted after pre-construction activities are completed in accordance with Section 9.0 of the OUCTP RAWP (Shaw, 2009). Since this work will be completed within the FONR, protection of environmental resources (primarily listed species and species of concern) will be an important part of intrusive activities. Requirements that will be implemented for the protection of listed species and species of concern are described in Section 10.4 the OUCTP RAWP (Shaw, 2009). The following sections provide the requirements for installation of the extraction well and mechanical equipment.

3.1 Extraction Well

A well will be installed to extract groundwater from the Upper 180-Foot Aquifer to support contaminant mass removal and capture of the OUCTP within the Upper 180-Foot Aquifer to minimize further migration into the Lower 180-Foot Aquifer. Well installation includes the following activities:

- Borehole drilling
- Geologic logging of the boring (continuous core, drive samples, or auger returns)
- Installation of well
- Well development and specific capacity testing

Extraction well EW-OU2-13-180 will be installed within the Upper 180-Foot Aquifer using a truck-mounted mud rotary, sonic, or air rotary casing hammer drill rig. Regardless of the drilling method, continuous sampling will be performed when the borehole is within the expected depth range of the screen interval (approximately 185 to 225 feet bgs). The final depth of the boring and position of the well screen shall be determined in the field by the field geologist.

Well installation and construction materials will comply with the *California Well Standards, Water Wells, Monitoring Wells, Cathodic Protection Wells, Bulletin 74-90* (Supplement to Bulletin 74-81) (DWR, 1991). Proposed extraction well EW-OU2-13-180 will be constructed similar to extraction well EW-OU2-09-180 and installed such that the bottom of the extraction well is at the approximate depth of the top of the Intermediate 180-Foot Aquitard. The planned installed depth for the well is approximately 225 feet bgs. Extraction well EW-OU2-13-180 will be screened to extend approximately 40 feet above the top of the Intermediate 180-Foot Aquitard. A piezometer tube will be installed in the same boring to the same depth and with the same screen interval as the extraction well. A diagram of a typical extraction well is provided on Figure 8 and Attachment C, Drawing No. CU6. The materials and specifications for the completion of the extraction well are summarized in Table 2. The specific construction materials and methods of drilling, soil logging, and well installation are summarized in the following sections. Additional information regarding well drilling, construction, and development is in Attachment E, Section 33 51 39.

3.1.1 Well Construction Materials

Well construction materials will be in accordance with the *California Well Standards, Water Wells, Monitoring Wells, Cathodic Protection Wells, Bulletin 74-90* (Supplement to Bulletin 74-81) (DWR, 1991).

The material specifications for proposed extraction well EW-OU2-13-180, well instrumentation and associated piping are included in Attachment C, Attachment E, and discussed in general below.

3.1.1.1 Well Casing

Casing for the proposed well and the piezometric tube will consist of flush-joint, threaded, Schedule 80 PVC manufactured per ASTM International (ASTM) F480. The specific casing diameter is included in Table 2 and Attachment C, Drawing No. CU6. Casing will be clean and new and joints between casing and screen will be compatible.

3.1.1.2 Well Screen

The piezometric tube screen will consist of new Schedule 80 PVC, 1.5 inches in diameter and with a slot size of 0.020 inch. The total piezometric tube screen length (approximately 40 feet) will be comprised of 10-foot sections. The extraction well screen will consist of new Type 316 stainless steel, 10 inches in diameter and with a slot size of 0.045 inch. The total extraction well screen length (approximately 40 feet) will be comprised of 10-foot sections. Extraction well screen will be wire wrapped, with the wire welded to an internal structure. The wire will be V-shaped in the cross section so the slots between the wires widen inward to minimize clogging. A bottom cap will be installed at the bottom of each well. The specific casing diameter, slot size, and bottom cap length are summarized in Table 2 and Attachment C, Drawing No. CU6.

3.1.1.3 Centralizers

The well will be constructed with centering guides comprised of stainless steel. Mounting will be provided such that centering guides can be securely attached to the well riser. Centralizers will be positioned to ensure the well screen in the center of the borehole. One centralizer will be placed above the screen and bentonite seal, with the remaining centralizers spaced approximately every 40 feet upward for the remainder of the casing.

3.1.1.4 Filter Pack and Fine Sand

A filter pack will be placed around the well screen and will extend 5 feet above the top of the well screen. The filter pack will consist of SiLibeads® (or equivalent glass beads) or clean, washed, rounded to subrounded siliceous sand material that is free from calcareous grains or material. The gradation of the filter pack is included in Table 2. The uniformity coefficient of the filter pack material will not exceed 2.5. The well will have 3 feet of fine sand placed directly above the filter pack sand. The fine sand will be well-sorted and have a predominant grain size of between 0.42 millimeter and 0.074 millimeter. Filter pack sand and fine sand will be hard, durable, and have an average specific gravity of not less than 2.50. The sand will be visibly free of clay, dust, micaceous, and organic matter.

3.1.1.5 Well Seal and Grout

A 5-foot bentonite seal will be placed directly above the fine sand filter pack using a tremie pipe. A bentonite-cement grout seal will be used in the construction of the well and placed directly above the bentonite seal. The well will be grouted to within 36 inches of ground surface. The bentonite-cement grout will be mixed in the ratio of 5 pounds bentonite gel, one 94-pound bag of Type I Portland cement, and 7 gallons of clean, potable water. The grout will have a weight of approximately 15.3 pounds per gallon. Cement will meet requirements of ASTM C150-00. Neither additives nor borehole cuttings shall be mixed with the grout.

3.1.2 Borings

The boring will be completed under the supervision of the professional geologist, who will be responsible for borehole logging, well installation, and development. The logging will be conducted in accordance with the Unified Soil Classification System. The boring will be drilled to the top of the Intermediate 180-Foot Aquitard, which is anticipated to be approximately 225 feet bgs. Continuous core sampling will be conducted over intervals of interest as required to determine aquifer lithology and depth of the Intermediate 180-Foot Aquitard. A core sample will be collected from the bottom of the boring to confirm the highly plastic clay common to the Intermediate 180-Foot Aquitard is encountered. The final depth of the boring and position of the well screen shall be determined in the field by the field geologist.

Drilling methods must prevent the collapse of formation material against or within 2 inches of the well screen and casing during installation and development of the well. If necessary, a temporary well casing of either iron or steel may be used to support the sides of the hole during drilling and placement of the screen, riser filter pack, and grout. Temporary casing shall have an internal diameter large enough to provide a 2-inch minimum annular space entirely around the well for sufficient thickness to retain its shape and maintain a true section throughout its depth.

The use of drilling mud during the rotary drilling operations requires careful management of drilling fluids both during drilling and during well installation. The drilling mud physical properties (filter cake thickness, fluid viscosity, sand content, and fluid density) will be monitored during the drilling of the boring. The maintenance of proper drilling mud consistency minimizes the invasion of drilling mud into the formation and reduces well development requirements. The drilling mud parameters will be measured and documented while drilling is in progress. Ideally, the parameters should be taken at intervals of 100 feet drilling progress. Drilling conditions may modify the practicality of measurement at these intervals. Use of additives to drilling mud installation should be avoided and will be pre-approved by the professional geologist. Water from a clean source may be used to assist drilling and well installation. The volume of water used at each well must be monitored and recorded.

3.1.3 Assembly of Well

The final position of the well screen shall be determined in the field by the field geologist. Filter pack will be placed around the well within the saturated zone. The filter pack will extend from a minimum of 1 foot beneath the bottom of the well to 5 feet above the top of the well screen. Three feet of fine sand will be placed above the filter pack. A 5-foot bentonite seal will be placed above the fine sand. The annular space from the top of bentonite seal to 36 inches bgs will consist of bentonite-cement grout. A diagram of a typical well is provided on Figure 8 and Attachment C, Drawing No. CU6. Well construction materials will be new, clean, and in good condition. If the protective plastic shipping sleeve is damaged, screen and casing will be decontaminated immediately prior to installation in the boring as described in Section 3.1.1.8. Care will be taken to ensure the pipe does not contact the ground. Joints and other accessory parts will be securely fastened prior to installation in the borehole. The screen and casing will be placed in the hole in such a manner as to avoid jarring impacts and to ensure the assembly is not damaged. Each well screen and casing will be emplaced while the temporary casing (depending on the drilling method used) is still in place in the boring. The well will be plumb, true, and centered in the hole by the use of centralizers. No centralizers shall be placed on the screen sections; one will be placed above the screen and bentonite seal, with the remaining centralizers spaced approximately every 40 feet upward for the remainder of the casing. Excessive misalignment or binding will be corrected before placing the filter pack.

3.1.3.1 Filter Pack Placement

To prevent compression of the well screen, the casing and screen will be suspended in the borehole until the filter pack is placed. The filter pack will be tremied into place, from the bottom of the borehole up, in such a manner as to ensure uniform placement around the screen. Temporary casing will be withdrawn from the boring as the filter pack is placed in a manner that will not cause the well to be displaced. During placement of the sand pack, frequent measurement of the top of the sand pack will be made to assure the bottom of the drive casing is not higher than 2 feet below the top of the sand pack. Water added to the sand during the tremie operation will be from a known clean source. The volume of water added will be monitored and recorded. Filter pack material will be protected from contamination prior to placement by either storing it in plastic-lined bags or in a location protected from the weather and contamination on plastic sheeting. Filter pack materials will be transported to the site in a manner that prevents contamination by other soils, oil and grease, and other chemicals.

3.1.3.2 Bentonite Seal and Grout Placement

The well will have 3 feet of fine sand placed directly above the filter pack and a bentonite seal placed directly above the fine sand. The fine sand and bentonite seal are intended to keep the bentonite-cement grout from infiltrating into the filter pack. Prior to placement of the seal, soundings will be conducted to verify the filter pack extends 5 feet above the top of well screen elevation. If it does not, sufficient filter pack material will be added to bring the pack to the specified level for the given well design. The bentonite seal will be added via a tremie pipe.

The well will be grouted to 36 inches bgs with a bentonite-cement grout. The grout will be placed by tremie pipe submerged in grout after initial placement of grout. The tremie pipe may be raised as the grout is placed as long as the discharge end remains submerged in grout. Additional grout will be added from the surface to maintain the level of grout, as specified, as settlement occurs.

3.1.4 Well Development and Sampling

Within one week after the well has been constructed, but no sooner than 48 hours after grouting is completed, the well will be developed using a bailer, vented surge block, and submersible pump. The total depth of the well and the depth to water measurements will be used to calculate the volume of water in the well casing. The well will be developed by alternately bailing and surging with a vented surge block. Care shall be taken so as not to dislodge the end plug or to disturb the well casing and screen. The well will be bailed prior to surging to remove debris.

Following bailing, the well screen will be carefully surged for a minimum of 15 minutes. During well surging, the vented surge plug will be placed at different depths within the screened portion of the well to expedite well development. If this development technique does not produce satisfactory results within one hour, then pumping the well with a submersible pump may be conducted. Care will be taken when developing with a submersible pump so as not to over pump the well and plug the sand pack. Additives and dispersing agents will not be used during well development without express permission of the professional geologist.

During development, the field geologist will monitor well development water for turbidity, pH, temperature, and specific conductance using a hand-held instrument (Horiba U-10 or equivalent). For each casing volume of water removed, measured water quality parameters (temperature, specific conductance, pH, and turbidity) will be recorded on the well development log. Water quality parameters will be measured in the following units:

- pH: standard pH units = -log [H+]
- Temperature: degrees Celsius (°C)
- Specific conductance: micromhos per centimeter (µmhos/cm)
- Turbidity: nephelometric turbidity units (NTU)

A minimum of ten (10) well casing volumes of water plus an additional 1,000 gallons of groundwater will be removed from the well; however, development should continue until water quality parameters have stabilized or the field geologist determines that additional development is not warranted. Stabilization is defined as three successive readings as follows:

- pH has changed less than 0.1 pH units.
- Temperature has changed 1 °C or less and is approximately equal to ambient groundwater temperature.
- Specific conductance has changed less than 10 percent.
- Development water registers less than 5 NTU.

Specific capacity testing will be conducted during well development to evaluate the production capacity of the well. Specific capacity is a term used to express the productivity of a well, and is defined as Q/s, where Q is the discharge rate and s is the drawdown in the well. The observed drawdown in the well is a function of aquifer and well loss; therefore, Q/s is a term incorporating both aquifer and well performance. Water levels and flowrates will be measured during the process of pumping the well. If specific capacity testing indicates the well does not have sufficient capacity to meet project objectives, additional well development measures may be implemented.

3.1.5 Groundwater Elevation Monitoring

A minimum of 48 hours after well construction and development activities are completed, the groundwater elevation will be measured at the new well using a hand-held measuring device and recorded.

3.1.6 Equipment Decontamination

Drilling, sampling, and support equipment brought to the site will be in operable condition and free of leaks in the hydraulic, lubrication, fuel, and other fluid systems. Drilling and sampling equipment and tools will be cleaned and decontaminated prior to rig mobilization to the well location and will be maintained in a clean condition throughout drilling and sampling activities.

Downhole drilling and development equipment will be: (1) cleaned of caked drill cuttings, soil, or other material using a brush; (2) steam-cleaned using a hot water high-pressure washer; and (3) rinsed with potable water prior to its use downhole and between boreholes. Decontaminated equipment will be kept off the ground by storing on clean metal racks (not wooden pallets) and/or wrapped in plastic.

3.1.7 Well Vault and Vault Lid

The extraction well surface completion will include an underground concrete vault to allow for wellhead access and extraction pipe and electrical connections below grade. The interior dimensions of the vault will be approximately 8 feet long by 6 feet wide by 4 feet deep. The vault may be pre-cast or constructed on site. The vault walls and floor will be a minimum 8 inches thick. The vault will have access holes for the wellhead, extraction piping, and electrical conduits. The vault will also include a 36-inch diameter sump that is 18 inches deep and is grouted to the bottom.

Following well installation, the area surrounding the extraction well will be excavated to allow for the construction of the vault and sump. The bottom of the excavation will be covered by a geotextile fabric. An 8-inch layer of class II aggregate base will be placed over the fabric and compacted to 95 percent of maximum compaction. Additional information regarding earthwork and geotextiles is in Attachment E, Section 31 00 00 and Section 31 05 19.13.

The vault will be constructed of concrete composed of Type I or II Portland cement conforming to ASTM C150; coarse and fine aggregate conforming to ASTM C33; and clean, potable water free of deleterious amounts of oils, acids, alkalis, salts, and organic material. Rebar will be sized and placed within the vault walls and floor to provide H-10 load rating. A construction joint will be installed in the vault between the walls and floor to resist hydrostatic pressure. Additional information regarding cast-in-place concrete is in Attachment E, Section 03 30 53. The top of the vault will be completed to just above the existing grade elevation and accessible through a traffic rated, lockable lid.

A vault lid constructed of corrosion-resistant aluminum will be attached to the concrete vault. The vault lid will be spring-loaded and hinged with a recessed lock box. The hinged lid will have a range of motion from being locked closed to 90 degrees open or greater. Two lids are required to meet the 60 pounds of maximum force to open. The lid will be attached to the well vault by stainless steel Type 303 mounting bolts and nuts. Lid frames, mounting hardware, washers, and other fittings will be composed of stainless-steel Type 304 or 316. Anchor bolts will be stainless steel Type 304 and penetrate the concrete a minimum of 4 inches on the vertical access and at least 3 inches on the horizontal access.

Vault lids will have a rainwater collection tray. When the lid is closed, falling rain will drain away from the vault. A concrete apron will be placed around the vault lid to support the lid and provide protection. The apron will extend a minimum of 12 inches in each horizontal direction, with the surface sloped away from the lid. Typical vault surface completion details are shown in Figure 9 and included in Attachment C, Drawing No. CU8.

3.2 Mechanical Installation

A groundwater extraction pump and motor will be installed in the well to bring contaminated groundwater to the surface. The groundwater flow and pressure will be measured and controlled at the wellhead within the vault and will then be conveyed through underground piping to the OU2 groundwater extraction pipeline near the location of the existing extraction well EW-OU2-09-180. The following sections provide a description of the mechanical equipment within the well and wellhead vault and the extraction conveyance pipeline.

3.2.1 Groundwater Extraction Equipment

A submersible pump will be installed in extraction well EW-OU2-13-180 to pump groundwater to the OU2 GWTP. The specific pump size will be determined by specific capacity testing conducted during well development following extraction well installation. The pump will be installed in the extraction well at a depth near the bottom of the screened interval to maximize the groundwater recovery from the well. The pump will be suspended by stainless steel Type 304 downhole pipe attached to the well cap, which rests on the top of the extraction well casing (Attachment C, Drawing No. CU7). A shroud constructed from PVC will be installed over the pump and motor to direct water flow over the motor to the impeller opening. Power cables with a water-proof termination fitting will be installed from the pump motor to the electrical panel in the well vault.

Piping at the wellhead will be Schedule 80 PVC and will include a globe valve to control the flow from the well and a check valve and gate valve to isolate the well from other wells connected to the header piping. Attachment C, Drawing No. CU7 includes an extraction well vault plan. Because of the potential pressure induced by the well pump, the globe valve and components between the well cap and globe valve will be rated for a minimum of 250 pounds per square inch (psi). Components after the globe valve within the well vault will be rated to 160 psi. A sample port will also be installed at the wellhead for system monitoring. A digital output PVC float switch will be installed in the well vault to indicate a high-water level in the vault as a result of a pipeline leak.

3.2.2 Electrical Power and Control Installation

An existing 200-amp, 3-phase, 480Y/277-volt commercial meter service drop is located north of the intersection of Abrams Drive and Bunker Hill Drive. The service drop feeds a Four-Well Power and Control Panel located next to extraction well EW-OU2-08-180. Power is fed through #4/0 wire between the drop and the panel. The panel provides a secure location for both the 480-volt power distribution and low voltage instrumentation control. The panel contains two circuit breakers/motor starters and a PLC. The panel also contains space for two additional circuit breakers/motor starters. The electrical site plan and wiring diagram are shown in Attachment C, Drawing Nos. S7, S8, S9, ELD01, ELD02, and ELD03. The following sections describe how power and control wiring will be distributed from the existing Four-Well Power and Control Panel to new extraction well EW-OU2-13-180.

3.2.2.1 Electrical Power

Electrical power will be distributed from the Four-Well Power and Control Panel to new extraction well EW-OU2-13-180 through PVC conduit installed between the panel and existing extraction well EW-OU2-09-180 and PVC conduit buried adjacent to the existing and new extraction conveyance pipeline. The wire and conduit will be sized based on the final extraction well pump size in accordance with industry standards and the pump manufacturer’s requirements. Pull boxes will be spaced along the length of the new conduit. Power will be terminated in the extraction well vault in a National Electric Manufacturers Association 4X panel with a lockable disconnect switch. The switch will be connected to a motor starter, which will then be connected to the downhole extraction pump through the motor power cable. The disconnect and motor starter will be sized based on the final extraction pump size in accordance with industry standards. The power in the extraction well vault will be grounded in accordance with National Electric Code requirements. Additional information regarding electrical power is in Attachment E, Section 26 05 00.00 40, Section 26 05 26 00 40, and Section 26 28 00.00 10.

3.2.2.2 Instrumentation

Instrumentation within the well vault will include a flow-indicator totalizer, pressure switch with gauge, downhole pressure transducer, level switch (leak detection), and motor-run VFD. The flow indicator totalizer will be installed at the wellhead to monitor instantaneous flowrate and total gallons extracted from the well. The flowmeter will be a Rosemount magnetic style water meter with 1.5 percent accuracy and a 4- to 20-milliamp output.

A digital pressure switch will also be installed to monitor the pump pressure and ensure safe operation of the extraction system. The switch will be adjustable and provide a digital output. The switch will have a pressure range to 200 psi. The pressure switch will be installed downstream of a pulsation dampener to reduce false high-pressure readings caused by pipeline pressure surges.

A pressure transducer will be installed in the extraction well piezometric tube at a depth near the bottom of the extraction pump to measure the water level within the extraction well and control the operation of the pump to prevent the pump from running dry and cavitating. The pressure transducer will be welded titanium with a sealed gauge, 0 to 60 psi gauge span, ±0.25 percent accuracy, with a 4- to 20-milliamp output.

A digital output stainless PVC float switch will be installed within the well vault to allow for detection of leaks within the well vault and extraction conveyance pipeline that would drain into the vault sump.

The upgraded PLC will control a 24-volt direct current relay to start and stop the extraction pump. The relay will control a 120-volt circuit connected to the motor starter. The relay will be used to start the pump remotely from the OU2 GWTP and to stop the pump under alarm conditions.

Instrumentation wiring will be distributed from the Four-Well Power and Control Panel to new extraction well EW-OU2-13-180 through electrical PVC conduit installed between the panel and existing extraction well EW-OU2-09-180 and PVC conduit buried adjacent to the existing and new extraction conveyance pipeline. The instrumentation conduit will be separate from the power distribution conduit to minimize interference. Pull boxes will be spaced along the length of the new conduit. The instrumentation wiring will be terminated at the upgraded PLC within the panel. Additional information regarding instrumentation is in Attachment C and Attachment E, Section 26 29 23, Section 27 21 10 00 40 and Section 40 60 00.

3.2.2.3 Supervisory Control and Data Acquisition/Instrumentation Interface

Information to operate the extraction well pump will be locally programmed into both the upgraded Bunker Hill PLC and within the Four-Well Power and Control Panel near EW-OU2-08-180. A separate effort will be required to integrate these signals into the existing supervisory control and data acquisition (SCADA) control system located at the OU2 GWTP. The anticipated effort includes adding an additional well to the existing monitoring screens and to verify data are being received, logged, and properly interpreted. Additional information regarding process control is in Attachment C and Attachment E, Section 27 21 10 00 40 and Section 40 60 00.

3.2.3 Extraction Conveyance Pipeline

The conveyance piping from the well vault will connect to a main header leading to the OU2 GWTP near extraction well EW-OU2-09-180. The proposed route is shown on Figure 7. Alignment will be field verified to ensure that there is sufficient clearance for the excavation work to be completed. The pipeline routes will be marked for belowground utilities and pipelines in accordance with the OUCTP RAWP (Shaw, 2009). The following sections provide the extraction conveyance pipeline construction details.

3.2.3.1 Trenching

After clearing and grubbing, the trench excavation will be performed using a suitable backhoe or excavator. The excavation will follow the pipe alignment and survey stakes. The side slopes will be laid back at the angle of repose of the *in situ* material if native soil lacks the physical characteristics to support the trench walls. Deeper excavations, if required, will be benched, laid back, or shored. The excavated soil will be placed adjacent to the trench at a minimum distance of 2 feet from the edge to minimize trench wall collapse.

Based on previous trenching in the area, native soil at the bottom of the trench is assumed to be adequate for bedding. If it is not, clean soil will be placed in the trench bottom and on the sides of the installed pipe. Appropriately spaced grade control stakes will be installed along the trench alignment. Grade stakes will be clearly marked as to horizontal offset of alignment, well locations, planned bottom of trench, planned pipe connections, and pipe invert elevations. During construction, grades will be checked to confirm that specified locations and elevations have been achieved. Grade checking will be confirmed by the surveyor under direction of contractor quality control personnel.

Trench backfilling will commence upon completion of conveyance pipeline placement and testing. A partial backfill to restrain the pipeline is allowed prior to the pressure testing. Backfill sand will be placed on both sides of each pipe, the full width of the trench, and up to the spring line. Vibratory plate compactors or water jetting may be used to compact the sand and ensure that the pipe is adequately supported. Fill will then be placed in loose lifts not to exceed 24 inches. Leak detection and electrical conduits will be placed as appropriate. Filling and compaction will continue until the trench is brought up to final grade. A colored, inscribed, metal-impregnated warning tape will be placed at approximately 1 foot below finish grade. Surface restoration will be minimized within the FONR to minimize impact to existing plant species. Additional information regarding earthwork is in Attachment E, Section 31 00 00 and Section 31 11 00.

3.2.3.2 Conveyance Pipeline

Following the gate valve in the well vault, the piping will transition from Schedule 80 PVC to double-contained HDPE. The extraction conveyance pipeline will include approximately 841 feet of 6-inch by 10-inch double-contained piping. Figure 7 shows the proposed alignment of the pipeline. Pipe lengths may be adjusted based on field routing to avoid utilities or other obstructions. The specified sizes of pipe, tees, elbows, and necessary vents and drains will be installed within the trench and connected per manufacturers' recommendations. Power and control wiring conduit will also be installed within the extraction pipeline trench. Typical layout of piping and conduit within a trench is shown in Figure 10.

3.2.3.3 High and Low Points

The profile for the proposed pipeline and the low and high points are shown in Attachment C, Drawing No. CU5. It is anticipated that the tie-in at the existing conveyance pipeline is the only high point in the proposed pipeline and the existing conveyance pipeline includes sufficient high point vents.

A low-point drain will be installed on the conveyance pipeline to allow water to be drained from the pipeline in case of leaks or for maintenance. The low-point drain will be placed inside a precast concrete vault. The vault will be located in nontraffic areas with the top placed 6 inches above ground to reduce stormwater drainage into the vaults. Covers will be incidental-traffic, H-10 load rated. Covers will be corrosion resistant and installed with a secure locking mechanism. Attachment C, Drawing No. CU8 presents the low-point drain details.

3.2.3.4 Isolation Valve

An isolation valve will be installed in the HDPE pipeline just before the connection to the existing extraction conveyance pipeline. This isolation valve serves to isolate the pipeline to proposed extraction well EW-OU2-13-180. The isolation valve will be placed inside a precast concrete vault. The vault will be located in nontraffic areas with the top placed 6 inches above ground to reduce stormwater drainage into the vaults. Covers will be incidental-traffic, H-10 load rated. Covers will be corrosion resistant and installed with a secure locking mechanism. Attachment C, Drawing No. CU9 presents the vault details.

3.2.3.5 Pressure Testing

The double-contained pipe will be visually checked prior to pressure testing. Carrier pipe will be hydrostatically pressure tested with potable water in sections prior to backfilling the trench. The annular space of the secondary contained pipe will be pressure tested with air in sections prior to backfilling the trench. Welds, fittings, and flanges will be left uncovered during pressure testing. Test pressure and procedures will follow the HDPE pipe manufacturers' instructions, as modified by design limitations of the ancillary connected components and following the recommendations of the field engineer.

3.2.3.6 Alignment Marking

A licensed surveyor will survey, prior to backfill, pipeline routes and tops of well vaults. As-built drawings locating the actual pipe alignments and construction details relative to permanent survey monuments will be developed. Horizontal and vertical control will be surveyed to ±0.1 foot.

4.0 Extraction Well Operations

The following sections provide guidance for checkout and startup of extraction well EW-OU2-13-180, initial baseline groundwater sampling, and specific requirements for long-term system operations, maintenance, and monitoring relative to this well.

4.1 System Checkout and Startup

Start-up of extraction well EW-OU2-13-180 will include inspections of the mechanical and electrical equipment to ensure proper installation and operation. Hydrogeologic testing will also be conducted to evaluate recovery and OUCTP capture from the new well operating alone and in conjunction with the OU2 GWTS.

4.1.1 Mechanical and Electrical Completion Check

A mechanical and electrical completion check will be performed to verify the correct installation of the equipment. Installation of all components need not be completed for this inspection to commence. Mechanically moving devices will be individually inspected prior to and immediately following installation. This initial inspection includes a visual check of the moving parts to confirm whether the parts are free to operate as specified after installation.

During the final mechanical check, a visual inspection of the entire system against the construction drawings will be made to confirm that equipment and pipelines are in their proper locations and are appropriately connected, bolts and fittings have been tightened, and supports have been secured to support the intended weight. The mechanical completion checklist for the initial shakedown/startup will be prepared after all mechanical items have been installed.

During the electrical check, electrical equipment and wiring will be visually checked against construction drawings to ensure proper installation and connections. Wiring will be tested with a megohmmeter to ensure the wiring is intact and properly insulated. Instrumentation will be calibrated in accordance with the manufacturers' recommendations and tested to verify proper operation. After the installation of the power system, an operating test will be performed to assure proper rotation of the extraction pump. Following the installation of the control system, the GWTP operator will perform tests to assure proper operating conditions. Alarms and automatic shutdowns will be tested by forcing a failed condition. The SCADA system will integrate the signals from the instruments installed within new extraction well EW-OU2-13-180 and associated extraction conveyance pipeline to the upgraded Bunker Hill PLC.

4.1.2 Hydrogeologic Testing

During the initial stages of continuous operation, extraction well testing will be performed. Static water levels at extraction well EW-OU2-13-180 and nearby monitoring wells will be recorded prior to continuous operation. After the extraction well is started, the flowrate will be maintained at a specific rate and water levels in the extraction well and surrounding wells will be measured and recorded. After a period of time, the flowrate may be adjusted higher or lower and the aquifer response will be evaluated. Results from the tests and analysis will be used to determine aquifer yields and recharge capabilities, determine a long-term operating flowrate for the well, and evaluate OUCTP capture. Extraction flowrates will be adjusted periodically during operation to maintain an appropriate in-well drawdown below the initial static water level.

4.2 Baseline Sampling and Analysis

Baseline groundwater sampling will be conducted as part of the well installation and startup procedure. The baseline sampling will be conducted prior to long-term operation of extraction well EW-OU2-13-180 and will include a comprehensive evaluation of COCs and hydrochemistry. The baseline sampling event will include a single sample from extraction well EW-OU2-13-180 to evaluate the pre-treatment concentrations of COCs and to establish the local *in situ* hydrochemistry of the Upper 180-Foot Aquifer. Baseline sampling will be conducted no sooner than 72 hours after development of the well and will include the following analytical suite:

- Water quality parameters – pH, temperature, conductivity, turbidity, dissolved oxygen (DO), and oxidation reduction potential (ORP)
- VOCs – U.S. Environmental Protection Agency (EPA) Method 8260 selected ion monitoring (SIM)
- Anions – EPA Method 300.0
  - nitrate
  - nitrite
  - sulfate
- Dissolved metals – EPA Method 6010D
  - iron
  - manganese

4.2.1 Groundwater Sampling Procedure

Baseline sampling of extraction well EW-OU2-13-180 will be consistent with QAPP Sampling Standard Operating Procedure (SOP) #5 (Ahtna, 2023c). The sample will be collected from the sample port in the well vault with the pump operating. The standard procedures to be followed when sampling include:

1. Don appropriate personal protective equipment per the Accident Prevention Plan (Ahtna, 2021).
2. Confirm the well identification.
3. Calibrate field instruments in accordance with the manufacturer’s directions. Record calibration documentation in the field logbook.
4. Monitor water quality parameters (i.e., DO, conductivity, pH, ORP, and temperature) every 3 to 5 minutes during purging. Record the water quality parameters on the groundwater sampling log form. If the water quality parameters are stable for three consecutive readings, then collect samples for chemical analysis. Stabilization is achieved if successive readings are within ±0.1 pH units, ±1 degree Celsius for temperature, 3 percent conductivity, and 10 percent DO reading. Turbidity and ORP readings will not be used as stabilization criteria. If the water quality parameters have not stabilized, then continue purging until stabilization occurs.
5. Collect samples from the sample port into the appropriate sample containers. Collect field quality control samples (e.g., field duplicates) per QAPP SOP #5.
6. Label, package, and prepare the samples for shipment to the laboratory per QAPP SOP #5. Transfer the samples to cold storage immediately after collection.
7. Document field activities and sample collection per QAPP SOP #5.

4.2.2 Laboratory Analytical Requirements

The baseline groundwater samples will be collected and submitted to an off-site laboratory for selected analysis. The specific analyses that will be completed by the off-site laboratories include:

- VOCs by EPA Method 8260 SIM
- Dissolved metals (iron and manganese) by EPA Method 6010 D
- Anions (nitrate, nitrite, and sulfate) by EPA Method 300.0

The specific requirements for these methods, including sample collection and preservation, laboratory quality control, laboratory quality assurance, laboratory corrective action, data management and quality assurance oversight, are described in the QAPP (Ahtna, 2023c).

4.3 System Operations and Maintenance

New extraction well EW-OU2-13-180 will be incorporated into and operated as part of the OU2 GWTS. The OU2 GWTS is currently operated in accordance with the O&M Manual (Ahtna, 2022), which provides the specific requirements for startup of the GWTS after major modifications and general guidance for system operations, maintenance, and monitoring. The O&M Manual will be revised following system construction to incorporate necessary changes related to the new equipment, including revisions to system control logic, changes to periodic checklists, and changes to as-built drawings. Future system optimization will consider operation of extraction well EW-OU2-13-180 for capture of the OUCTP in the Upper 180-Foot Aquifer.

5.0 Sampling and Analysis

Monitoring for the operation of the OU2 GWTS is currently conducted in accordance with the QAPP (Ahtna, 2023c). The QAPP will continue to be the governing guidance document for monitoring the OU2 GWTS and will be modified as required to incorporate new extraction well EW-OU2-13-180.

Groundwater monitoring for the OUCTP in the Upper 180-Foot Aquifer is currently conducted as part of the Groundwater Monitoring Program (GWMP) in accordance with the QAPP (Ahtna, 2023c). The GWMP includes quarterly and annual sample collection and analysis from specific monitoring wells located throughout the former Fort Ord property. This sampling and analysis will continue as part of the monitoring of the implementation of the remedial action for OUCTP in the Upper 180-Foot Aquifer in accordance with the QAPP.

The QAPP (Ahtna, 2023c) describes the specific methods that will be used to collect and analyze samples during remediation of the OUCTP Upper 180-Foot Aquifer. Groundwater sampling and analysis will be conducted to determine baseline conditions at the site, monitor long-term changes in the extent of the OUCTP, monitor the effectiveness of groundwater extraction, and support site closure. The following sections describe the specific data quality objectives for the OUCTP Upper 180-Foot Aquifer and specific issues associated with the sampling design, analytical methods, and sampling procedures that will be used in collecting data relative to the existing plans.

The design and implementation of the remedy for OUCTP in the Upper 180-Foot Aquifer will include:

- Baseline sampling and analysis
- Performance monitoring
- Long-term monitoring

Baseline sampling and analysis will precede the long-term operation of extraction well EW-OU2-13-180 (see Section 4.2). Performance monitoring will be conducted as part of the monitoring of groundwater extraction and treatment activities. Long-term monitoring will evaluate the overall impact of the remedial efforts in the Upper 180-Foot Aquifer and to ensure that concentrations of COCs remain below Aquifer Cleanup Levels (ACLs) for a sufficient period of time to support site closure. The GWMP will incorporate pre-existing wells and wells installed during the remediation process.

5.1 Performance Monitoring

Performance monitoring will continue for the OU2 GWTS throughout the Upper 180-Foot Aquifer remediation activities. Extraction well EW-OU2-13-180 will be included in the OU2 GWTS monitoring program and will be monitored for the same analytes and at the same frequency as other extraction wells per the QAPP (Ahtna, 2023c). Performance monitoring will be conducted using samples collected from sample ports located in the process equipment as described in the QAPP. The samples will be analyzed for VOCs by EPA Method 8260 SIM. The criteria for the modification of analytical suites and for changes in sampling frequency are outlined in the QAPP.

5.2 Long-Term Monitoring

Long-term groundwater monitoring will continue for OUCTP throughout the Upper 180-Foot Aquifer remediation activities. The OUCTP monitoring wells currently included in the GWMP will continue to be monitored for the same analytes and at the same frequency as outlined in the QAPP (Ahtna, 2023c).

Long-term monitoring will be conducted using passive diffusion bags set at specific intervals within monitoring wells as described in the QAPP (Ahtna, 2023c). The samples will be analyzed for VOCs by EPA Method 8260 SIM. The criteria for the modification of analytical suites and changes in sampling frequency are outlined in the QAPP.

Long-term monitoring will continue until the concentrations of COCs in all wells are below ACLs in accordance with the decision criteria described in the QAPP (Ahtna, 2023c). If the concentrations of COCs in all wells within the OUCTP remain below the ACLs and all other closure criteria are met, monitoring will be discontinued and a remedial action completion report will be prepared to support site closure.

6.0 Program Evaluation, Modification, and Reporting

The effectiveness of the remediation program for the OUCTP Upper 180-Foot Aquifer will ultimately be measured by a reduction in the extent and concentrations of COCs. The configuration of the remedial treatment system is based on the current understanding of site conditions as derived from previous work.

6.1 Design Modifications

Modifications to the extraction pump size, conveyance pipeline size, wire size, etc. may be required after well installation and initial hydrogeologic testing. The system operating conditions will be constantly reevaluated to optimize OUCTP capture and system O&M requirements. System effectiveness, hydrogeologic conditions, and current trends in plume concentrations will be factored into the re-evaluation. Trend analysis and localized groundwater modeling will be used to evaluate progress and update system operating conditions.

6.2 Reporting

An update to the O&M Manual will be prepared following the system expansion/extraction well installation to document as-built conditions and changes during construction. Reporting for OUCTP Upper 180-Foot Aquifer monitoring and remediation activities is included in regular reports prepared for the OU2 GWTS and groundwater monitoring at OUCTP. This includes:

- OU2 GWTS and OUCTP status updates presented at regular Base Realignment and Closure Cleanup Team Meetings. The information provided includes current analytical data and GWTS operational data.
- Annual OUCTP groundwater monitoring reports that summarize analytical data, evaluate COC distribution and concentration trends, discuss the overall impacts to the plume as a result of treatment, and propose modifications to the GWMP. The annual reports also include an evaluation of the existing monitoring well network and recommend wells for installation and decommissioning per QAPP decision criteria.
- Annual OU2 GWTS reports that describe system operations during the 12-month reporting period, including treatment system configuration, a summary of analytical data, production rates, COC removal rates and effectiveness, recommendations for future action, GAC performance, well performance, and system optimization considerations.
- Quarterly OUCTP and OU2 reports containing analytical data and groundwater elevation measurements collected every three months as part of the ongoing GWMP and a general discussion of changes in COC concentrations and plume configuration over time.

7.0 References[1]

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[1] At the end of references included in the Fort Ord Administrative Record are the Administrative Record Numbers (AR#s) (e.g., BW-1234). To find the referenced document, this number may be typed into the Online Search tool at: http://www.fortordcleanup.com/documents/search/. Please note the referenced documents were available in the Fort Ord Administrative Record at the time this document was issued; however, some may have been superseded by more current versions and were subsequently withdrawn.

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TABLES

Table 1. Chemicals of Concern and Aquifer Cleanup Levels

Chemical of Concern (COC)	OUCTP A-Aquifer ACLs (µg/L)	OUCTP Upper 180-Foot Aquifer ACLs (µg/L)	OUCTP Lower 180-Foot Aquifer ACLs (µg/L)
1,1-Dichloroethene (1,1-DCE)	6.0	-	-
1,2-Dichloroethane (1,2-DCA)	-	-	0.5
Carbon tetrachloride (CT)	0.5	0.5	0.5
Chloroform	2.0	-	-
Methylene chloride	5.0	-	-
Tetrachloroethylene (PCE)	5.0	-	-
Total 1,2-Dichloroethene (total 1,2-DCE)	6.0	-	-
Trichloroethene (TCE)*	5.0	-	-
Vinyl Chloride	0.1	-	-

Notes:

-: not a COC at the specified aquifer

*TCE is not a COC for the Lower 180-Foot Aquifer, but is monitored to evaluate for potential impacts to downgradient Fort Ord supply wells.

Acronyms and Abbreviations:

µg/L: micrograms per liter

ACL: Aquifer Cleanup Level. Groundwater COCs and ACLs are taken from the Record of Decision (Army, 2008).

OUCTP: Operable Unit Carbon Tetrachloride Plume

Table 2. Extraction Well Materials and Construction

Well Type	Casing Type	Casing Diameter (in)	Screen Length (ft)	Screen Type	Screen Slot (in)	Sump	Backfill	Filter Pack[1]	Transition Sand[2]	Bentonite Seal	Grout Seal	Pump Piping Type	Surface Completion
Extraction well EW-OU2-13-180 in 16-inch diameter borehole	Flush-joint threaded Sch 80 PVC; SS centralizers at 40-foot intervals	10	40 (4x 10-foot sections)	Type 316 SS, continuous wire-wrapped	0.045	Type 316 welded SS, 2-ft blank casing and end cap	bentonite pellets	SiLibeads® or #8/16 silica sand (8 mesh)	#60 sand	3/8-inch pellets or slurry placed by tremie pipe	5 lbs bentonite, 94-lbs Type I Portland cement, 7 gals clean water	2-inch diameter Type 304 SS	8-ft x 6-ft x 4-ft concrete vault with double-hinged aluminum, traffic-rated lid
Piezometer installed in same borehole, offset 1 inch from extraction well casing	Flush-joint threaded Sch 80 PVC	1.5	40 (4x 10-foot sections)	Sch 80 PVC	0.020	Sch 80 PVC, 1-foot blank casing and end cap						NA	

Notes:

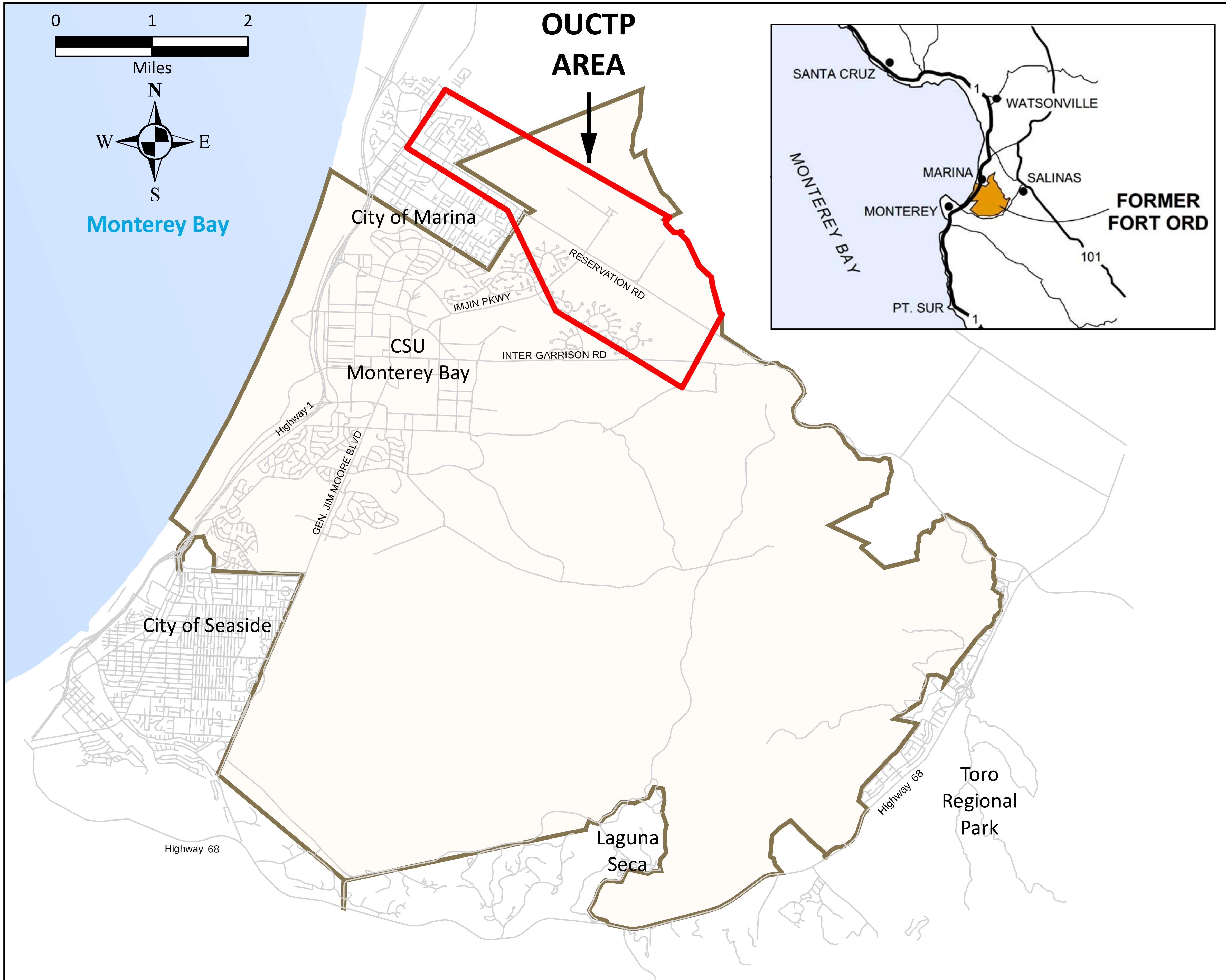
[1] Filter pack sand shall be rounded to subrounded siliceous material free of calcareous grains or material.

[2] Tranistion sand shall be well sorted with predominant grain size of between 0.42 and 0.074 millimeter.

Acronyms and Abbreviations:

EW = extraction well
ft = feet
gal = gallon
in = inch
lb = pound
NA = not applicable
PVC = polyvinyl chloride
Sch = Schedule
SS = Stainless Steel

FIGURES



EXPLANATION

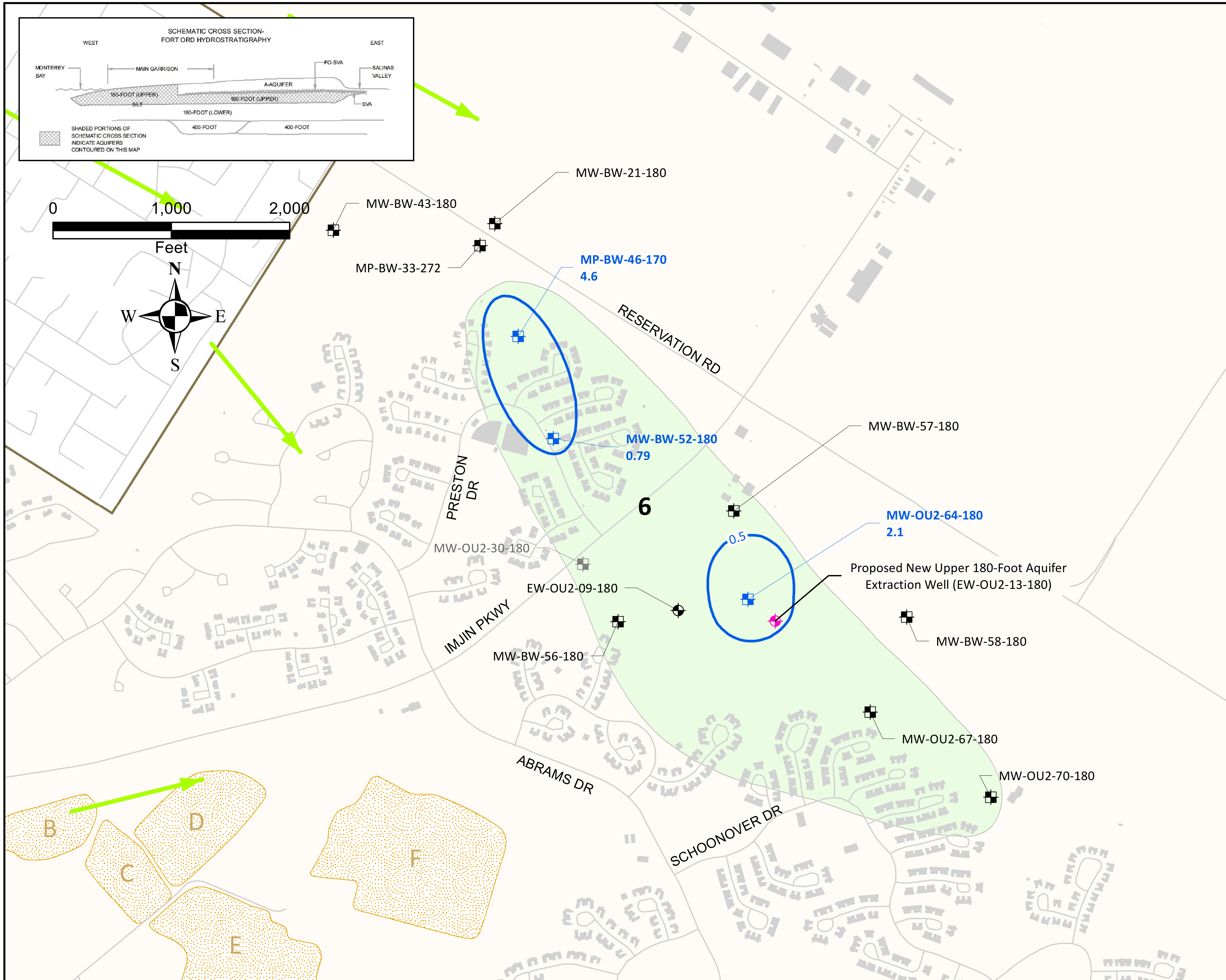
Roads

Operable Unit Carbon Tetrachloride (OUCTP) Area

Former Fort Ord boundary

LOCATION MAP
OPERABLE UNIT CARBON TETRACHLORIDE PLUME
Operable Unit Carbon Tetrachloride Plume
Upper 180-Foot Aquifer Remedial Design Addendum
Former Fort Ord, California

Ahtna	Date: 11/3/2022	Figure: 1



EXPLANATION

General groundwater flow direction

Roads

Facilities

Approximate extent of landfill areas (Areas B through F)

Former Fort Ord boundary

Well Type and CT Detection

New Upper 180-Foot Aquifer extraction well (EW-OU2-13-180)

Extraction well with no carbon tetrachloride (CT) detected

Monitoring well with CT detected

Monitoring well with no CT detected

Monitoring well not sampled

Chemical of Concern (COC) Aquifer Cleanup Level (ACL) exceedance contour in µg/L.

0.5 Carbon tetrachloride (CT)

OUCTP Upper 180-Foot Aquifer Hydraulic Zone

6

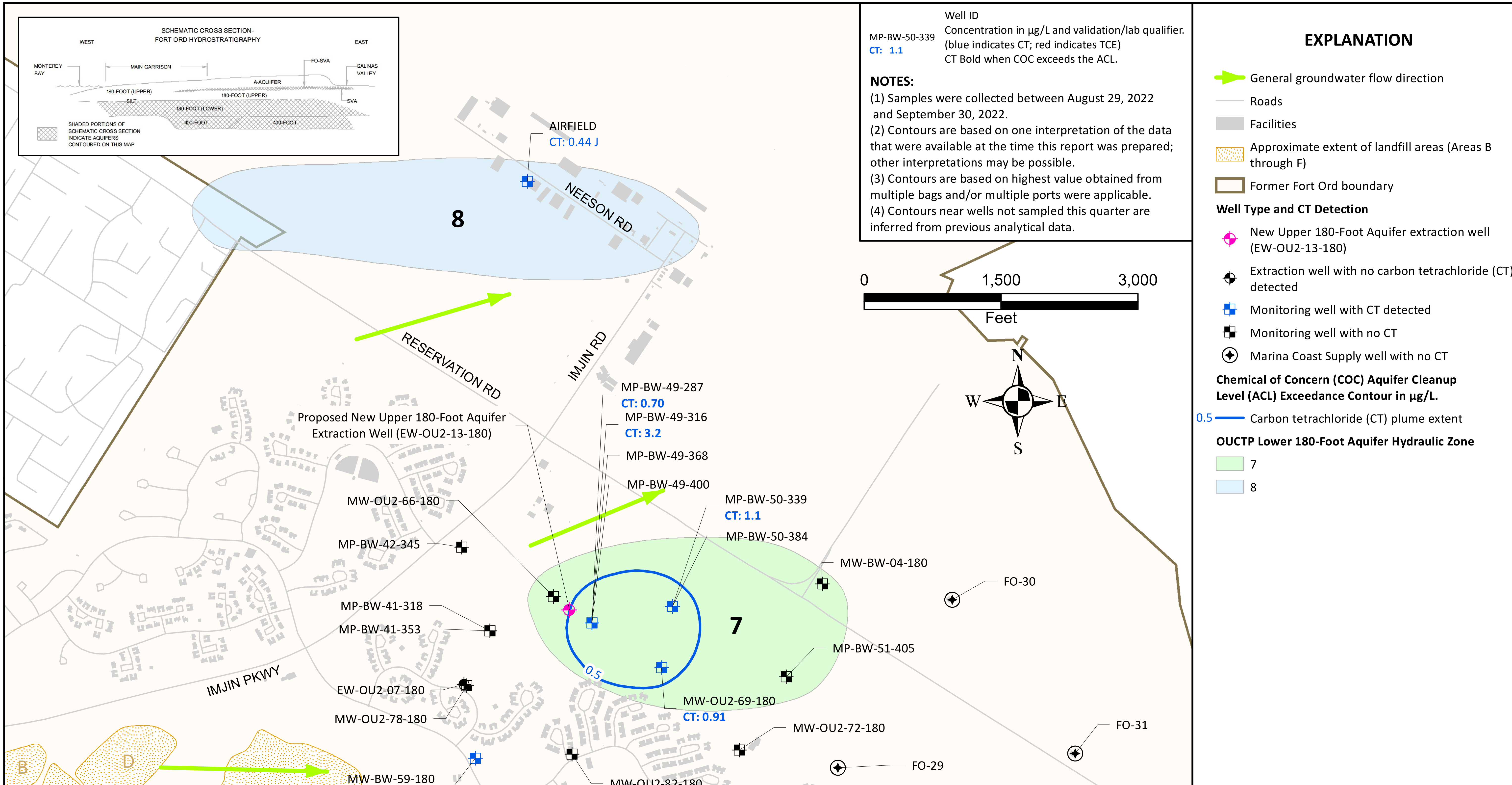
MW-OU2-64-180
2.1
Well ID - Bold When Concentration Exceeds the ACL for CT
CT Concentrations (µg/L) and validation/lab qualifier.

NOTES:

(1) Samples were collected between August 29, 2022 and September 2, 2022.
(2) Contours are based on one interpretation of the data that were available at the time this report was prepared; other interpretations may be possible.
(3) Contours are based on highest value obtained from multiple bags and/or multiple ports were applicable.
(4) Contours near wells not sampled this quarter are inferred from previous analytical data.

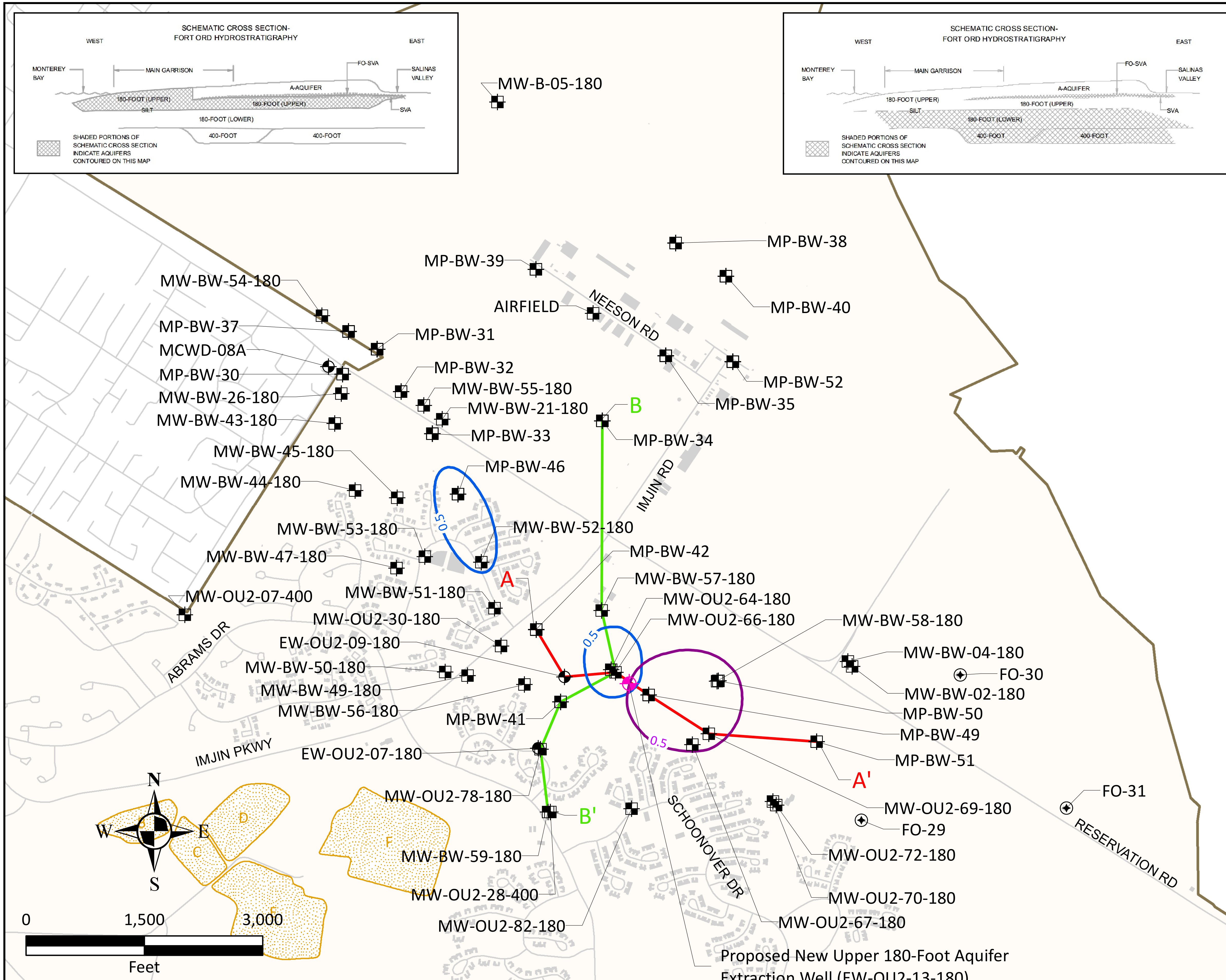
CARBON TETRACHLORIDE PLUME
UPPER 180-FOOT AQUIFER
THIRD QUARTER 2022
Operable Unit Carbon Tetrachloride Plume
Upper 180-Foot Aquifer Remedial Design Addendum
Former Fort Ord, California

Ahtna | Date: 7/17/2023 | Figure: 2



CARBON TETRACHLORIDE PLUME
LOWER 180-FOOT/400-FOOT AQUIFERS
THIRD QUARTER 2022
Operable Unit Carbon Tetrachloride Plume
Upper 180-Foot Aquifer Remedial Design Addendum
Former Fort Ord, California

Ahtna | Date: 7/18/2023 | Figure: 3



EXPLANATION

Roads

Facilities

Former Fort Ord boundary

Approximate extent of landfill areas (Areas B through F)

Well Type

New Upper 180-Foot Aquifer extraction well (EW-OU2-13-180)

Extraction well

Monitoring well

Marina Coast active supply well

Cross Sections

Cross Section A - A'

Cross Section B - B'

3Q2022 Chemical of Concern (COC) Aquifer Cleanup Level (ACL) Exceedance Contour in µg/L.

0.5 Upper 180-Foot aquifer carbon tetrachloride (CT) plume extent

0.5 Lower 180-Foot aquifer CT plume

CARBON TETRACHLORIDE PLUME
AND CROSS SECTION MAP
THIRD QUARTER 2022
Operable Unit Carbon Tetrachloride Plume
Upper 180-Foot Aquifer Remedial Design Addendum
Former Fort Ord, California

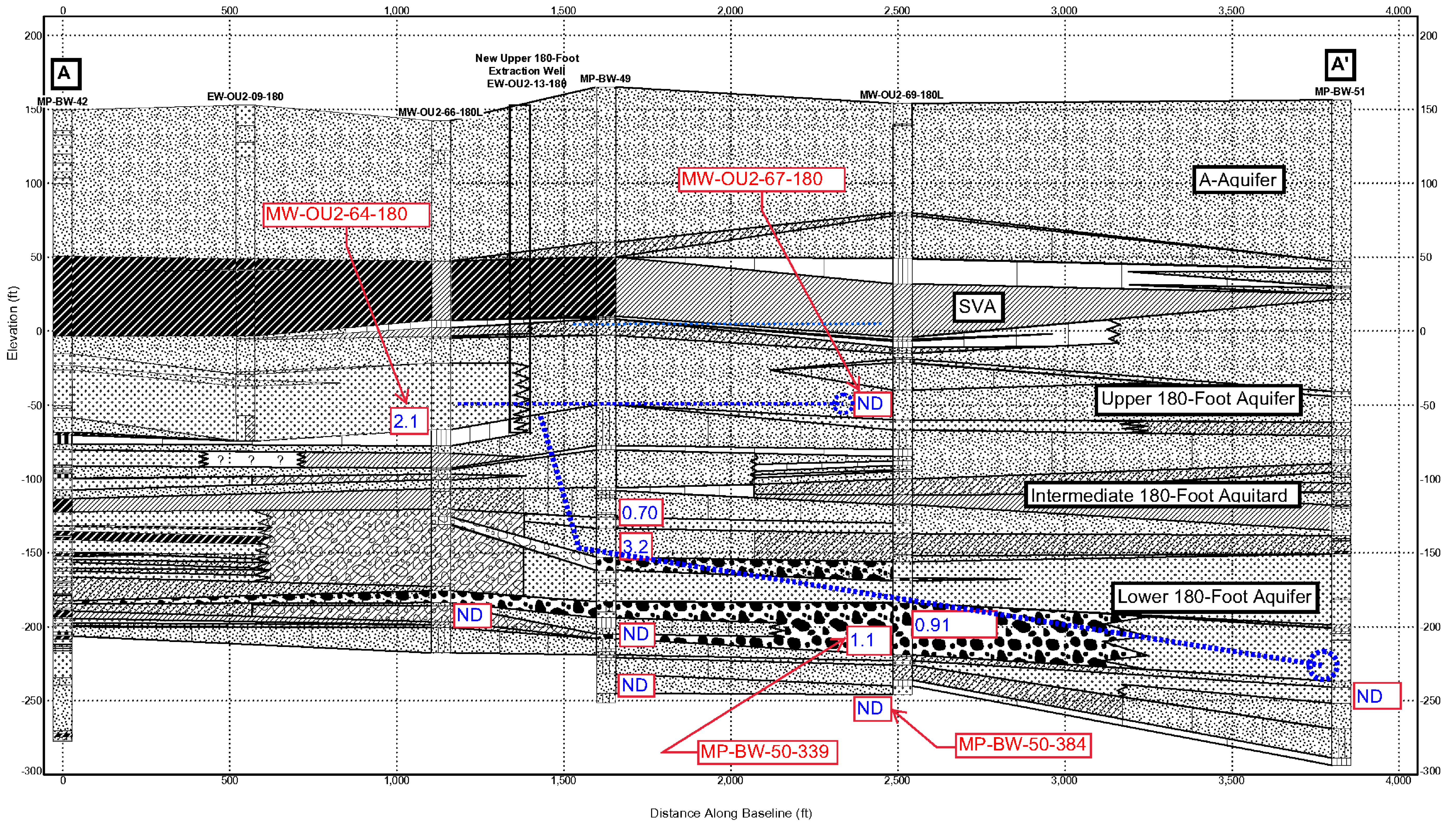
Ahtna | Date: 7/17/2023 | Figure: 4

Project Name: OUCTP Upper 180-Foot Aquifer Remedial Design Addendum
Project Location: Former Fort Ord, California
Client: U.S. Army Corps of Engineers
Project Number: W91238-14-C-0048

Potential Plume migration pathway from Upper 180-foot Aquifer to Lower 180-foot Aquifer

SUBSURFACE DIAGRAM A-A'

- USCS Well-graded Sand
- USCS Poorly-graded Sand
- USCS High Plasticity Clay
- USCS Low Plasticity Clay
- USCS Clayey Sand
- USCS Well-graded Sand with Clay
- USCS Elastic Silt
- USCS Silty Sand
- USCS Silt
- USCS Poorly-graded Sand with Silt
- USCS Well-graded Gravel
- USCS Well-graded Gravel with Silt



Ahtna

Date: 11/5/2022

CROSS SECTION A-A' CARBON TETRACHLORIDE PLUME
THIRD QUARTER 2022
Operable Unit Carbon Tetrachloride Plume
Upper 180-Foot Aquifer Remedial Design Addendum
Former Fort Ord, California

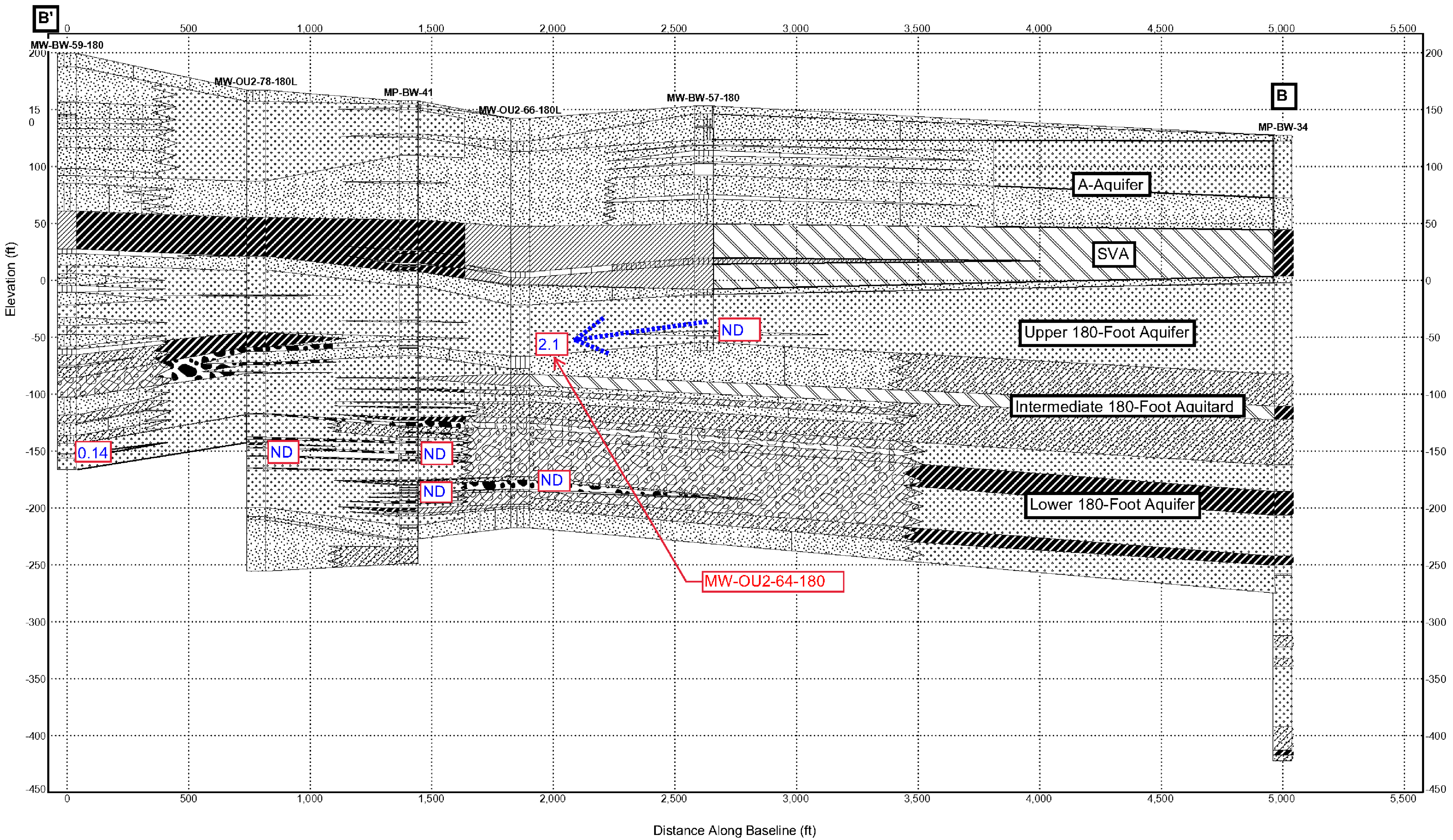
Figure: 5

Project Name: OUCTP Upper 180-Foot Aquifer Remedial Design Addendum
Project Location: Former Fort Ord, California
Client: U.S. Army Corps of Engineers
Project Number: W91238-14-C-0048

Potential Plume migration pathway from Upper 180-foot Aquifer to Lower 180-foot Aquifer

SUBSURFACE DIAGRAM B-B'

- USCS Silty Sand
- USCS High Plasticity Clay
- USCS Clayey Gravel
- USCS Silt
- USCS Well-graded Sand
- USCS Clayey Sand
- USCS Poorly-graded Sand with Silt
- USCS Low Plasticity Clay
- USCS Poorly-graded Sand
- USCS Well-graded Gravel
- USCS Low Plasticity Silty Clay

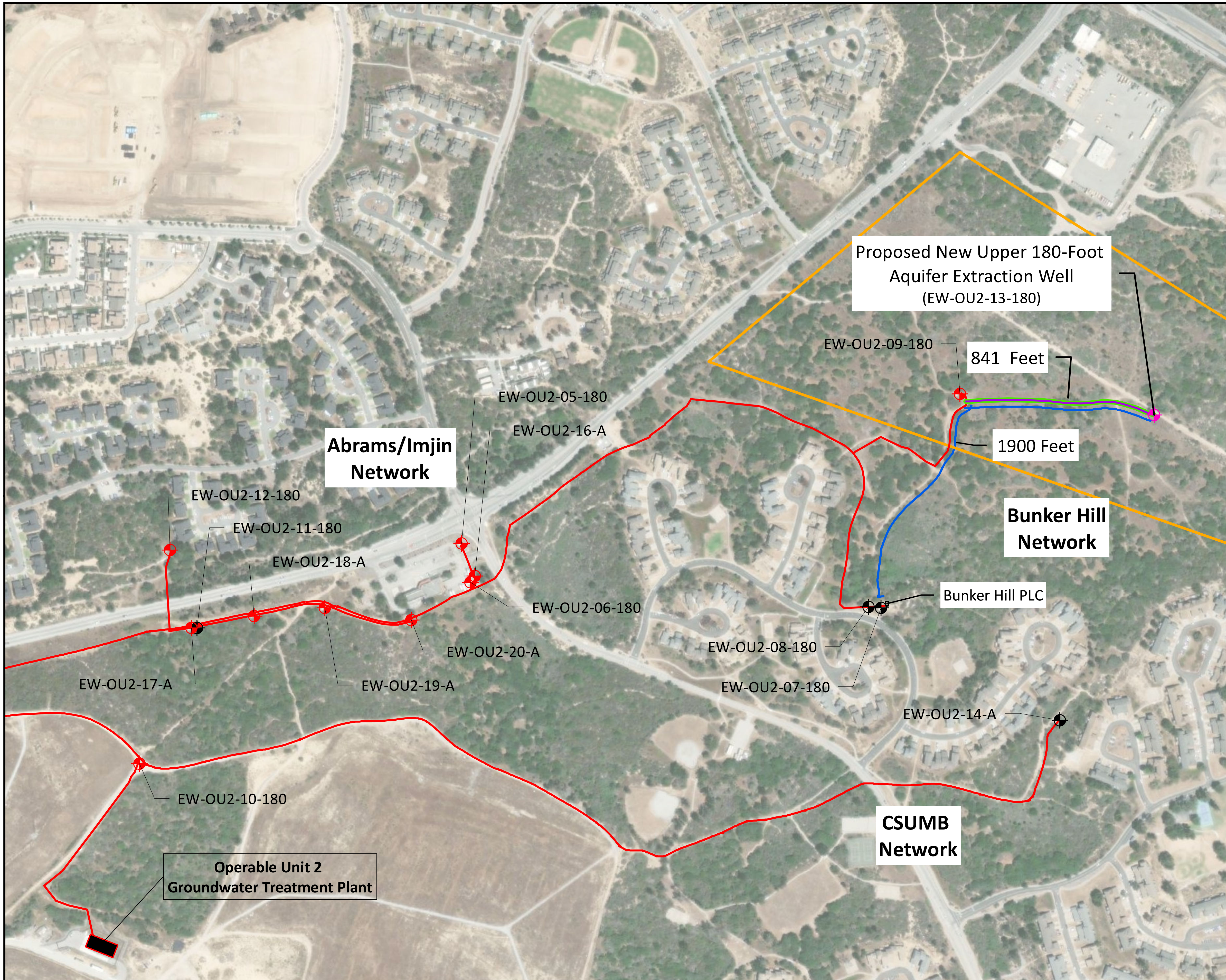


Ahtna

Date: 11/5/2022

CROSS SECTION B-B' CARBON TETRACHLORIDE PLUME
THIRD QUARTER 2022
Operable Unit Carbon Tetrachloride Plume
Upper 180-Foot Aquifer Remedial Design Addendum
Former Fort Ord, California

Figure: 6



EXPLANATION

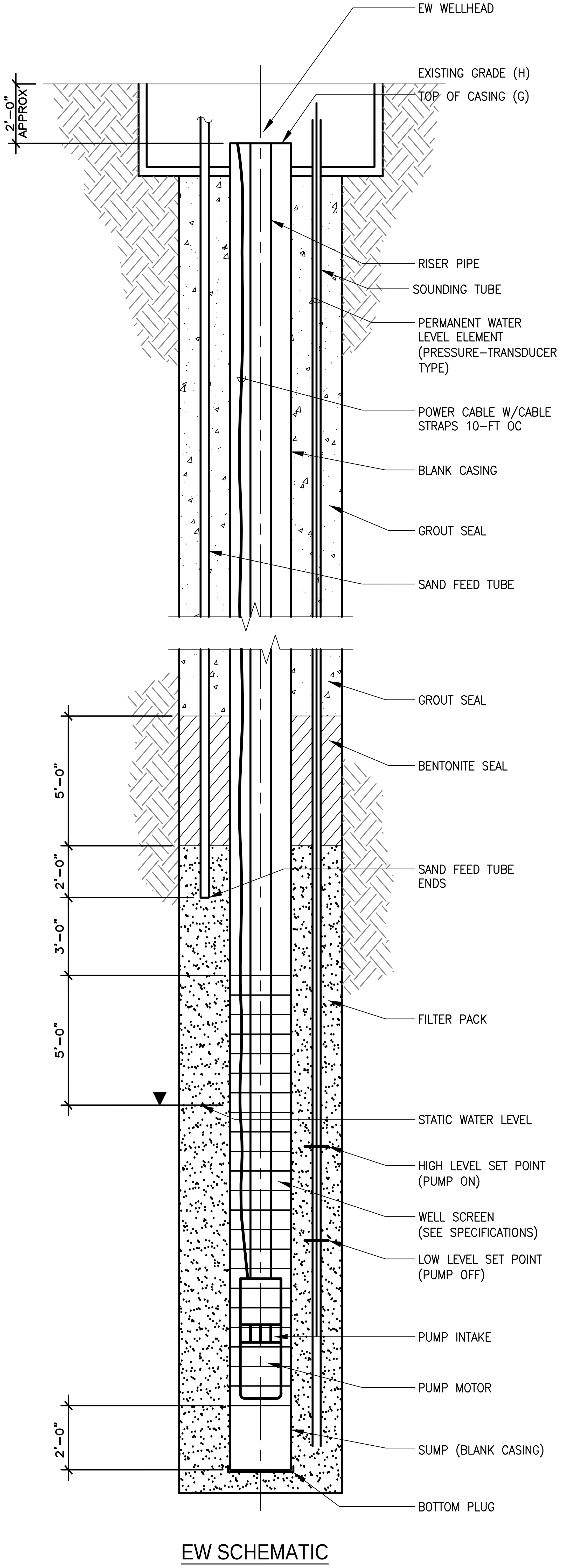
- New Upper 180-Foot Aquifer extraction well
- Extraction well operated
- Extraction well not operated
- Proposed untreated water conveyance pipeline to connect to EW-OU2-09-180 existing pipeline (Total 841 feet)
- Groundwater collection pipeline
- New Electrical Power and Control Conduits (Total 1900 feet)
- Fort Ord Natural Reserve (South-West)

N
W E
S

0 500 1,000
Feet

PROPOSED UPPER 180-FOOT AQUIFER EXTRACTION WELL LOCATION AND CONVEYANCE ROUTE
Operable Unit Carbon Tetrachloride Plume
Upper 180-Foot Aquifer Remedial Design Addendum
Former Fort Ord, California

Ahtna | Date: 9/7/2023 | Figure: 7



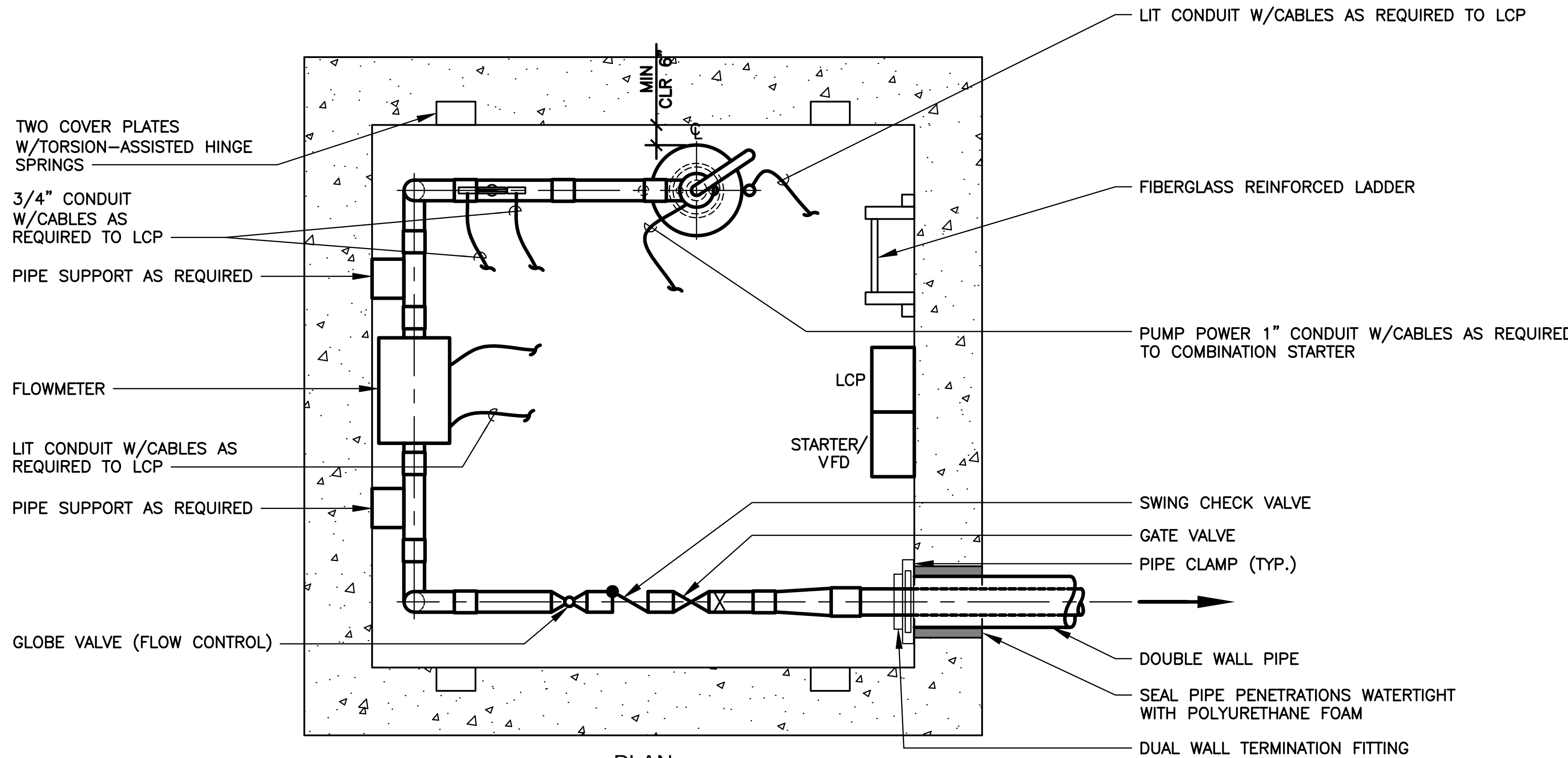
EW SCHEMATIC

Not to Scale

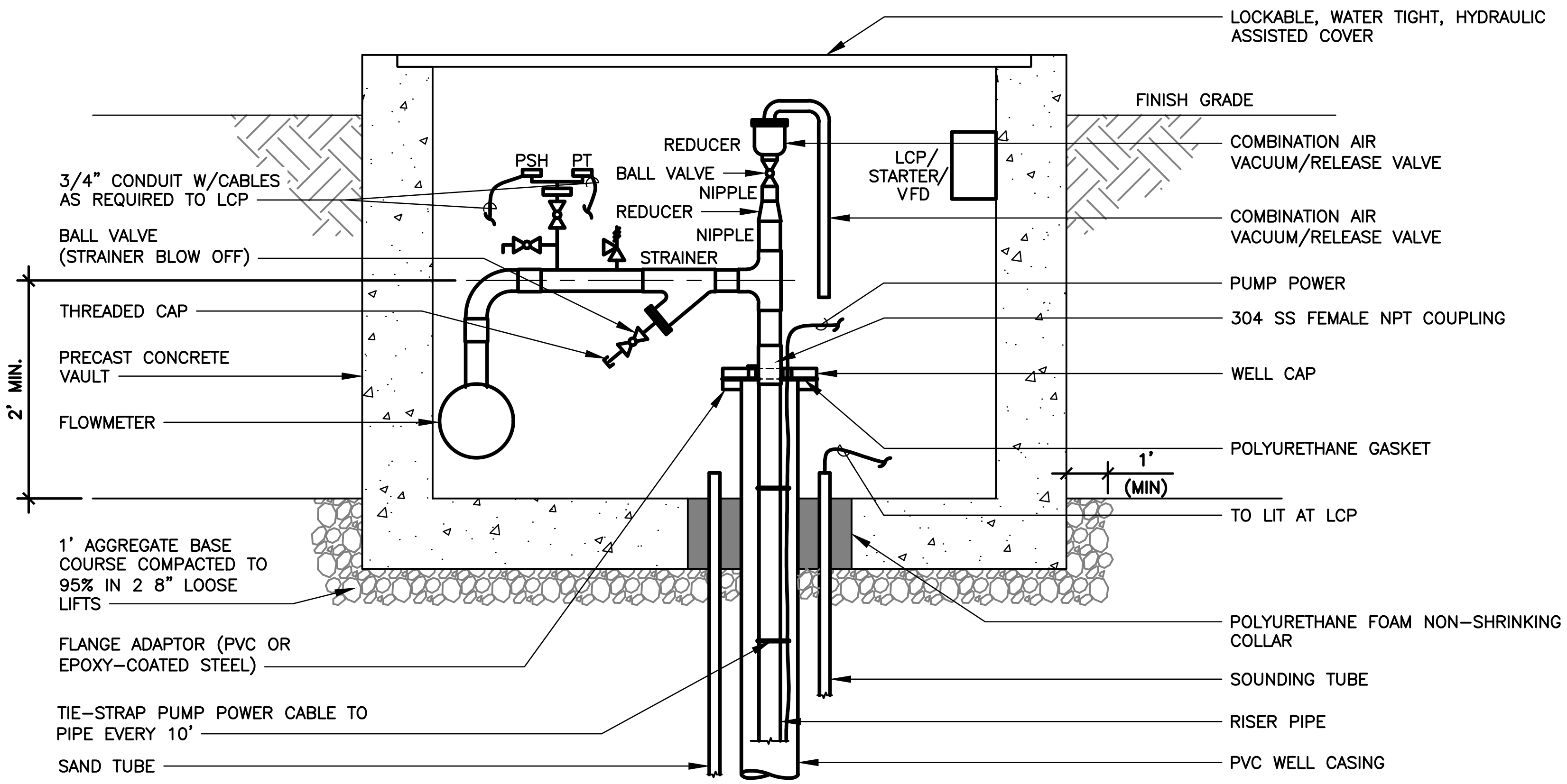
TYPICAL EXTRACTION WELL CONSTRUCTION
CARBON TETRACHLORIDE PLUME
UPPER 180-FOOT AQUIFER

Operable Unit Carbon Tetrachloride Plume
Upper 180-Foot Aquifer Remedial Design Addendum
Former Fort Ord, California

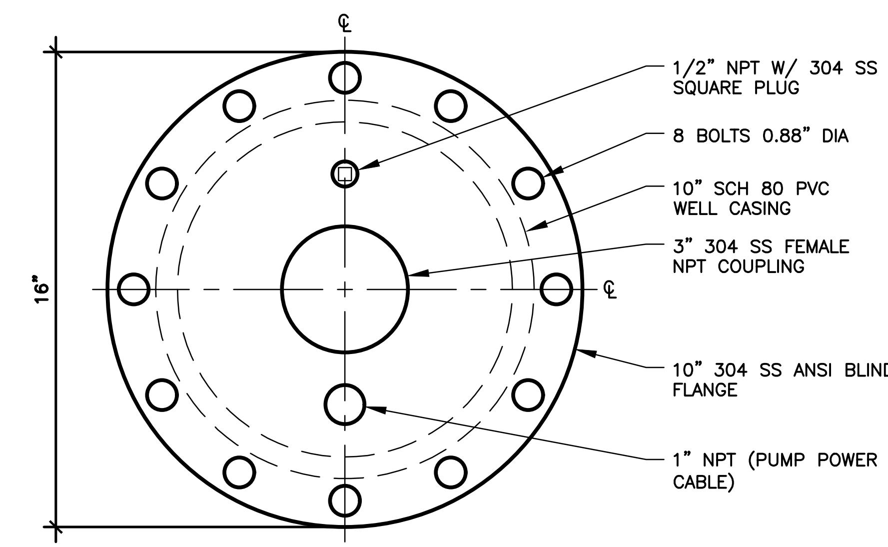
Ahtna	Date: 11/5/2022	Figure: 8



PLAN



ELEVATION

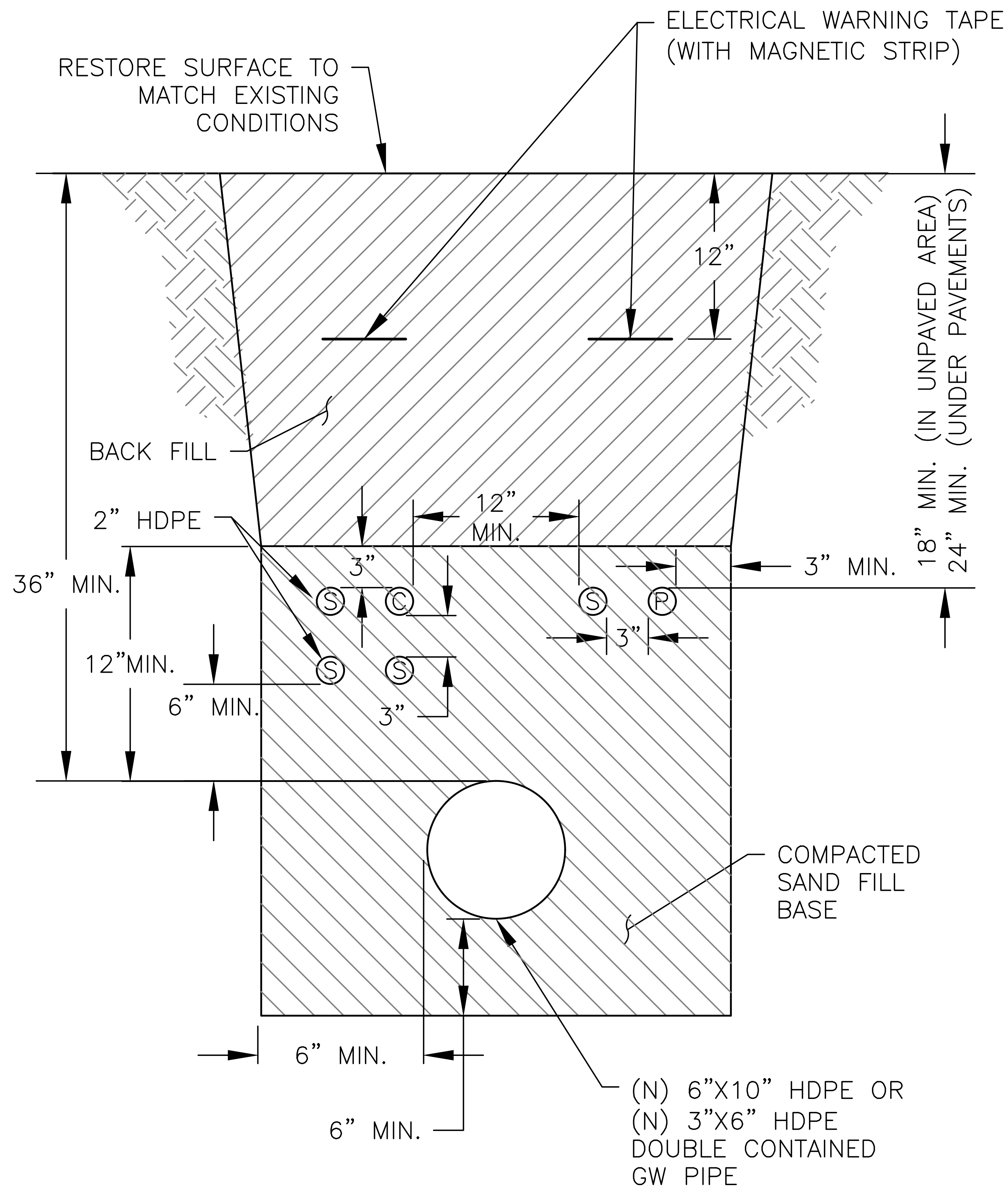


WELL CAP - 180-FT-AQUIFER WELLS

TYPICAL EXTRACTION WELL VAULT CONSTRUCTION

Operable Unit Carbon Tetrachloride Plume
Upper 180-Foot Aquifer Remedial Design Addendum
Former Fort Ord, California

Ahtna | Date: 11/5/2022 | Figure: 9



CONDUIT LEGEND

- Ⓒ – CONTROL CONDUIT (2" PVC)
- Ⓟ – POWER CONDUIT (2" PVC)
- Ⓢ – SPARE CONDUIT (2" PVC U.N.O.)

TYPICAL EXTRACTION CONVEYANCE LINE CONSTRUCTION
Operable Unit 2 Groundwater Treatment System Expansion
Remedial Design/Remedial Action Work Plan Addendum
Former Fort Ord, California

Ahtna	Date: 11/5/2022	Figure: 10

ATTACHMENTS

ATTACHMENT A

Fort Ord Groundwater Model Report, 2022

U.S. Army Corps of Engineers

Groundwater Model Report
Fort Ord
Monterey County, California

Prepared for

U.S. Army Corps of Engineers

Sacramento District

Prepared by

U.S. Army Corps of Engineers

Philadelphia District

November 2022

Table of Contents

1 Introduction

The basewide numerical groundwater flow model used to simulate groundwater conditions beneath the former Fort Ord has undergone numerous updates since its original development. The purpose of this model is to evaluate hydraulic capture of Chemicals of Concern (COCs) by the Upper 180-Foot Aquifer groundwater extraction (GWE) wells at Sites 2 and 12 (2/12) and Operable Unit 2 (OU2). The model used for this 2022 update was based on the version of the model developed by the USACE Hydraulic Engineering Center in January 2016 (USACE-HEC, 2016) and updated annually thereafter.

The 2022 model update was performed by the USACE Philadelphia District (NAP) for the USACE Sacramento District (SPK). The first step in the modeling process is to define clear, achievable goals and objectives for the model based on the desired purposes. Both the modeling team and the end user must begin with the end goal in mind and understand the abilities and limitations of the model. The objectives of this modeling effort are to:

- Improve the understanding of the complex groundwater flow system in the vicinity Sites 2/12 and OU2.
- Assess the model construction and boundary conditions used for previous modeling efforts.
- Evaluate the capture zones of the GWE wells currently operating at Ft. Ord.
- Provide recommendations for future monitoring.

The following is a summary of the updates implemented for this effort.

2 Modeling Approach

Prior to construction of any model, it is important to properly conceptualize the flow system in question. This is done using a Conceptual Site Model (CSM), which is a detailed description of groundwater behavior that directs the assumptions used in the proposed numerical model. The conceptual model should identify the various hydrologic and hydrogeologic features that physically drive the flow of water through the groundwater system. System drivers generally include the boundary of the model domain, various types of source/sink and boundary conditions, subsurface features that convey water or interrupt flow, rainfall and evapotranspiration zones, and site stratigraphy.

The conceptual model should start with the basic components that have the greatest effect on groundwater flow. Once the preliminary CSM has been developed, the grid used by the numerical model can be constructed and the desired simulations can be set up to portray the conceptual model. Complexity can be added to the conceptual and computational models as a better understanding of the flow systems is defined. This often is an iterative process where the numerical model results and questions are used to help improve the conceptual model.

The Fort Ord Groundwater Model is based on the finite-difference MODFLOW-2005 software (Harbaugh, 2005) originally completed for the Fort Ord basewide hydrogeological characterization and used in the Basewide Remedial Investigation/Feasibility Study (HLA, 1995). Particle tracking was originally generated using the PATH3D model code (Zheng, 1989) and is currently generated using MODPATH (Pollock, 1994) in conjunction with MODFLOW-2005. Groundwater model construction, calibration, and capture zone analysis are performed using the Aquaveo Groundwater Modeling System (GMS), Version 9.4., which works in conjunction with MODFLOW-2005 and MODPATH.

In the 2022 model update, the existing CSM was evaluated and updated based on current available data. This included changes to several boundary conditions (including recharge, river boundary and ocean boundary, etc.). The number of wells used for calibration was also increased to include all applicable monitoring well data. This includes wells in the A-Aquifer, Upper and Lower 180-Foot Aquifers, and the 400-Foot Aquifer. Hydraulic conductivity values in all geologic units were adjusted using both manual and automated parameter estimation techniques to obtain a reasonable model calibration. Pilot points were added in the A-aquifer to capture the spatial variation of hydraulic conductivity in that model layer based on the observed water level variations. The updated, calibrated flow model was then used to simulate backward-tracking groundwater flow paths induced by operation of the Sites 2/12 and OU2 GWE wells. The following sections summarize the background, data inputs, calibration and results of the model.

2.1 Model Extent

The three-dimensional nature of the study area must be considered during numerical model development. MODFLOW uses a structured three-dimensional (3-D) grid as the computational framework for the groundwater flow calculations. The grid is comprised of cubic elements and must balance accurate depiction of topography, geology, and groundwater sources/sinks with model goals and computational resources. The computational grid must also incorporate features at resolutions appropriate for accurate evaluation of model results.

For the purposes of this model update, the numerical grid and geologic layering used in previous modeling efforts were not modified. The extent of the model domain was large enough to allow for the simulation of any potential remediation efforts. The grid extends from the Monterey Bay in the west to the Salinas River and Salinas River Valley in the east; and from the southern watershed to an area north of what once was Operable Unit 1 (OU1). The model uses a 100-ft x 100-ft regular grid, which was originally used in the 2016 model update (USACE-HEC, 2016). Further documentation related to the geologic layering used in the model is documented in the HEC publication, Development and Application of Groundwater Flow Model of the Former Fort Ord Military Installation, Monterey County CA (USACE-HEC, 2020).

Figure 1 shows the horizontal extents of the model domain (approximately 17.1 square miles). Figure 2 shows the vertical model extent and geologic units modeled. Although the depth of the model varies, the topographic high is at approximately 337 ft. National Geodetic Vertical Datum of 1929 (NGVD29) in the southern portion of the model and the base of the 400-Foot Aquifer extends to -300 ft. NGVD29. The entire 3-D grid for this model is comprised of 245,567 active elements and 40,633 inactive elements.

2.2 Model Datum

Numerous data sources were compiled to generate the model input parameters and calibration/validation data sets. All data sets were converted to a common horizontal and vertical datum. The horizontal datum used for this model is feet NAD83, California State Plane Zone 4. The vertical datum used is feet NGVD 29.

2.3 Boundary Conditions

A combination of surface recharge (RCH), river (RIV), constant head (CHD) and no-flow boundaries were applied to the model domain. The value of these boundary conditions was based on historical and regional observed data.

2.3.1 Recharge

As stated in Development and Application of Groundwater Flow Model of the Former Fort Ord Military Installation, Monterey County CA (USACE-HEC, 2020), the average annual precipitation at Fort Ord is approximately 15 in/yr. Previous iterations of the model utilized two zones of recharge applied to the model surface. The eastern zone was given 0.001 ft/day (4.4 in/yr). This recharge rate is consistent with the model report and is based on the assumption that approximately 30% of precipitation (14-15 in/yr) recharges groundwater. The western recharge zone used a recharge rate of 0.02 ft/day (87.6 in/yr), which appeared excessive given the rainfall in this area. For the 2022 model update, the recharge applied to the model surface was spatially distributed based on land use observed in current aerial photography. Figure 3 shows this spatial distribution, which varied between 0.9 inches/year and 13.1 inches/year. These recharge values were adjusted during the course of model calibration to ensure the flow balance in the model is consistent with the CSM. Areas of higher recharge are generally consistent with open spaces or portions of the base that appear to have been demolished in recent years. Lower recharge areas are generally consistent with more urbanized areas.

2.3.2 Salinas River

The RIV boundary condition was applied to Model Layer 1 that is coincident with the Salinas River. In previous versions of the model the stage at this boundary was applied at 1.2 ft NGVD29. According to the modeling report, this boundary condition was based on recent long-term averages for the river stage in the area. However, according to the SALINAS R NR SPRECKELS CA gage (11152500: https://waterdata.usgs.gov/monitoring-location/11152500), the water level since October 2007 (when data collection began at this gage) varied from a low of approximately 1.35 (between 2014 and 2017) to approximately 3.4 (in recent years). This excludes short-term flooding events where the gage level can be between 5 and 20 ft. The altitude of the gage is 20.56 ft NGVD29, which results in a stage at this location in recent years of approximately 23.96 ft

NGVD29. As shown in Figure 4, the SPRECKELS gage is located approximately 5 miles upstream of the model boundary and the confluence with Monterey Bay is approximately 5.5 miles downstream of the model boundary. Based on topographic data downloaded from NOAA coastal Lidar, the riverbed elevation at the upstream river boundary in the model is 11 ft NAVD88 (8.27 ft NGVD29) and the downstream river boundary is 7.0 ft NAVD88 (4.27 ft NGVD29). Based on the existing water level and topographic data, the applied RIV stage for the model boundary of 1.2 ft in previous models is likely low. Since the 2020 HEC groundwater modeling report indicates that the river depth is relatively shallow in this area, for the 2022 model update the RIV boundary applied to the model varied between 9.25 ft NGVD29 (upstream boundary) and 5.25 ft NGVD29 (downstream boundary). This assumes a low (approximately 1 ft above ground surface) river stage within the model domain. This RIV stage is notably higher than that used in the previous model but lower than a rudimentary interpolation between the SPRECKELS gage and Monterey Bay, which would indicate a river stage of approximately 12 ft NGVD29 along the model boundary. A riverbed conductance of 1560 (ft^2/day)/ft was applied to the RIV boundary cells, which is consistent with previous modeling efforts. A sensitivity analysis showed that the computed heads in Sites 2/12 and OU2 were relatively insensitive to this model boundary condition.

2.3.3 Monterey Bay and Regional Groundwater Boundaries

Constant Head (CHD) boundary conditions were applied along the western coast in all model layers based on tidal data in Monterey Bay. In the previous version of the model, the western boundary at Monterey Bay was applied a CHD of 5 ft NGVD29. The NOAA Monterey tide gage (9413450) indicates that the average ocean elevation is 0 MSL (0.24 ft NGVD29). In 2022 the average high tide was approximately 2.5 ft MSL (2.74 ft NGVD29). As such a boundary along Monterey Bay of 5 ft MSL appears high. For the 2022 model update, the CHD applied along Monterey Bay varied by aquifer between -1 and 2 ft NGVD29. The CHD values used for each model layer are shown in Figures 4 to 9. The variation in CHD boundary condition elevation was used to ensure consistency with the observed tidal data, variations in the distance between the edge of the model and the geologic outcrops in Monterey Bay, as well as regional groundwater level trends. Although the assumed CHD boundary conditions applied along Monterey Bay are consistent with available data, it is recommended that future iterations of the model consider the expansion of the model grid to the geologic outcrops in Monterey Bay or the use of General Head (GHB) conditions.

As shown in Figures 4 to 9, CHD boundaries were also applied to the primary aquifers based on regional water level data. These boundary conditions were approximated based on regional water level data from site investigations and groundwater contours published by the Monterey County Water Resources Agency (MCWRA). Figure 10 shows the regional groundwater contours in the A-Aquifer based on groundwater level data collected by Ahtna (Ahtna Global, LLC, May 2022). These contours were extrapolated to the model boundary to develop CHD boundary conditions (other than those used for the Salinas River and Monterey Bay) in Layer 1. In the deeper aquifers, the MCWRA data from 2021 and 2022 groundwater monitoring was used to set the boundary conditions. Figures 11 and 12 show the variations in observed water level in the 180-Foot Aquifer, while Figures 13 and 14 show the variations in observed water level is the 400-Foot Aquifer. Although these figures show the aquifer head contours in 2021, they do indicate a substantial reduction in heads in the later (dryer) part of the water year, which is indicative of when regional groundwater withdrawals occur. More information on how these heads were varied during model calibration and validation is presented in Section 3. Although the assumed CHD boundary conditions applied along the regional boundaries are consistent with available data and inherently capture the impacts of regional pumping, it is recommended that future iterations of the model determine if additional large scale regional pumping centers have changed their pumping rates and/or locations of extraction.

The remaining model boundaries have no flow boundary conditions assigned where CHD or RIV boundary conditions are not assigned. No-flow boundaries were also utilized along the bottom of the model at the base of the 400-Foot Aquifer.

2.4 Extraction and Injection Wells

Extraction and injection wells across Fort Ord were incorporated into the model to properly simulate the regional groundwater flow patterns. This includes wells from both Sites 2/12 and OU2. The following table summarizes the extraction and injection rates used in the model from October 2021 through September 2022.

Sites 2/12 GWTS Model Data Inputs

GWE Well	2022 Ave (GPM)	2021-4Q (GPM)	2022-1Q (GPM)	2022-2Q (GPM)	2022-3Q (GPM)
EW-12-05-180M	99.75	100	101	99	99
EW-12-06-180M	0	0	0	0	0
EW-12-07-180M	0	0	0	0	0
EW-12-08-180U	42.5	40	39	44	47
EW-12-03-180U	0	0	0	0	0
EW-12-03-180M	0	0	0	0	0
EW-12-04-180U	0	0	0	0	0
EW-12-04-180M	0	0	0	0	0

Injection/ Infiltration Well	2022 Ave (GPM)	2021-4Q (GPM)	2022-1Q (GPM)	2022-2Q (GPM)	2022-3Q (GPM)
INF-02-01-180	165.75	165	162	144	192
INF-02-02-180	165.75	165	162	144	192
INF-02-03-180	250	250	250	250	250
IW-02-01-180	0	0	0	0	0
IW-02-02-180	0	0	0	0	0

OU2 GWTS Model Data Inputs

GWE Well	2022 Ave (GPM)	2021-4Q (GPM)	2022-1Q (GPM)	2022-2Q (GPM)	2022-3Q (GPM)
EW-OU2-01-A	0	0	0	0	0
EW-OU2-02-A	56.25	53	57	57	58
EW-OU2-03-A	0	0	0	0	0
EW-OU2-04-A	42.75	42	43	42	44
EW-OU2-05-A	15.25	61	0	0	0
EW-OU2-06-A	55	59	59	61	41
EW-OU2-07-A	0	0	0	0	0
EW-OU2-08-A	0	0	0	0	0
EW-OU2-09-A	21.5	22	22	21	21
EW-OU2-10-A	8	10	8	7	7
EW-OU2-11-AR	9	9	7	9	11
EW-OU2-12-A	4	4	4	4	4
EW-OU2-13-A	14.75	15	15	14	15
EW-OU2-14-A	0	0	0	0	0
EW-OU2-15-A	0	0	0	0	0
EW-OU2-16-A	8.5	7	9	9	9
EW-OU2-17-A	6.5	8	6	6	6
EW-OU2-18-A	5.5	7	5	5	5
EW-OU2-19-A	6	8	7	5	4
EW-OU2-20-A	3.25	3	3	3	4
EW-OU2-01-180	0	0	0	0	0
EW-OU2-02-180R	90.5	63	68	111	120
EW-OU2-03-180	149	150	148	149	149
EW-OU2-04-181	0	0	0	0	0
EW-OU2-05-180	140.75	134	115	113	201
EW-OU2-06-180	119	135	111	113	117
EW-OU2-07-181	0	0	0	0	0
EW-OU2-08-180	38.25	0	55	48	50
EW-OU2-09-180	54.5	56	55	53	54
EW-OU2-10-180	103.25	106	103	97	107
EW-OU2-11-180	3.25	3	4	3	3
EW-OU2-12-180	49	55	49	46	46
Injection/ Infiltration Well	**2022 Ave (GPM)**	**2021-4Q (GPM)**	**2022-1Q (GPM)**	**2022-2Q (GPM)**	**2022-3Q (GPM)**
INF-OU2-01-180	183.5	185	187	192	170
INF-OU2-02-180	186.75	192	178	188	189

GWE Well	2022 Ave (GPM)	2021-4Q (GPM)	2022-1Q (GPM)	2022-2Q (GPM)	2022-3Q (GPM)
IW-OU2-01-180	0	0	0	0	0
IW-OU2-02-180	0	0	0	0	0
IW-OU2-04-180	89.5	90	87	90	91
IW-OU2-05-180	50.25	45	45	54	57

As discussed in Section 3, model calibration and validation were performed to the data sets for the first quarter of 2022 as well as the third quarter of 2022. Although the extraction and injection rates from the wells did not vary substantially during the year, the pumping rates used for the calibration/validation periods were taken from the time period modeled.

2.5 Hydrogeology

As discussed in Section 2.1, the model layering used to represent the hydrogeology across the model domain was not changed as part of this modeling update and is assumed to be consistent with the CSM. However, due to the revisions in boundary conditions and pumping rates during the modeling period, changes were made to the hydrogeologic properties in each of the geologic layers. This generally resulted in slightly lower hydraulic conductivity values in comparison to previous iterations of the model; however, the hydraulic conductivity values remained consistent with available site data.

In the A-Aquifer (Layer 1), the model was updated to utilize pilot points to spatially distribute the hydraulic conductivity. This was justified since there were 141 observation points available for calibration in the A-Aquifer and the observed head change of nearly 90 feet in the upper layer of the model showed distinct spatial variations. The spatial distribution of hydraulic conductivity adopted for the calibration and validation of this model update in Layer 1 is shown in Figure 15.

In the lower layers of the model, hydraulic conductivity was applied using a zonation similar to that from the previous modeling efforts. Although this zonation has less variation in these deeper geologic layers, it is commensurate with the available water level data in each layer. Figures 16 to 20 show the hydraulic conductivity used in Layers 2 through 6 of the model for this update.

3 Calibration/Validation

Model calibration is the process of varying model input parameters within a reasonable range in order to match simulated output to observed conditions within acceptable error criteria. The Fort Ord model has been modified several times since its inception to incorporate changes to extraction or injection well configurations or results from additional groundwater investigations. In the past, each annual update to evaluate the groundwater treatment system (GWTS) was generally limited to updating average extraction and injection well flow rates and observed water levels. For this update period there are 369 wells within the model domain that have at least one reading during the 2022 modeling period. Of those monitoring points, 282 wells have data for all 4 quarters of 2022. Previous versions of the model only used 71 of these observed water level data points. To ensure accurate regional flow patterns across the site, all available water level data (except that from active extraction and injection wells) was used for model calibration. In addition, special attention was paid to ensure a reasonable calibration in both primary areas of interest (Sites 2/12 and OU2). Due to the exceedingly dry second and third quarter of 2022, primary calibration was to the first quarter of 2022 which was preceded by more average rainfall conditions in the area. Validation simulations were also performed on the dryer third quarter of 2022. For this validation simulation the CHD boundary conditions in the deeper aquifers were reduced consistent with the regional flow patterns developed by the MCWRA. Pumping from the injection and extraction wells was also adjusted to reflect the rates during this period.

Figures 21 to 24 show the steady-state calibration results for the first quarter of 2022 in the A-Aquifer, Upper 180-Foot Aquifer, Lower 180-Foot Aquifer and the 400-Foot Aquifer, respectively. Overall the model is doing a good job of replicating the groundwater flow patterns in the areas of interest. Minor boundary effects are noted in the deeper aquifers in the north and south of the model. This illustrates the uncertainty in the model near these boundaries. Although additional data would help to alleviate these minor boundary effects, the impacts to the computed flow fields in the areas of interest are minimal. Figures 25 to 27 show the steady-state calibration results for the third quarter of 2022 in the A-Aquifer, Upper 180-Foot Aquifer, and Lower 180-Foot Aquifer, respectively.

In order to see the spatial variation of the computed heads for the calibration period, computed water elevations for each aquifer were contoured along with calibration targets for each observation well. The calibration targets show the location of each observed water level and the relative residual error between computed and observed heads. Each target is color coded. Green means that the computed head is within two feet of the observed head; yellow means that the computed head is within four feet of the observed head; and red means that the computed head is more than four feet different than the observed head. If the target is colored above its centerline, the computed head is greater than the observed head. If the target is colored below its centerline, the computed head is less than the observed head.

Linear plots of simulated versus observed groundwater elevation for each monitoring point are provided for each calibration figure. A perfectly calibrated model would result in data plotting directly along the 45-degree line. As shown in Figures 21 to 27, residuals in each hydrogeologic model layer generally plotted along the 45-degree line and the sign and magnitude of residuals are randomly distributed within the model domain with relatively few outliers, as is desired for an acceptably calibrated model.

A model’s calibration is measured mathematically by the use of error statistics on the residual (difference between observed and calculated heads). Two error criteria generally used to evaluate steady state models are the mean error and the root mean square error. The mean error (ME) is the average residual and indicates whether computed heads are overall too high or low. The root mean square error (RMSE) is the square root of average squared residual and gives greater weight to greater residuals. For both of these criteria the optimum value is zero.

As stated in Anderson, 2015, "A model might be considered sufficiently calibrated if the RMSE is less than some set percentage of the calibration target range of values. That is, if head targets range from 50 to 150 m, an acceptable RMSE is on the order of 10 m using 10% as a criterion. However, no reasoning supports an assertion that simply meeting such a criterion defines an appropriately calibrated model. Nor are there established industry guidelines regarding the acceptable magnitude of the ME or RMSE, other than it is desirable to minimize these values." Although evaluation of the RMSE as compared to the range of observations does not define the quality of the calibration, it does provide a useful point of comparison. Figures 21 to 27 show the observed head change in the available water level data as well as the error statistics in each aquifer. Calibration is well within acceptable error tolerances, with the bulk of the observed error noted in the northern portion of the model (away from Sites 2/12 and OU2) in the A-Aquifer. In this area the observed water level changes by more than 30 feet over a relatively short distance of 1,500 ft. Local variations in hydrogeology may not be fully captured in the CSM in this area; however, the general trend of this change is simulated and is reasonable for the purposes of this modeling.

As with all numeric modeling exercises, limitations and uncertainties in model input directly affect the model results. Model predictions (including the predicted particle pathlines used to evaluate capture herein), therefore, have the same uncertainties and limitations as the numeric model. Uncertainties in model input parameters include hydraulic conductivities, porosity, recharge, model water balance, or model boundary conditions. Uncertainty is also introduced by the simulated steady-state model conditions, which necessarily vary from transient conditions such as seasonal precipitation or pumping rates and associated groundwater elevation changes.

4 Capture Zone Analysis

Upon successful calibration of the model, steady state flow fields were used to evaluate capture zones at Sites 2/12 and OU2. Groundwater capture was evaluated by comparing the simulated groundwater particle pathlines and associated capture zones from the active extraction wells during the period modeled. The particle travel times are backwards tracks for 15 years, which is consistent with previous modeling efforts. A soil porosity value of 0.20, which is common for medium sands, was used in the model to simulate transport in the unconfined Upper 180-Foot Aquifer. It should be noted that the distance each particle travels can be very sensitive to variations in the soil porosity.

For Sites 2/12, Figure 28 shows the particle pathlines under the more average first quarter 2022 conditions and Figure 29 shows the particle pathlines under the dryer third quarter 2022 conditions. When compared to the particle pathlines simulated in the 2021 study, the particle pathlines in Figure 28 are notably different in that they track more towards the south and east. This is the result of the numerical changes in the model to adjust the ocean boundary and recharge along the coast to values more representative of current conditions. In addition, the infiltration rate for the Sites 2/12 wells was reduced and the infiltration rate of INF-OU2-02-180 was increased in 2022 in comparison to 2021. As such the computed particle pathlines from the active Sites 2/12 extraction wells more directly track back towards INF-OU2-02-180. In Figure 29, a similar pattern is seen in the particle pathlines, with a portion of the particle paths tracking towards the coast as seen in the 2021 model results. Although these particle pathlines for Sites 2/12 do differ from the 2021 model results, they are consistent with previous versions of the model (e.g. 2015, 2018 and 2019).

For OU2, Figures 30 and 31 show the particle pathlines in the A-Aquifer extraction wells in the first quarter 2022 and third quarter 2022, respectively. These A-Aquifer pathlines track back along the distinct regional gradient to the south in the A-Aquifer. This pattern of capture is consistent with the previous modeling efforts. Figures 32 and 33 show the particle pathlines in the Upper 180-Foot Aquifer extraction wells in the first quarter 2022 and third quarter 2022, respectively. These 180-Foot Aquifer pathlines have a more westerly track in comparison to the A-Aquifer back to the approximate end of the Fort Ord-Salinas Valley Aquitard (FO-SVA) where the Upper 180-Foot Aquifer receives recharge in areas where the SVA does not exist. Subsequent to reaching the FO-SVA, particles continue to track back in the A-Aquifer in a manner similar to that shown in Figures 30 and 31. Although the overall width of these capture zones varies slightly between the wet and dry conditions modeled for this update, these capture zones are also consistent with previous modeling efforts.

5 Conclusions/Recommendations

The purpose of this modeling study was to update the existing Fort Ord groundwater model based on new data, assess assumptions made in previous modeling efforts and evaluate the existing capture zones at Sites 2/12 as well as OU2. Several revisions were made to the model during this update to ensure it reflects current conditions at the site. A more robust regional calibration was performed to all the available monitoring well data within the model domain, which resulted in a more defensible model suitable for its intended purposes. Although these model revisions were notable in some areas, the general capture zones computed at Sites 2/12 as well as OU2 were similar to those previously identified.

6 References

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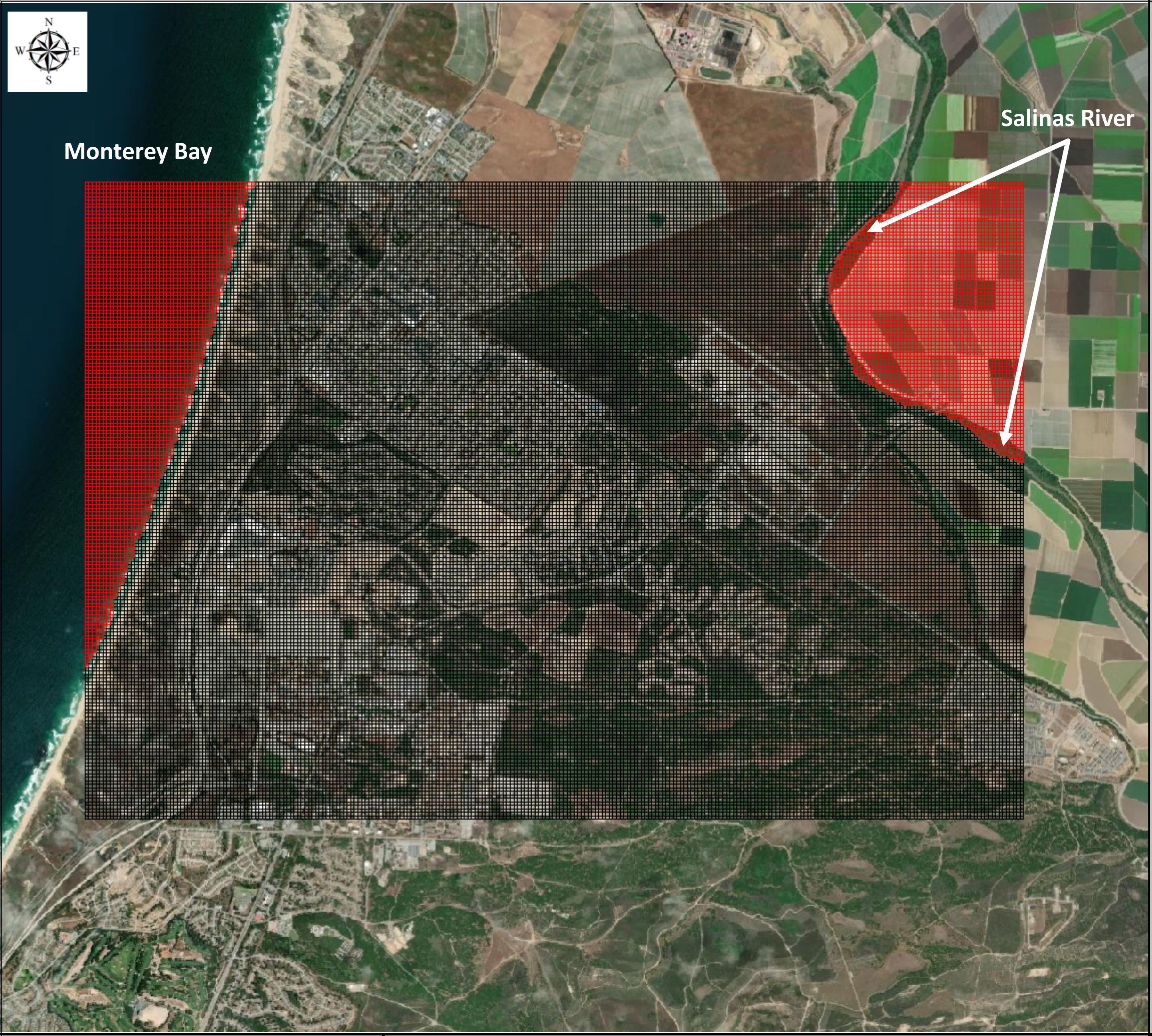


Legend

Active Model Cells

Inactive Model Cells

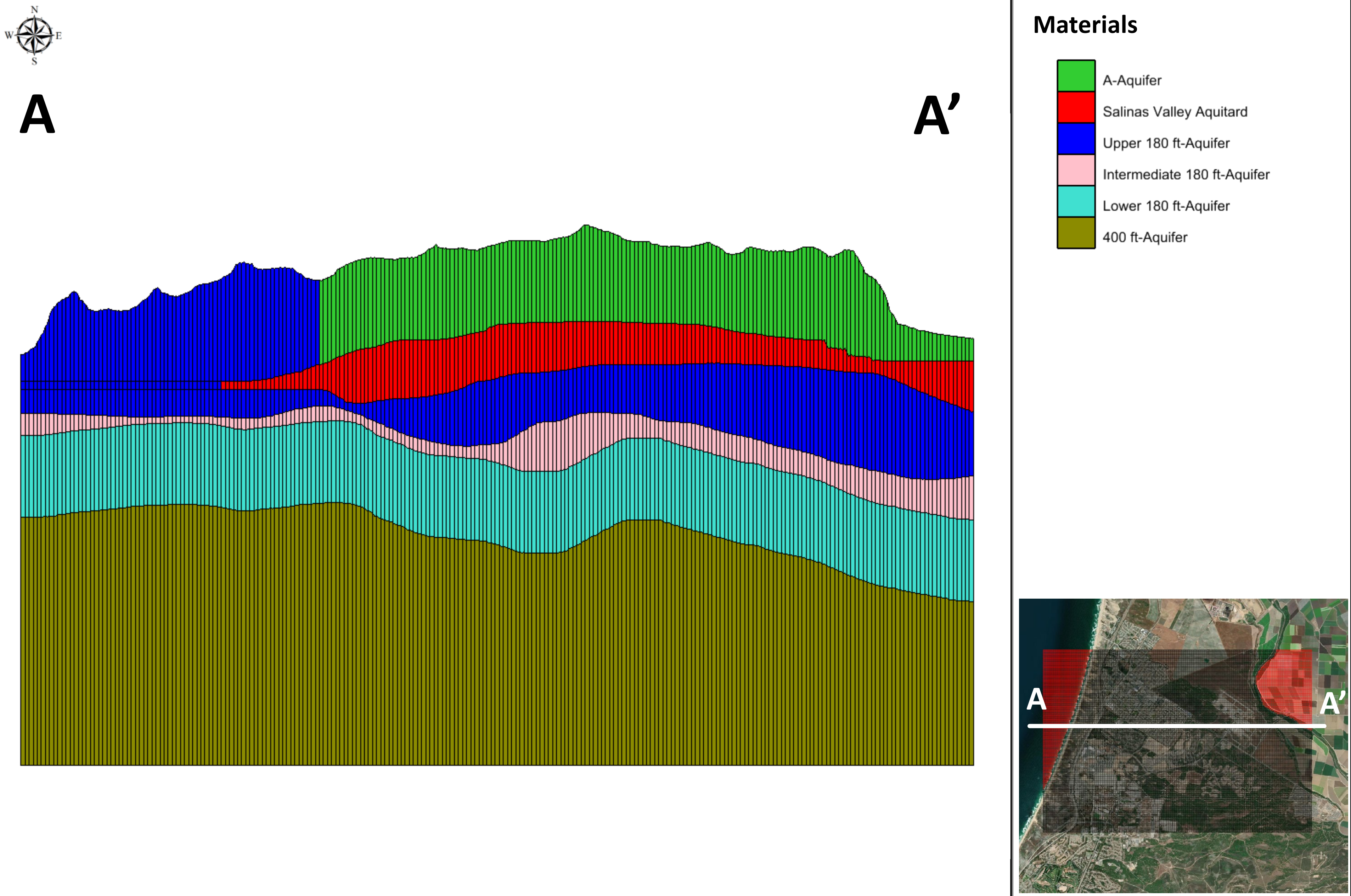
Notes:

Background imagery: World Imagery from the Groundwater Modeling System (GMS)

Fort Ord Model
Horizontal Model Extents

Figure 1

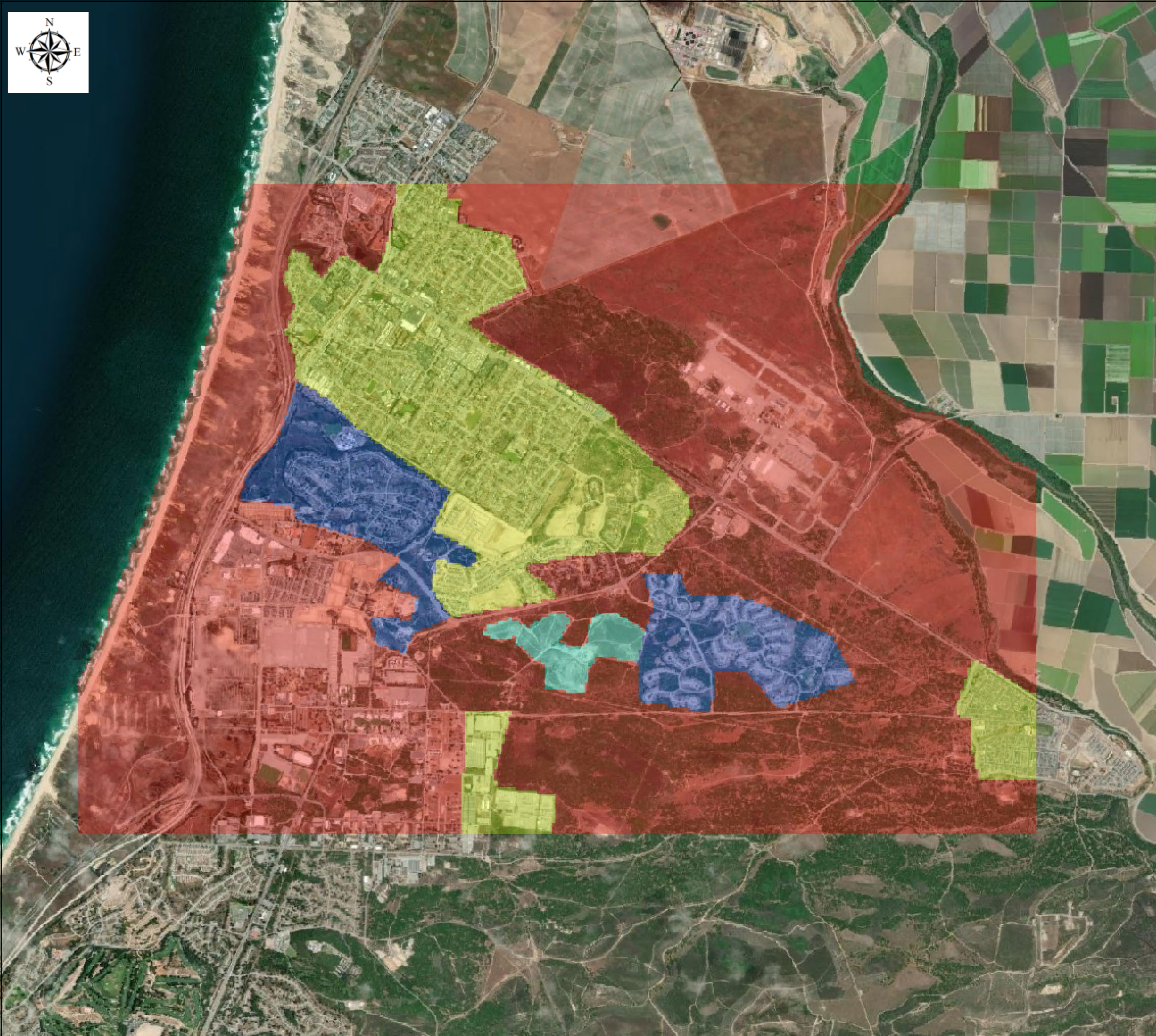
November 2022



Fort Ord Model
Vertical Model Extents

Figure 2

November 2022



Recharge (inches/year)

- 13.1 in/yr
- 9.4 in/yr
- 3.7 in/yr
- 0.9 in/yr

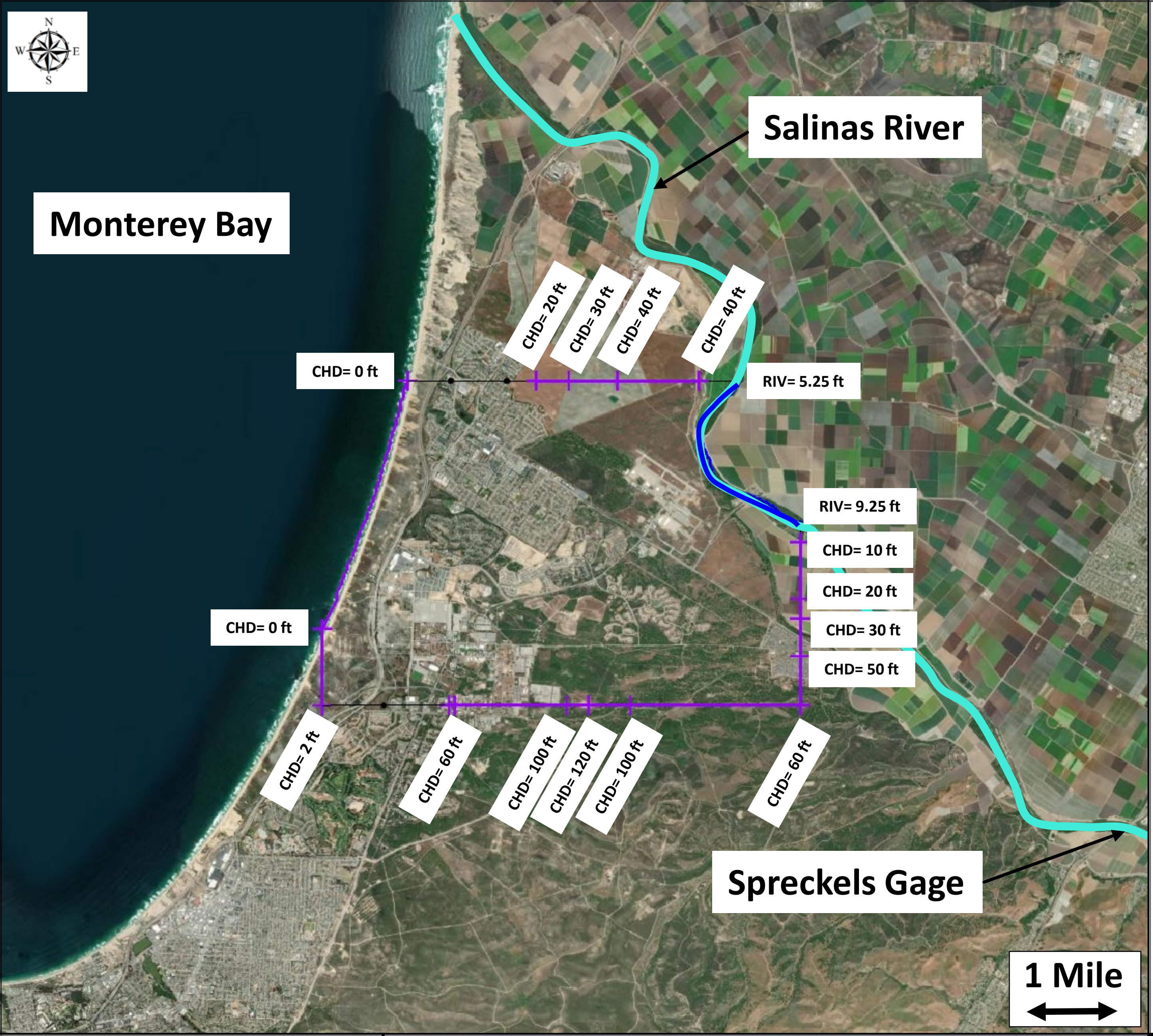
Notes:

Background imagery: World Imagery from the Groundwater Modeling System (GMS)

Fort Ord Model
Recharge

Figure 3

November 2022



Legend

RIV Boundary Condition

CHD Boundary Condition

Notes:

Background imagery: World Imagery from the Groundwater Modeling System (GMS)

Fort Ord Model
Layer 1 Boundary Conditions

Figure 4

November 2022

Legend

- RIV Boundary Condition
- CHD Boundary Condition
- Approx. Layer Outcrop

Notes:

Background imagery: World Imagery from the Groundwater Modeling System (GMS)

Fort Ord Model
Layer 2 Boundary Conditions

Figure 5

November 2022

Legend

- RIV Boundary Condition
- CHD Boundary Condition
- Approx. Layer Outcrop
- Approx. Upper 180 ft-Aquifer Hydraulic Divide

Notes:

Background imagery: World Imagery from the Groundwater Modeling System (GMS)

	Fort Ord Model Layer 3 Boundary Conditions	Figure 6 November 2022

Legend

- RIV Boundary Condition
- CHD Boundary Condition
- Approx. Layer Outcrop
- Approx. Upper 180 ft-Aquifer Hydraulic Divide

Notes:

Background imagery: World Imagery from the Groundwater Modeling System (GMS)

Fort Ord Model
Layer 4 Boundary Conditions

Figure 7

November 2022

Legend

- RIV Boundary Condition
- CHD Boundary Condition
- Approx. Layer Outcrop
- Approx. Upper 180 ft-Aquifer Hydraulic Divide

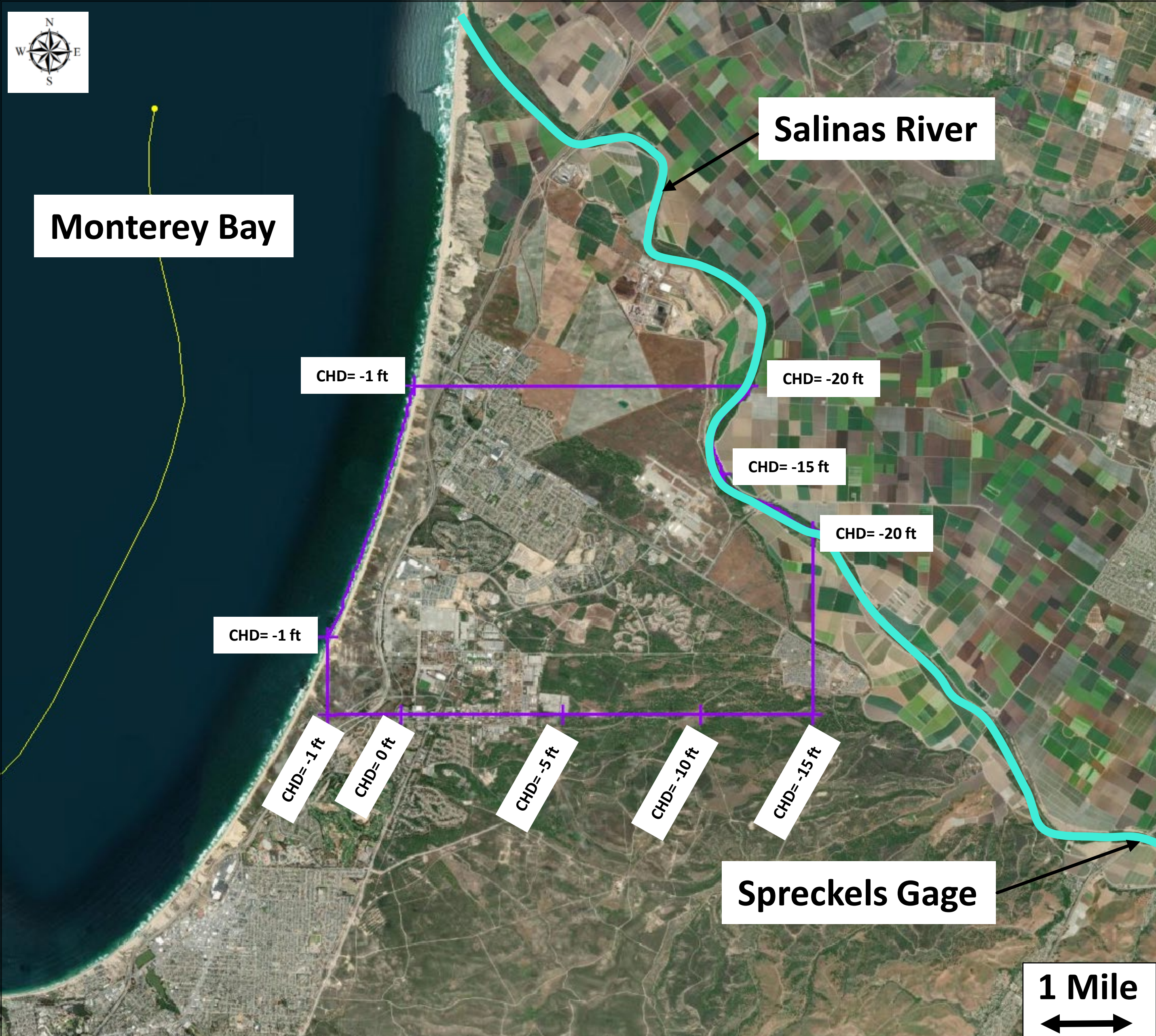
Notes:

Background imagery: World Imagery from the Groundwater Modeling System (GMS)

Fort Ord Model
Layer 5 Boundary Conditions

Figure 8

November 2022



Legend

RIV Boundary Condition

CHD Boundary Condition

Approx. Layer Outcrop

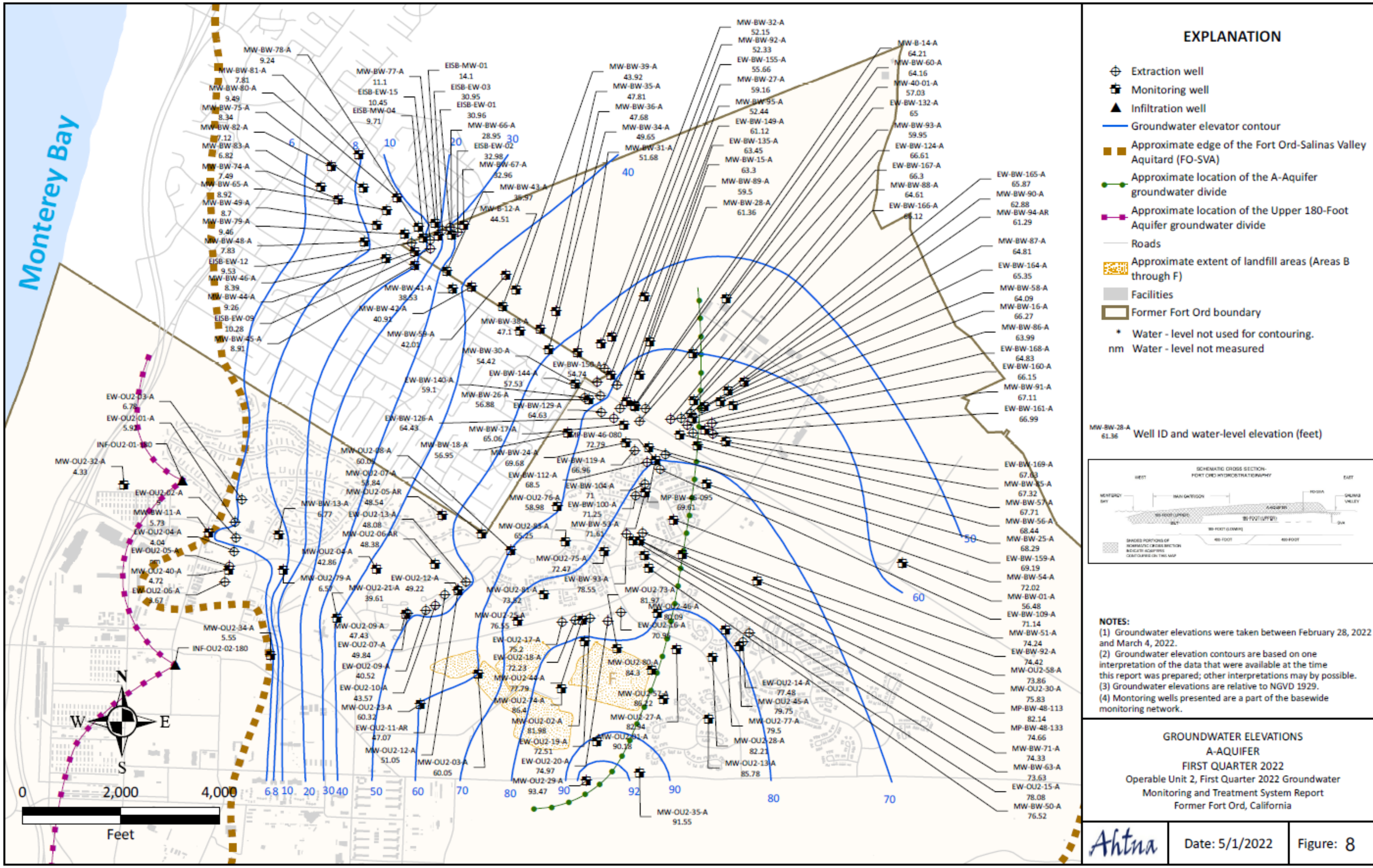
Notes:

Background imagery: World Imagery from the Groundwater Modeling System (GMS)

Fort Ord Model
Layer 6 Boundary Conditions

Figure 9

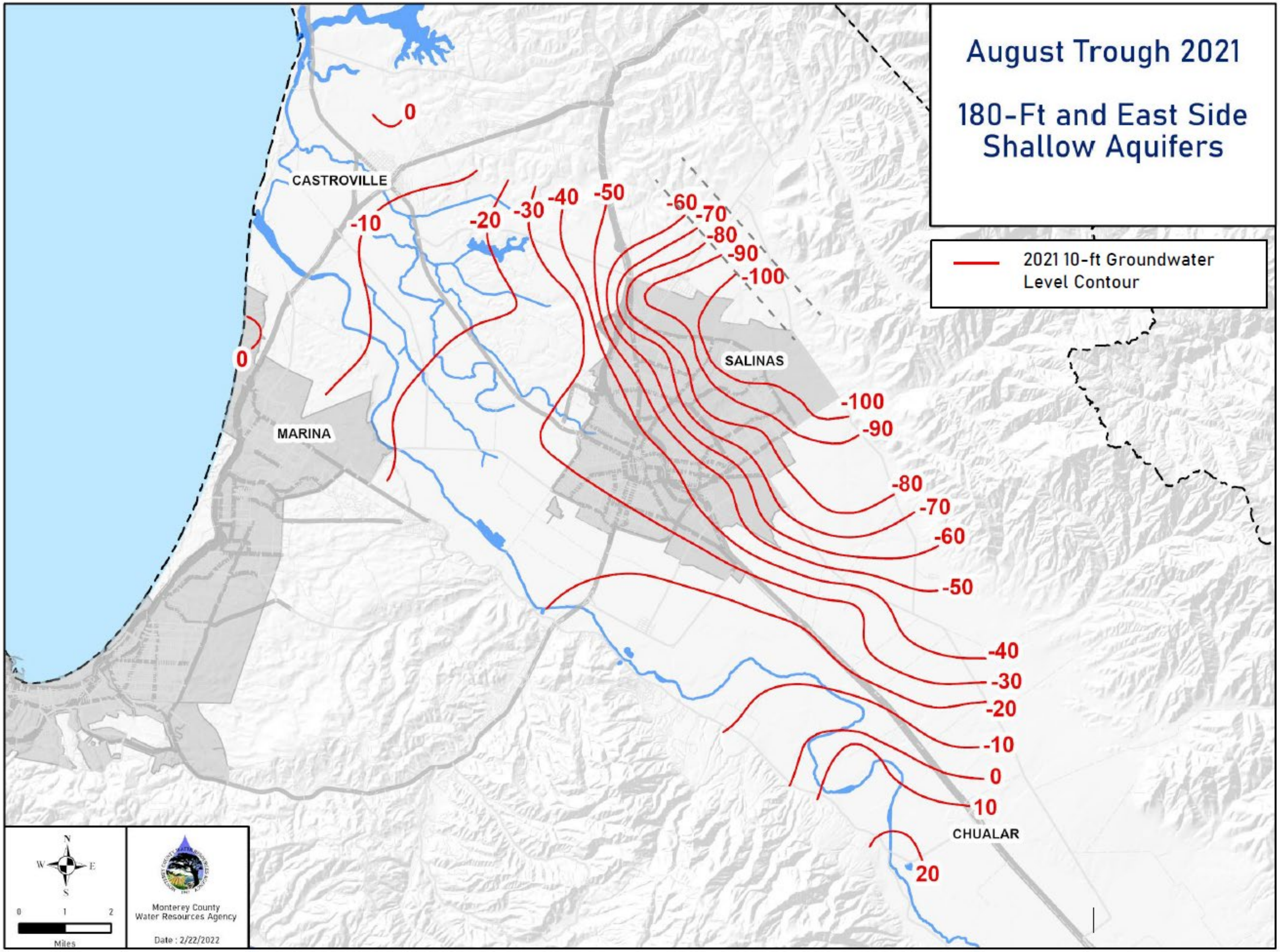
November 2022



Fort Ord Model
A-Aquifer Observed Water Levels
First Quarter 2022

Figure 10

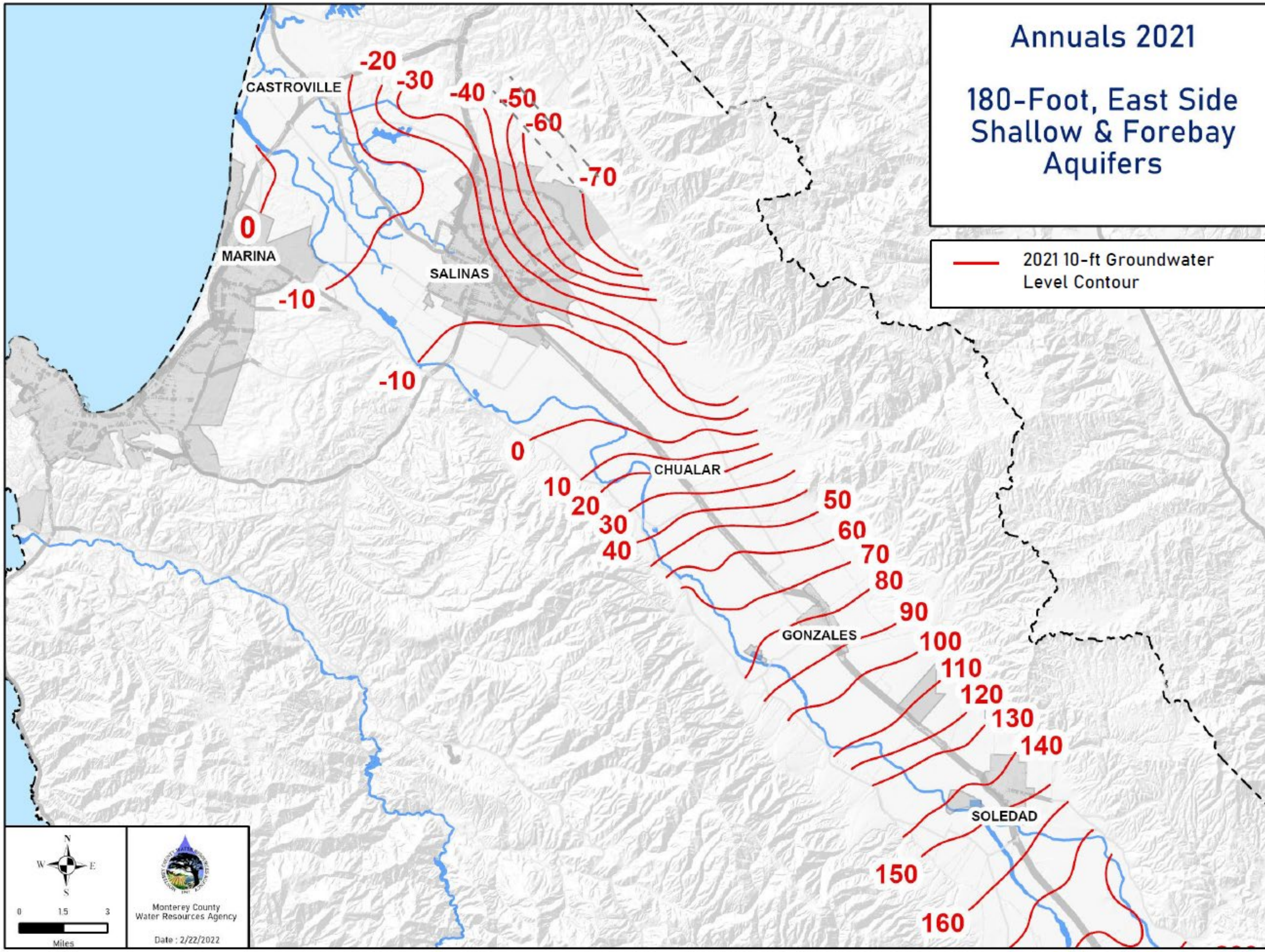
November 2022



Fort Ord Model
180 ft-Aquifer Water Level Contours
August Through 2021

Figure 11

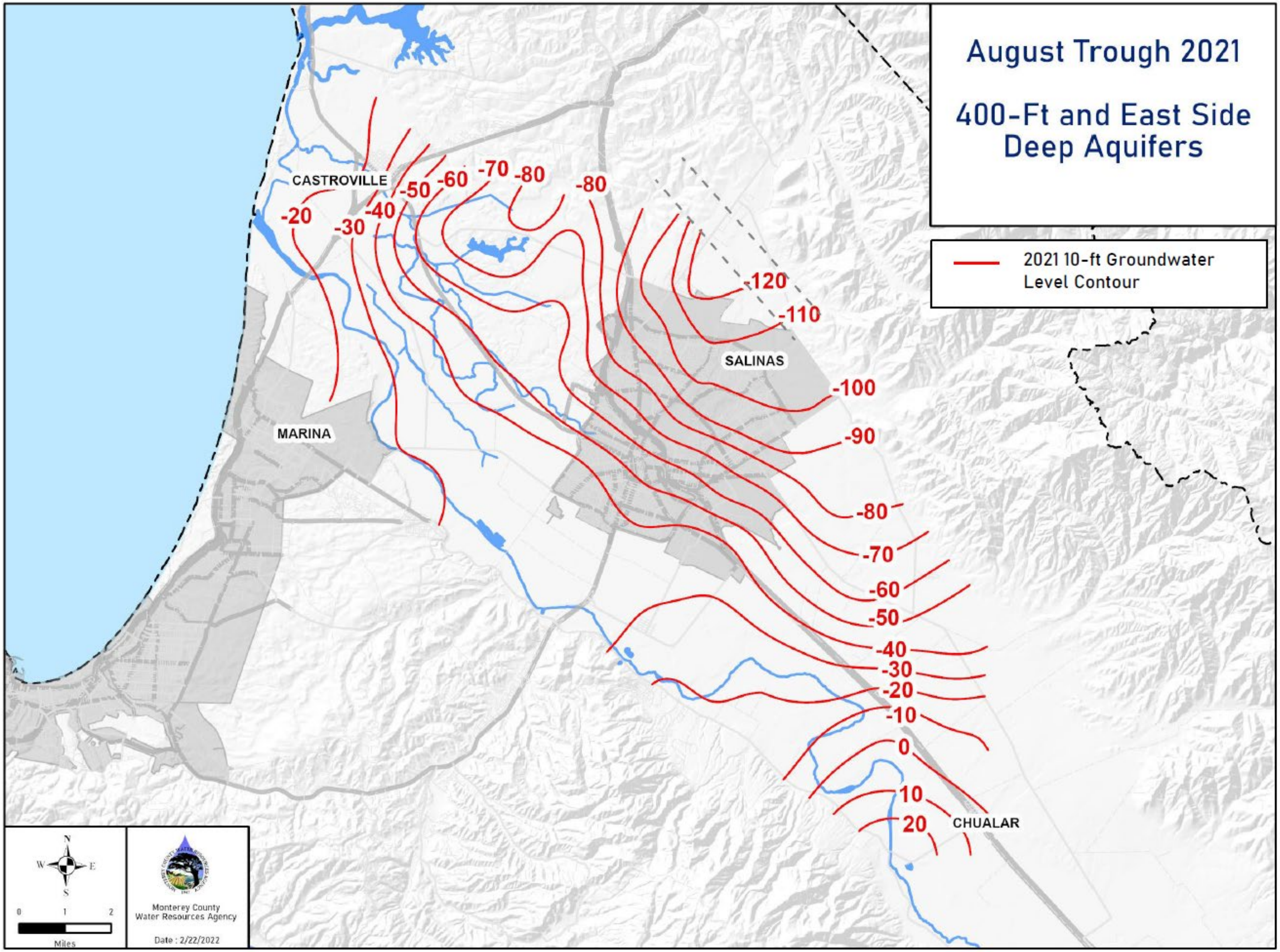
November 2022



Fort Ord Model
180 ft-Aquifer Water Level Contours
2021 Annuals

Figure 12

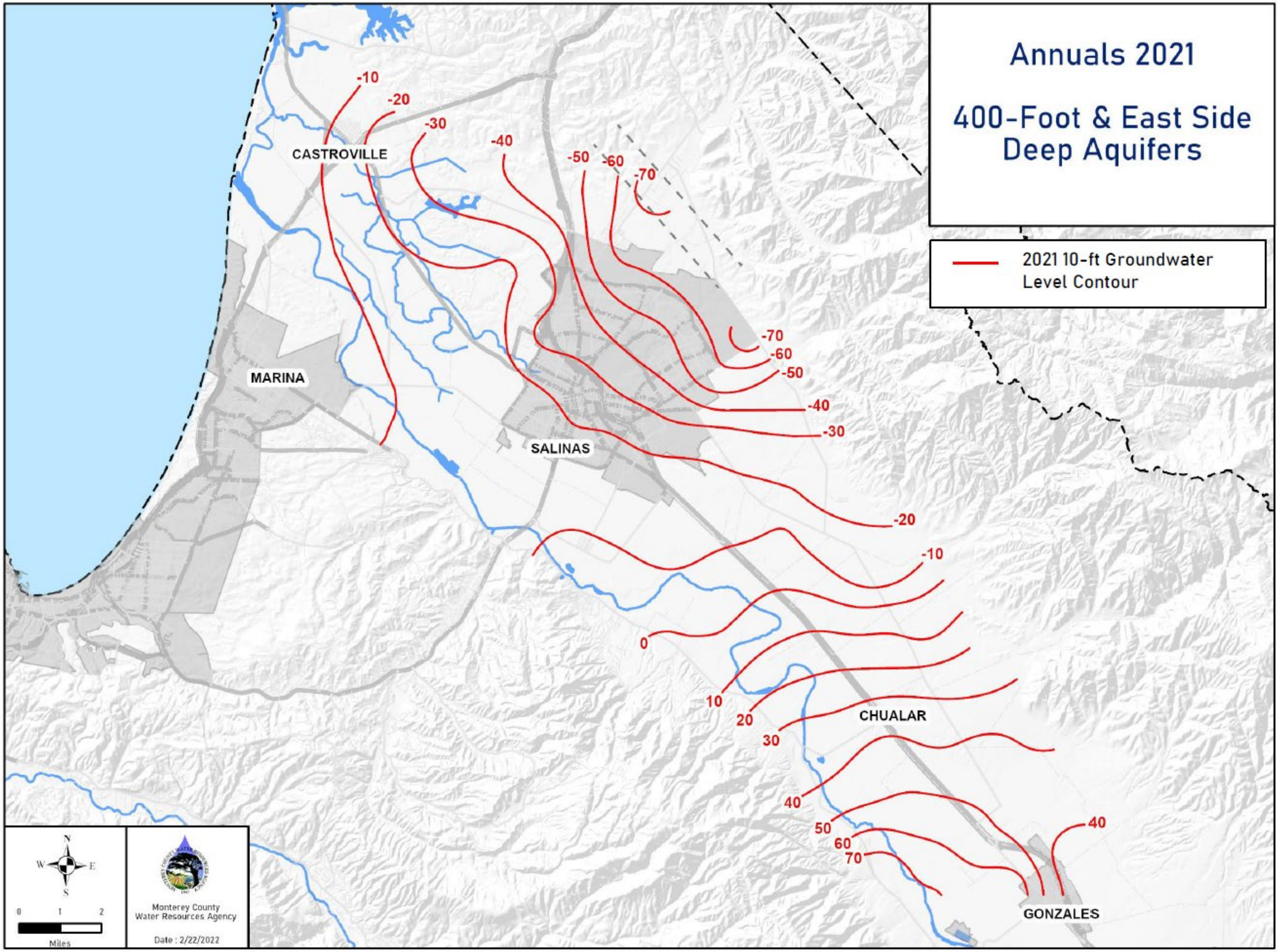
November 2022



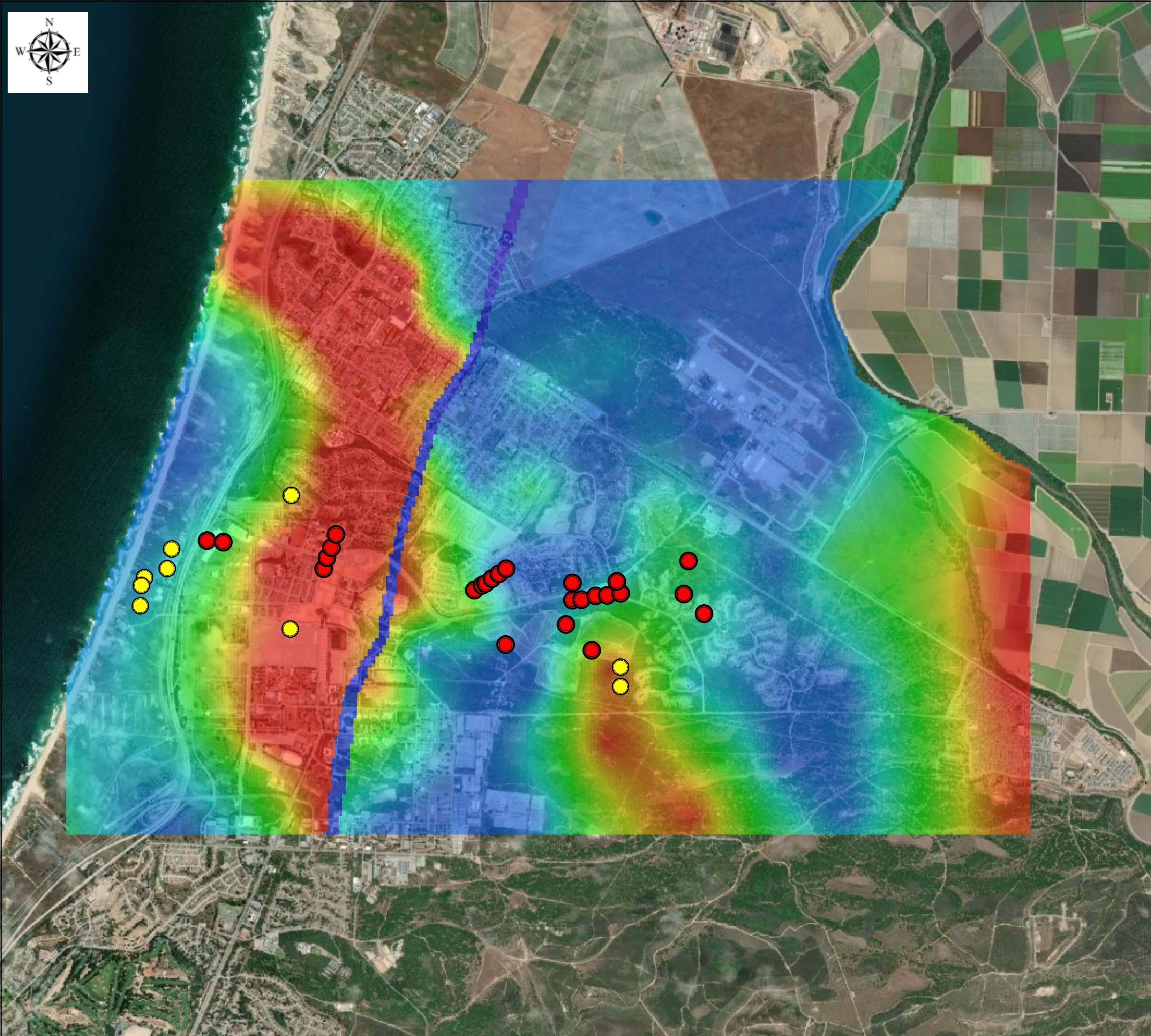
Fort Ord Model
400 ft-Aquifer Water Level Contours
August Through 2021

Figure 13

November 2022



	Fort Ord Model 400 ft-Aquifer Water Level Contours 2021 Annuals	Figure 14 November 2022



Hydraulic Conductivity (feet/day)

500 10

Legend

Modeled Extraction Wells

Modeled Injection Wells

Notes:

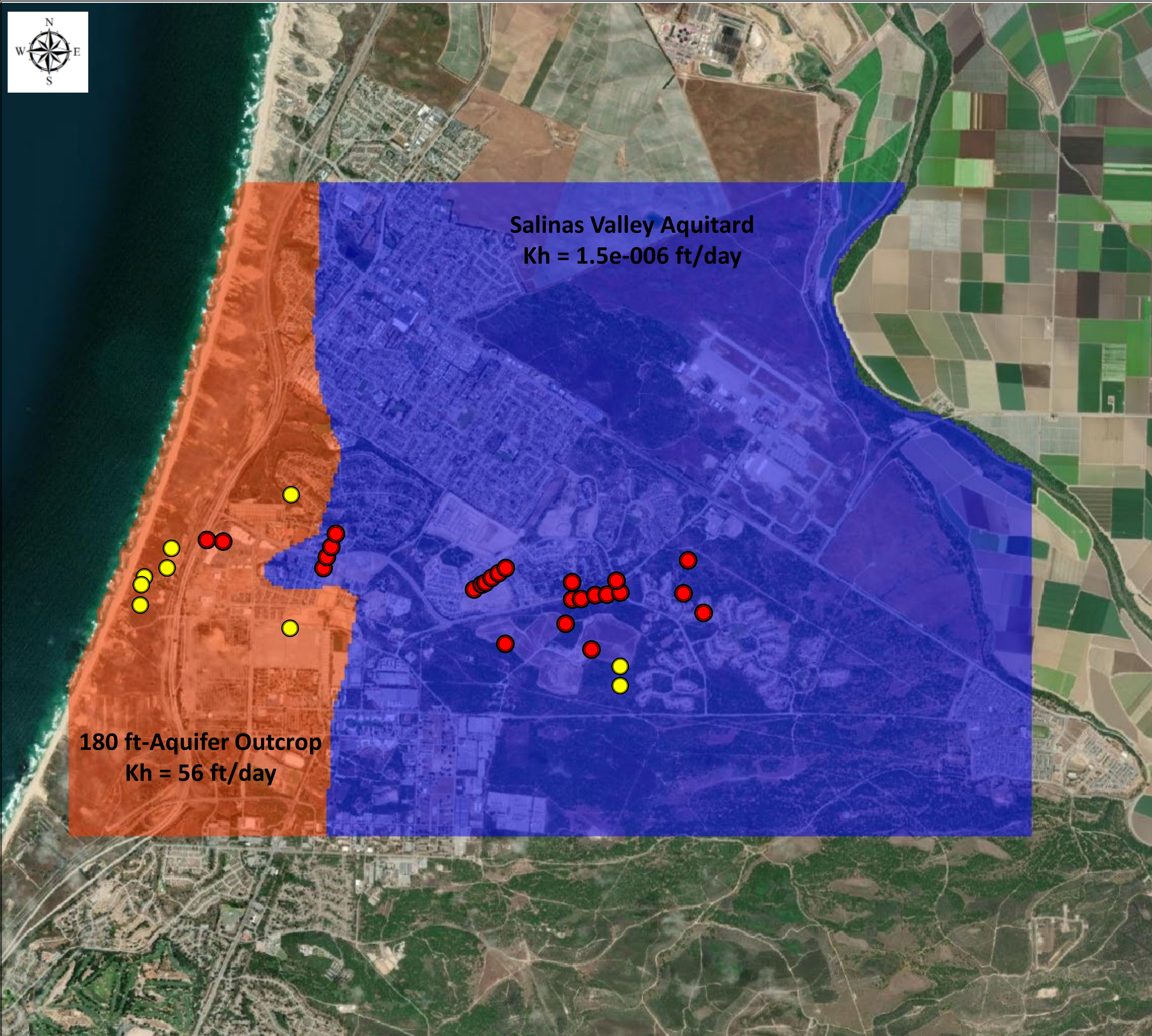
Well locations are for reference and not necessarily active in the model layer shown.

Background imagery: World Imagery from the Groundwater Modeling System (GMS)

Fort Ord Model Update
Hydraulic Conductivity
A-Aquifer (Layer 1)

Figure 15

November 2022



Hydraulic Conductivity (feet/day)

60 — 0

Legend

- Modeled Extraction Wells
- Modeled Injection Wells

Notes:

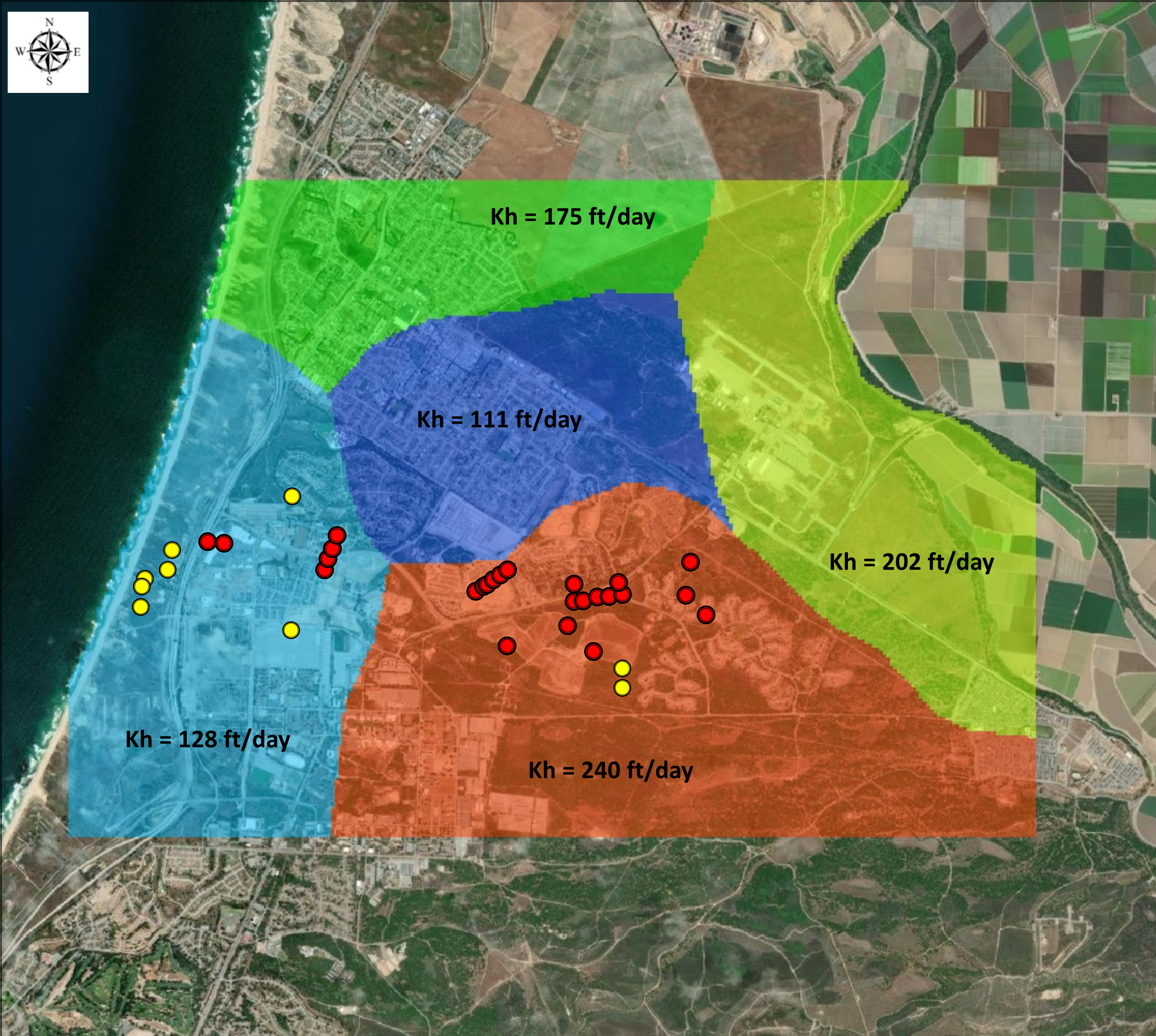
Well locations are for reference and not necessarily active in the model layer shown.

Background imagery: World Imagery from the Groundwater Modeling System (GMS)

Fort Ord Model Update
Hydraulic Conductivity
Salina Valley Aquitard (Layer 2)

Figure 16

November 2022



Hydraulic Conductivity (feet/day)

250 100

Legend

- Modeled Extraction Wells
- Modeled Injection Wells

Notes:

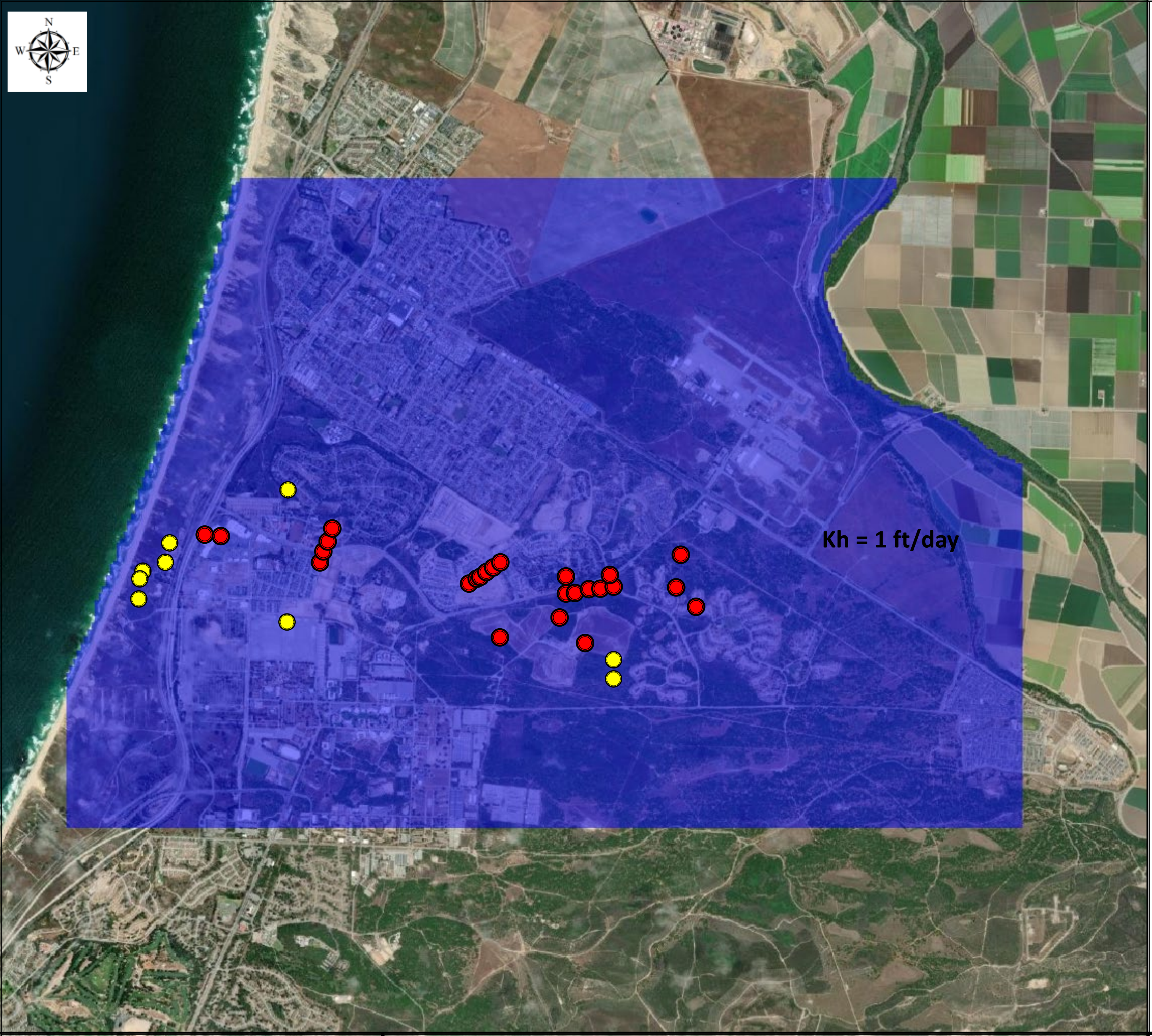
Well locations are for reference and not necessarily active in the model layer shown.

Background imagery: World Imagery from the Groundwater Modeling System (GMS)

Fort Ord Model Update
Hydraulic Conductivity
Upper 180 ft-Aquifer (Layer 3)

Figure 17

November 2022



Hydraulic Conductivity (feet/day)

75 — 1

Legend

- Modeled Extraction Wells
- Modeled Injection Wells

Notes:

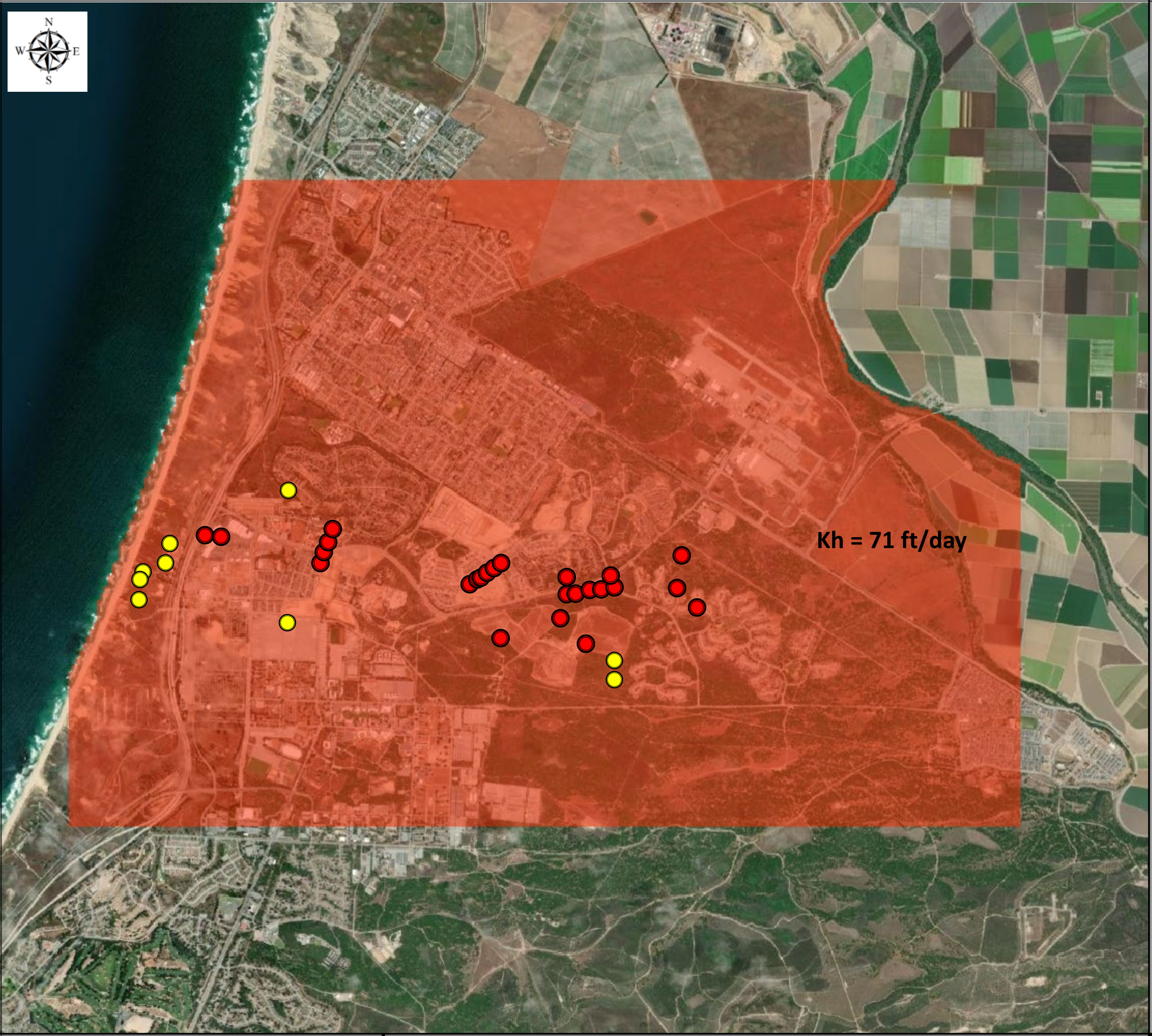
Well locations are for reference and not necessarily active in the model layer shown.

Background imagery: World Imagery from the Groundwater Modeling System (GMS)

Fort Ord Model Update
Hydraulic Conductivity
Intermediate 180 ft-Aquifer (Layer 4)

Figure 18

November 2022



Hydraulic Conductivity (feet/day)

75 — 1

Legend

- Modeled Extraction Wells
- Modeled Injection Wells

Notes:

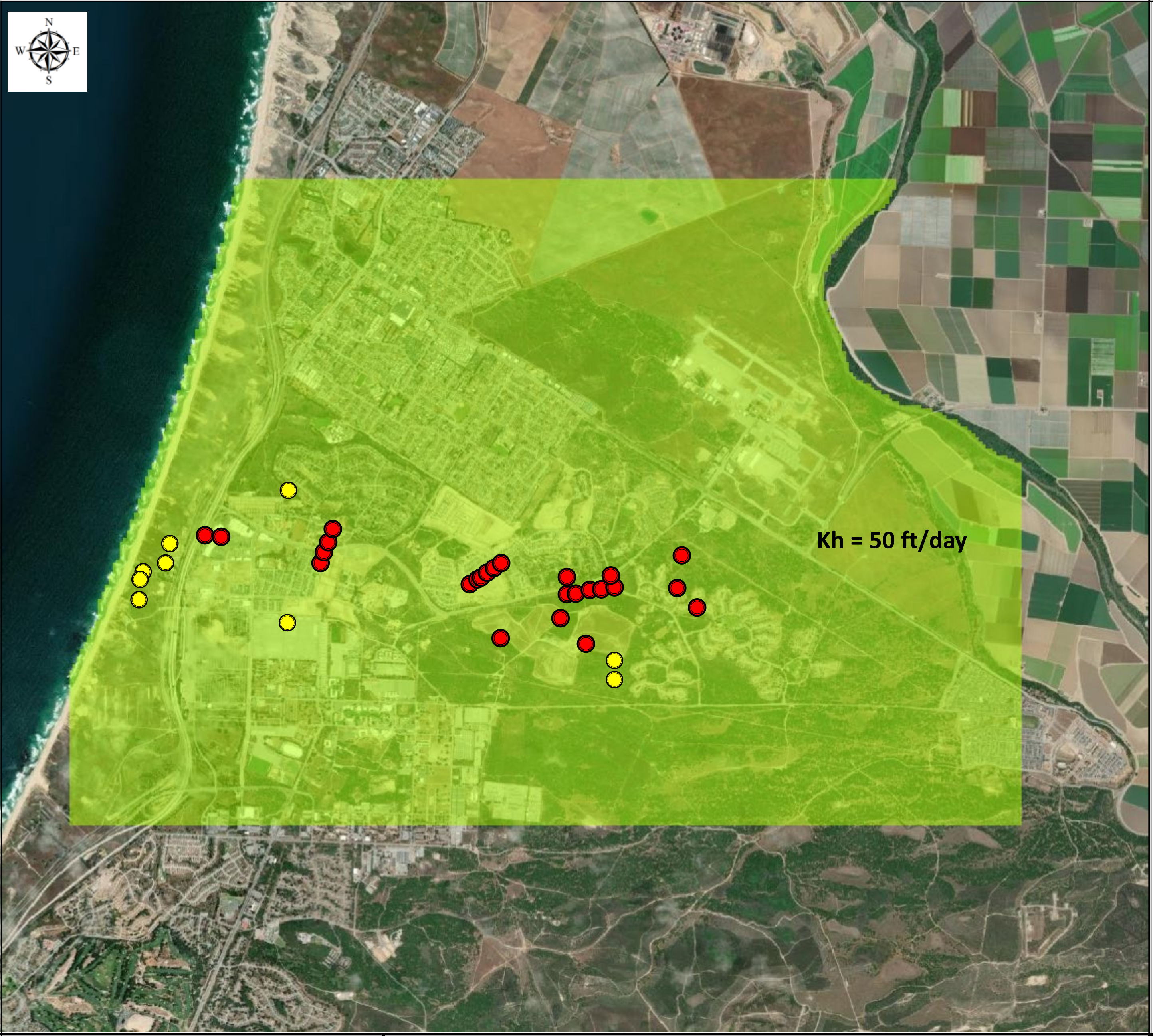
Well locations are for reference and not necessarily active in the model layer shown.

Background imagery: World Imagery from the Groundwater Modeling System (GMS)

Fort Ord Model Update
Hydraulic Conductivity
Lower 180 ft-Aquifer (Layer 5)

Figure 19

November 2022



Hydraulic Conductivity (feet/day)

75 — 1

Legend

- Modeled Extraction Wells
- Modeled Injection Wells

Notes:

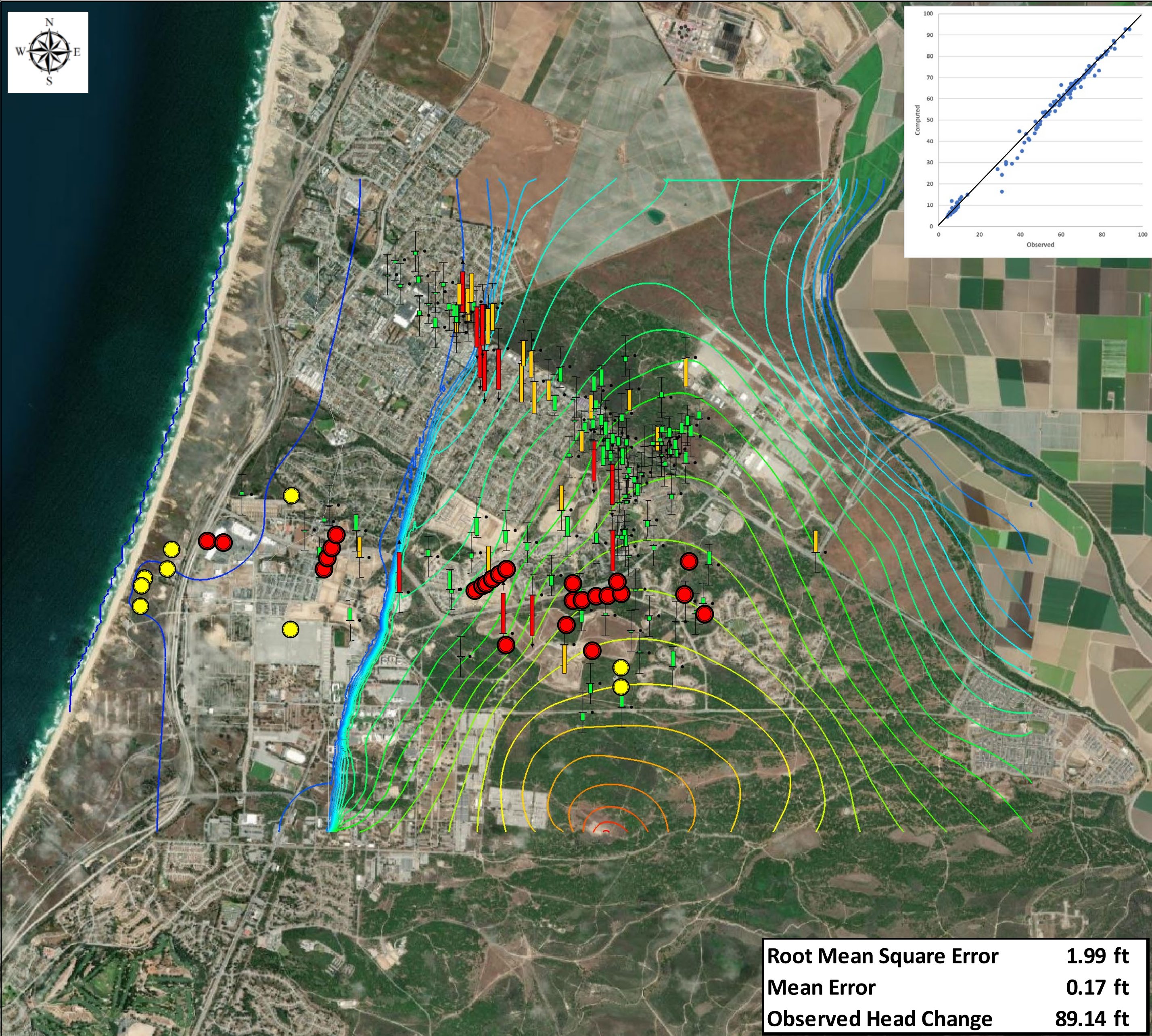
Well locations are for reference and not necessarily active in the model layer shown.

Background imagery: World Imagery from the Groundwater Modeling System (GMS)

Fort Ord Model Update
Hydraulic Conductivity
Lower 180 ft-Aquifer (Layer 5)

Figure 20

November 2022



Total Head (ft NGVD29)

120 0

Calibration Targets

Computed head within 2.0 ft of observed head

Computed head within 4.0 ft of observed head

Computed head more than 4.0 ft from observed head

Modeled Extraction Wells

Modeled Injection Wells

Notes:

Contours shown are for the A-Aquifer

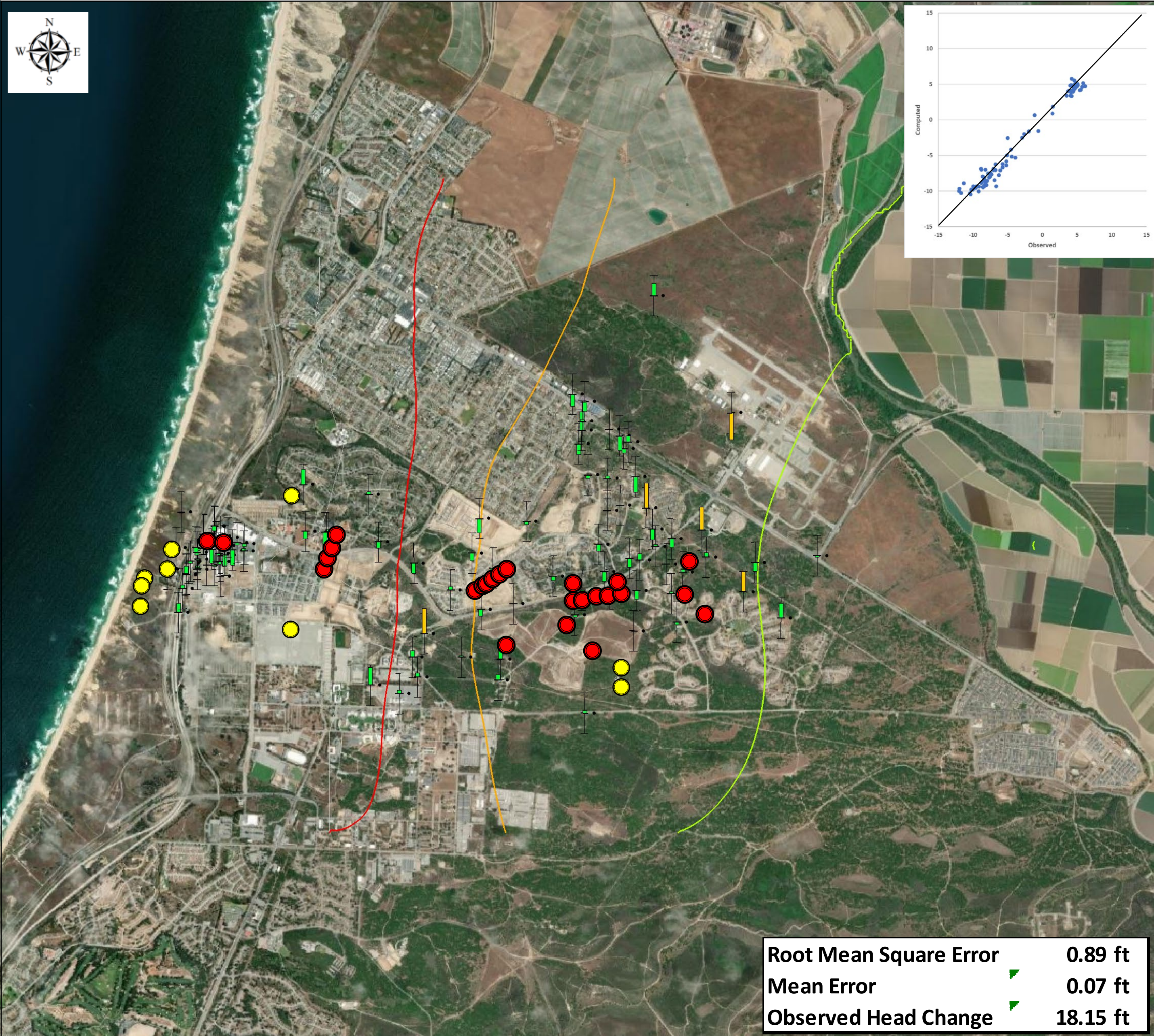
Contour interval = 5 foot

Background imagery: World Imagery from the Groundwater Modeling System (GMS)

Fort Ord Steady State Model Calibration
Calibration Date – First Quarter 2022
A-Aquifer

Figure 21

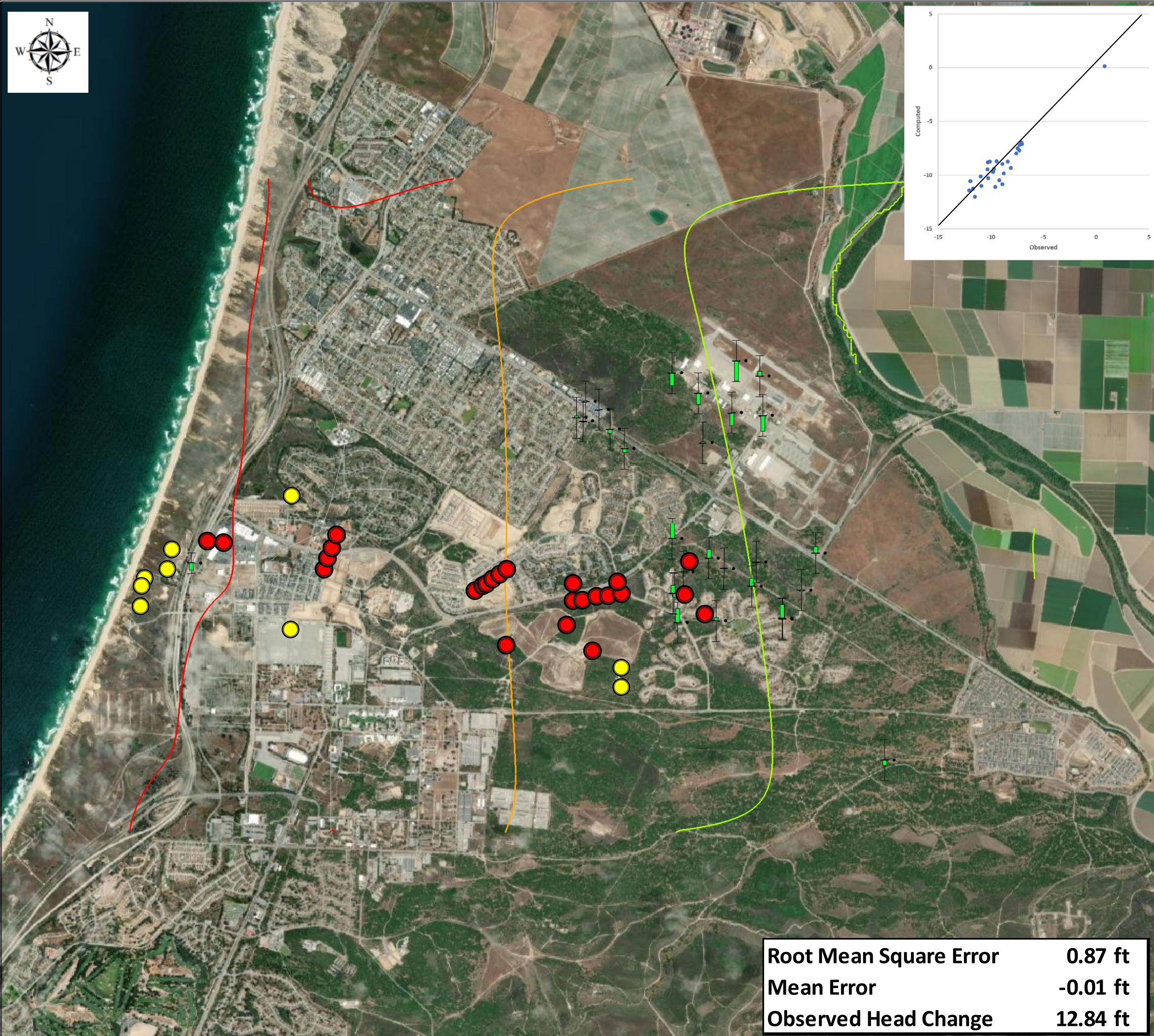
November 2022



Fort Ord Steady State Model Calibration
Calibration Date – First Quarter 2022
Upper 180 ft Aquifer

Figure 22

November 2022



Total Head (ft NGVD29)

0 -30

Calibration Targets

Computed head within 2.0 ft of observed head

Computed head within 4.0 ft of observed head

Computed head more than 4.0 ft from observed head

Modeled Extraction Wells

Modeled Injection Wells

Notes:

Contours shown are for the Lower 180 ft Aquifer

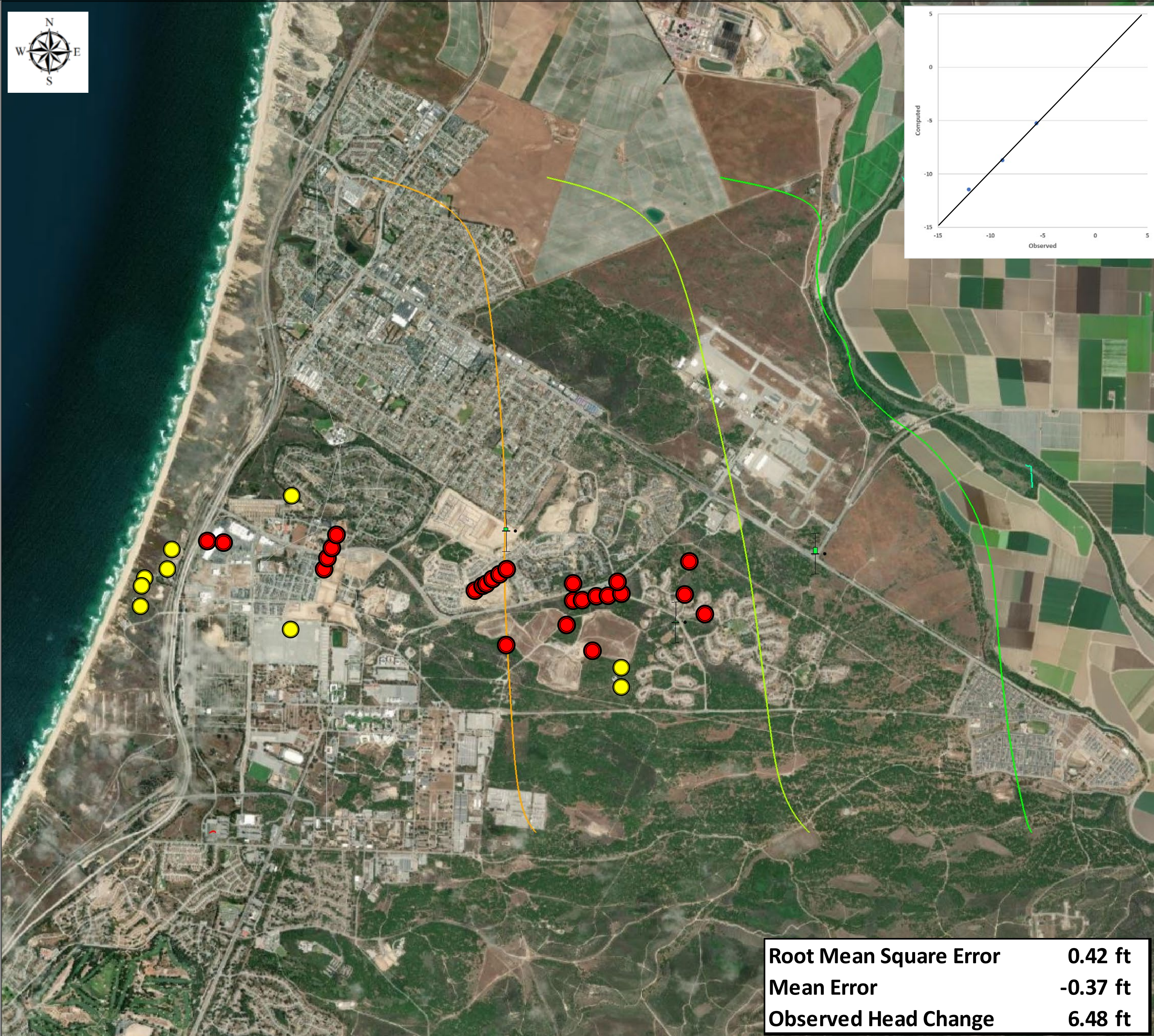
Contour interval = 5 foot

Background imagery: World Imagery from the Groundwater Modeling System (GMS)

Fort Ord Steady State Model Calibration
Calibration Date – First Quarter 2022
Lower 180 ft Aquifer

Figure 23

November 2022



Total Head (ft NGVD29)

0 -30

Calibration Targets

- Computed head within 2.0 ft of observed head
- Computed head within 4.0 ft of observed head
- Computed head more than 4.0 ft from observed head
- Modeled Extraction Wells
- Modeled Injection Wells

Notes:

Contours shown are for the 400 ft Aquifer

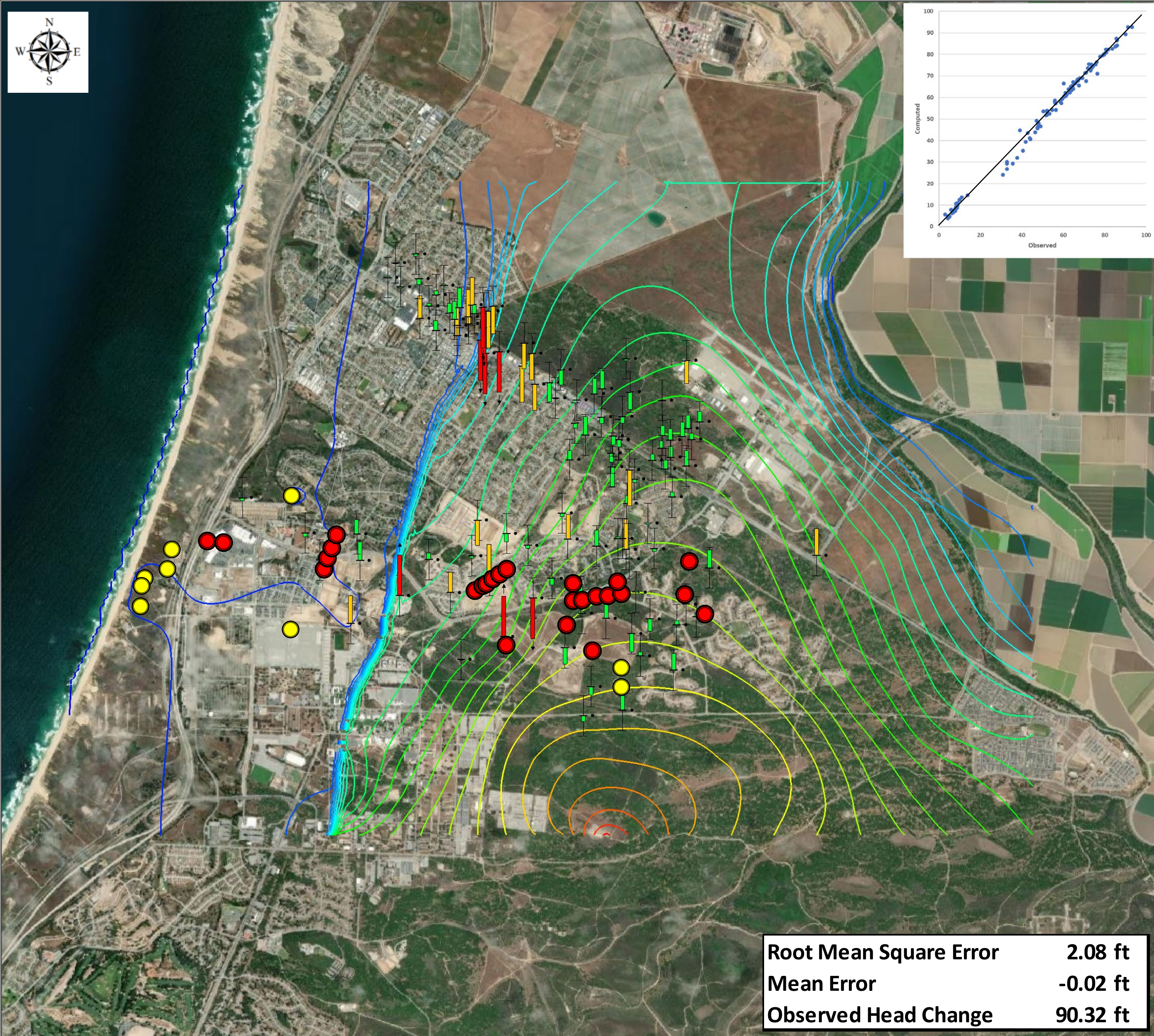
Contour interval = 5 foot

Background imagery: World Imagery from the Groundwater Modeling System (GMS)

Fort Ord Steady State Model Calibration
Calibration Date – First Quarter 2022
400 ft Aquifer

Figure 24

November 2022



Total Head (ft NGVD29)

120 0

Calibration Targets

Computed head within 2.0 ft of observed head

Computed head within 4.0 ft of observed head

Computed head more than 4.0 ft from observed head

Modeled Extraction Wells

Modeled Injection Wells

Notes:

Contours shown are for the A-Aquifer

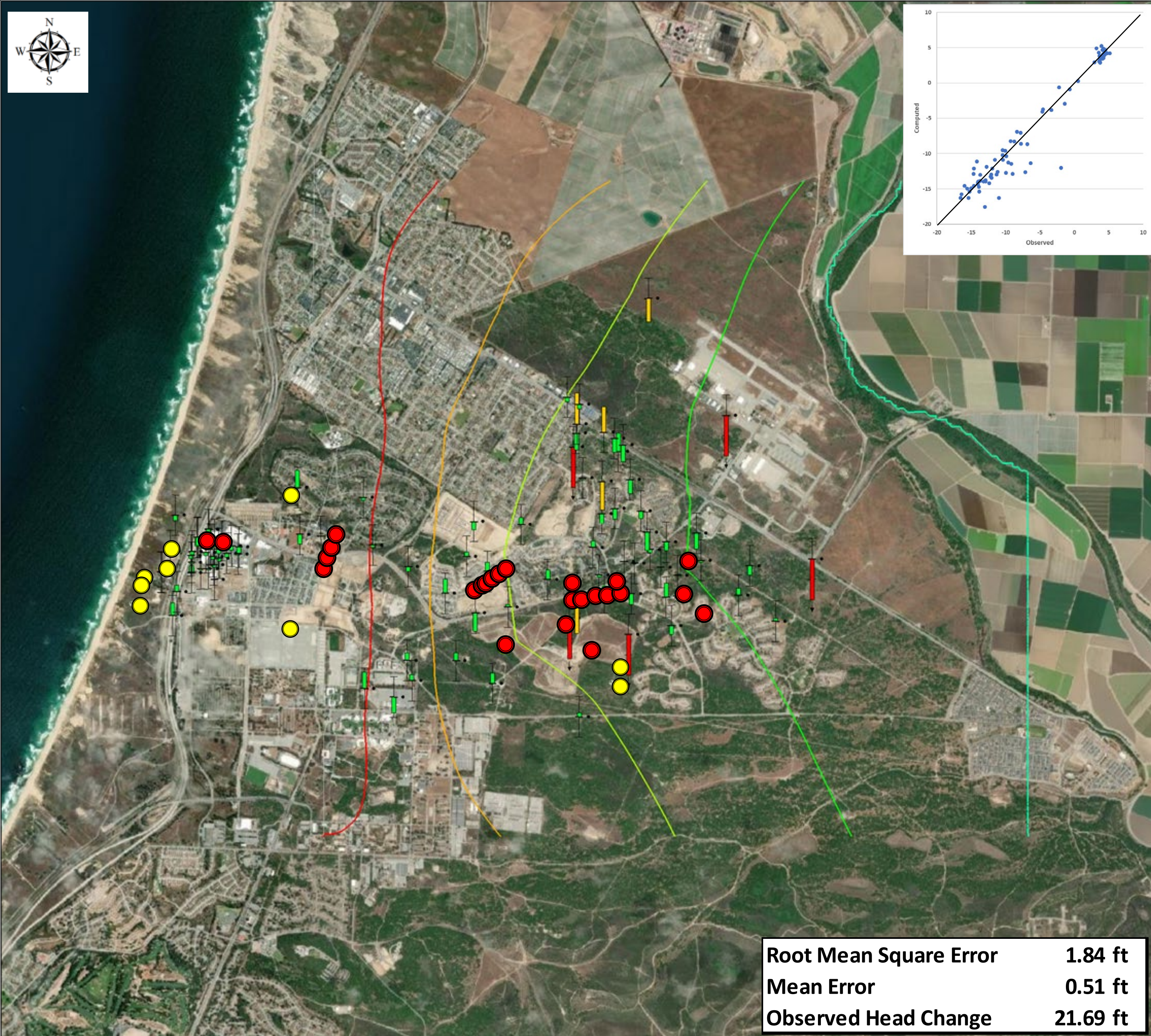
Contour interval = 5 foot

Background imagery: World Imagery from the Groundwater Modeling System (GMS)

Fort Ord Steady State Model Calibration
Calibration Date – Third Quarter 2022
A-Aquifer

Figure 25

November 2022



Total Head (ft NGVD29)

0 -30

Calibration Targets

Computed head within 2.0 ft of observed head

Computed head within 4.0 ft of observed head

Computed head more than 4.0 ft from observed head

Modeled Extraction Wells

Modeled Injection Wells

Notes:

Contours shown are for the Upper 180 ft Aquifer

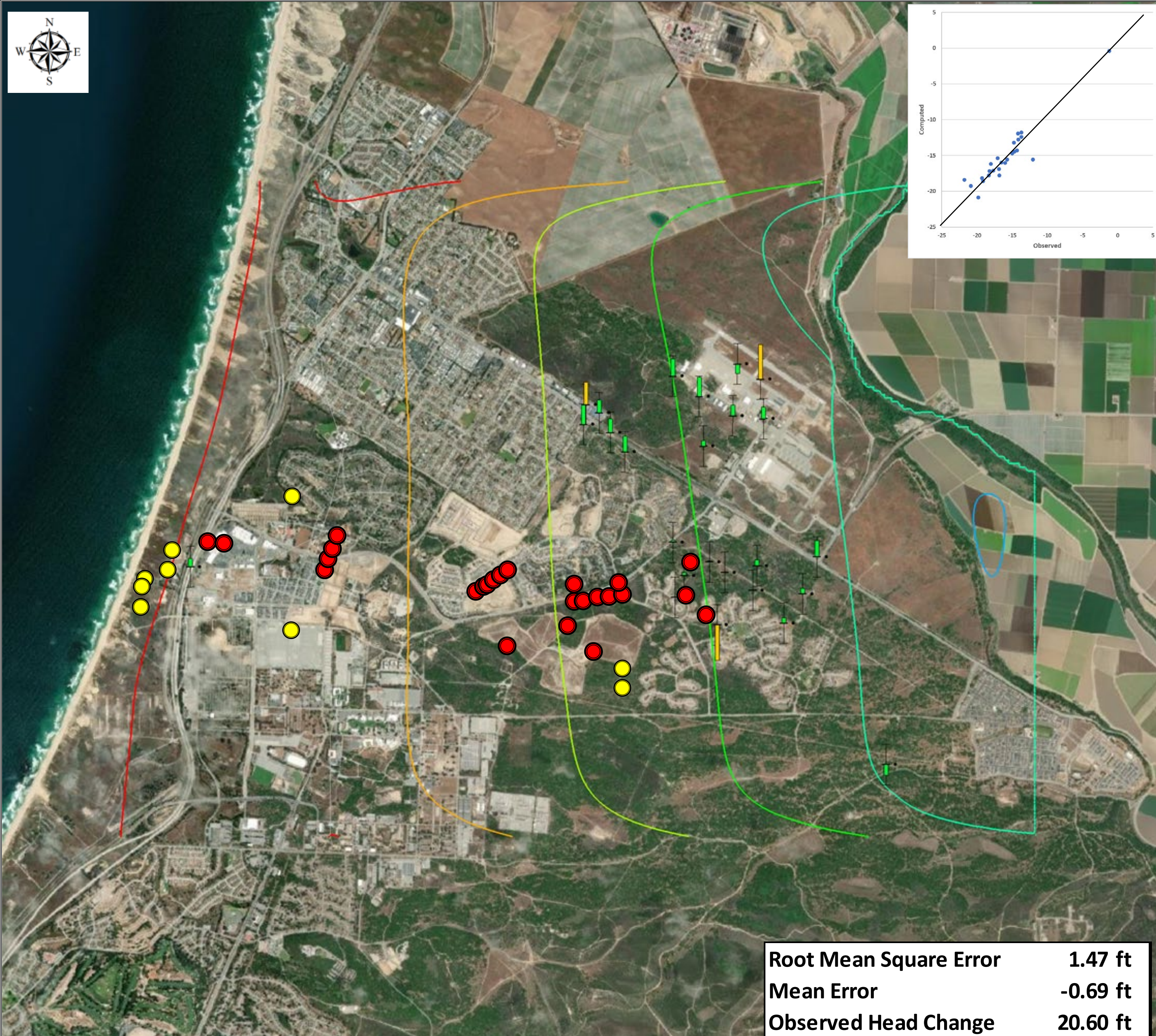
Contour interval = 5 foot

Background imagery: World Imagery from the Groundwater Modeling System (GMS)

Fort Ord Steady State Model Calibration
Calibration Date – Third Quarter 2022
Upper 180 ft Aquifer

Figure 26

November 2022



Total Head (ft NGVD29)

0 -30

Calibration Targets

Computed head within 2.0 ft of observed head

Computed head within 4.0 ft of observed head

Computed head more than 4.0 ft from observed head

Modeled Extraction Wells

Modeled Injection Wells

Notes:

Contours shown are for the Lower 180 ft Aquifer

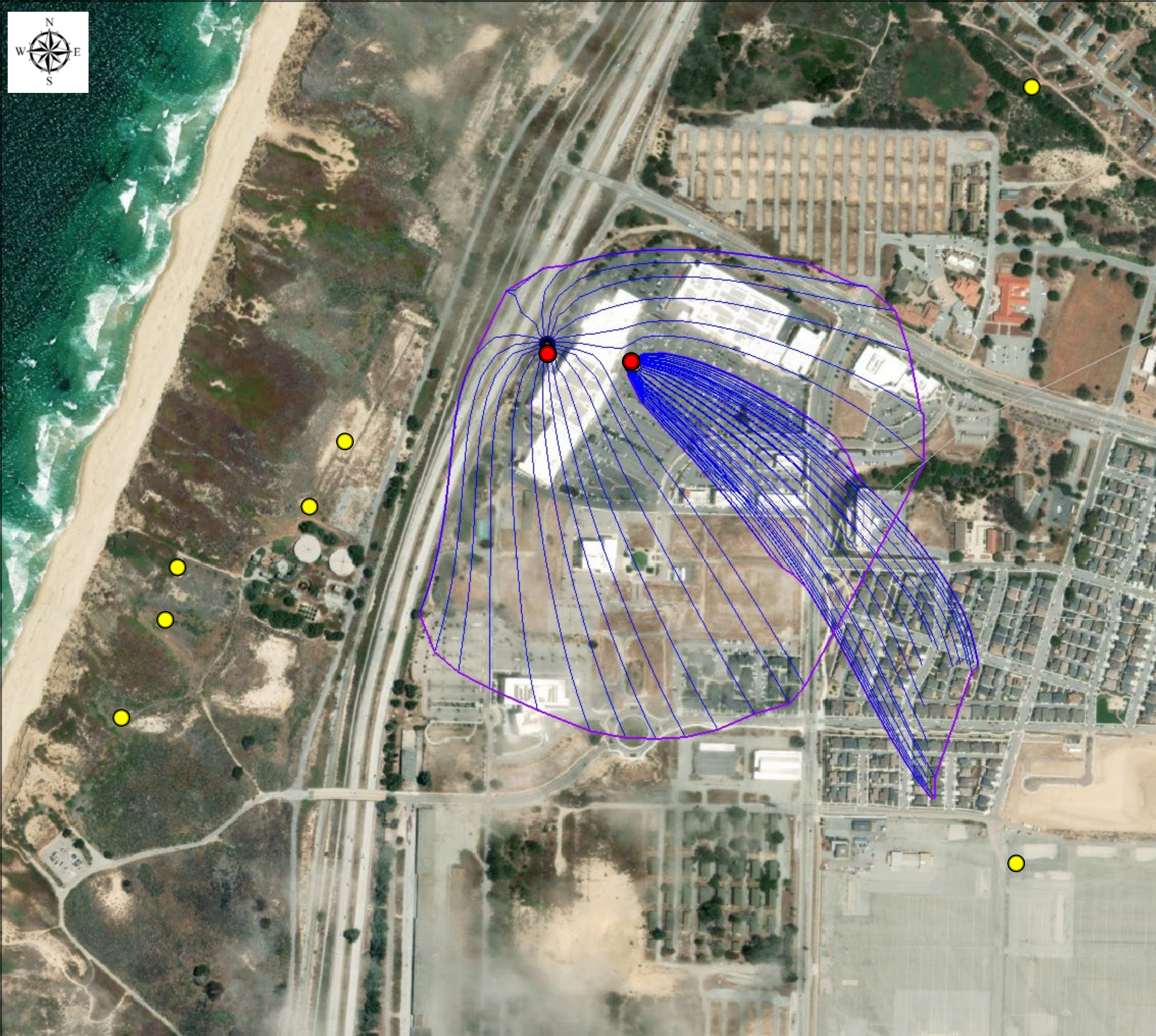
Contour interval = 5 foot

Background imagery: World Imagery from the Groundwater Modeling System (GMS)

Fort Ord Steady State Model Calibration
Calibration Date – Third Quarter 2022
Lower 180 ft Aquifer

Figure 27

November 2022



Legend

Capture Boundary

Particle Tack Path Lines

Extraction Wells

Injection/Infiltration Wells

Notes:

Simulation based on the Steady State simulated heads for Quarter 1 of 2022

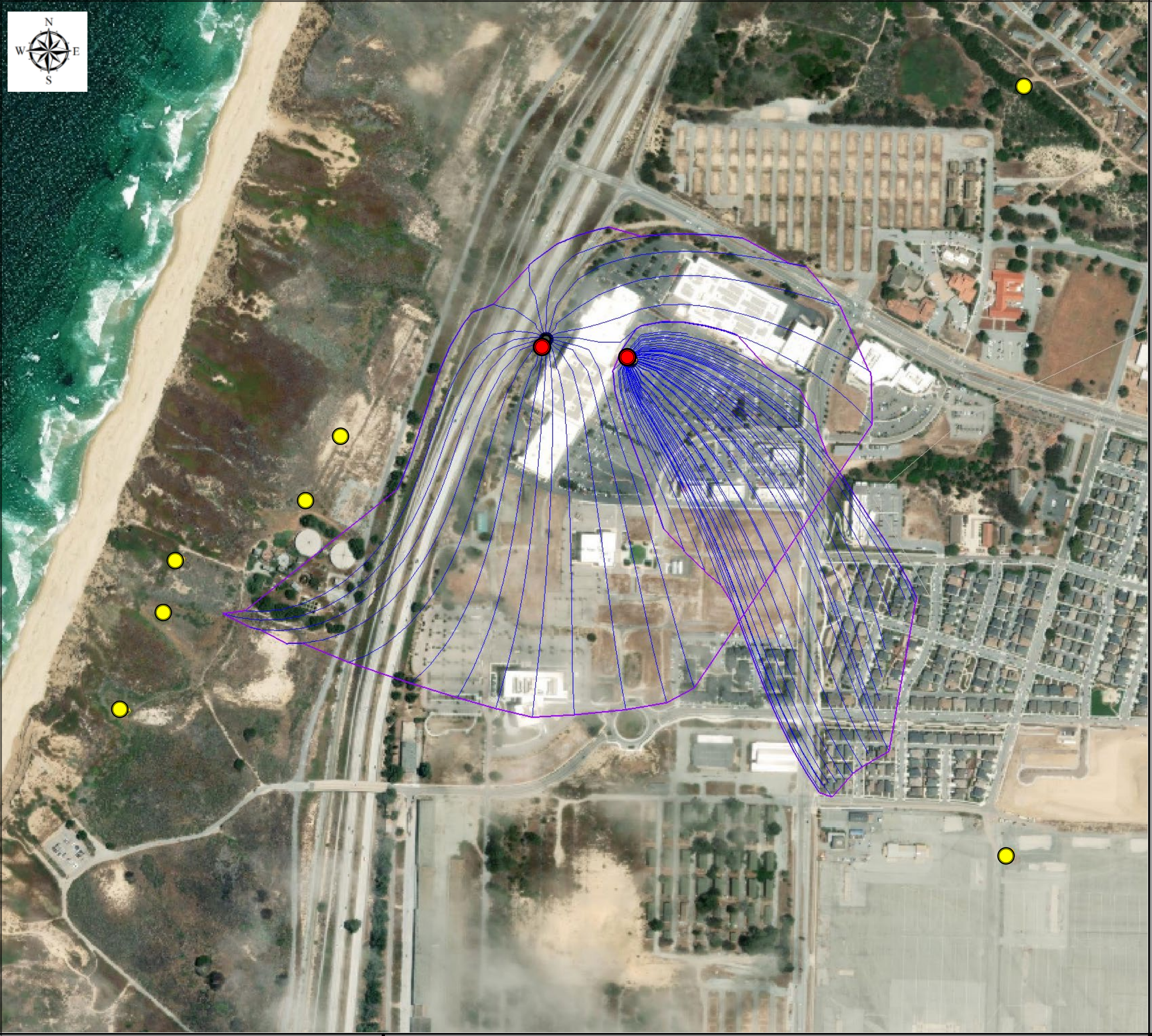
Particle Pathways represent backwards tracking for 15 years

Background imagery: World Imagery from the Groundwater Modeling System (GMS)

Fort Ord Steady State Model
Simulated Groundwater Capture – Sites 2 and 12
Quarter 1 2022

Figure 28

November 2022



Legend

- Capture Boundary
- Particle Tack Path Lines
- Extraction Wells
- Injection/Infiltration Wells

Notes:

Simulation based on the Steady State simulated heads for Quarter 3 of 2022

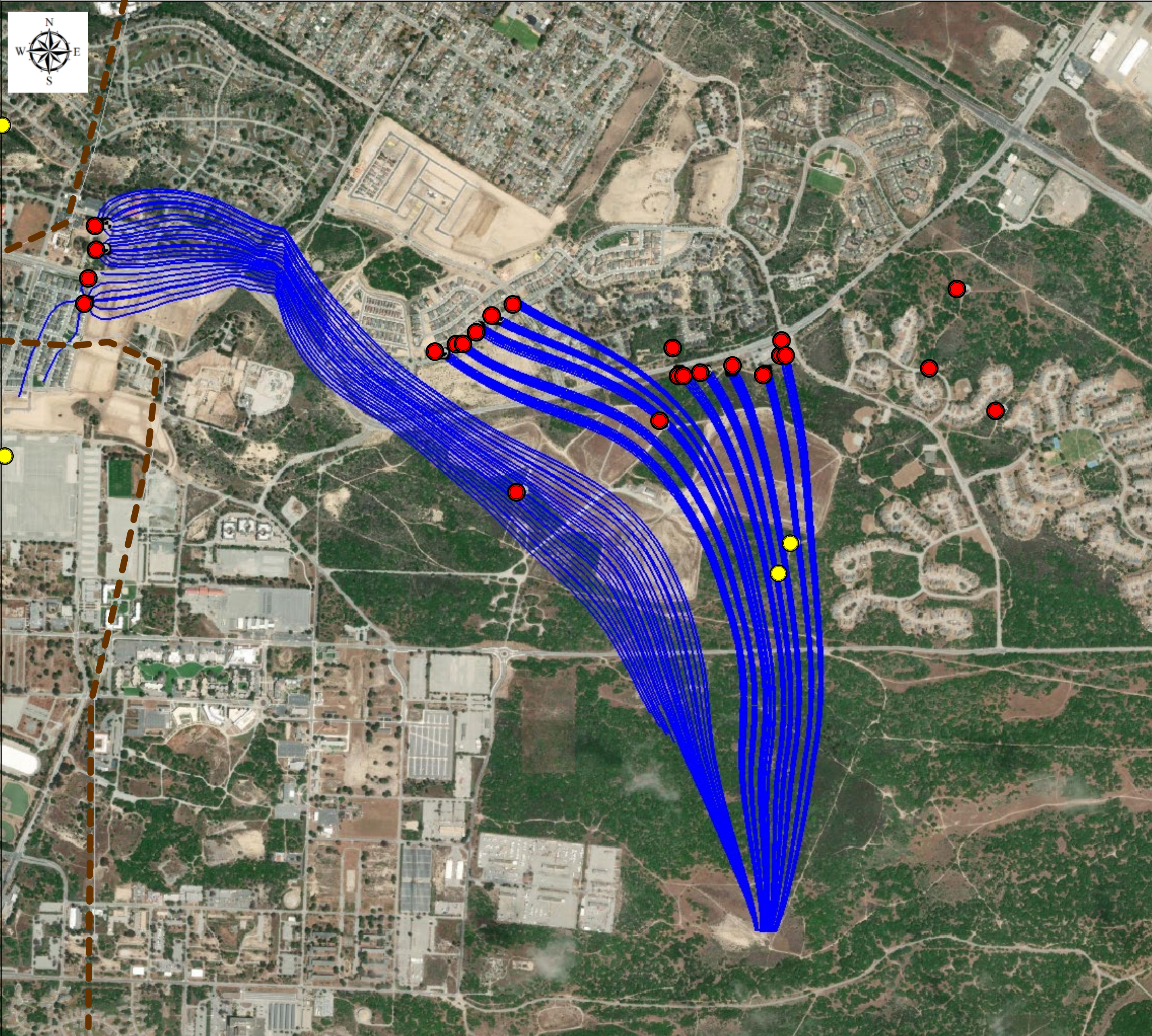
Particle Pathways represent backwards tracking for 15 years

Background imagery: World Imagery from the Groundwater Modeling System (GMS)

Fort Ord Steady State Model
Simulated Groundwater Capture – Sites 2 and 12
Quarter 3 2022

Figure 29

November 2022



Legend

- Particle Tack Path Lines
- Extraction Wells
- Injection/Infiltration Wells
- Approx. End of Salinas Valley Aquitard (SVA)

Notes:

Simulation based on the Steady State simulated heads for Quarter 1 of 2022

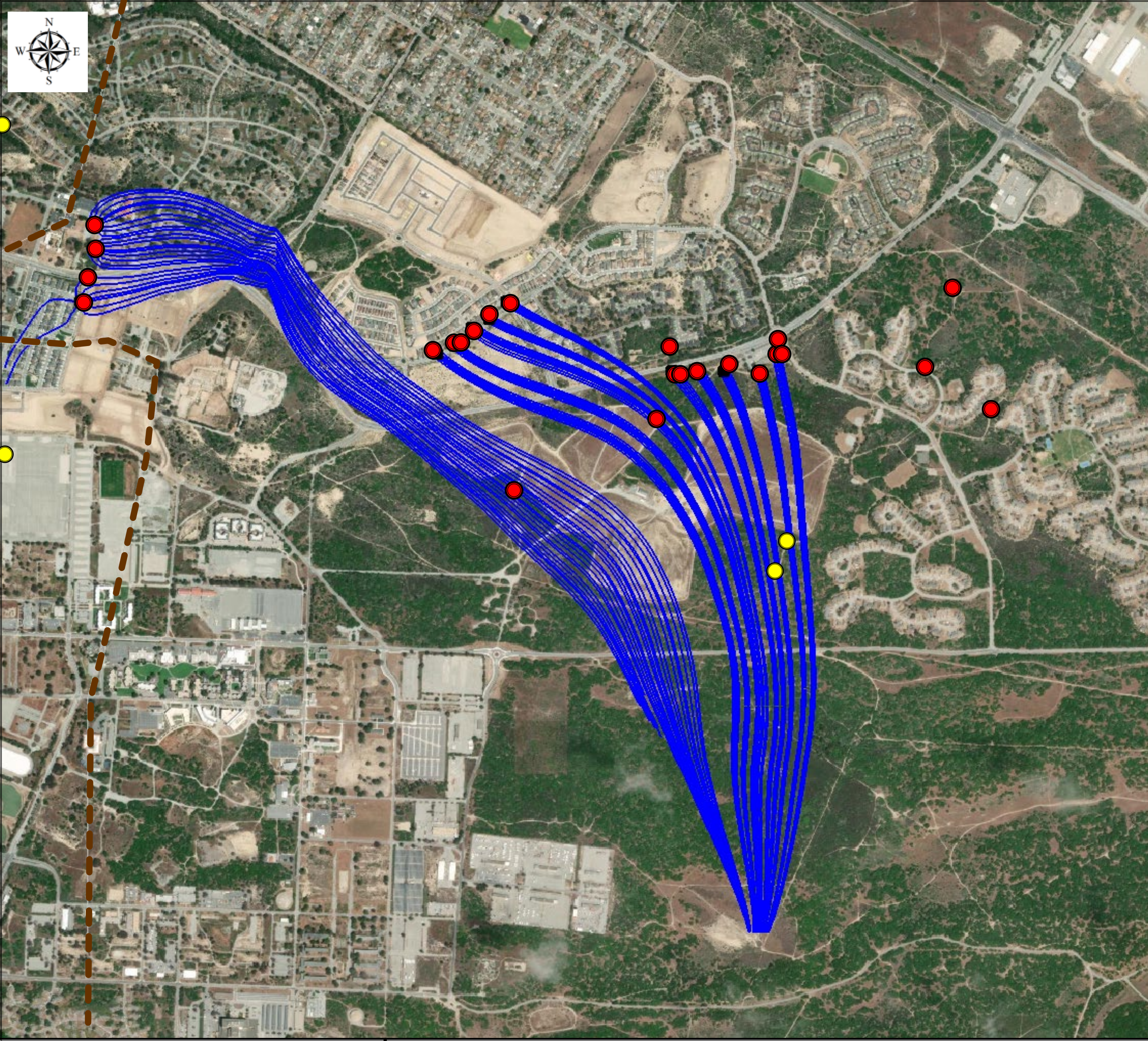
Particle Pathways represent backwards tracking for 15 years

Background imagery: World Imagery from the Groundwater Modeling System (GMS)

Fort Ord Steady State Model
Simulated Groundwater Capture – OU2 (A-Aquifer)
Quarter 1 2022

Figure 30

November 2022



Legend

- Particle Tack Path Lines
- Extraction Wells
- Injection/Infiltration Wells
- Approx. End of Salinas Valley Aquitard (SVA)

Notes:

Simulation based on the Steady State simulated heads for Quarter 3 of 2022

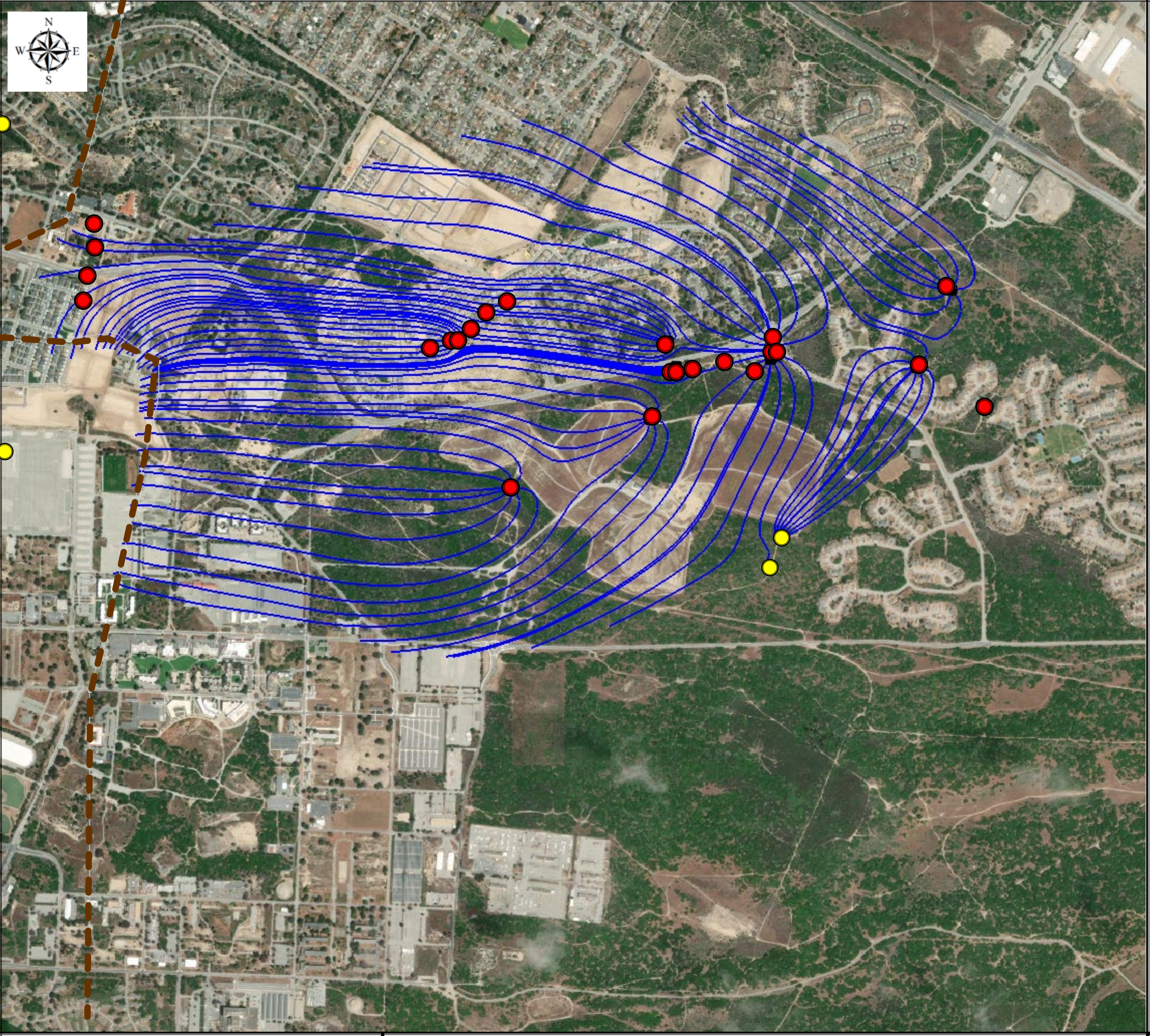
Particle Pathways represent backwards tracking for 15 years

Background imagery: World Imagery from the Groundwater Modeling System (GMS)

Fort Ord Steady State Model
Simulated Groundwater Capture – OU2 (A-Aquifer)
Quarter 3 2022

Figure 31

November 2022



Legend

- Particle Tack Path Lines
- Extraction Wells
- Injection/Infiltration Wells
- Approx. End of Salinas Valley Aquitard (SVA)

Notes:

Simulation based on the Steady State simulated heads for Quarter 1 of 2022

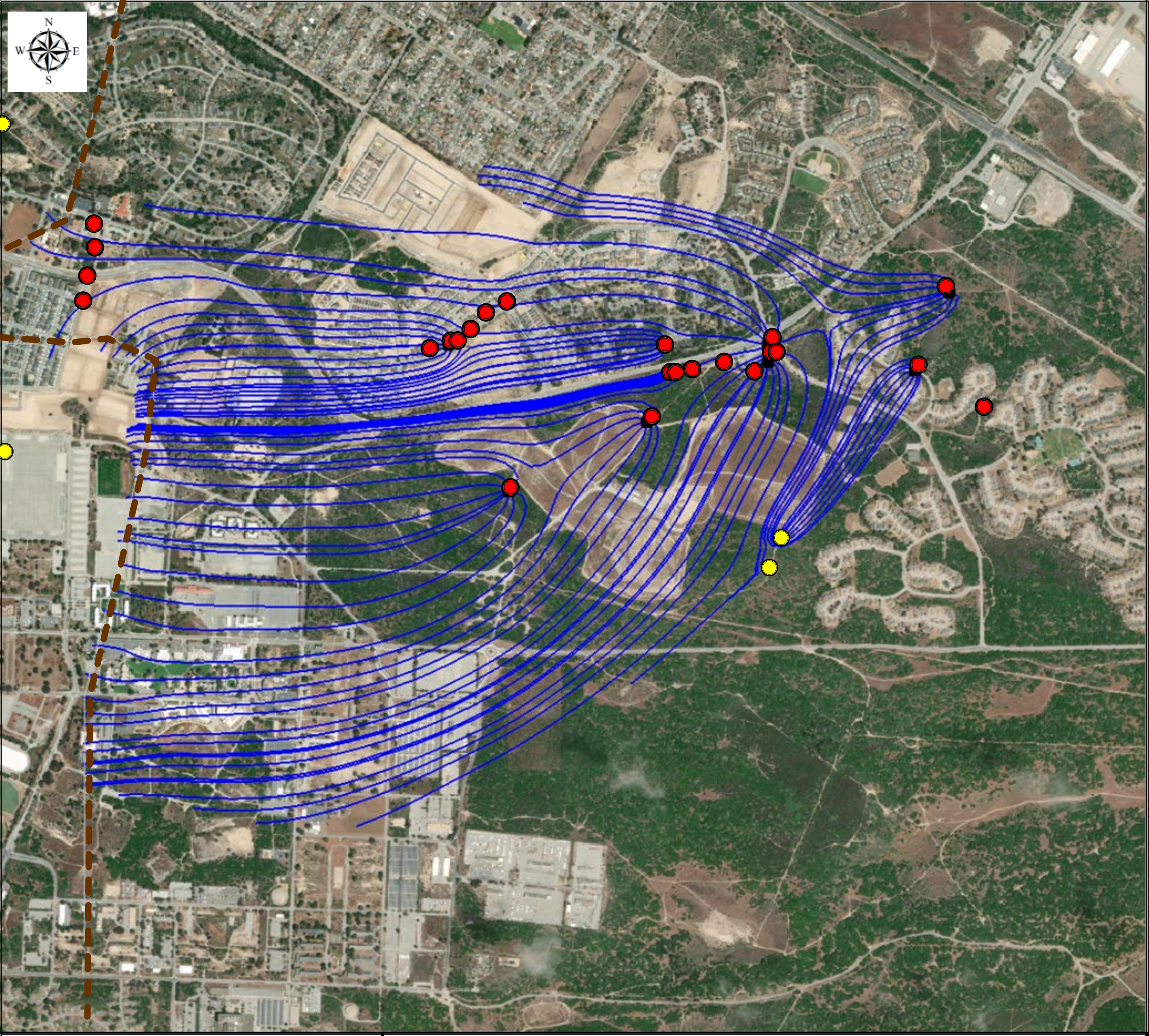
Particle Pathways represent backwards tracking for 15 years

Background imagery: World Imagery from the Groundwater Modeling System (GMS)

Fort Ord Steady State Model
Simulated Groundwater Capture – OU2 (180 ft-Aquifer)
Quarter 1 2022

Figure 32

November 2022



Legend

- Particle Tack Path Lines
- Extraction Wells
- Injection/Infiltration Wells
- Approx. End of Salinas Valley Aquitard (SVA)

Notes:

Simulation based on the Steady State simulated heads for Quarter 3 of 2022

Particle Pathways represent backwards tracking for 15 years

Background imagery: World Imagery from the Groundwater Modeling System (GMS)

Fort Ord Steady State Model
Simulated Groundwater Capture – OU2 (180 ft-Aquifer)
Quarter 3 2022

Figure 33

November 2022

ATTACHMENT B

Fort Ord Steady State Model Simulated Groundwater Capture – OU2
(Upper 180-Aquifer)

Legend

- Particle Track Path Lines
- Proposed Upper 180ft Aquifer Well
- Extraction Well Upper 180-Aquifer
- Injection/Infiltration Well Upper 180-Aquifer
- Approx. End of Salinas Valley Aquitard (SVA)
- CT

Notes:

Simulation based on the Steady State simulated heads for Quarter 1 (average period) of 2022 with the addition of one new Upper 180-Aquifer well pumping at 60 gpm

Particle Pathways represent backwards tracking for 15 years (or until particles reach the SVA outcrop)

Background imagery: World Imagery from ArcGIS Pro

SIMULATION 2a- Fort Ord Steady State Model Simulated Groundwater Capture - OU2 (Upper 180-Aquifer) Quarter 1 2022

Figure 1

April 2023

Legend

- Particle Track Path Lines
- Proposed Upper 180ft Aquifer Well
- Extraction Well Upper 180-Aquifer
- Injection/Infiltration Well Upper 180-Aquifer
- Approx. End of Salinas Valley Aquitard (SVA)
- CT

Notes:

Simulation based on the Steady State simulated heads for Quarter 1 (average period) of 2022 with the addition of one new Upper 180-Aquifer well pumping at 30 gpm

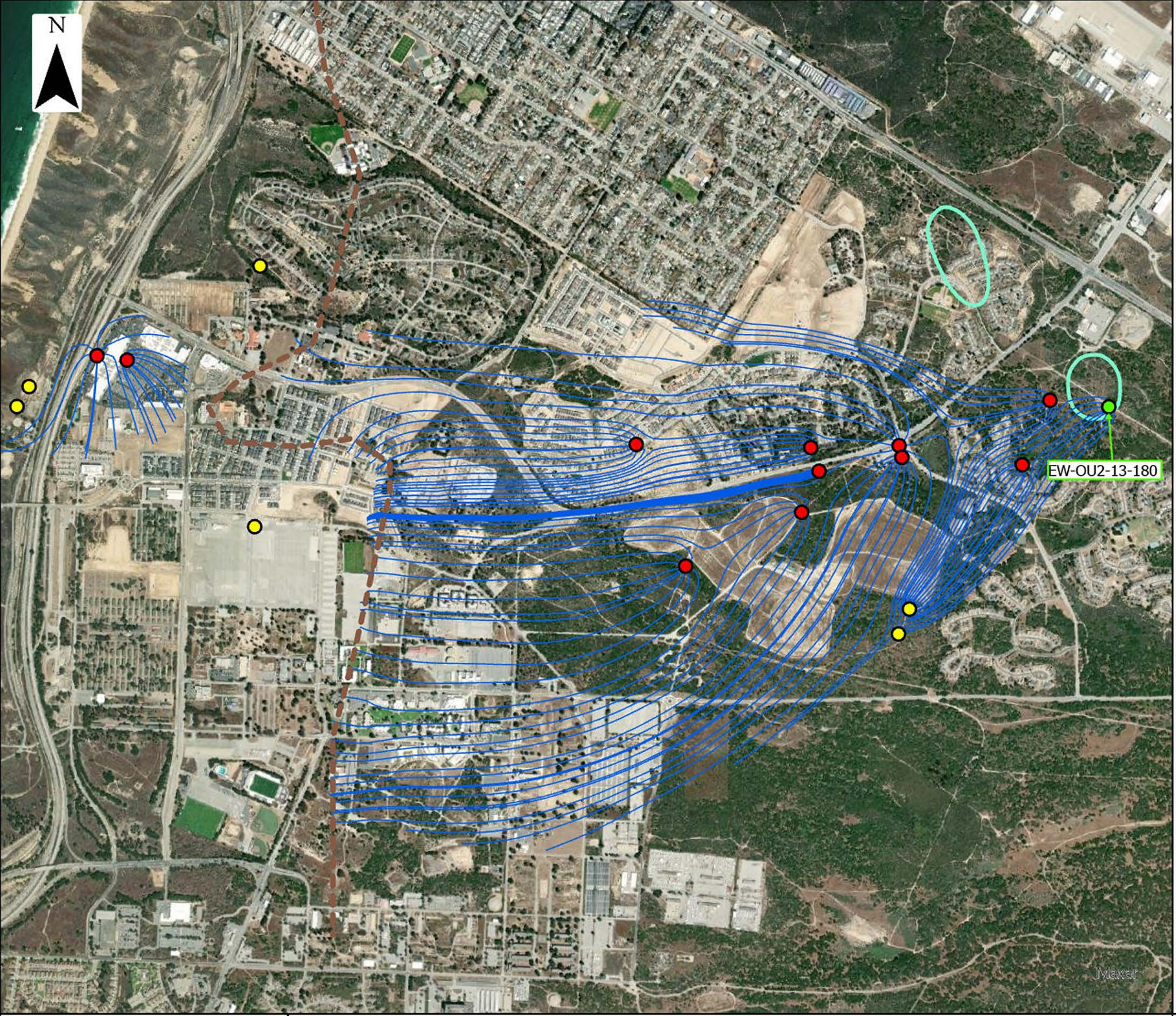
Particle Pathways represent backwards tracking for 15 years (or until particles reach the SVA outcrop)

Background imagery: World Imagery from ArcGIS Pro

SIMULATION 2a_30- Fort Ord Steady State Model Simulated Groundwater Capture - OU2 (Upper 180-Aquifer) Quarter 1 2022

Figure 2

April 2023



Legend

- Particle Track Path Lines
- Proposed Upper 180ft Aquifer Well
- Extraction Well Upper 180-Aquifer
- Injection/Infiltration Well Upper 180-Aquifer
- Approx. End of Salinas Valley Aquitard (SVA)
- CT

Notes:

Simulation based on the Steady State simulated heads for Quarter 3 (dry period) of 2022 with the addition of one new Upper 180-Aquifer well pumping at 60 gpm

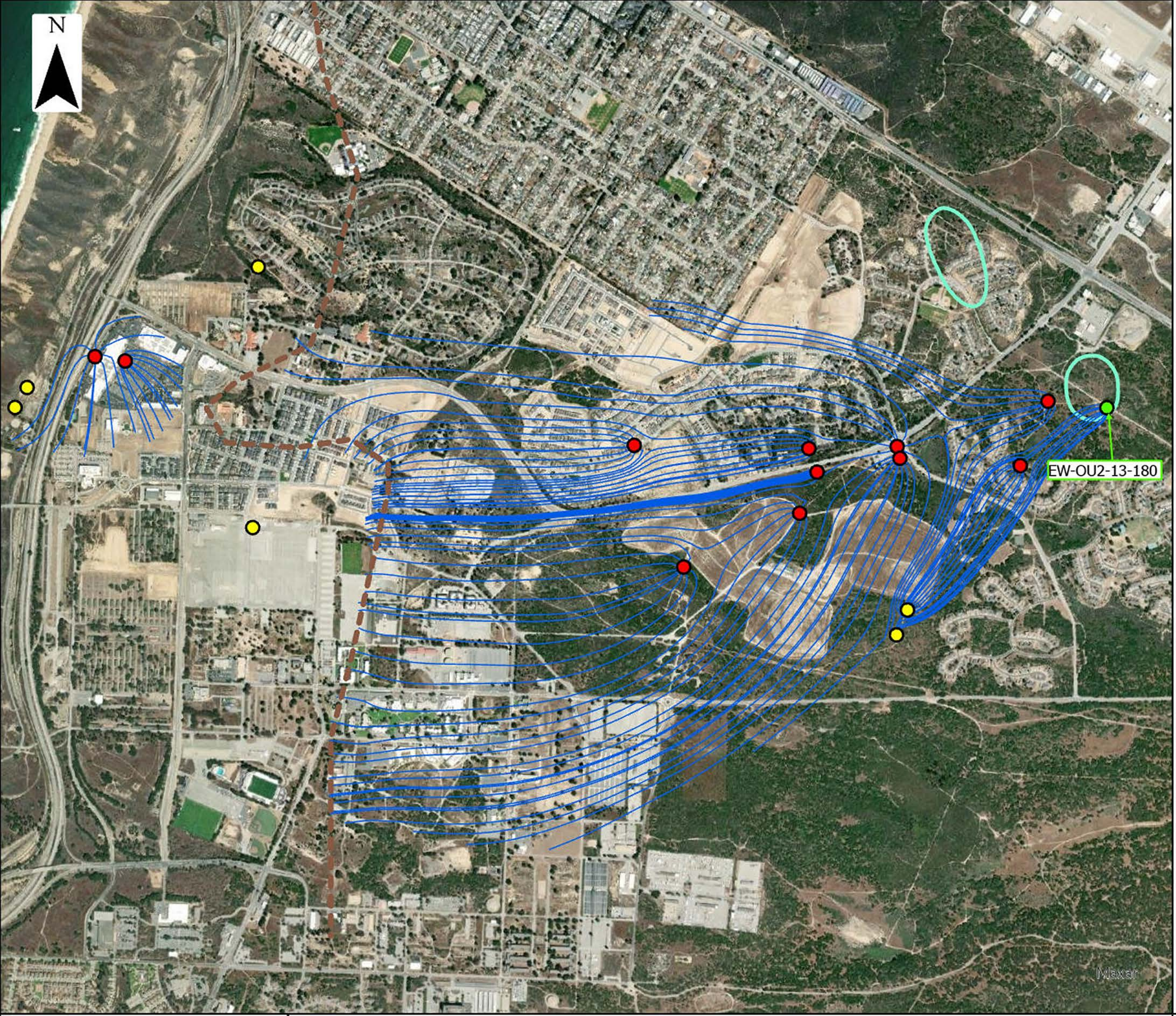
Particle Pathways represent backwards tracking for 15 years (or until particles reach the SVA outcrop)

Background imagery: World Imagery from ArcGIS Pro

SIMULATION 2b- Fort Ord Steady State Model Simulated Groundwater Capture - OU2 (Upper 180-Aquifer) Quarter 3 2022

Figure 3

April 2023



Legend

- Particle Track Path Lines
- Proposed Upper 180ft Aquifer Well
- Extraction Well Upper 180-Aquifer
- Injection/Infiltration Well Upper 180-Aquifer
- Approx. End of Salinas Valley Aquitard (SVA)
- CT

Notes:

Simulation based on the Steady State simulated heads for Quarter 3 (dry period) of 2022 with the addition of one new Upper 180-Aquifer well pumping at 30 gpm

Particle Pathways represent backwards tracking for 15 years (or until particles reach the SVA outcrop)

Background imagery: World Imagery from ArcGIS Pro

SIMULATION 2b_30- Fort Ord Steady State Model Simulated Groundwater Capture - OU2 (Upper 180-Aquifer) Quarter 3 2022

Figure 4

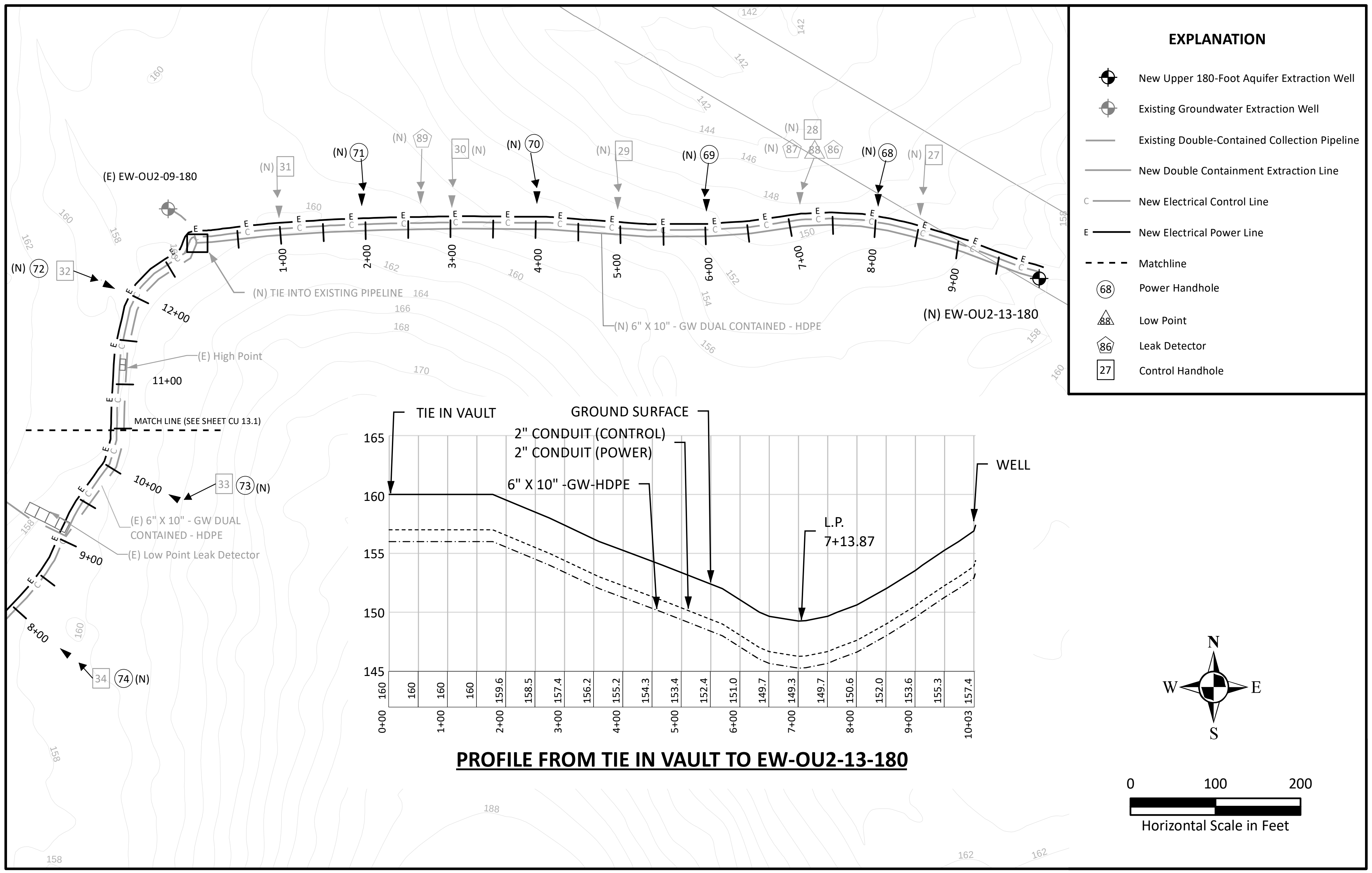
April 2023

ATTACHMENT C

Construction Drawings

UPPER 180-FOOT AQUIFER REMEDIAL DESIGN
CONSTRUCTION DESIGN PLAN

FORMER FORT ORD, CALIFORNIA



INSTRUMENTATION DRAWING INDEX

FORT ORD, CA

SHEET NO.	DRAWING NO.	DRAWING TITLE
1	CU1	COVER SHEET
2	CU2	INSTRUMENTATION SYMBOLS AND ABBREVIATIONS
3	CU3	GWTP FIELD PIPING
4	CU4	BUNKER HILL FIELD PIPING
5	CU5	EW-OU2-13-180 FIELD PIPING
6	CU5.1	EW-OU2-13-180 FIELD PIPING
7	CU6	EXTRACTION WELL SCHEMATIC
8	CU7	EXTRACTION WELLHEAD DETAILS
9	CU8	VAULT DETAILS
10	CU9	VAULT PIPING DETAILS
11	CU10	TRENCH DETAILS
12	CU11	GWTP FIELD ELECTRICAL
13	CU12	BUNKER HILL FIELD ELECTRICAL
14	CU13	EW-OU2-13-180 FIELD ELECTRICAL

NOT FOR CONSTRUCTION

LINE IS 2 INCHES AT FULL SIZE (IF NOT 2"-SCALE ACCORDINGLY)

DATE:
FILE:
DRAWN:
DESIGNED:
CHECKED:

SUBMITTED: DATE:
SUBMITTAL APPROVED: DATE:

Ahtna

REVISIONS

ZONE	REV.	DESCRIPTION	BY	DATE	APP.

APPROVAL RECOMMENDED: DATE

APPROVED: DATE

CONTRACT NUMBER

AHTNA GLOBAL, LLC
FORT ORD, CA
CONSTRUCTION DRAWING
COVER SHEET

SCALE NONE

DRAWING NUMBER CU1

SHEET NUMBER 1 OF 13

SINGLE LINE LEGEND:

- NORMALLY OPEN RELAY CONTACT
- NORMALLY CLOSED RELAY CONTACT
- GROUND CONNECTION
- PRESSURE SWITCH OPEN ON INCREASE
- NORMALLY CLOSED FLOAT SWITCH
- SINGLE BREAK SWITCH
- NORMALLY OPEN MOMENTARY PUSH BUTTON
- NORMALLY CLOSED MOMENTARY PUSH BUTTON
- TWO POSITION CONTACT
- THERMAL OVERLOAD DEVICE
- THREE PHASE MOTOR WITH 5HP (5 HP)
- ELECTRONIC METERING AND PROTECTION PANEL (EMP)
- CONTROL RELAY (R)
- PLC PANEL
- FUSE WITH RATING
- DRAW-OUT BREAKER 4,000A FRAME 4,000A TRIP
- TRANSFORMER W/GROUNDED SECONDARY – KVA, SIZE AND VOLTAGE RATIO AS NOTED
- CURRENT TRANSFORMER (IR)
- CURRENT SENSING RELAY (M)
- METER
- CONTROL POWER TRANSFORMER
- "Y" TRANSFORMER, CENTER GROUNDED
- DELTA TRANSFORMER
- EQUIPMENT DISCONNECT
- MOTOR STARTER (COORDINATE WITH MECHANICAL FOR CONTROL)
- TRANSFORMER (MOUNTED ON THE PAD)
- EQUIPMENT ENCLOSURE
- PANEL MOUNTED GROUND BUS BAR
- GROUND ROD
- UFER GROUND
- GROUNDED WATER PIPE
- COMMUNICATION GROUND BAR

400 A
3P LSIG

CIRCUIT BREAKER 400 AMPERE, 3 POLE
L CIRCUIT PROTECTION AGAINST OVERLOAD WITH LONG INVERSE TIME DELAY TRIP
S CIRCUIT PROTECTION AGAINST OVERLOAD WITH SHORT INVERSE OR DEFINITE TIME DELAY TRIP
I CIRCUIT PROTECTION AGAINST INSTANTANEOUS SHORT CIRCUIT ADJUSTABLE TRIP
G CIRCUIT PROTECTION AGAINST EARTH FAULTS

MOLDED CASE CIRCUIT BREAKER

ABBREVIATIONS:

1HA	480/277V PANEL (# INDICATES FLOOR)
1LA	120/208V PANEL (# INDICATES FLOOR)
A	AMPERES
AC	AIR CONDITIONING UNIT
AFF	ABOVE FINISHED FLOOR
AHU	AIR HANDLING UNIT
AWG	AMERICAN WIRE GAUGE
C	CONDUIT
CB	CIRCUIT BREAKERS
CH	CHILLER
CHW	CIRCULATING PUMP HOT WATER
DWG	DRAWING
(E)	EXISTING
IAC	INTERRUPTABLE ALLOWABLE CURRENT
EF	EXHAUST FAN
ES	EMERGENCY SHOWER
EWH	ELECTRIC WATER HEATER
EWS	EYE WASH STATION
FC	FIRE CONTROL
FSCP	FIRE SPRINKLER CONTROL PANEL
GFCI	GROUND FAULT CIRCUIT INTERRUPTER
GW	GROUND WIRE
H	INFRARED HEATER
HDPE	HIGH-DENSITY POLYETHYLENE
HF	HARMONIC FILTER
HOA	HAND-OFF-AUTO SWITCH
HP	HORSE POWER
HZ	HERTZ
IAC	INTERRUPTABLE ALLOWABLE CURRENT
IDC	INDICATOR CONTROL SWITCH
ISH	INDICATOR SWITCH HIGH
J	JUNCTION BOX
LSH	LEVEL SWITCH HIGH
MSB	MAIN SWITCH BOARD
MTG	MOUNTING
(N)	NEW
(O)	OHM CURRENT RESISTANCE IN OHMS
P	PRIMARY CONDUIT
PDSH	PRESSURE DIFFERENTIAL SWITCH HIGH
PH,ø	PHASE
PLC	PROGRAMMABLE LOGIC CONTROLLER
PNL	PANEL
PR	PAIR
PSH	PRESSURE SWITCH HIGH
(RE)	REMOVE
S	SPARE CONDUIT
SHT	SHEET
SPS	SAFETY PRESSURE SWITCH
SUB	SUBSTATION
SW	SWITCH
SWF	SINE WAVE FILTER
TVSS	TRANSIENT VOLTAGE SURGE SUPPRESSOR
TYP	TYPICAL
V	VOLTS
VFD	VARIABLE FREQUENCY DRIVE
W	WATTS
W/A	WATTS/AMPS
WP	WATER PROOF
XFRM	TRANSFORMER

GENERAL NOTES:

1. ALL ELECTRICAL WORK SHALL BE PERFORMED IN ACCORDANCE WITH THE LATEST NATIONAL ELECTRICAL CODE (NEC), NFPA, IEEE AND APPLICABLE U.S. ARMY REGULATIONS.
2. THE ELECTRICAL INSTALLATION SHALL BE GROUNDED IN ACCORDANCE WITH ARTICLE 250 OF THE NEC.
3. MOUNTING HEIGHTS ABOVE FINISHED FLOOR ARE AS INDICATED BELOW UNLESS OTHERWISE NOTED ON THE DRAWINGS:

PANELBOARD	72" TO TOP OF PANELBOARD
WALL TOGGLE SWITCH	48" TO CENTER OF COVER PLATE
RECEPTACLE	12" TO CENTER OF COVER PLATE
MOTOR STARTER	60" TO CENTER OF COVER PLATE

4. ALL POWER PANELBOARDS AND COMMUNICATIONS CABINETS SHALL BE PROVIDED WITH GROUNDING SYSTEMS PER NEC ARTICLE 250.
5. MINIMUM SIZE CONDUIT/CONDUCTORS IS 3/4" W/ (2) #12ga+12ga GROUND.
6. ALL VDF'S SHALL BE PROVIDED WITH LINE SIDE FILTER AND MANUAL BYPASS SWITCH.

COMMUNICATION LEGEND

- DATACOMM RECEPTACLE
- TELEPHONE/DATA RECEPTACLE
- CCTV INTERNET PROTOCOL (IP) ADDRESSABLE FIXED CAMERA (RATED FOR THE ENVIRONMENT)

TELECOMMUNICATION & CONTROL CONDUIT LEGEND

- CLOSED CIRCUIT TV
- EXISTING TELEPHONE AERIAL
- NEW TELEPHONE AERIAL
- NEW TELEPHONE UNDERGROUND
- CONDUIT TURNING UP
- CONDUIT TURNING DOWN
- NEW CONTROL CONDUIT UNDERGROUND

ELECTRICAL CONDUIT LEGEND

- EXISTING ELECTRICAL AERIAL
- NEW ELECTRICAL AERIAL
- NEW ELECTRICAL UNDERGROUND

LEGEND:

- "*" WALL MOUNTED FIXTURE (SUITABLE FOR OUTDOOR) (* REPRESENT TYPE OF FIXTURE; SEE LIGHTING SCHEDULE)
- 2x4 LIGHT FIXTURE
- 2x4 LIGHT FIXTURE WITH BATTERY
- 1x4 LIGHT FIXTURE
- 1x4 LIGHT FIXTURE WITH BATTERY
- FLUORESCENT STRIP LINEAR FIXTURE (SUSPENDED)
- FLUORESCENT STRIP LINEAR FIXTURE (WALL MOUNTED)
- FLUORESCENT STRIP LINEAR FIXTURE (SUSPENDED) EMERGENCY ILLUMINATION
- EMERGENCY LIGHT, BATTERY POWERED
- RECESSED DOWNLIGHT IN HARDLID CEILING
- WALL MOUNTED EXIT SIGN – SINGLE FACE
- POLE MOUNTED FIXTURE (SUITABLE FOR OUTDOORS)
- SURFACE MOUNTED ELECTRICAL PANEL
- FLUSH MOUNTED PANEL BOARD
- $a SINGLE POLE SWITCH (20A, 120V) ("a" DENOTES LCP CHANNEL)
- RP 4 SQ. MM. METAL JUNCTION BOX. LEADER REPRESENT CIRCUIT DESIGNATION (TYP)
- WALL MOUNTED JUNCTION BOX
- RP 20A, 120V DUPLEX RECEPTACLE. LEADER REPRESENT CIRCUIT DESIGNATION (TYP)
- +42" 20A, 120V GFCI RECEPTACLE. (+42" INDICATES MOUNTING HEIGHT)
- 20A, 120V QUAD RECEPTACLE
- WALL MOUNTED PHOTO CELL (SUITABLE FOR OUTDOORS)
- TRAFFIC RATED HANDHOLE
- DULL TECHNOLOGY OCCUPANCY SENSOR
- UTILITY POLE
- THREE PHASE MOTOR
- R 20A, SINGLE POLE RELAY, VOLTAGE AS NOTED
- HAND HOLD
- 21 HAND HOLD NUMBER
- EF 1 MECHANICAL EQUIPMENT (REFER TO MECHANICAL DRAWINGS FOR EXACT LOCATION AND DETAILS) LEADER REPRESENT CIRCUIT DESIGNATION (TYP)

LINE IS 2 INCHES AT FULL SIZE (IF NOT 2"-SCALE ACCORDINGLY)

DATE: 01/25/2023
FILE:
DRAWN: HR
DESIGNED: HR
CHECKED: HR

SUBMITTED: DATE:
SUBMITTAL APPROVED: DATE:

KORE systems Inc

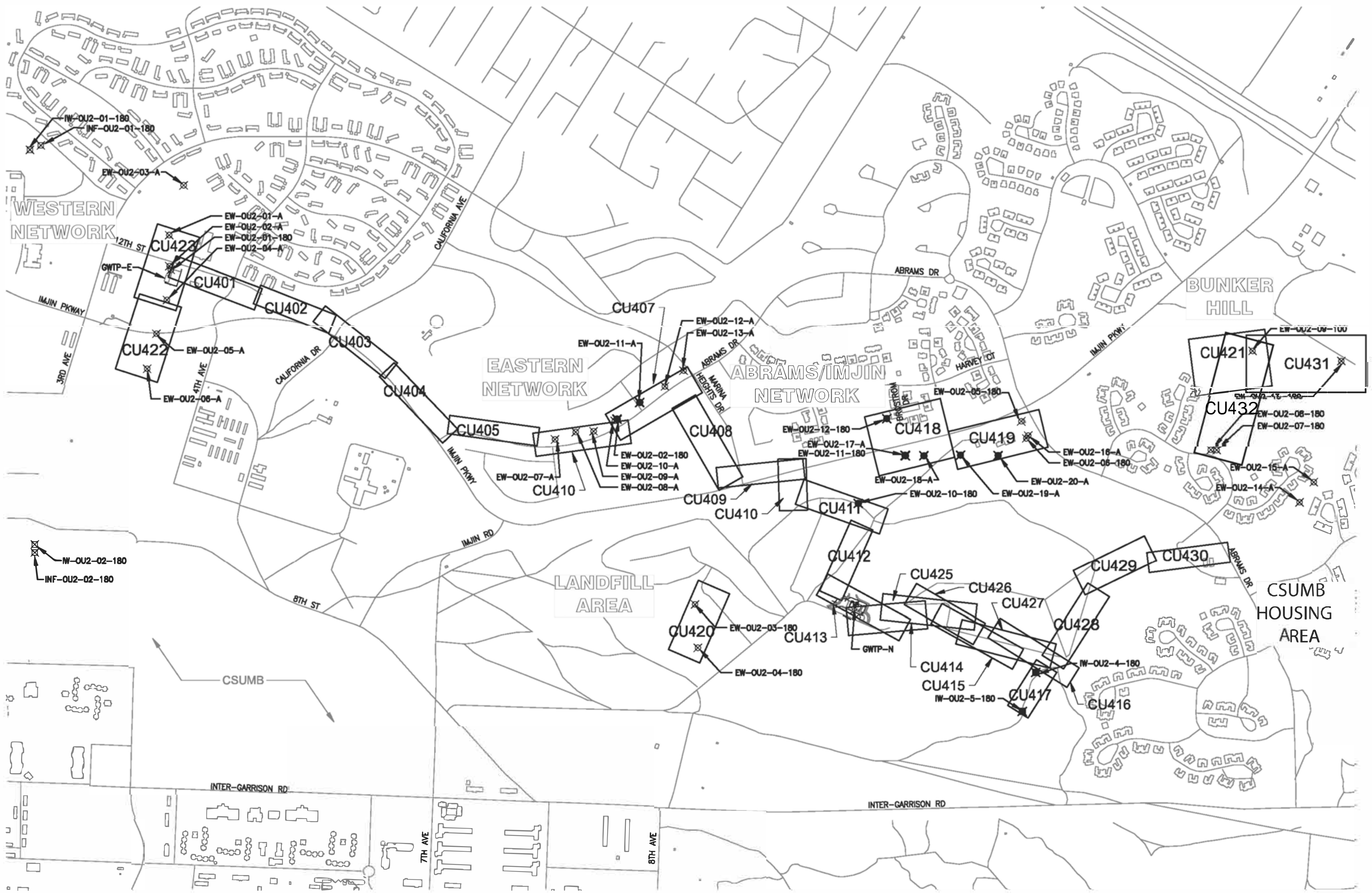
REVISIONS					
ZONE	REV.	DESCRIPTION	BY	DATE	APP.

APPROVAL RECOMMENDED ____ DATE
APPROVED ____ DATE
CONTRACT NUMBER

AHTNA GLOBAL, LLC
FORT ORD

FORT ORD GWTP
INSTRUMENTATION SYMBOLS & ABBREVIATION

SCALE NONE
DRAWING NUMBER CU2
SHEET NUMBER 2 OF 13



CU431 WILL BE THE LOCATION OF THE NEW EXTRACTION WELL

NOTES.

1. SHEETS CU401 THOUGH CU423 INDICATE THE ALIGNMENTS FOR THE EW AND TW PIPELINES.
2. SHEETS CU425 THROUGH CU430 INDICATE THE ALIGNMENT FOR THE PW PIPELINE.

NOT FOR CONSTRUCTION

LINE IS 2 INCHES AT FULL SIZE (IF NOT 2"-SCALE ACCORDINGLY)

DATE: 01/25/2023
FILE:
DRAWN: HR
DESIGNED:
CHECKED:

SUBMITTED: DATE:
SUBMITTAL APPROVED: DATE:

Ahtna

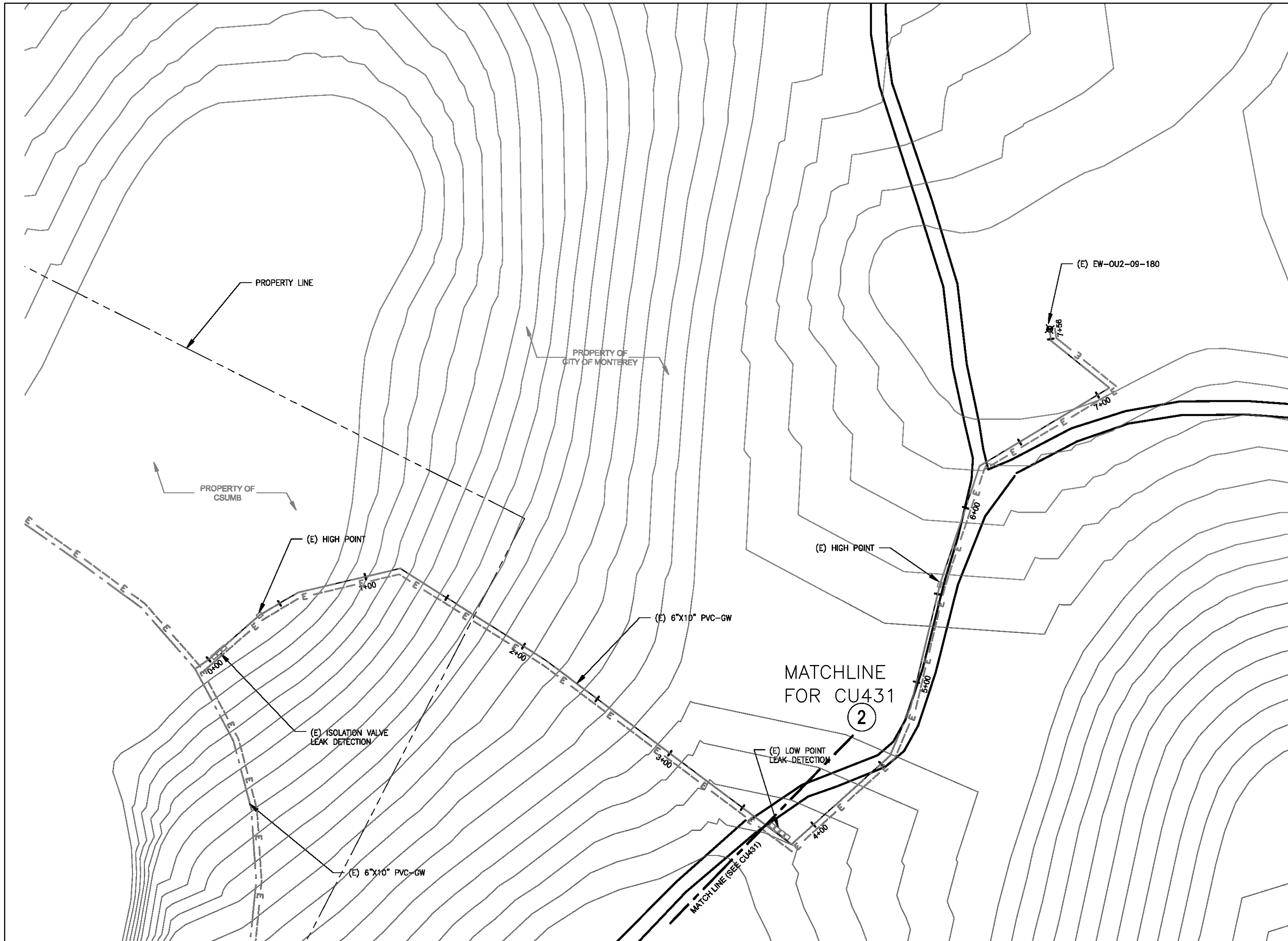
REVISIONS

ZONE	REV.	DESCRIPTION	BY	DATE	APP.
	1				
	2				
	3				
	4				

APPROVAL RECOMMENDED DATE
APPROVED DATE
CONTRACT NUMBER

AHTNA GLOBAL, LLC
FORT ORD, CA
FORT ORD GWTP
FIELD PIPING

SCALE
NOT TO SCALE
DRAWING NUMBER
CU3
SHEET NUMBER
3 OF 13



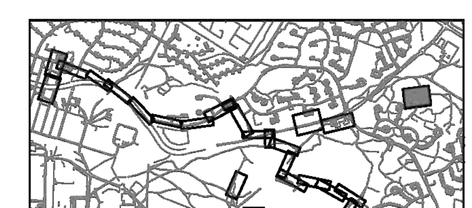
PLAN VIEW
(EXTRACTION LATERAL LINE FROM EW-OU2-09-180)
SCALE: 1"=30'

N

30 0 30 60
GRAPHIC SCALE IN FEET

NOTES

1. EXISTING VAULTS, HIGH POINTS, AND LEAK DETECTION VAULTS ARE BASED ON SURVEY PERFORMED BY POLARIS CONSULTING ON 7/31/2015.
2. SEE SHEET CU501, CU502 AND CU503 FOR WELL SCHEDULE AND ADDITIONAL NOTES ON REDEVELOPMENT AND VIDEO LOGGING OF EXISTING EXTRACTION WELLS, CONSTRUCTION OF NEW EXTRACTION AND INJECTION WELLS, CONVERSION OF EXTRACTION WELL TO MONITORING WELL, AND ABANDONMENT OF EXISTING WELLS.
3. SEE ELECTRICAL AND INSTRUMENTATION DRAWINGS FOR ADDITIONAL INFORMATION ON POWER, LEAK DETECTION, AND INSTRUMENTATION AND CONTROL.
4. WATER PIPE SEPARATION SHOWN ON PLAN VIEW ARE WITH GREATER SEPARATION GRAPHICALLY FOR CLARITY. SEE DETAILS ON CU505 AND CU506 FOR TYPICAL TRENCH SECTIONS.



KEY PLAN

REVISED AS-BUILT
NOT FOR CONSTRUCTION

LINE IS 2 INCHES AT FULL SIZE (IF NOT 2"-SCALE ACCORDINGLY)

DATE: 01/25/2023
FILE:
DRAWN: HR
DESIGNED: AHTNA
CHECKED:

SUBMITTED: DATE:
SUBMITTAL APPROVED: DATE:

Ahtna

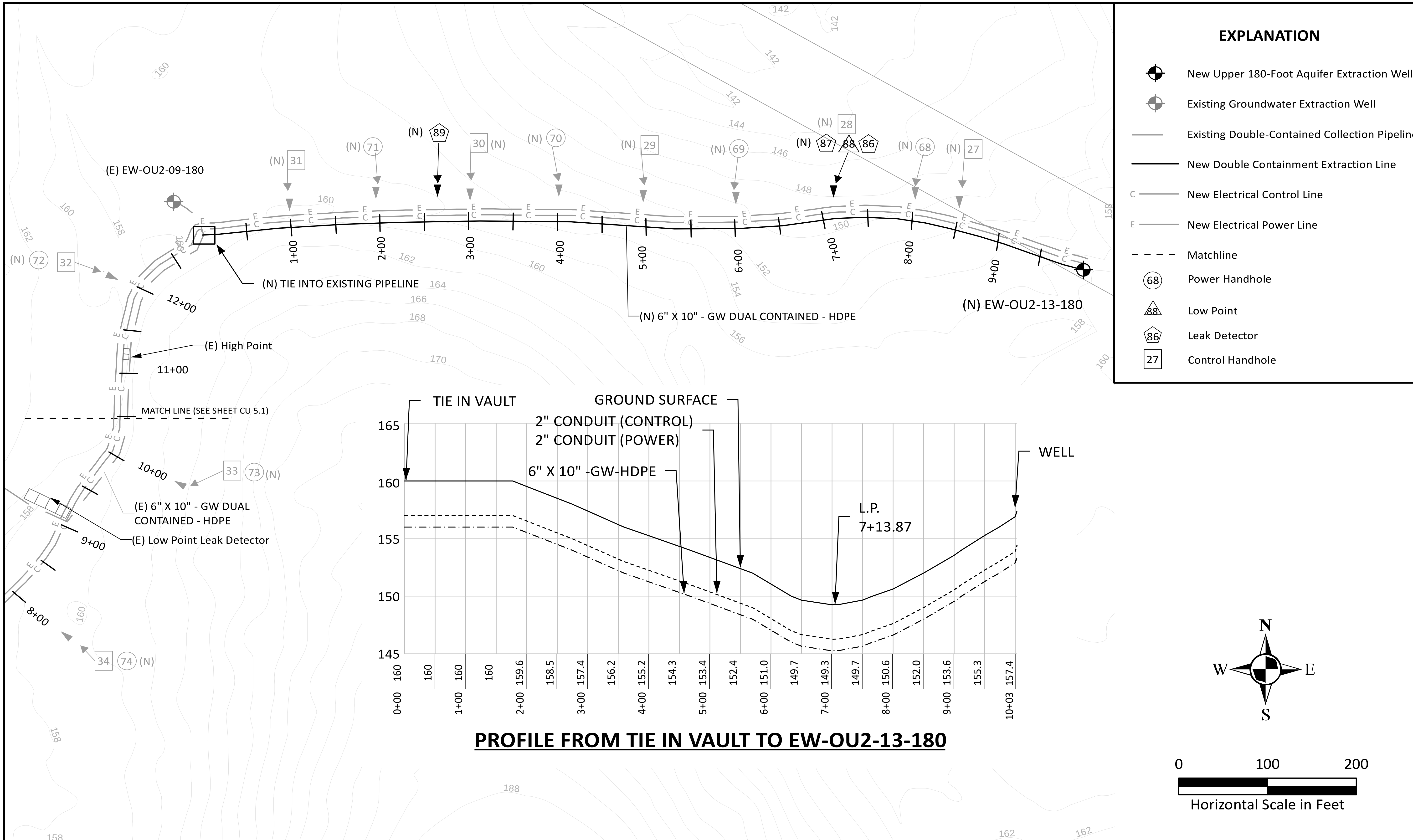
ZONE	REV.	DESCRIPTION	BY	DATE	APP.

REVISIONS

APPROVAL RECOMMENDED ______ DATE
APPROVED ______ DATE
CONTRACT NUMBER

AHTNA GLOBAL, LLC
FORT ORD, CA
BUNKER HILL NETWORK
FIELD PIPING

SCALE
NONE
DRAWING NUMBER
CU4
SHEET NUMBER
4 OF 13



PROFILE FROM TIE IN VAULT TO EW-OU2-13-180

NOT FOR CONSTRUCTION

LINE IS 2 INCHES AT FULL SIZE (IF NOT 2"-SCALE ACCORDINGLY)

DATE: 01/25/2023
FILE:
DRAWN: HR
DESIGNED: AHTNA
CHECKED:

SUBMITTED: DATE:
SUBMITTAL APPROVED: DATE:

Ahtna

REVISIONS

ZONE	REV.	DESCRIPTION	BY	DATE	APP.

APPROVAL RECOMMENDED ______ DATE
APPROVED ______ DATE

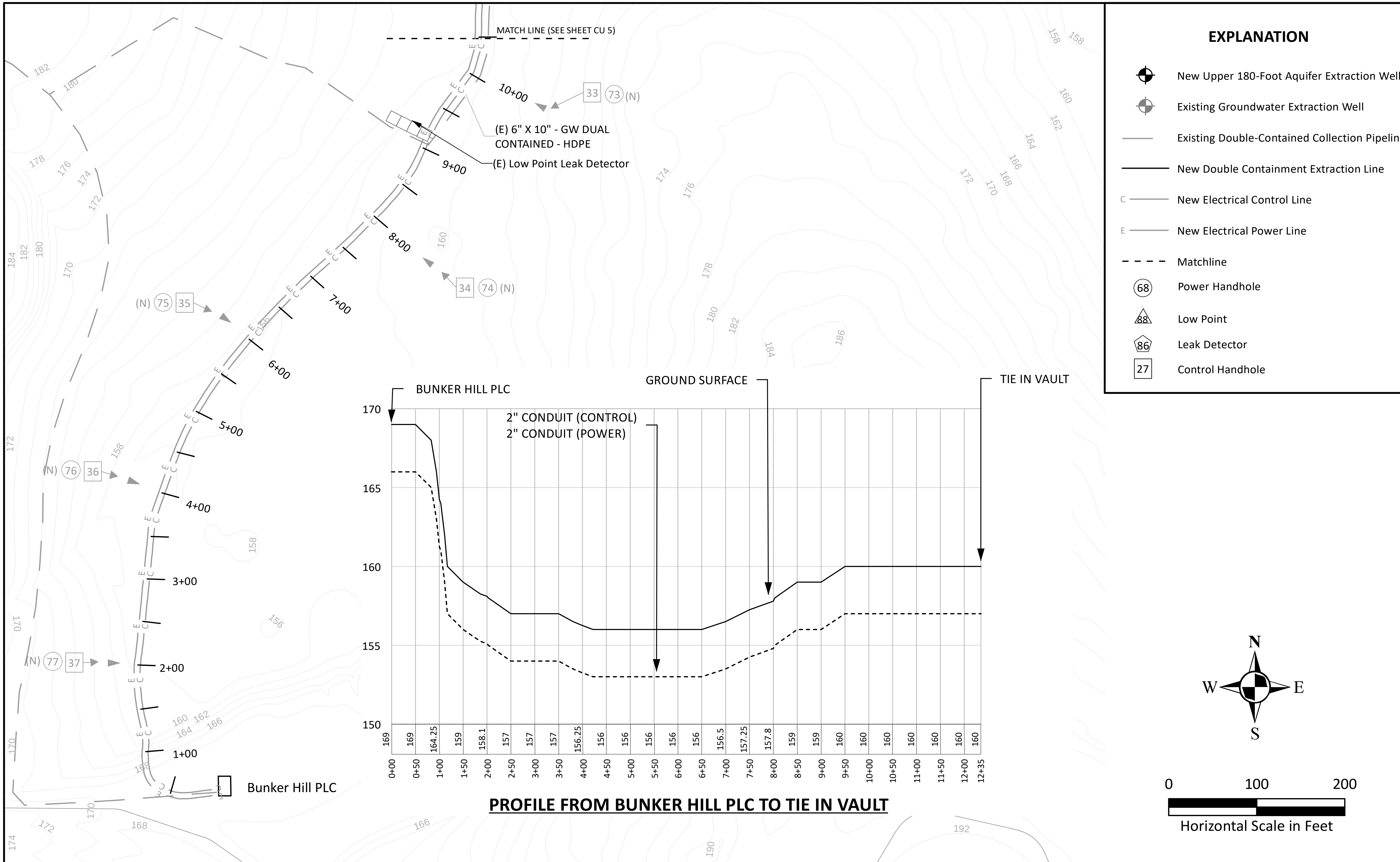
CONTRACT NUMBER

AHTNA GLOBAL, LLC
FORT ORD, CA
EW-OU2-13-180
FIELD PIPING

SCALE
NONE

DRAWING NUMBER
CU5

SHEET NUMBER
5 OF 13



NOT FOR CONSTRUCTION

LINE IS 2 INCHES AT FULL SIZE (IF NOT 2"-SCALE ACCORDINGLY)	DATE: 01/25/2023 FILE: DRAWN: HR DESIGNED: AHTNA CHECKED:
SUBMITTED:	DATE:
SUBMITTAL APPROVED:	DATE:

Ahtna

REVISIONS

ZONE	REV.	DESCRIPTION	BY	DATE	APP.

APPROVAL RECOMMENDED ____ DATE

APPROVED ____ DATE

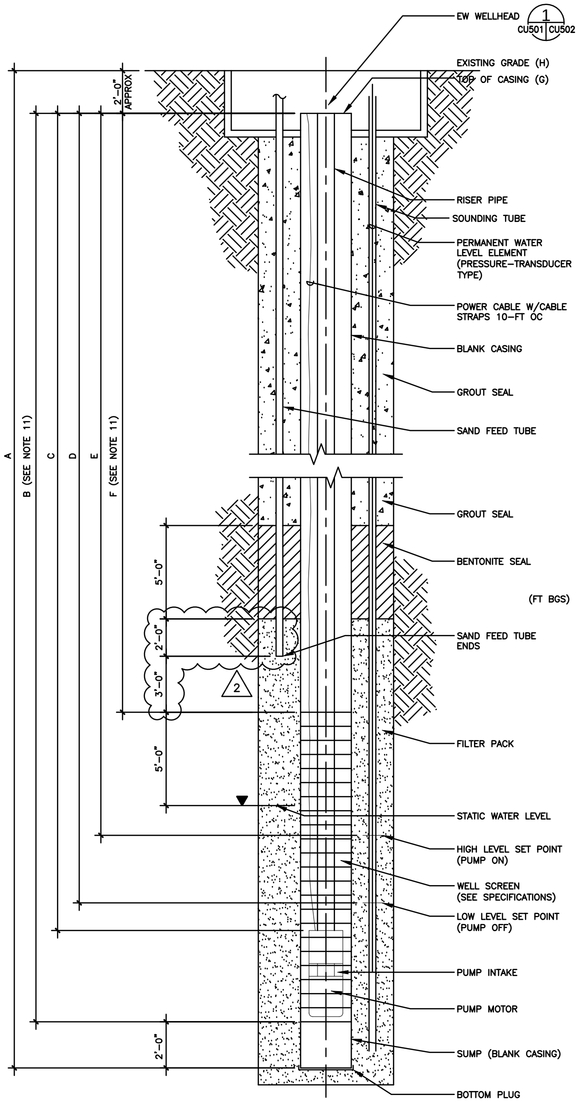
CONTRACT NUMBER

AHTNA GLOBAL, LLC
FORT ORD, CA
EW-OU2-13-180
FIELD PIPING

SCALE: NONE

DRAWING NUMBER: CU5.1

SHEET NUMBER: 5 OF 13



EW SCHEMATIC

NTS

SCHEDULE OF EXISTING EXTRACTION WELLS

	WELL ID	TOTAL CASING DEPTH (FT BGS)	BOTTOM OF SCREEN (FT BGS)	DEPTH TO TOP OF PUMP (FT BTOC)	PUMP-OFF SET PT (FT BTOC)	PUMP-ON SET PT (FT BTOC)	TOP OF SCREEN (FT BGS)	TOC ELEV (FT BTOC)	TOS ELEV (FT BTOC)	NEW PUMP MODEL	FLOW RATE (GPM)	Pressure At Top of Riser (psi)	Pressure At Top of Riser + Surge Pressure (psi)	(E) PUMP HORSE POWER (HP)	(N) PUMP HORSE POWER (HP)	COMMENT
		(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)	(J)	(K)	(L)	(M)	(N)	
WESTERN NETWORK																
1	EW-OU2-01-A	144	143				113	109.98	-3.02	-	0			5	-	WELL TO BE OFFLINE
2	EW-OU2-02-A	141.5	139.5				109.5	116.26	6.76	-	0			5	-	WELL TO BE OFFLINE
3	EW-OU2-03-A	116	115				75	84.33	9.33	-	0			5	-	WELL TO BE OFFLINE
4	EW-OU2-04-A	136	135				96	109.47	13.47	-	0			5	-	WELL TO BE OFFLINE
5	EW-OU2-05-A	131	130				100	108.99	8.99	90FA10S4-PE	50	125	160	10	10	REPLACE EXIST PUMP
6	EW-OU2-06-A	131	130				100	105.57	5.57	90FA10S4-PE	50	125	150	10	10	REPLACE EXIST PUMP
7	EW-OU2-01-180	174	173				143	110.79	-32.21	2366169020	160	120	165	30	30	REPLACE EXIST PUMP
EASTERN NETWORK																
8	EW-OU2-07-A	129	128				103	158.56	55.56	-	0			3	-	WELL TO BE OFFLINE
9	EW-OU2-08-A	137	136				106	162.96	56.96	-	0			3	-	WELL TO BE OFFLINE
10	EW-OU2-09-A	137	136				106	162.91	56.91	35FA5S4-PE	31	90	165	3	5	VIDEO, RE-DEVELOP, AND RE-VIDEO; REPLACE EXIST PUMP
11	EW-OU2-10-A	142	141				111	167.58	56.58	35FA5S4-PE	30	90	165	3	5	VIDEO, RE-DEVELOP, AND RE-VIDEO; REPLACE EXIST PUMP
12	EW-OU2-11-A	141	140				110	170.78	60.78	-	-			3	-	ABANDON
13	EW-OU2-12-A	142	141				106	175.39	68.39	60FA5S4-PE	30	80	120	5	5	VIDEO, RE-DEVELOP, AND RE-VIDEO; REPLACE EXIST PUMP
14	EW-OU2-13-A	147	146				116	180.15	64.15	25FA3S4-PE	25	80	100	5	3	VIDEO, RE-DEVELOP, AND RE-VIDEO; REPLACE EXIST PUMP
15	EW-OU2-02-180	241	240				200	167.28	-32.72	-	-			15	-	ABANDON
ABRAMS/IMJIN NETWORK																
16	EW-OU2-16-A	114.5	109.5				79.5	165.43	87.93	35FA5S4	27	90	115	3	5	VIDEO, RE-DEVELOP, AND RE-VIDEO; REPLACE EXIST PUMP
17	EW-OU2-05-180	245	240				180	170.72	-6.78	175STS30D6X-1064	160	90	110	20	30	REPLACE EXIST PUMP
18	EW-OU2-06-180	235.5	230.5				170.5	166.96	-3.54	150STS25DA-0964	135	90	140	20	25	REPLACE EXIST PUMP
BUNKER HILL AREA																
19	EW-OU2-07-180	265	260				210	163.39	-46.61	-	0			-	-	WELL TO BE OFFLINE
20	EW-OU2-08-180	220	215				215	162.31	-12.69	-	0			15	-	WELL TO BE OFFLINE
21	EW-OU2-09-180	220	215				175	149.55	-35.13	100SR15F66-1163	55	95	110	7.5	15	REPLACE EXIST PUMP
CSUMB EAST CAMPUS HOUSING AREA																
22	EW-OU2-14-A	137	129.5				89.5	185.85	96.35	-	0			3	-	WELL TO BE OFFLINE
23	EW-OU2-15-A	142.5	132.5				97.5	194.26	96.76	-	-			3	-	CONVERT TO MONITORING WELL
LANDFILL AREA																
24	EW-OU2-03-180	265	257.5				207	188.39	-18.61	150SR25F66-1163	150	65	95	20	25	REPLACE EXIST PUMP
25	EW-OU2-04-180	302	294.5				244.5	238.55	-5.95	-	0			20	-	WELL TO BE OFFLINE

SCHEDULE OF NEW EXTRACTION WELLS

	WELL ID	TOTAL CASING DEPTH (FT BGS)	BOTTOM OF SCREEN (FT BTOC)	DEPTH TO TOP OF PUMP (FT BTOC)	PUMP-OFF SET PT (FT BTOC)	PUMP-ON SET PT (FT BTOC)	TOP OF SCREEN (FT BTOC)	TOC ELEV (FT BTOC)	TOS ELEV (FT BTOC)	NEW PUMP MODEL	FLOW RATE (GPM)	WELLHEAD PRES (PSI)	WELLHEAD SURGE PRES (PSI)	(E) PUMP HORSE POWER (HP)	(N) PUMP HORSE POWER (HP)	COMMENT
		(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)	(J)			(K)	(L)	
ABRAMS/IMJIN NETWORK																
1	EW-OU2-17-A	117.5	115	109.5			75			60FA5S4-PE	30	85	170	-	5	NEW WELL
2	EW-OU2-18-A	107	104.5	99			64.5			60FA5S4-PE	30	90	150	-	5	NEW WELL
3	EW-OU2-19-A	112.5	110	104.5			70			60FA5S4-PE	30	85	145	-	5	NEW WELL
4	EW-OU2-20-A	124	121.5	116			81.5			60FA5S4-PE	30	85	135	-	5	NEW WELL
5	EW-OU2-10-180	305	302.3	297.12			242.3			150SR20F66-0963	130	40	95	-	20	NEW WELL
6	EW-OU2-11-180	241.3	238.5	232.9			178.5			150SR25F66-1163	130	85	105	-	25	NEW WELL
7	EW-OU2-12-180	231.8	229	221.15			169			150STS25DA-0964	130	90	100	-	25	NEW WELL
EASTERN NETWORK																
8	EW-OU2-11-AR	142.5	140	131.69			100			90FA7S4-PE	30	80	105	-	7.5	NEW WELL
9	EW-OU2-02-180R	267.8	265	256.64			205			175STS30D6X-1064	130	85	155	-	30	NEW WELL
1 **BUNKER HILL**																
10	EW-OU2-13-180	220	215				175	149.55	-35.13						20.0	NEW WELL (ESTIMATION) TO BE INSTALLED

NOTES

1. DIMENSIONS ARE IN FEET UNLESS OTHERWISE NOTED.
2. CASINGS AND SCREENS FOR WELLS W/ "A" OR "AR" DESIGNATIONS SHALL BE 6-INCH NOMINAL. CASINGS AND SCREENS FOR WELLS W/ "180" OR "180R" DESIGNATIONS SHALL BE 10-INCH NOMINAL.
3. FOR WELLS TO BE VIDEO LOGGED, SUBCONTRACTOR SHALL PULL ALL EXISTING DOWNHOLE APPURTENANCES BEFORE REHABILITATION AND RE-INSTALL ALL DOWNHOLE APPURTENANCES AFTER REHABILITATION. WELL PUMP AND APPURTENANCES SHALL BE RESTORED TO FULLY OPERATIONAL CONDITION.
4. PUMP MODEL NUMBERS ARE GRUNDFOS.
5. EACH SUBMERSIBLE PUMP SHALL BE INSTALLED WITH SHROUD TO DIRECT INTAKE WATER PAST PUMP MOTOR.
6. RISER PIPES FOR WELLS W/ "A" OR "AR" DESIGNATIONS SHALL BE 1 1/2-INCH NOMINAL PIPES. RISER PIPES FOR WELLS W/ "180" OR "180R" DESIGNATIONS SHALL BE 3-INCH NOMINAL PIPES.
7. CONVERSION OF EW-OU2-15-A TO MONITORING WELL (MW) SHALL INCLUDE REMOVAL OF PUMP, PIPING, ELECTRICAL AND PUMPING APPARATUS FROM WELL AND VAULT AND PLACEMENT OF MONITORING WELL HEAD. EXTEND WELL CASING WITH A 3' STICK-UP ABOVE GROUND SURFACE USING SIMILAR MATERIAL AS WELL CASING. PROVIDE AN ALUMINUM PROTECTIVE CASING WITH A LOCKING HINGED LID OVER THE WELL CASING STICK-UP AND GROUT IN PLACE. A 3'X3'X4" CONCRETE PAD SHALL BE INSTALLED AROUND THE WELL HEAD. INSTALL FOUR BOLLARDS PAINTED SAFETY YELLOW AND FILLED WITH CEMENT. THE BOLLARDS SHALL BE MINIMUM 2" DIAMETER, EXTEND 3' BELOW GROUND SURFACE AND STICKING UP 3' ABOVE GROUND SURFACE. THE WELL ID TAG SHALL INCLUDE WELL ID, WELL DEPTH, SCREENED INTERVAL DEPTH, GROUND SURFACE ELEVATION, AND DATE INSTALLED.
8. TBD DURING WELL DRILLING:
   COLUMN (C): DEPTH TO TOP OF PUMP TBD DURING WELL DRILLING
   COLUMN (D): PUMP – OFF SET POINT
   COLUMN (E): PUMP – ON SET POINT
   COLUMN (G): TOP OF CASING (FOR NEW WELLS)
   COLUMN (H): TOP OF SURFACE (FOR NEW WELLS)
9. SCREENED INTERVAL FOR SOUNDING TUBE SHALL MATCH SCREENED INTERVAL FOR WELL.
10. SEE SPECIFICATIONS FOR WELL CONSTRUCTION MATERIALS.
11. ELEVATIONS OF TOP OF SCREEN AND BOTTOM OF SCREEN ARE ESTIMATED. ACTUAL ELEVATIONS SHALL BE SET IN THE FIELD BY THE PROJECT GEOLOGIST. THE TOP OF SCREENED INTERVAL SHALL BE AT LEAST 5 FEET ABOVE THE STATIC WATER LEVEL.
12. COLUMN (H) SURFACE ELEVATIONS AT EACH EW TBD AFTER DRILLING.
13. ALL PUMP MOTORS ARE 480V/3P.

1.IS BEING PROPOSED FOR THE NEW EXTRACTION WELL.

NOT FOR CONSTRUCTION

LINE IS 2 INCHES AT FULL SIZE (IF NOT 2"-SCALE ACCORDINGLY)

DATE: 01/25/2023
FILE:
DRAWN: HR
DESIGNED:
CHECKED:

SUBMITTED: ____ DATE: ____
SUBMITTAL APPROVED: ____ DATE: ____

Ahtna

REVISIONS						
ZONE	REV.	DESCRIPTION	BY	DATE	APP.	
		1				
		2				
		3				
	4					

APPROVAL RECOMMENDED ____ DATE

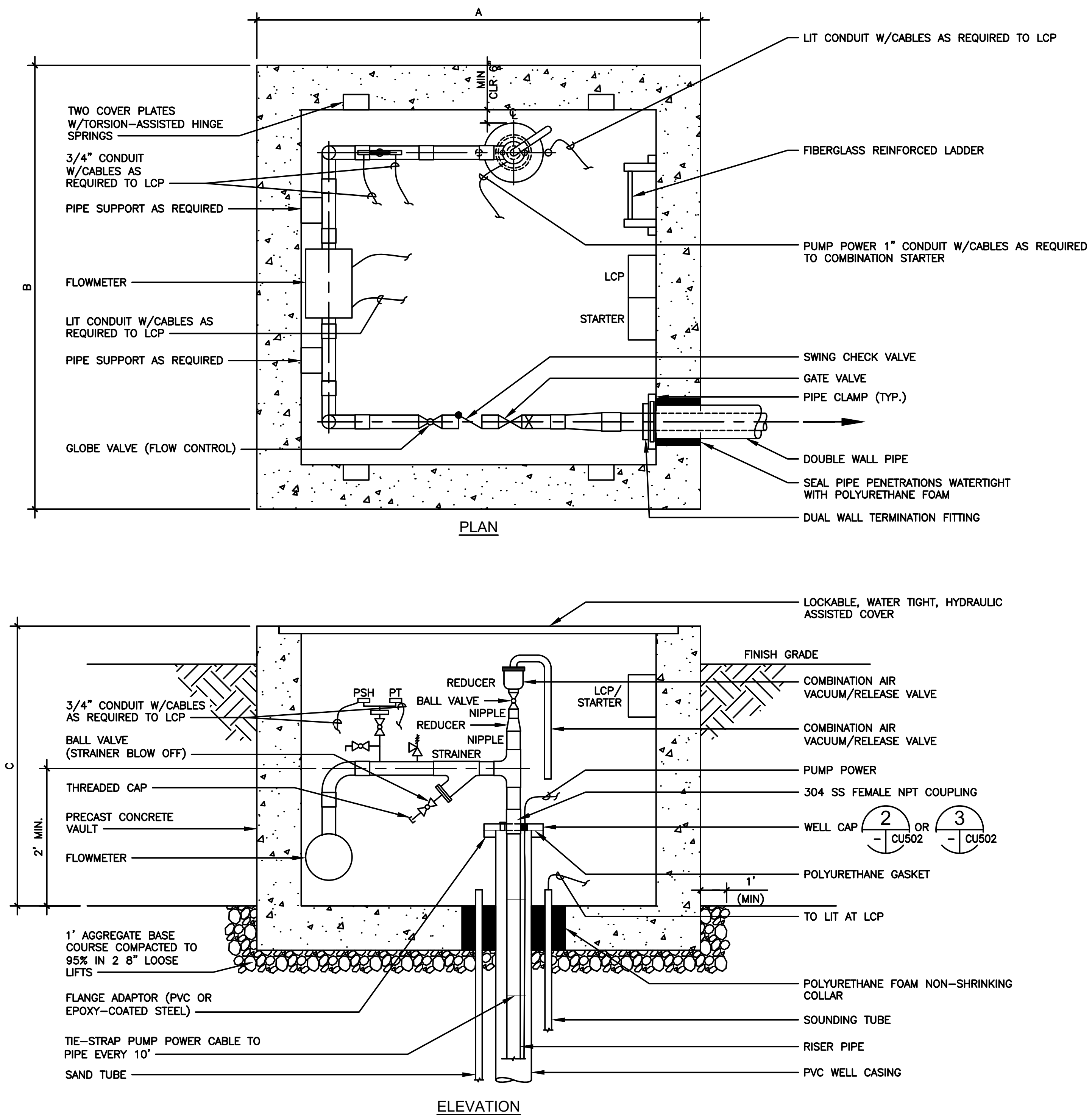
APPROVED ____ DATE

CONTRACT NUMBER

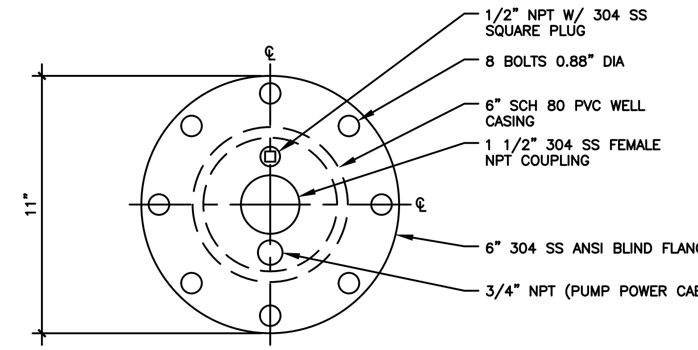
AHTNA GLOBAL, LLC
FORT ORD, CA

BUNKER HILL NETWORK
EXTRACTION WELL SCHEMATIC

SCALE: NOT TO SCALE
DRAWING NUMBER: CU6
SHEET NUMBER: 6 OF 13

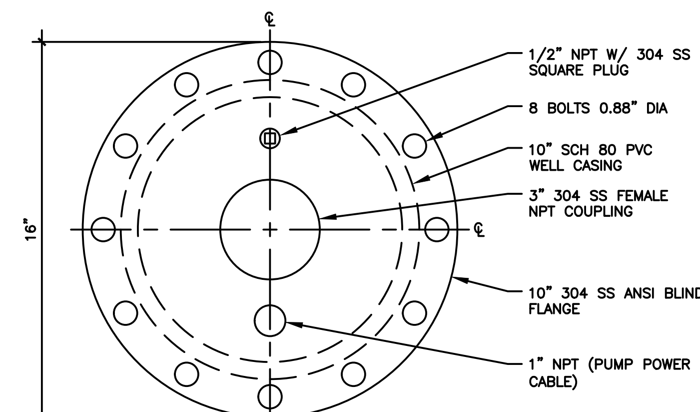


1 EW WELLHEAD
CU501 | CU502 NTS



2 WELL CAP - A-AQUIFER WELLS
CU501 | CU502 SCALE: 3"=1'-0"

3" 0 3" 6" 9"
SCALE: 3" = 1'-0"



3 WELL CAP - 180-FT-AQUIFER WELLS
CU501 | CU502 SCALE: 3"=1'-0"

3" 0 3" 6" 9"
SCALE: 3" = 1'-0"

GRADE LOAD REQUIREMENT – WELL VAULTS

A. 150 PSI
B. H-20 OFF-STREET LOCATION (OCCASIONAL H20 LOADING)

CLASS WATER TIGHTNESS REQUIREMENT – WELL VAULTS

1. NONE – PROVIDE 1 1/2"DIA HOLE 6" FROM EACH CORNER OF EACH LEAF
2. WATER RESISTANT
3. WATER TIGHT

NOTES:

1. DRILLER SHALL INSTALL TEMPORARY CS SLEEVE TO PROTECT WELL CASING EXTENDING APPROXIMATELY 3' ABOVE GRADE.
2. CLASS 2 AND 3 VAULT COVERS SHALL BE EQUIPPED WITH A JOINT GUTTER AND A MOAT TYPE EDGE DRAIN. A 1 1/2" DIA MIN DRAIN CONNECTION SHALL BE PROVIDED.
3. ALL HATCHES SHALL INCLUDE A RECESSED HASP FOR A PADLOCK THAT IS COVERED BY A HINGED LID FLUSH WITH THE SURFACE.
4. COVER SHALL BE GASKET-SEALED AND TORSION-SPRING ASSISTED.
5. ALL HARDWARE FOR THE COVER SHALL BE 304 SS.
6. PRECAST CONCRETE REQUIREMENTS:
   CONCRETE SHALL HAVE A MINIMUM 28 DAY COMPRESSIVE STRENGTH OF 4000 PSI. THE VAULT SHALL BE DESIGNED IN ACCORDANCE WITH ACI 318-89 FOR THE FOLLOWING LATERAL SOIL LOADINGS:
   70 PCF EQUIVALENT FLUID PRESSURE SURCHARGE
   240 PSF FOR WELLHEADS WITH GRADE B OR C COVERS.
7. SEAL ALL PENETRATIONS WITH NON-SHRINKING POLYURETHANE FOAM AND SPECIFICATION.
8. FOR ELECTRICAL REQUIREMENTS SEE ELECTRICAL SHEETS.
9. ALL CABLES EXPOSED TO PHYSICAL DAMAGE SHALL BE RUN IN CONDUIT.
10. SEE SHEET M-501 FOR DETAILS FOR SAMPLE PORTS AND PRESSURE INSTRUMENTS.

NOT FOR CONSTRUCTION

LINE IS 2 INCHES AT FULL SIZE (IF NOT 2"-SCALE ACCORDINGLY)

DATE: 01/25/2023
FILE:
DRAWN: HR
DESIGNED: AHTNA
CHECKED:

SUBMITTED: DATE:
SUBMITTAL APPROVED: DATE:

Ahtna

REVISIONS

ZONE	REV.	DESCRIPTION	BY	DATE	APP.

APPROVAL RECOMMENDED ____ DATE
APPROVED ____ DATE

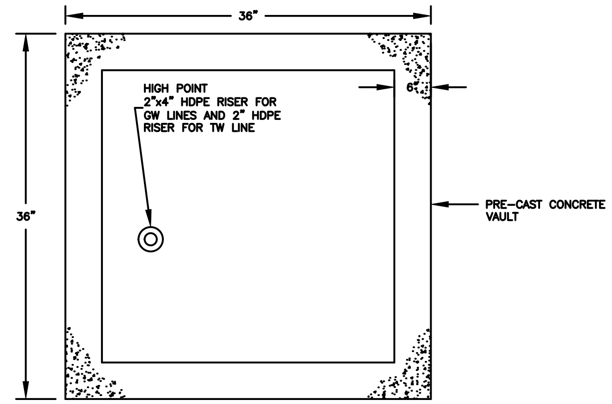
CONTRACT NUMBER

AHTNA GLOBAL, LLC
FORT ORD, CA

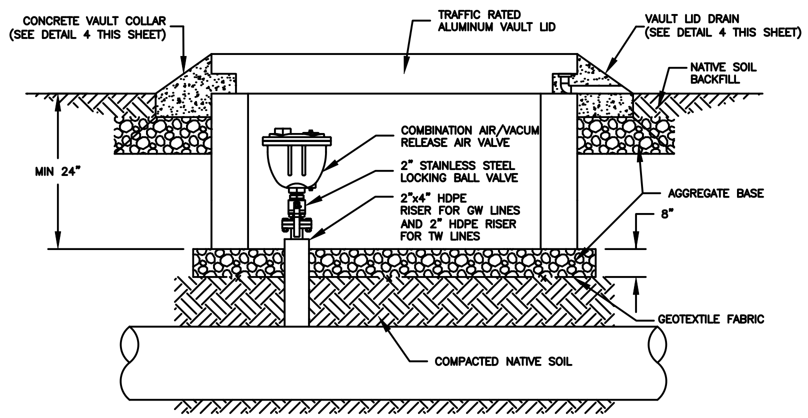
BUNKER HILL NETWORK
EXTRACTION WELLHEAD DETAILS

SCALE: NONE
DRAWING NUMBER: CU7
SHEET NUMBER: 7 OF 13

A B C D E F G H I J K L M N O



PLAN VIEW

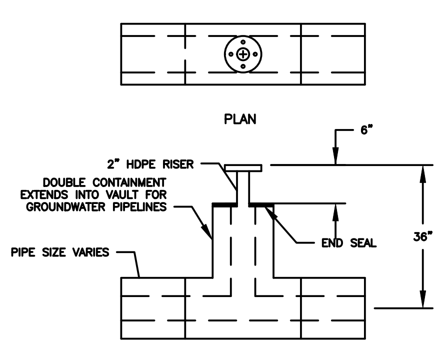


CROSS SECTION

NOTES

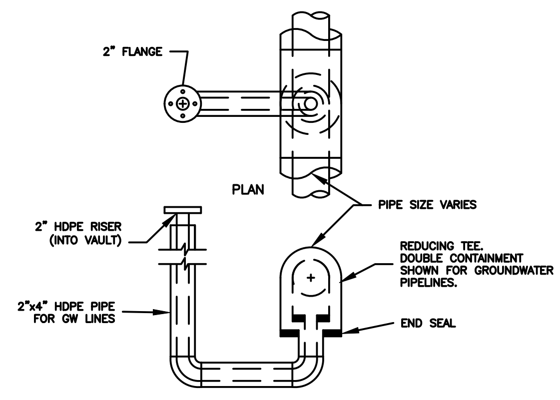
1. AT HIGH POINTS INSTALL NON-SHOCK COMBINATION VACUUM BREAK AND PRESSURE RELEASE VALVE ON RISER.

1 HIGH POINT VAULT
CU SHEET | CU507 SCALE: N.T.S.



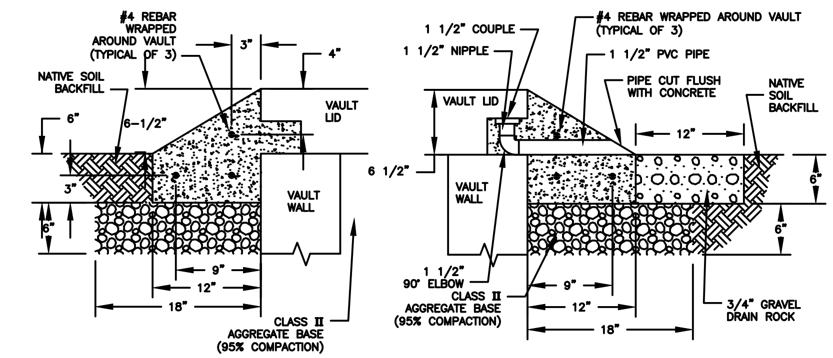
CROSS SECTION

2 HIGH POINT VENT DETAIL
CU SHEETS | CU507 SCALE: N.T.S.

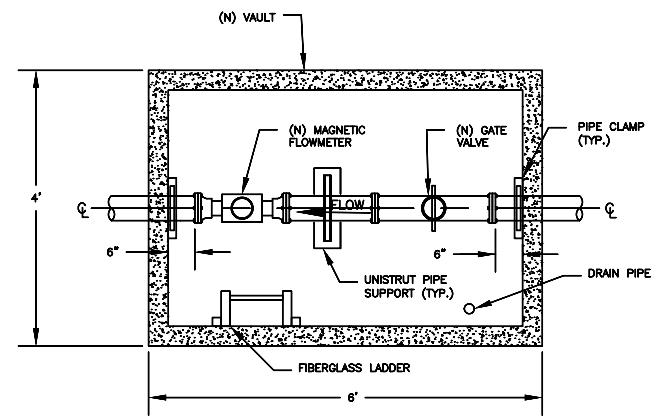


CROSS SECTION

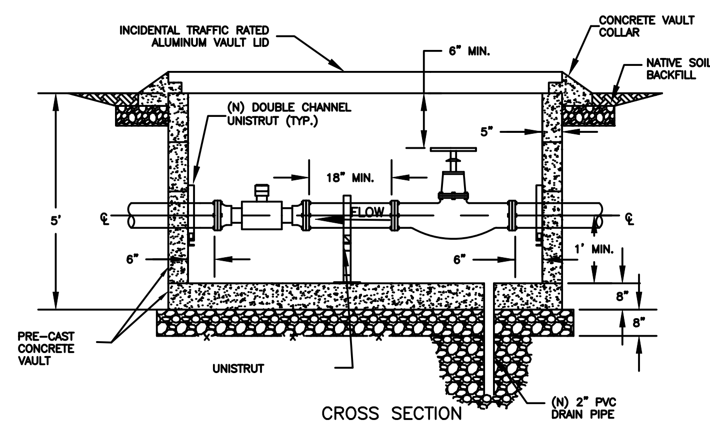
3 LOW POINT DRAIN DETAIL
CU SHEETS | CU507 SCALE: N.T.S.



4 LOW/HIGH POINT VAULT
CU SHEETS | CU507 SCALE: N.T.S.



PLAN VIEW

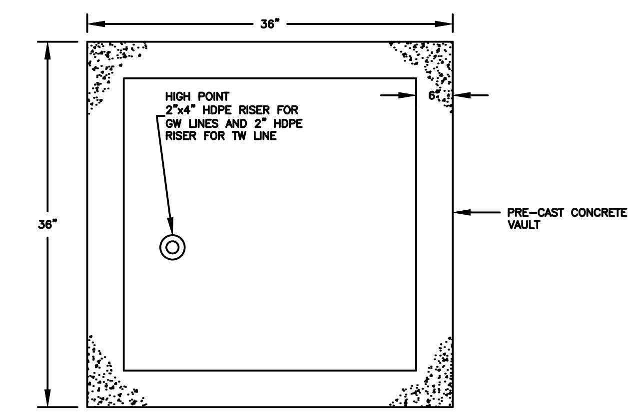


CROSS SECTION

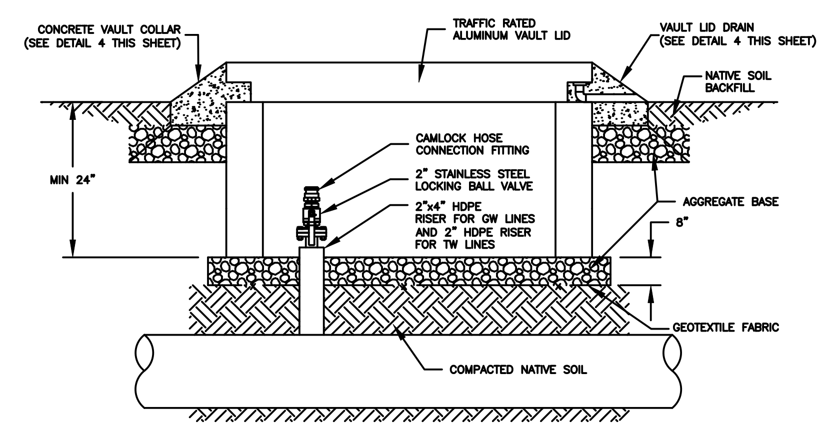
NOTES

1. A MINIMUM OF FIVE (5) PIPE DIAMETERS OF STRAIGHT PIPE MUST BE MAINTAINED FROM THE CENTER OF THE MAGNETIC FLOWMETER ON THE UPSTREAM SIDE.
2. A MINIMUM OF TWO (2) PIPE DIAMETERS OF STRAIGHT PIPE MUST BE MAINTAINED FROM THE CENTER OF THE MAGNETIC FLOWMETER ON THE DOWNSTREAM SIDE.
3. A MINIMUM OF TEN (10) PIPE DIAMETERS OF STRAIGHT PIPE MUST BE MAINTAINED FROM THE CENTER OF THE MAGNETIC FLOWMETER TO ANY PIPE TEE ON THE UPSTREAM SIDE.
4. FOR ADDITIONAL INFORMATION ON THE MAGNETIC FLOWMETER, REFER TO ELECTRICAL, INSTRUMENTATION, AND CONTROLS DRAWINGS.

5 FLOW METER VAULT
CU423 | CU507 SCALE: N.T.S.



PLAN VIEW



CROSS SECTION

NOTES

1. AT HIGH POINTS INSTALL NON-SHOCK COMBINATION VACUUM BREAK AND PRESSURE RELEASE VALVE ON RISER.

6 LOW POINT VAULT
CU SHEET | CU507 SCALE: N.T.S.

NOT FOR CONSTRUCTION

LINE IS 2 INCHES AT FULL SIZE
(IF NOT 2"-SCALE ACCORDINGLY)

DATE: 01/25/2023
FILE:
DRAWN: HR
DESIGNED:
CHECKED:

SUBMITTED: DATE:
SUBMITTAL APPROVED: DATE:

Ahtna

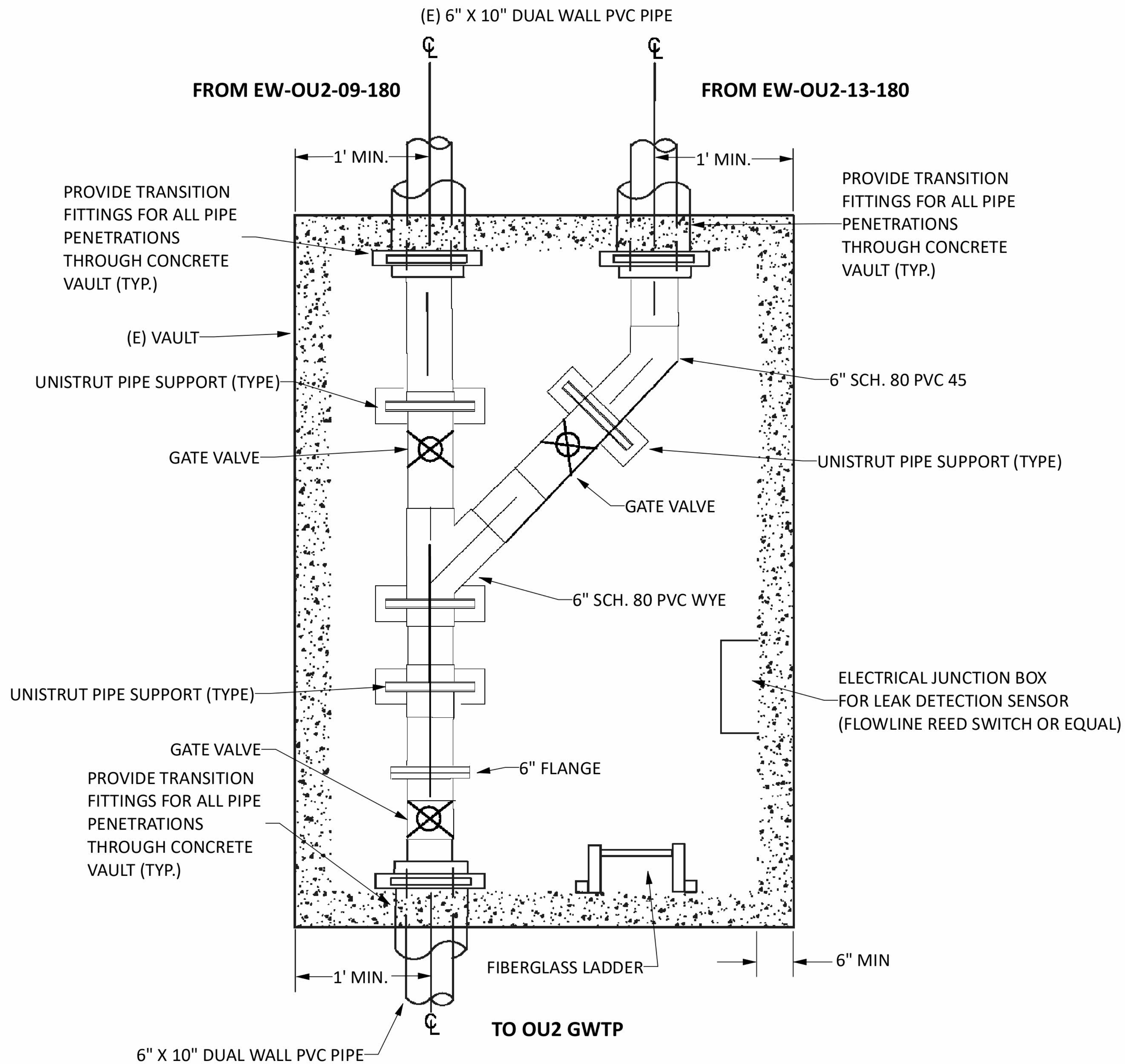
ZONE	REV.	DESCRIPTION	BY	DATE	APP.

REVISIONS

APPROVAL RECOMMENDED ____ DATE
APPROVED ____ DATE
CONTRACT NUMBER

AHTNA GLOBAL, LLC
FORT ORD, CA
BUNKER HILL NETWORK
VAULT DETAILS

SCALE: NOT TO SCALE
DRAWING NUMBER: CU8
SHEET NUMBER: 8 OF 13



NOT FOR CONSTRUCTION

LINE IS 2 INCHES AT FULL SIZE (IF NOT 2"-SCALE ACCORDINGLY)

DATE: 01/25/2023
FILE:
DRAWN: HR
DESIGNED: AHTNA
CHECKED:

SUBMITTED: DATE:
SUBMITTAL APPROVED: DATE:

Ahtna

REVISIONS

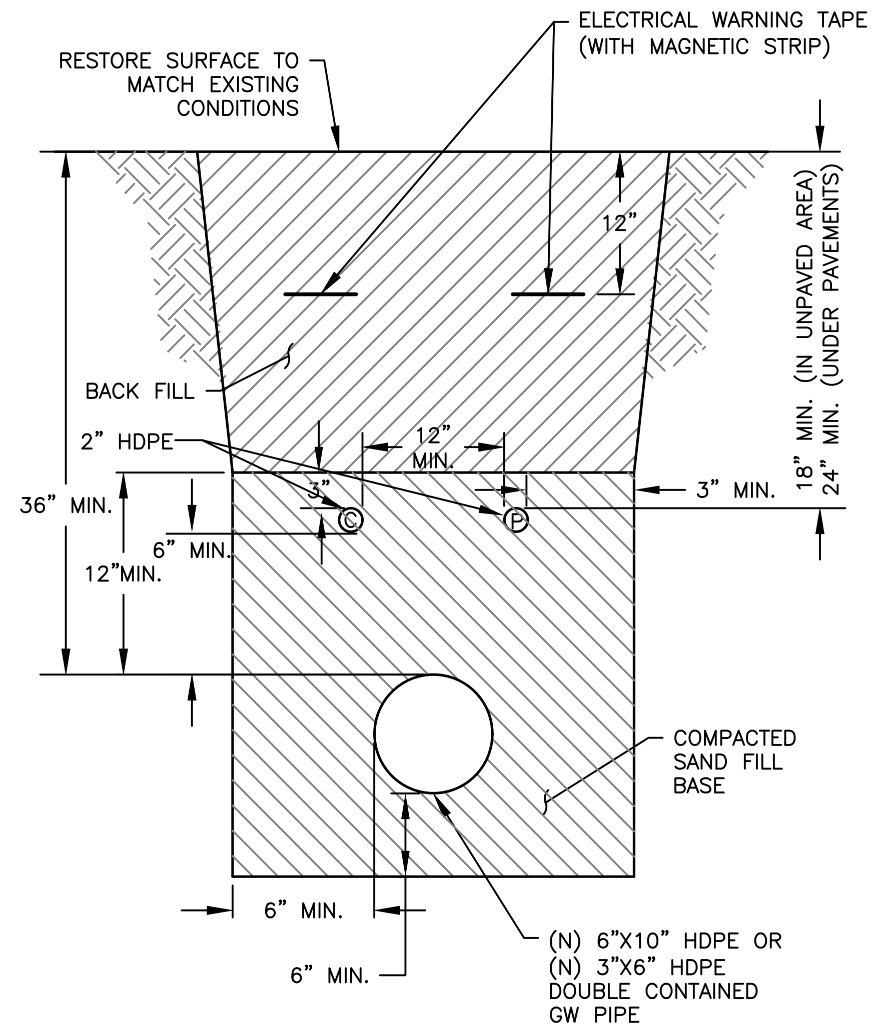
ZONE	REV.	DESCRIPTION	BY	DATE	APP.

APPROVAL RECOMMENDED ____ DATE
APPROVED ____ DATE
CONTRACT NUMBER

AHTNA GLOBAL, LLC
FORT ORD, CA

BUNKER HILL NETWORK
VAULT PIPING DETAILS

SCALE NONE
DRAWING NUMBER CU9
SHEET NUMBER 9 OF 13

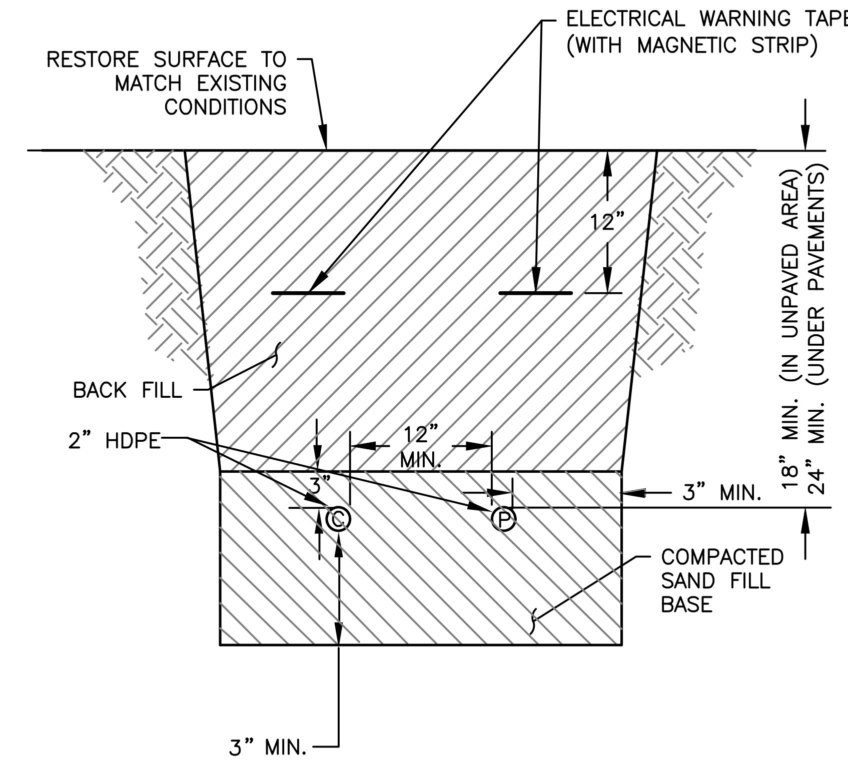


NOTE:
1. FROM EW-OU2-13-180 TO TIE-IN VAULT

1 TRENCH DETAIL

CU5 | CU10
CU13
S15

SCALE : N.T.S.



NOTE:
1. FROM TIE-IN VAULT TO BUNKER HILL PLC

2 TRENCH DETAIL

CU5.1 | CU10
CU12
CU13.1
S14
S15.1

SCALE : N.T.S.

CONDUIT LEGEND
Ⓒ – CONTROL CONDUIT (2" PVC)
Ⓟ – POWER CONDUIT (2" PVC)

NOT FOR CONSTRUCTION

LINE IS 2 INCHES AT FULL SIZE
(IF NOT 2"–SCALE ACCORDINGLY)

DATE: 01/25/2023
FILE:
DRAWN: HR
DESIGNED:
CHECKED:

SUBMITTED: DATE:
SUBMITTAL APPROVED: DATE:

Ahtna

REVISIONS

ZONE	REV.	DESCRIPTION	BY	DATE	APP.
	3				
	4				

APPROVAL RECOMMENDED ______ DATE
APPROVED ______ DATE

CONTRACT NUMBER

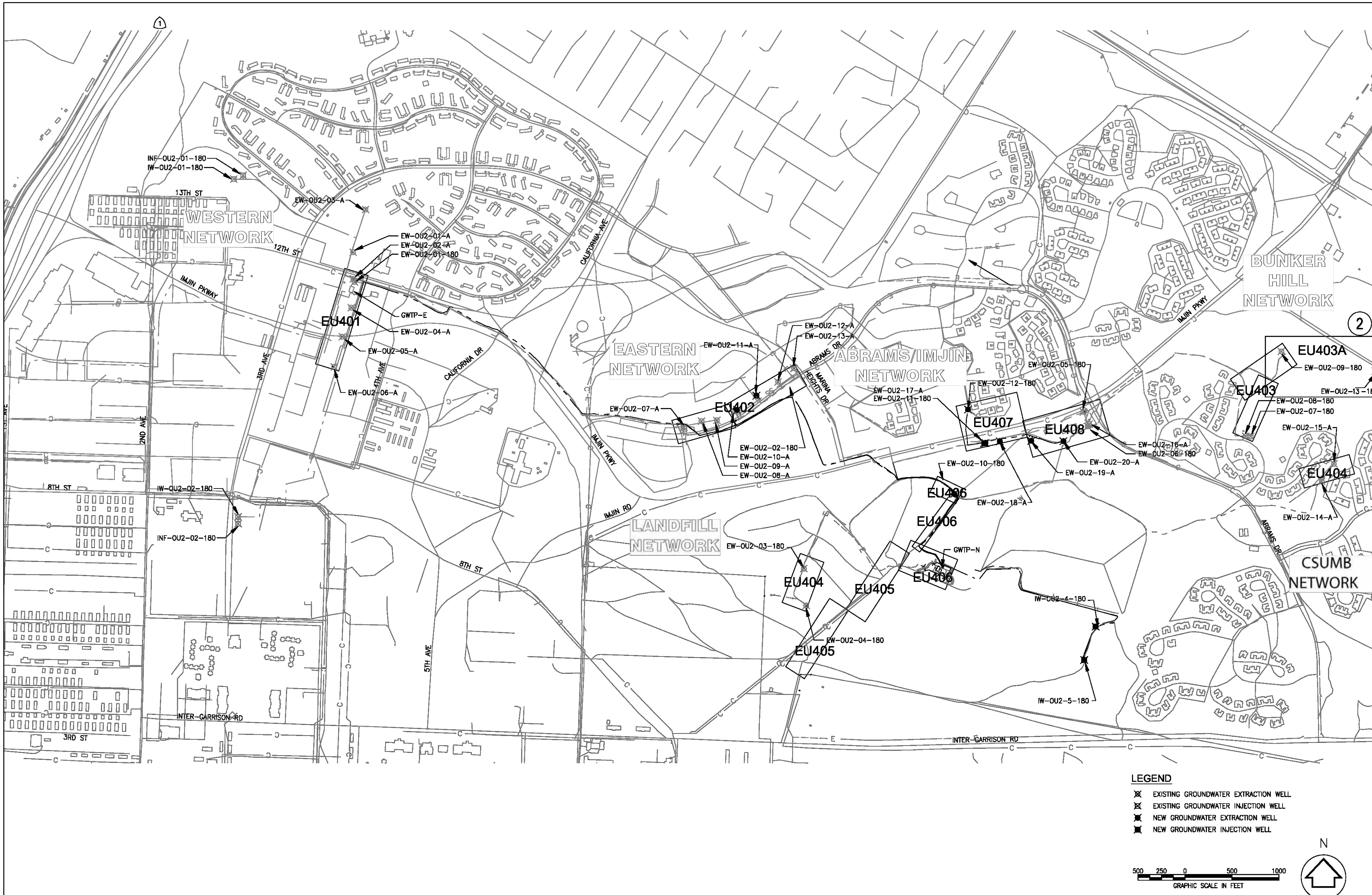
AHTNA GLOBAL, LLC
FORT ORD, CA

BUNKER HILL NETWORK
TRENCH DETAILS

SCALE
NOT TO SCALE

DRAWING NUMBER
CU10

SHEET NUMBER
10 OF 13



2

ADDED KEYBOX EU403A FOR NEW EXTRACTION WELL.

NOT FOR CONSTRUCTION

LINE IS 2 INCHES AT FULL SIZE (IF NOT 2"-SCALE ACCORDINGLY)

DATE: 01/25/2023
FILE:
DRAWN: HR
DESIGNED:
CHECKED:

SUBMITTED: ______ DATE: ______
SUBMITTAL APPROVED: ______ DATE: ______

Ahtna

REVISIONS

ZONE	REV.	DESCRIPTION	BY	DATE	APP.
	1				
	2				
	3				
	4				

APPROVAL RECOMMENDED ______ DATE
APPROVED ______ DATE

CONTRACT NUMBER

AHTNA GLOBAL, LLC
FORT ORD, CA

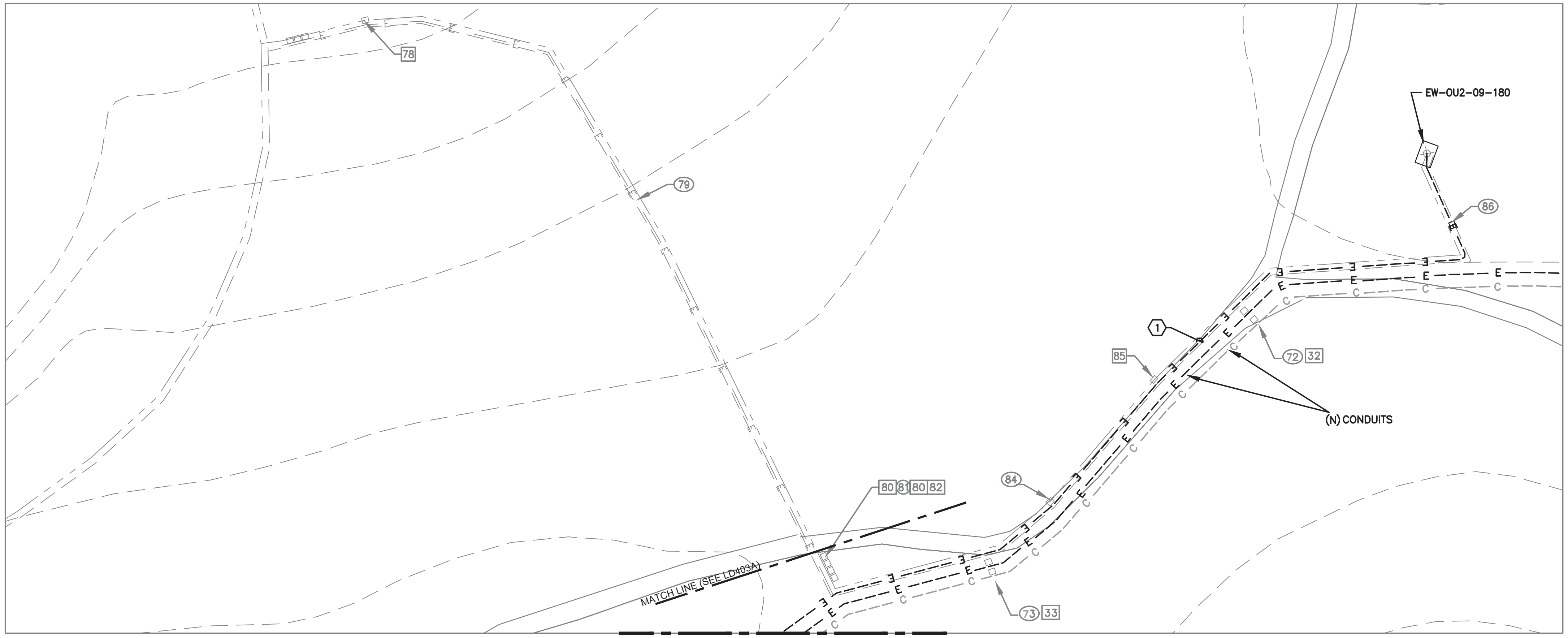
FORT ORD GWTP
FIELD ELECTRICAL MAP

SCALE
NOT TO SCALE

DRAWING NUMBER
CU11

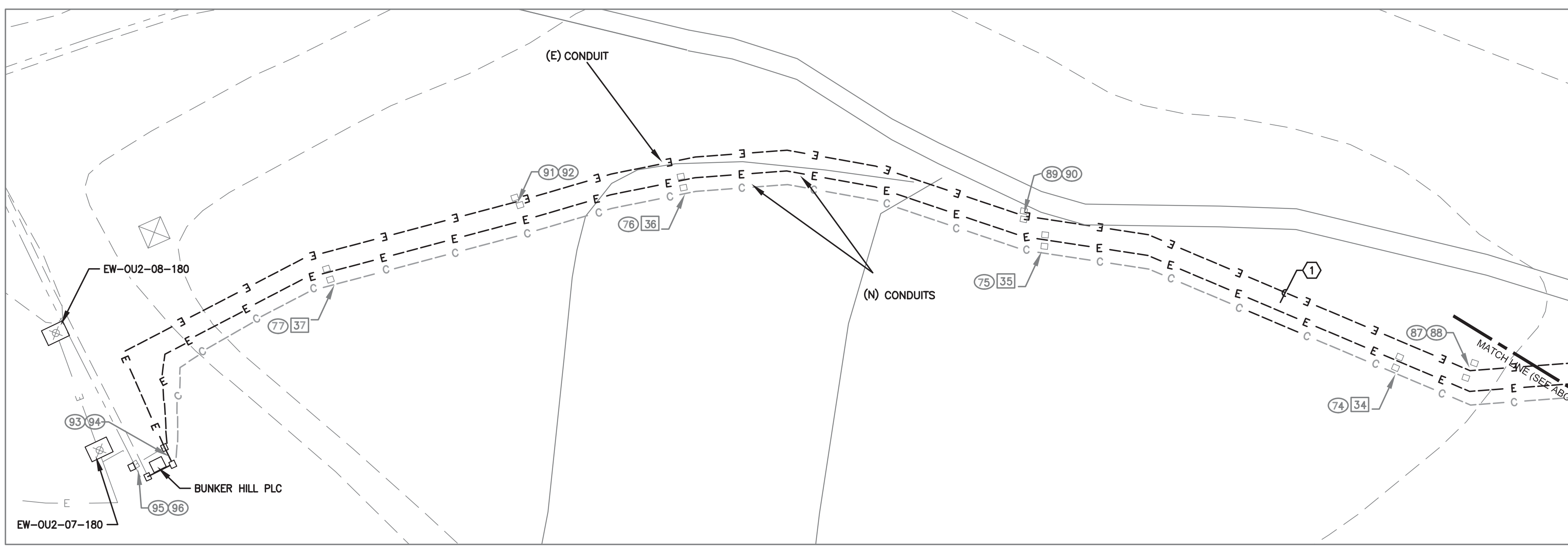
SHEET NUMBER
11 OF 13

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O



1 BUNKER HILL NETWORK
SCALE 1 : 30

N



2 BUNKER HILL NETWORK
SCALE 1 : 30

N

GENERAL NOTES

1. FOR ALL (N) UNDERGROUND METALLIC STRUCTURES PROVIDE CORROSION PROTECTION. THE CONTRACTOR MAY MODIFY THE CATHODIC PROTECTION SYSTEM AS SHOWN IN DETAILS ON E-504 AFTER SITE VERIFICATION AND ANALYSIS.
2. FOR TRAFFIC AND NON-TRAFFIC HANDHOLES SEE DETAIL 1 ON IU501 AND DETAIL 13 ON E-502.
3. SEE CU SHEETS FOR ADDITIONAL TRENCH PROFILES AND DETAILS.

KEYED NOTES

1 ~~(N) CONDUCTORS IN (E) CONDUITS.~~


KEY PLAN

NOT FOR CONSTRUCTION

LINE IS 2 INCHES AT FULL SIZE
(IF NOT 2"-SCALE ACCORDINGLY)

DATE: 01/25/2023
FILE:
DRAWN: HR
DESIGNED: AHTNA
CHECKED:

SUBMITTED: ____ DATE: ____
SUBMITTAL APPROVED: ____ DATE: ____

Ahtna

REVISIONS

ZONE	REV.	DESCRIPTION	BY	DATE	APP.

APPROVAL RECOMMENDED ____ DATE
APPROVED ____ DATE
CONTRACT NUMBER

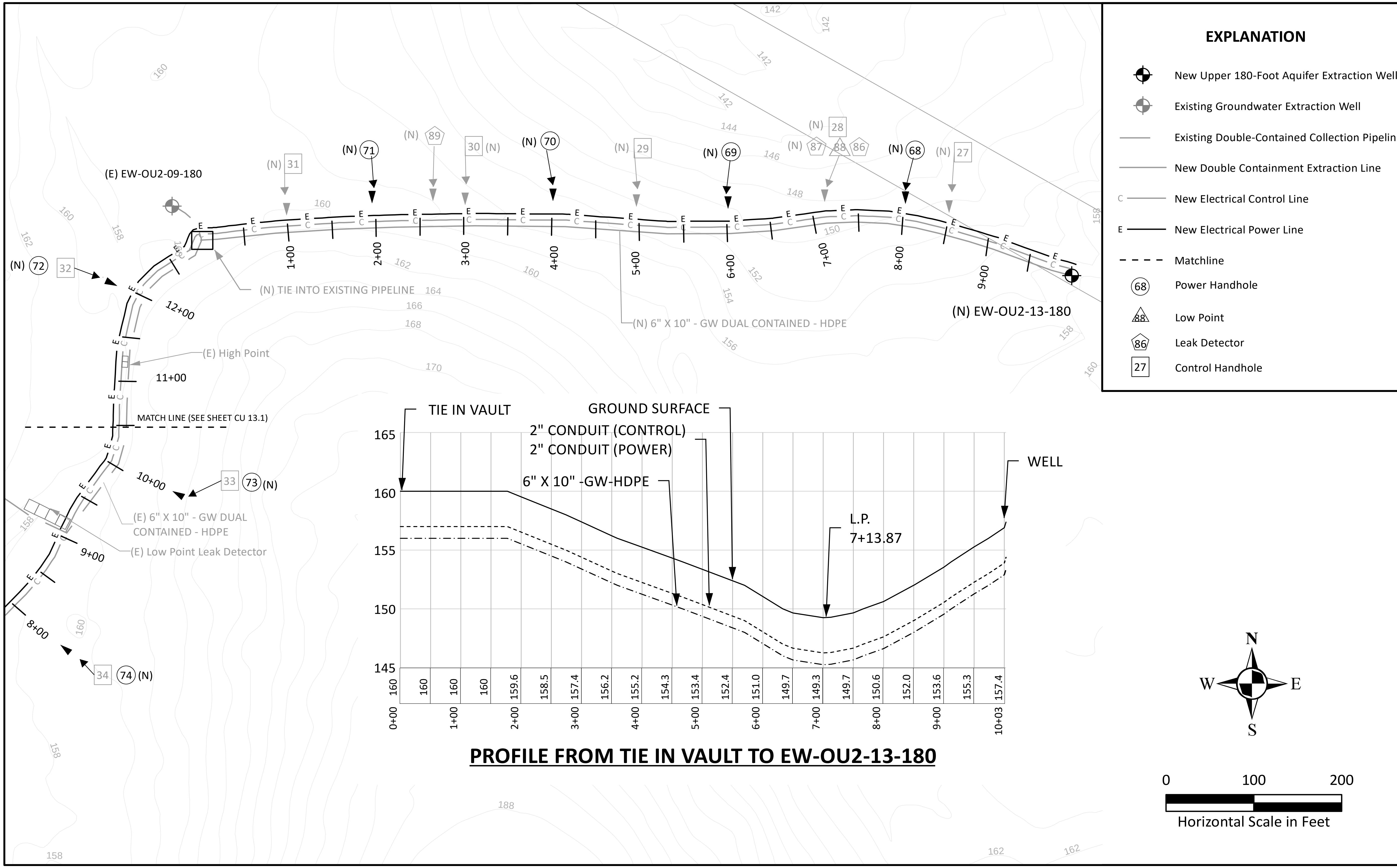
AHTNA GLOBAL, LLC
FORT ORD, CA

BUNKER HILL
FIELD ELECTRICAL MAP

SCALE
NONE

DRAWING NUMBER
CU12

SHEET NUMBER
12 OF 13



NOT FOR CONSTRUCTION

LINE IS 2 INCHES AT FULL SIZE (IF NOT 2"-SCALE ACCORDINGLY)

DATE: 01/25/2023
FILE:
DRAWN: HR
DESIGNED: AHTNA
CHECKED:

SUBMITTED: DATE:
SUBMITTAL APPROVED: DATE:

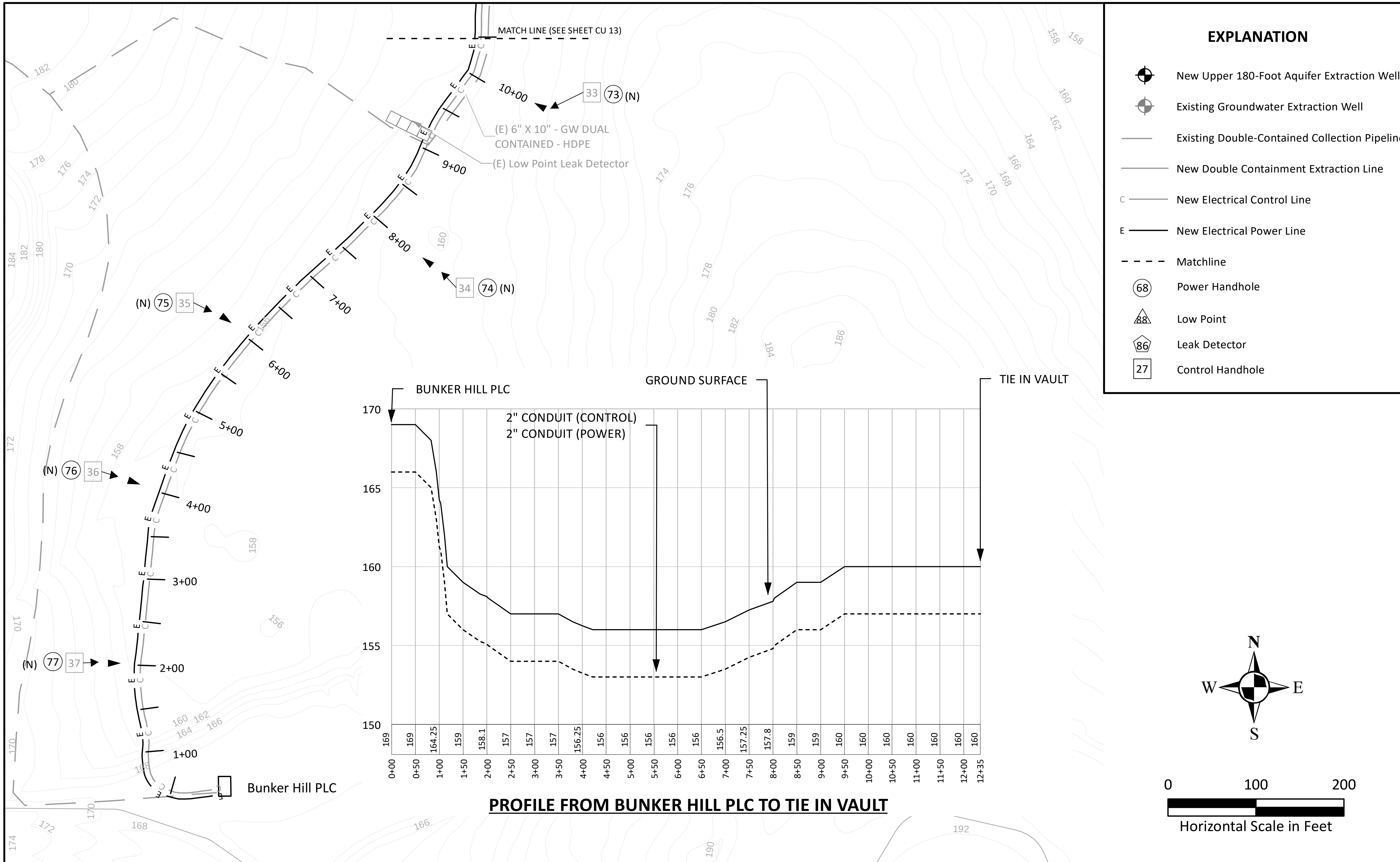
Ahtna

REVISIONS					
ZONE	REV.	DESCRIPTION	BY	DATE	APP.

APPROVAL RECOMMENDED ______ DATE
APPROVED ______ DATE
CONTRACT NUMBER

AHTNA GLOBAL, LLC
FORT ORD, CA
EW–OU2–13–180
FIELD ELECTRICAL MAP

SCALE
NONE
DRAWING NUMBER
CU13
SHEET NUMBER
13 OF 13



NOT FOR CONSTRUCTION

LINE IS 2 INCHES AT FULL SIZE (IF NOT 2"-SCALE ACCORDINGLY)

DATE: 01/25/2023
FILE:
DRAWN: HR
DESIGNED: AHTNA
CHECKED:

SUBMITTED: DATE:
SUBMITTAL APPROVED: DATE:

Ahtna

REVISIONS

ZONE	REV.	DESCRIPTION	BY	DATE	APP.

APPROVAL RECOMMENDED ____ DATE
APPROVED ____ DATE

CONTRACT NUMBER

AHTNA GLOBAL, LLC
FORT ORD, CA
EW-OU2-13-180
FIELD ELECTRICAL MAP

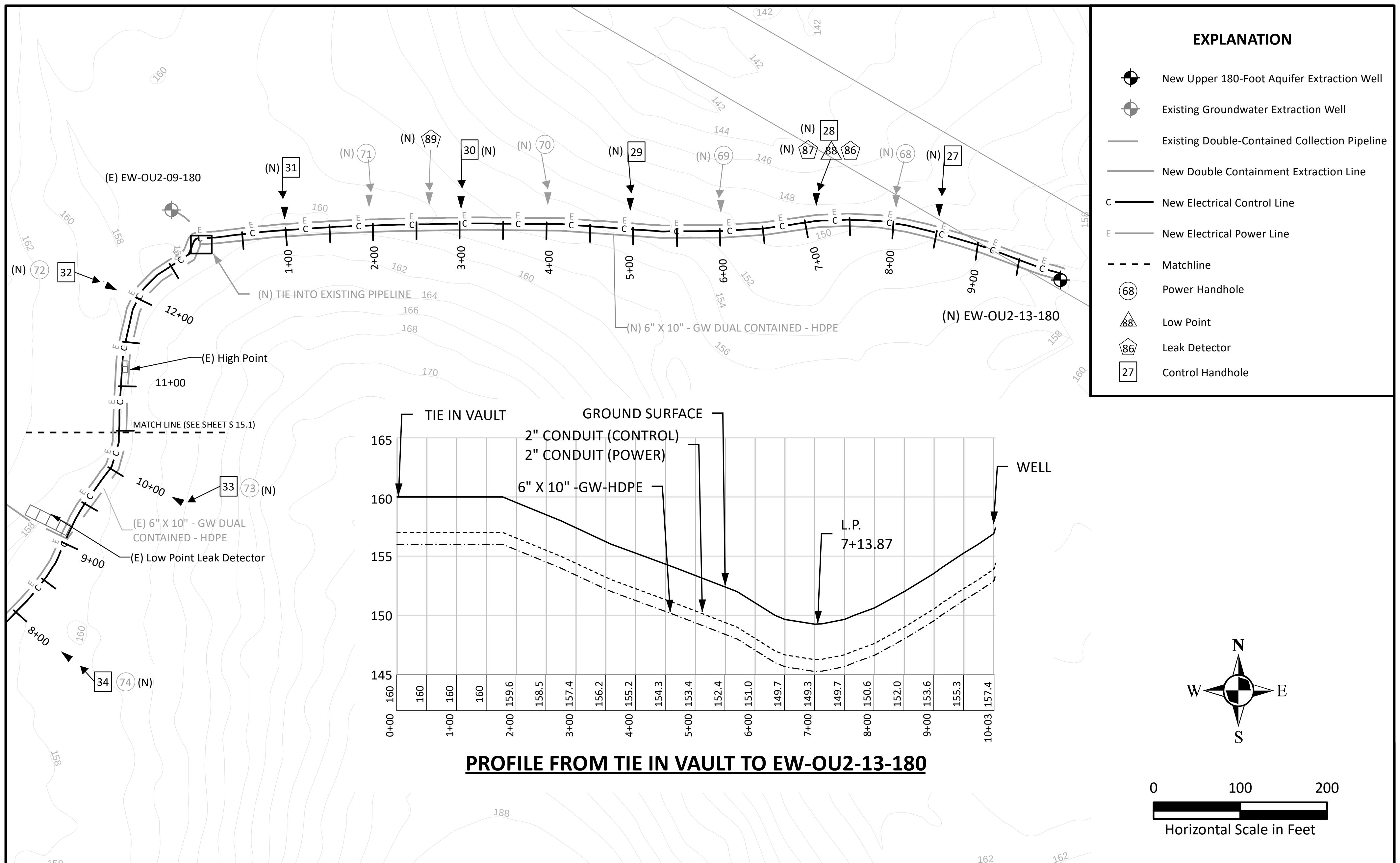
SCALE
NONE

DRAWING NUMBER
CU13.1

SHEET NUMBER
13 OF 13

UPPER 180-FOOT AQUIFER REMEDIAL DESIGN
ELECTRICAL DESIGN PLAN

FORMER FORT ORD, CALIFORNIA



INSTRUMENTATION DRAWING INDEX

FORT ORD, CA

SHEET NO.	DRAWING NO.	DRAWING TITLE
1	S1	COVER SHEET
2	S2	INSTRUMENTATION SYMBOLS AND ABBREVIATIONS
3	S3	ELEMENTARY DIAGRAM
4	S4	P&ID EW-OU2-08-180
5	S5	P&ID EW-OU2-09-180
6	S6	P&ID EW-OU2-13-180
7	S7	LADDER DIAGRAM DIGITAL
8	S8	LADDER DIAGRAM ANALOG
9	S9	ONE LINE
10	S10	INTERNAL PANEL LAYOUT
11	ELD01	FLOW TRANSMITTER LOOP DIAGRAM
12	ELD02	LEVEL TRANSMITTER LOOP DIAGRAM
13	ELD03	PRESSURE TRANSMITTER LOOP DIAGRAM
14	S14	CONDUIT NETWORK ROUTING
15	S15	CONDUIT EXTRACTION WELL ROUTING
16	S15.1	CONDUIT EXTRACTION WELL ROUTING
17	S16	COMMUNICATION HUB
18	S17	LEAK DETECTION DETAILS
19	S18	LEAK DETECTION SCHEMATIC

NOT FOR CONSTRUCTION

LINE IS 2 INCHES AT FULL SIZE (IF NOT 2"-SCALE ACCORDINGLY)

DATE:
FILE:
DRAWN:
DESIGNED:
CHECKED:

SUBMITTED: DATE:
SUBMITTAL APPROVED: DATE:

KORE systems Inc

REVISIONS

ZONE	REV.	DESCRIPTION	BY	DATE	APP.

APPROVAL RECOMMENDED DATE
APPROVED DATE
CONTRACT NUMBER

AHTNA GLOBAL, LLC
FORT ORD, CA
BUNKER HILL PLC
COVER SHEET

SCALE NONE
DRAWING NUMBER S1
SHEET NUMBER 1 OF 18

A B C D E F G H I J K L M N O

PUMP AND BLOWER SYMBOLS

- CENTRIFUGAL PUMP, INCLUDES MOTOR
- SUMP PUMP
- SUBMERSIBLE WELL PUMP
- BLOWER
- METERING PUMP
- WELL VAULT

VALVE SYMBOLS

- BALL VALVE
- BUTTERFLY VALVE, CLOSED
- BUTTERFLY VALVE, OPEN
- CHECK VALVE
- DIAPHRAGM VALVE
- GATE VALVE
- SAMPLE PORT (NORMALLY CLOSED)
- GLOBE VALVE
- AIR VENT/VACUUM VALVE
- THREE WAY VALVE

MISCELLANEOUS SYMBOLS

- PROPOSED EXTRACTION WELL
- EXISTING EXTRACTION WELL
- PROPOSED TRANSFORMER
- EXISTING TRANSFORMER
- TREATMENT PLANT
- PULL BOX
- EXTRACTION WELL CONCRETE PAD
- CONDUIT RUN UNDER PAVED AREA

LINE SYMBOLS

- PRIMARY PROCESS FLOW LINE
- UTILITY/SECONDARY PROCESS LINE
- SOFTWARE/COMMUNICATION LINK
- ELECTRIC SIGNAL OR POWER
- INSTRUMENT AIR SUPPLY LINE
- LIMIT LINE
- FENCE
- EXT — EXISTING EXTRACTION PIPELINE
- W — EXISTING WATER LINE
- E — EXISTING ELECTRICAL LINE

DETAIL/SECTION REFERENCE

FT
2020

- FIRST LETTER
  SUCCEEDING LETTER
- FIRST TWO NUMBERS: WELL NUMBER
  SECOND TWO NUMBERS: INSTRUMENT NUMBER

WELL NOMENCLATURE

EWC5
- WELL IDENTIFIER
- EXTRACTION WELL

ELECTRICAL SYMBOLS

- NORMALLY OPEN RELAY CONTACT
- NORMALLY CLOSED RELAY CONTACT
- GROUND
- CIRCUIT BREAKER
- PRESSURE SWITCH
- FLOAT SWITCH
- ON/OFF SWITCH
- FUSABLE PULLOUT
- NORMALLY OPEN MOMENTARY PUSH BUTTON
- NORMALLY CLOSED MOMENTARY PUSH BUTTON
- OL CONTACTOR
- TRANSFORMER
- THERMAL OVERLOAD DEVICE
- 3#10 THREE NUMBER 10 CONDUCTORS
- 5 MOTOR WITH 5 HP
- CR CURRENT SENSING RELAY
- EMP ELECTRONIC METERING AND PROTECTION PANEL
- OFF ON TWO POSITION CONTACT SWITCH

INPUT/OUTPUT SCHEMATIC LAYOUT

- FIELD INSTRUMENT
- 3 WAY SELECTOR SWITCH
- NORMALLY CLOSED CONTACT
- TERMINAL BLOCK
- FUSE
- FIELD WIRING
- PANEL/VAULT WIRING
- COIL
- PROGRAMMABLE SOLID STATE RELAY

PANEL LAYOUT (S10)

COMPONENT	DESCRIPTION
A	5 PORT MANAGED ETHERNET SWITCH
B	PHOENIX DIN BUSSMANN RAIL FUSED TERM BLOCK 110V
C	TRIPLE LEVEL SCREW TYPE TERMINAL BLOCKS
D	DIN RAIL FUSE TERMINAL BLOCKS
E	24 VDC POWER SUPPLY
F	SINGLE PORT 5-15 OUTLET
G	10A CIRCUIT BREAKER
H	15A CIRCUIT BREAKER
I	3 POLE DIN RAIL MOUNT SWITCH DISCONNECTOR
J	PLC
K	ANALOG INPUT EXPANSION CARD
L	ANALOG OUTPUT EXPANSION CARD
M	24 VDC ISOLATION RELAY
N	FUSED TERMINAL BLOCKS
O	15A CIRCUIT BREAKER
P	VFD
Q	POWER DISTRIBUTION BLOCK
R	480VAC -120VAC TRANSFORMER
S	LEVEL SWITCH

INSTRUMENT ABBREVIATIONS

Instrument Abbreviations

	Alarm L-low H-high	Controller	Control Valve	Detection Element	Glass Guage	Indicator	Integrator	Relay/ Compute	Safety Valve	Switch L-low H-high	Transmitter	Well or Probe	Interlock L-low H-high
Analysis	AAL AAH	AC	AV	AE		AI		AY		ASL ASH	AT	AW	
Flow	FAL FAH	FC	FV	FE	FG	FI	FO	FY		FSL FSH	FT		FAXL FAXH
Hand		HC	HV					HY					
Level	LAL LAH	LC	LV	LE	LG	LI		LY		LSL LSH	LT	LW	LAXL LAXH
Pressure or Vacuum	PAL PAH	PC	PV	PE		PI		PY		PSL PSH	PT		PAXL PAXH
Pressure Differential	PDAL PDAH	PDC	PDV	PDE		PDI		PDY	PSV	PDSL PDSH	PDT		
Speed or Frequency	SAL SAH	SC	SV	SE		SI	SO	SY		SSL SSH	ST		SAXL SAXH
Temperature	TAL TAH	TC	TV	TE		TI		TY	TSV	TSL TSH	TT	TW	TAXL TAXH
Vibration	VAL VAH			VE		VI		VY		VSL VSH	VT		VAXL VAXH
Position	ZAL ZAH	ZC		ZE		ZI		ZY		ZSL ZSH	ZT		
Electrical Current	ISL ISH			IE		II		IY		ISL ISH	IT		IAXL IAXH

INSTRUMENT INDENTIFIERS

Instrument Identification Letters

	FIRST LETTER		SUCCEEDING LETTERS		
	Measured or Initiating Variable	Modifier	Readout or Passive Function	Output Function	Modifier
A	ANALYSIS		ALARM		
B	BURNER FLAME	BY PASS	USER'S CHOICE	USER'S CHOICE	USER'S CHOICE
C	CONDUCTIVITY (ELECTRICAL) OR USER'S CHOICE			CONTROL	
D	DENSITY (MASS) OR SPECIFIC GRAVITY OR USER'S CHOICE	DIFFERENTIAL			
E	VOLTAGE		PRIMARY ELEMENT		
F	FLOW RATE	RATIO (FRACTION)			
G	GAGING (DIMENSIONAL)		GLASS		
H	HAND (MANUALLY INITITATED)				HIGH
I	CURRENT (ELECTRICAL)		INDICATE		
J	POWER	SCAN			
K	TIME OR TIME SCHEDULE			CONTROL STATION	
L	LEVEL		LIGHT (PILOT)		LOW
M	MOISTURE OR HUMIDITY OR USER'S CHOICE				MIDDLE OR INTERMEDIATE
N	USER'S CHOICE		USER'S CHOICE	USER'S CHOICE	USER'S CHOICE
O	USER'S CHOICE		OFFICE (RESTRICTION)		
P	PRESSURE OR VACUUM		POINT (TEST CONNECTION)		
Q	QUANTITY OR EVENT	INTEGRATE OR TOTALIZE			
R	RUN OR RADIOACTIVITY	RATIO	RECORD OR PRINT		
S	SPEED OR FREQUENCY	SAFETY		SWITCH	
T	TEMPERATURE			TRANSMITTER	
U	MULTIVARIABLE		MALFUNCTION	MALFUNCTION	MALFUNCTION
V	VISCOSITY OR VIBRATION			LVE, DAMPER, OR LOUVER	
W	WEIGHT OR FORCE		WELL		
X	LOGIC / INTERLOCK		UNCLASSIFIED	LOGIC / INTERLOCK	UNCLASSIFIED OR RECEIVER
Y	USER'S CHOICE, EVENTS			RELAY OR COMPUTE	
Z	POSITION			DRIVER, ACTUATOR, UNCLASSIFIED CONTROL ELEMENT	

NOT FOR CONSTRUCTION

LINE IS 2 INCHES AT FULL SIZE
(IF NOT 2"-SCALE ACCORDINGLY)

DATE: 01/25/2023
FILE:
DRAWN: HR
DESIGNED: HR
CHECKED: HR

SUBMITTED: ________ DATE: ________
SUBMITTAL APPROVED: ________ DATE: ________

KORE systems Inc

REVISIONS					
ZONE	REV.	DESCRIPTION	BY	DATE	APP.

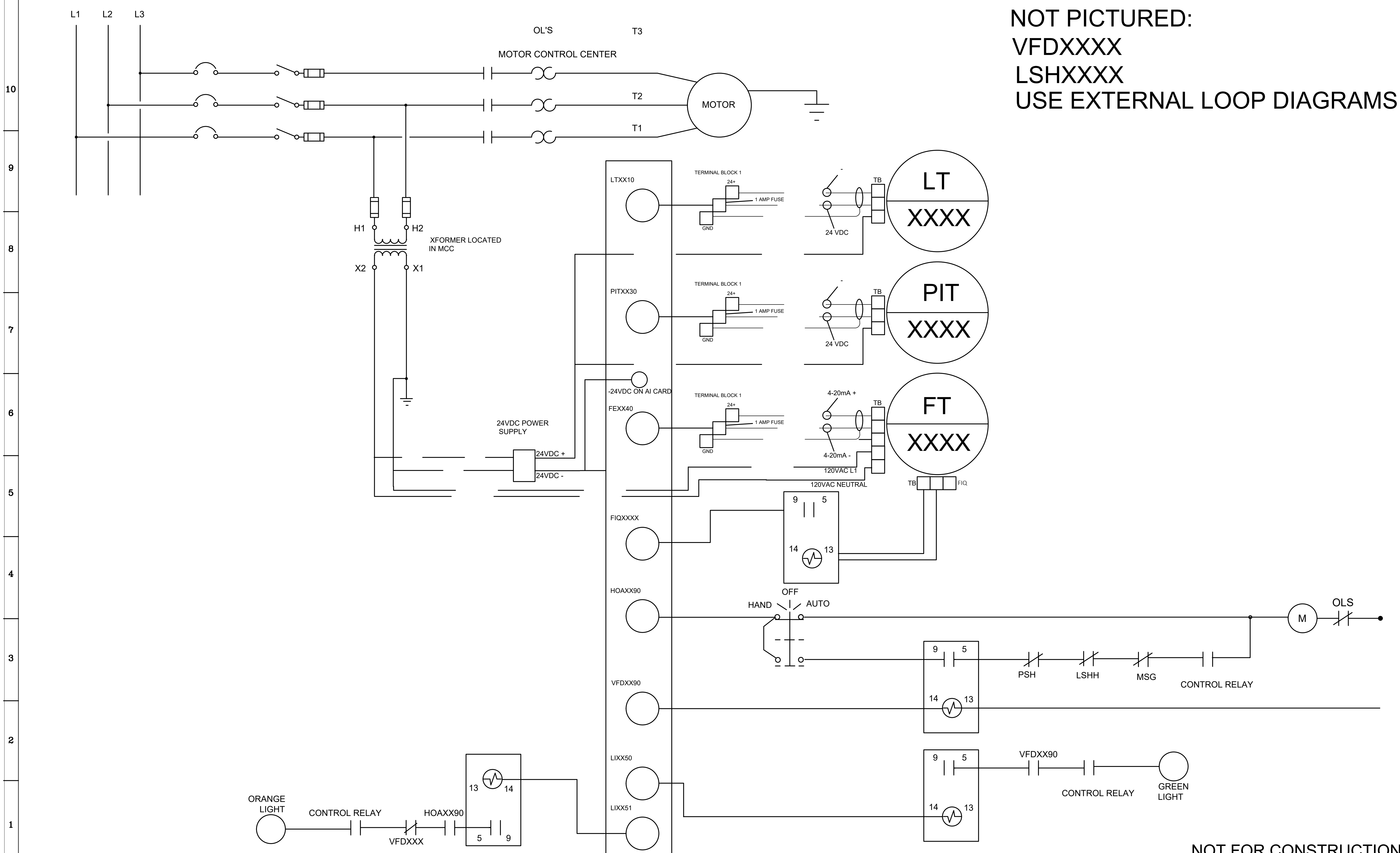
APPROVAL RECOMMENDED ________ DATE
APPROVED ________ DATE

CONTRACT NUMBER

AHTNA GLOBAL, LLC
FORT ORD
BUNKER HILL PLC
INSTRUMENTATION SYMBOLS & ABBREVIATION

SCALE NONE
DRAWING NUMBER S2
SHEET NUMBER 2 OF 18

NOT PICTURED:
VFDXXXX
LSHXXXX
USE EXTERNAL LOOP DIAGRAMS



NOT FOR CONSTRUCTION

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CHECKED:

SUBMITTED: DATE:
SUBMITTAL APPROVED: DATE:

Ahtna Global, LLC

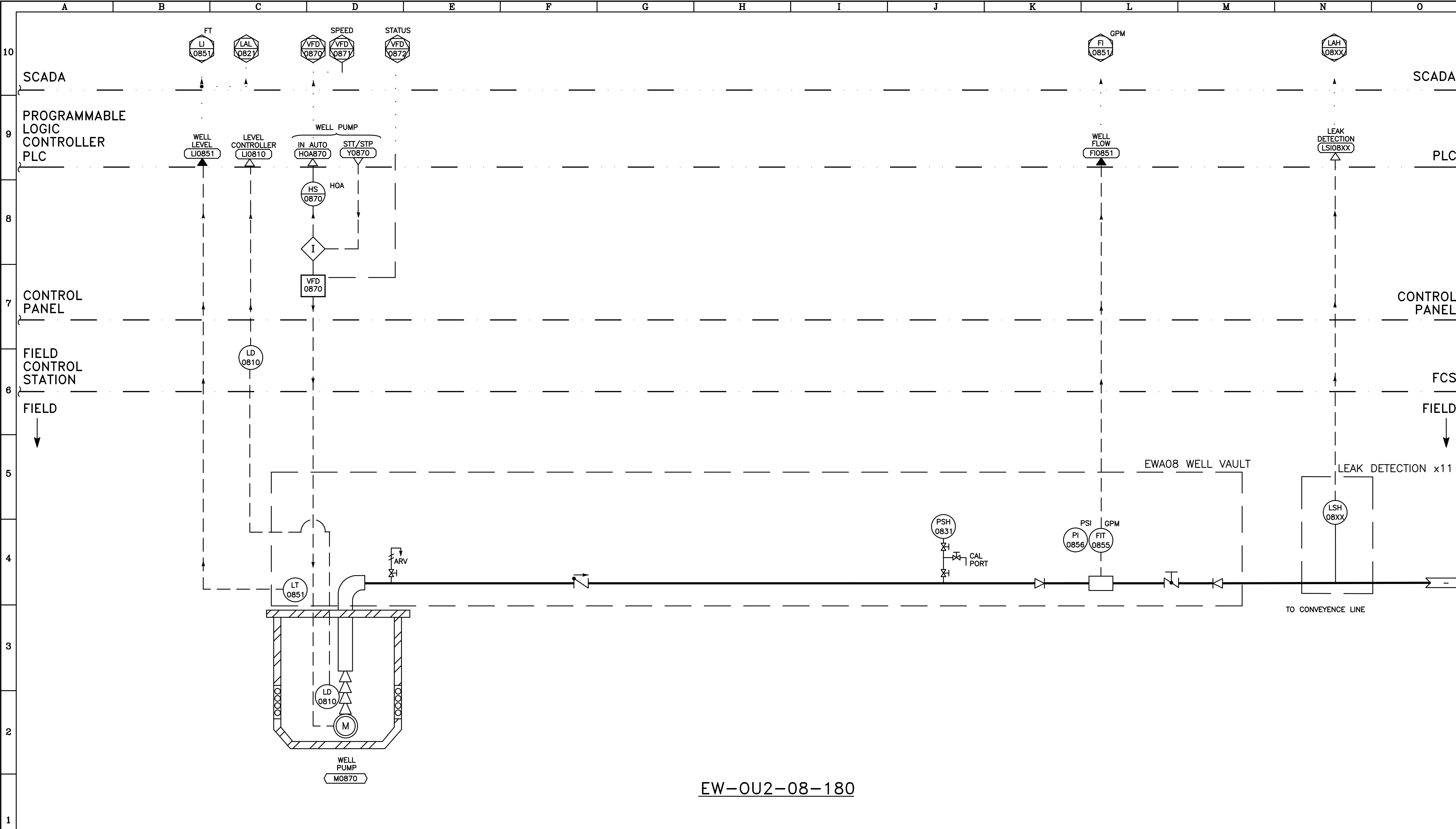
REVISIONS

ZONE	REV.	DESCRIPTION	BY	DATE	APP.

APPROVAL RECOMMENDED DATE
APPROVED DATE
CONTRACT NUMBER

AHTNA GLOBAL, LLC
FORT ORD, CA
BUNKER HILL PLC
ELEMENTARY DIAGRAM

SCALE
NOT TO SCALE
DRAWING NUMBER
S3
SHEET NUMBER
3 OF 18



NOT FOR CONSTRUCTION

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DATE: 01/19/2023
FILE:
DRAWN: FV
DESIGNED:
CHECKED:

SUBMITTED: DATE:
SUBMITTAL APPROVED: DATE:

REVISIONS

ZONE	REV.	DESCRIPTION	BY	DATE	APP.
	1				
	2				
	2				

APPROVAL RECOMMENDED DATE

APPROVED CONTROL SYSTEMS ENGINEER DATE

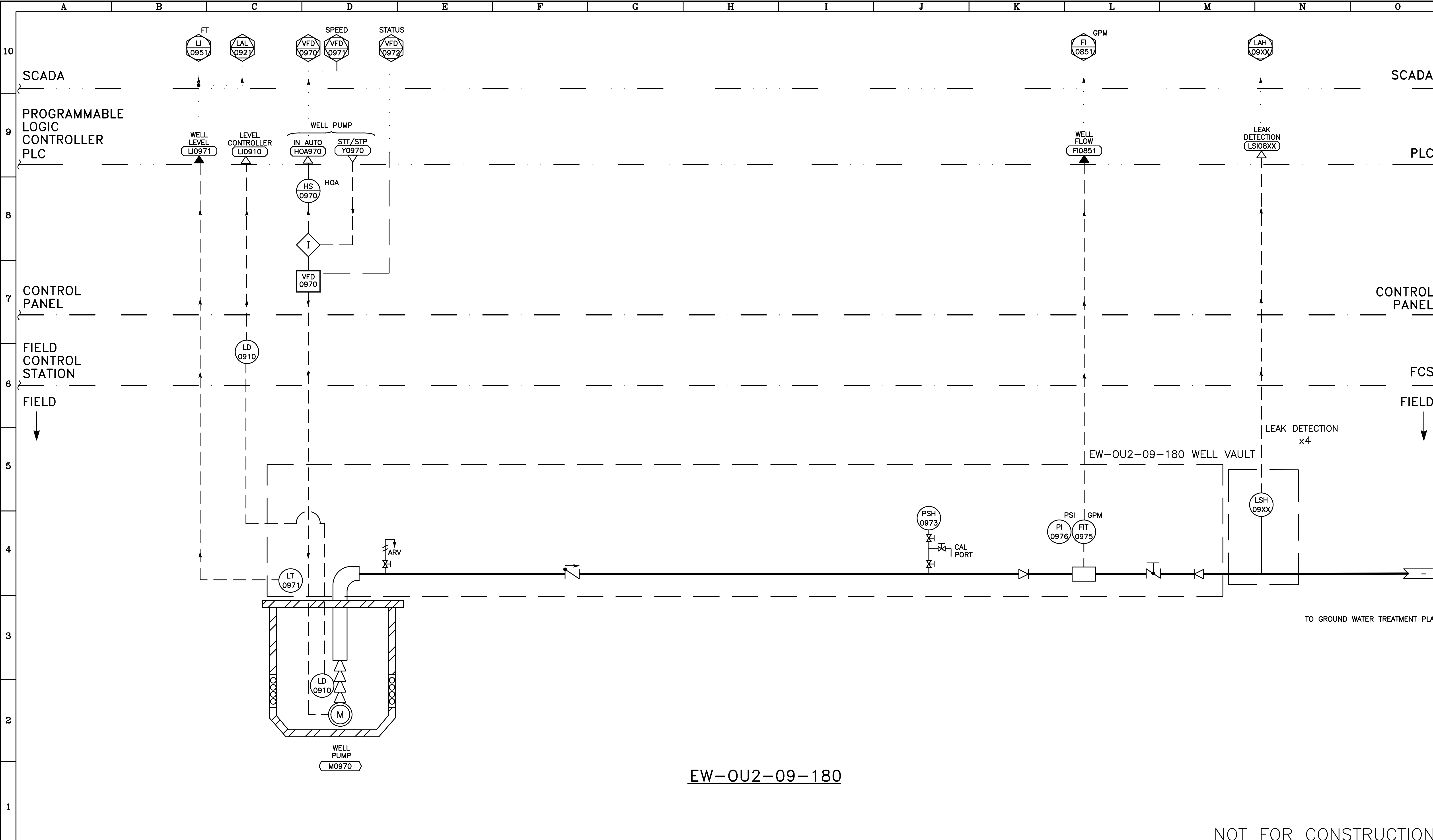
CONTRACT NUMBER

AHTNA GLOBAL, LLC
FORT ORD, CA
EW-OU2-08-180
P&ID DRAWING

SCALE NONE

DRAWING NUMBER S4

SHEET NUMBER 4 OF 18



LINE IS 2 INCHES AT FULL SIZE (IF NOT 2"-SCALE ACCORDINGLY)	DATE: 01/19/2023 FILE: DRAWN: FV DESIGNED: CHECKED:
SUBMITTED:	DATE:
SUBMITTAL APPROVED:	DATE:

KORE systems Inc

REVISIONS

ZONE	REV.	DESCRIPTION	BY	DATE	APP.
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	2				

APPROVAL RECOMMENDED ________ DATE

APPROVED ________ CONTROL SYSTEMS ENGINEER DATE

CONTRACT NUMBER

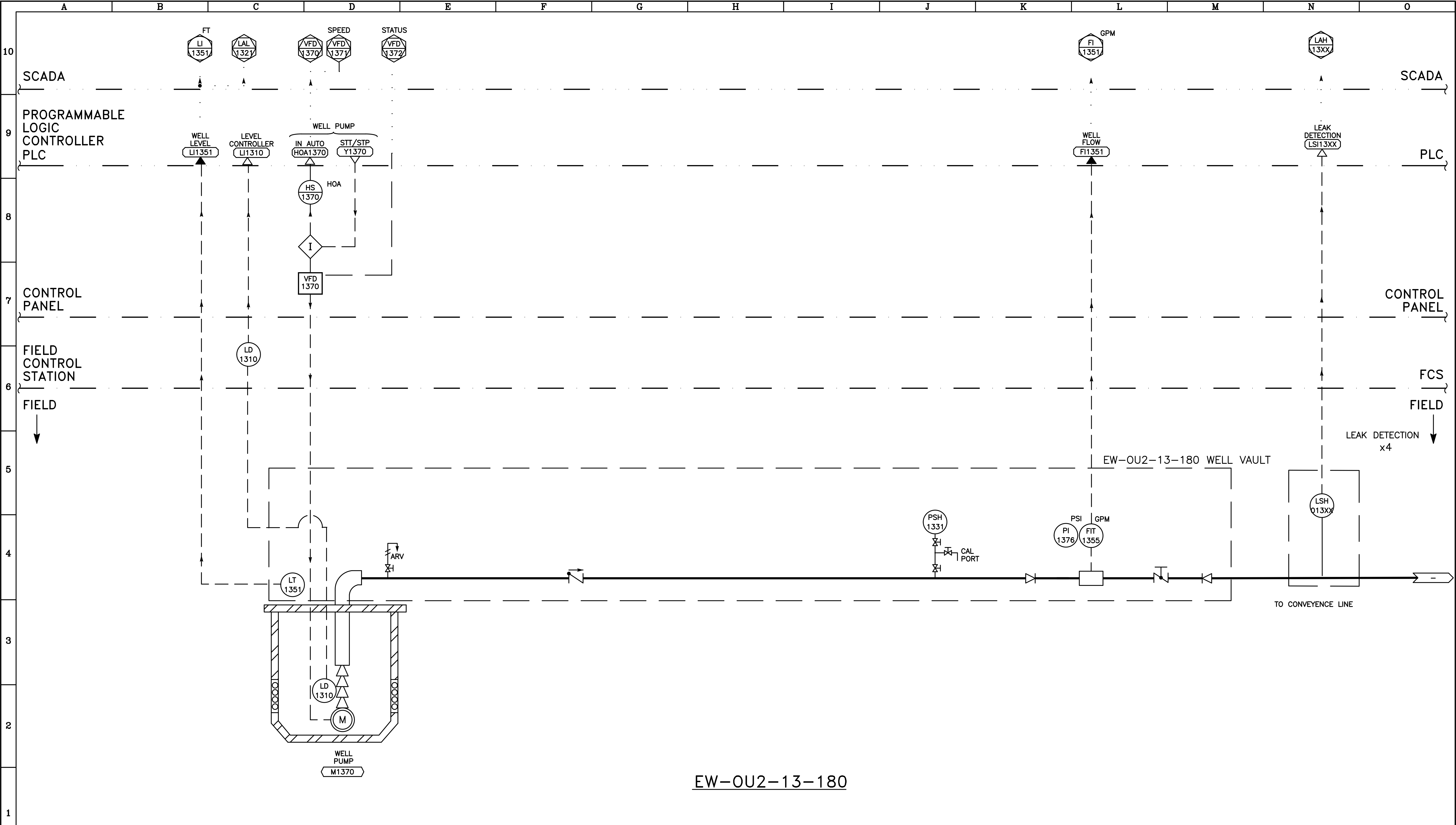
AHTNA GLOBAL, LLC
FORT ORD, CA

EW-OU2-09-180
P&ID DRAWING

SCALE NONE

DRAWING NUMBER S5

SHEET NUMBER 5 OF 18



NOT FOR CONSTRUCTION

LINE IS 2 INCHES AT FULL SIZE (IF NOT 2"-SCALE ACCORDINGLY)

DATE: 01/19/2023
FILE:
DRAWN: FV
DESIGNED:
CHECKED:

SUBMITTED: DATE:
SUBMITTAL APPROVED: DATE:

KORE systems inc

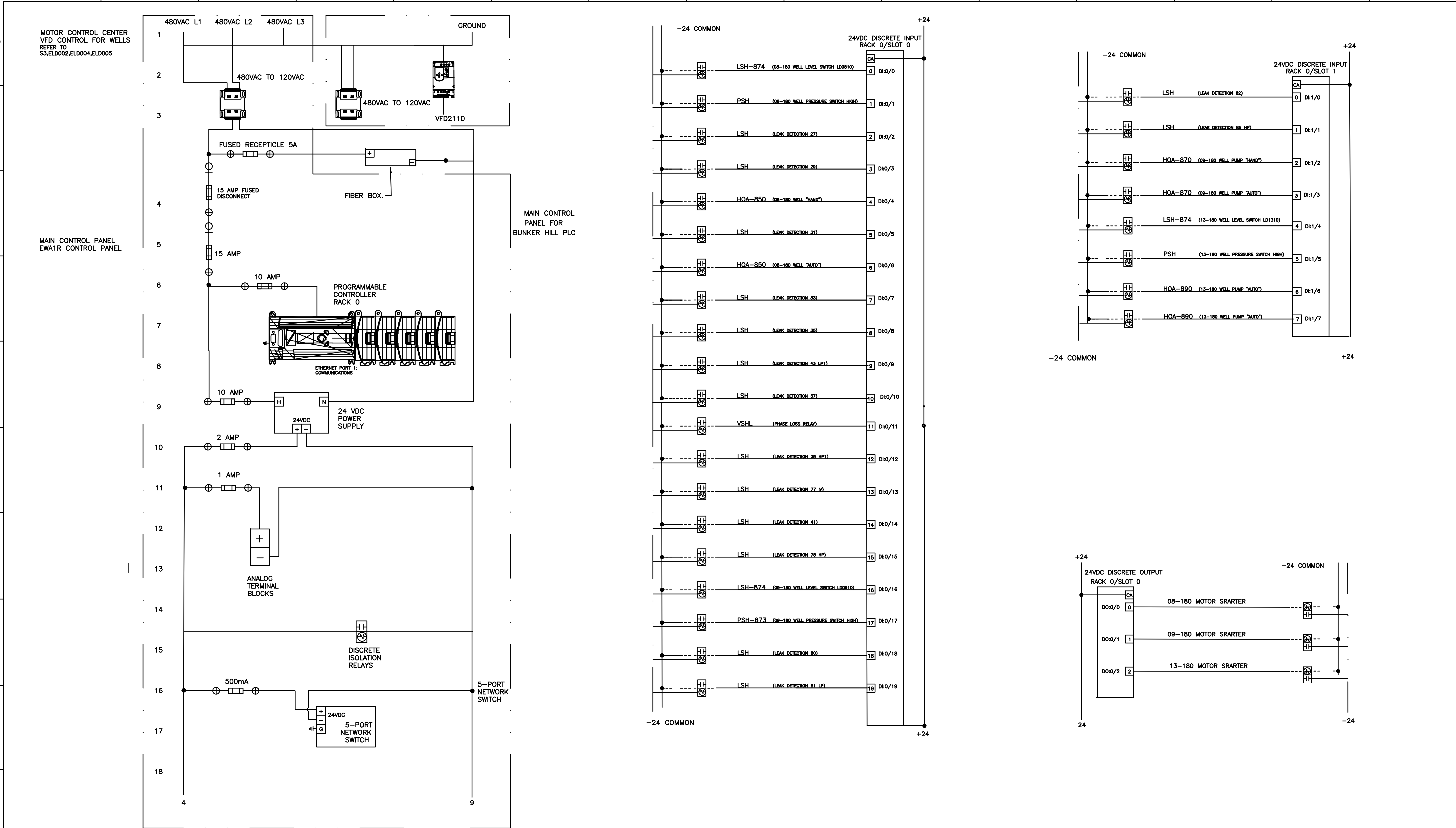
REVISIONS

ZONE	REV.	DESCRIPTION	BY	DATE	APP.
	1				
	2				
	2				

APPROVAL RECOMMENDED DATE
APPROVED CONTROL SYSTEMS ENGINEER DATE
CONTRACT NUMBER

AHTNA GLOBAL, LLC
FORT ORD, CA
EW-OU2-13-180
P&ID DRAWING

SCALE NONE
DRAWING NUMBER S6
SHEET NUMBER 6 OF 18



NOT FOR CONSTRUCTION

LINE IS 2 INCHES AT FULL SIZE (IF NOT 2"-SCALE ACCORDINGLY)

DATE: 01/24/2023
FILE:
DRAWN: FV
DESIGNED:
CHECKED:

SUBMITTED: ________ DATE: ________
SUBMITTAL APPROVED: ________ DATE: ________

KORE systems Inc

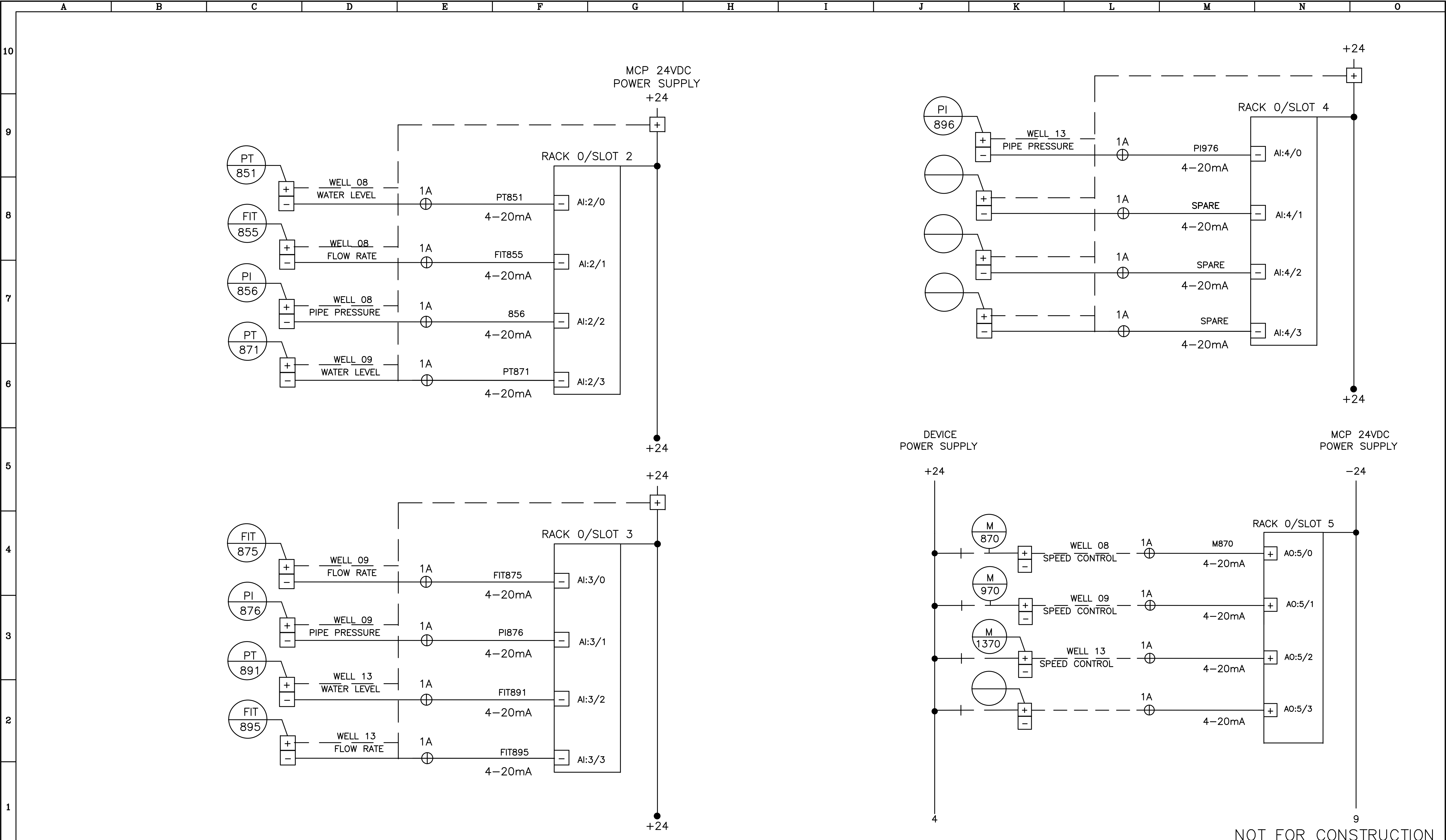
REVISIONS					
ZONE	REV.	DESCRIPTION	BY	DATE	APP.

APPROVAL RECOMMENDED ________ DATE
APPROVED ________ DATE
CONTROL SYSTEMS ENGINEER
CONTRACT NUMBER

AHTNA GLOBAL, LLC
FORT ORD, CA

BUNKER HILL PLC
IO SCHEMATIC

SCALE NONE
DRAWING NUMBER S7
SHEET NUMBER 7 OF 18



NOT FOR CONSTRUCTION

LINE IS 2 INCHES AT FULL SIZE (IF NOT 2"–SCALE ACCORDINGLY)

DATE: 01/25/2023
FILE:
DRAWN: HR
DESIGNED:
CHECKED:

SUBMITTED: DATE:
SUBMITTAL APPROVED: DATE:

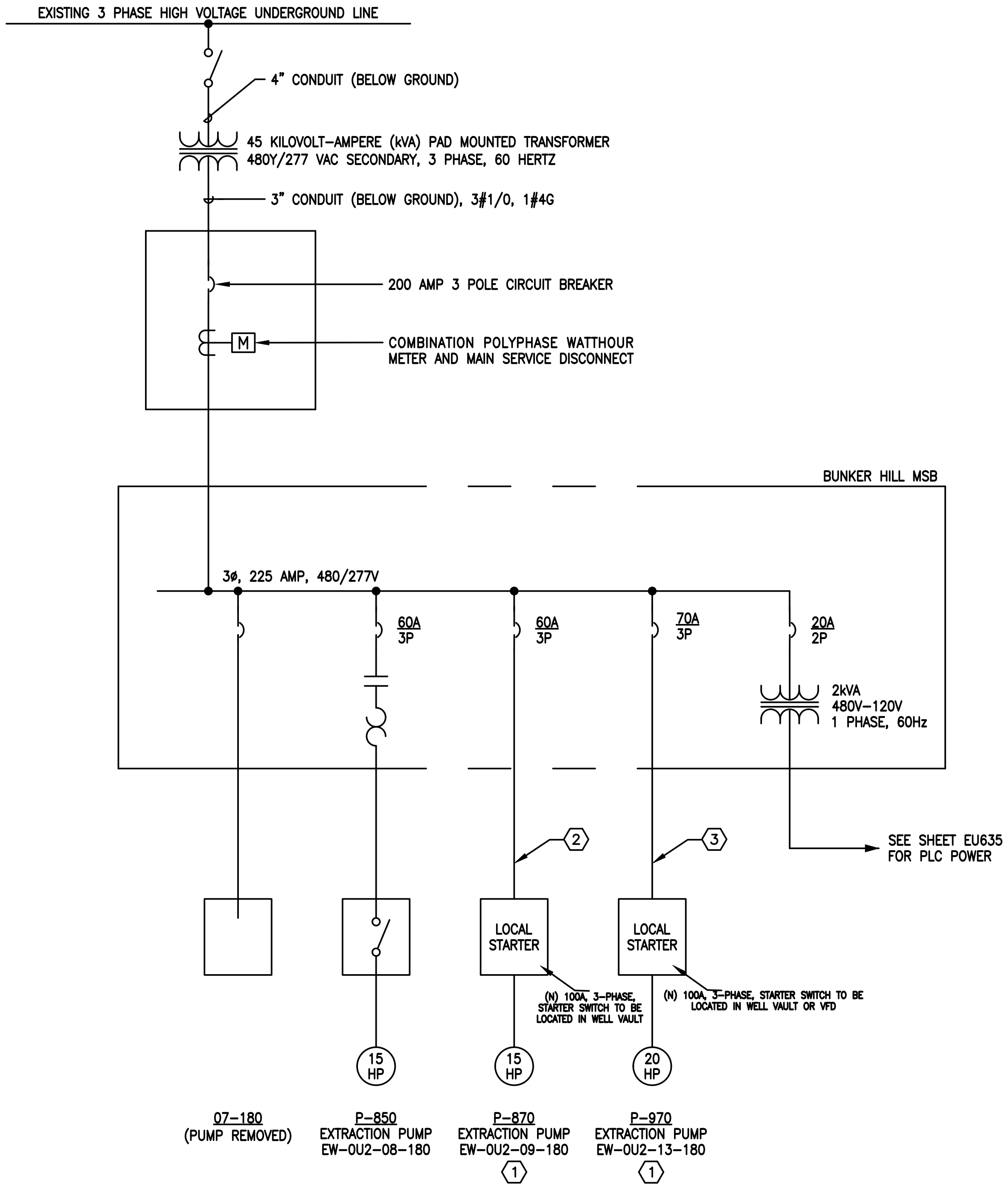
KORE systems Inc

REVISIONS					
ZONE	REV.	DESCRIPTION	BY	DATE	APP.
	1				
	2				
	2				

APPROVAL RECOMMENDED ____ DATE
APPROVED ____ CONTROL SYSTEMS ENGINEER DATE
CONTRACT NUMBER

AHTNA GLOBAL, LLC
FORT ORD, CA
BUNKER HILL PLC
IO SCHEMATIC

SCALE NONE
DRAWING NUMBER S8
SHEET NUMBER 8 OF 18



PLC PANEL LOAD CALCULATOR	LOAD (VA)			
	Aø	Bø	Cø	TOTAL
PLC XFRM (2k XFRM)	1000	1000		60002
EW-OU2-08-180 (15hp motor)	5800	5800	5800	
EW-OU2-09-180 (15hp motor)	5800	5800	5800	
EW-OU2-13-180 (20hp motor)	7734	7734	7734	
Phase Total (VA)	20334	20334	19334	
Phase Balance (%)	33.9%	33.9%	32.2%	
TOTALS	LOAD (VA)	LOAD (A)	LOAD (W)	
Total Demand	60002	72.3	51002	
Total Demand + Spare	75003	90.32	63753	

ASSUMPTIONS

1. THE 2KVA TRANSFORMER USES 2 WIRES OF THE 3-PHASE POWER.
2. NO EXTRA DEVICES/COMPONENTS ARE ATTACHED TO THIS POWER SOURCE.
3. SPARE LOADS INCLUDE EXTRA 25% CAPACITY.
4. POWER FACTOR = 0.85
5. ADDITIONAL 20 HP MOTOR HAS THE SAME POWER EFFICIENCY AS PREVIOUS 15 HP MOTORS.

KEYED NOTES

1 EXTRACTION PUMP SHALL BE FITTED WITH A TEMPERATURE SENSOR, RUN SENSOR WIRES FROM LOCAL STARTER BOX TO VAULT LOW-VOLTAGE CONTROL ENCLOSURE AND WIRE TO MOTOR PROTECTION UNIT THAT IS ALSO INSTALLED IN ENCLOSURE, REFER TO PUMP MANUFACTURER INSTALLATION INSTRUCTIONS.

2 (N) CONDUCTORS IN (E) CONDUIT, VERIFY EXTRACTION PUMP HP & WIRING PRIOR TO INSTALLING (N) CONDUCTORS.

3 (N) CONDUCTORS IN (E) CONDUIT, VERIFY EXTRACTION PUMP HP & WIRING PRIOR TO INSTALLING (N) CONDUCTORS.

LINE IS 2 INCHES AT FULL SIZE (IF NOT 2"-SCALE ACCORDINGLY)

DATE:
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DESIGNED:
CHECKED:

SUBMITTED: DATE:
SUBMITTAL APPROVED: DATE:

KORE systems Inc

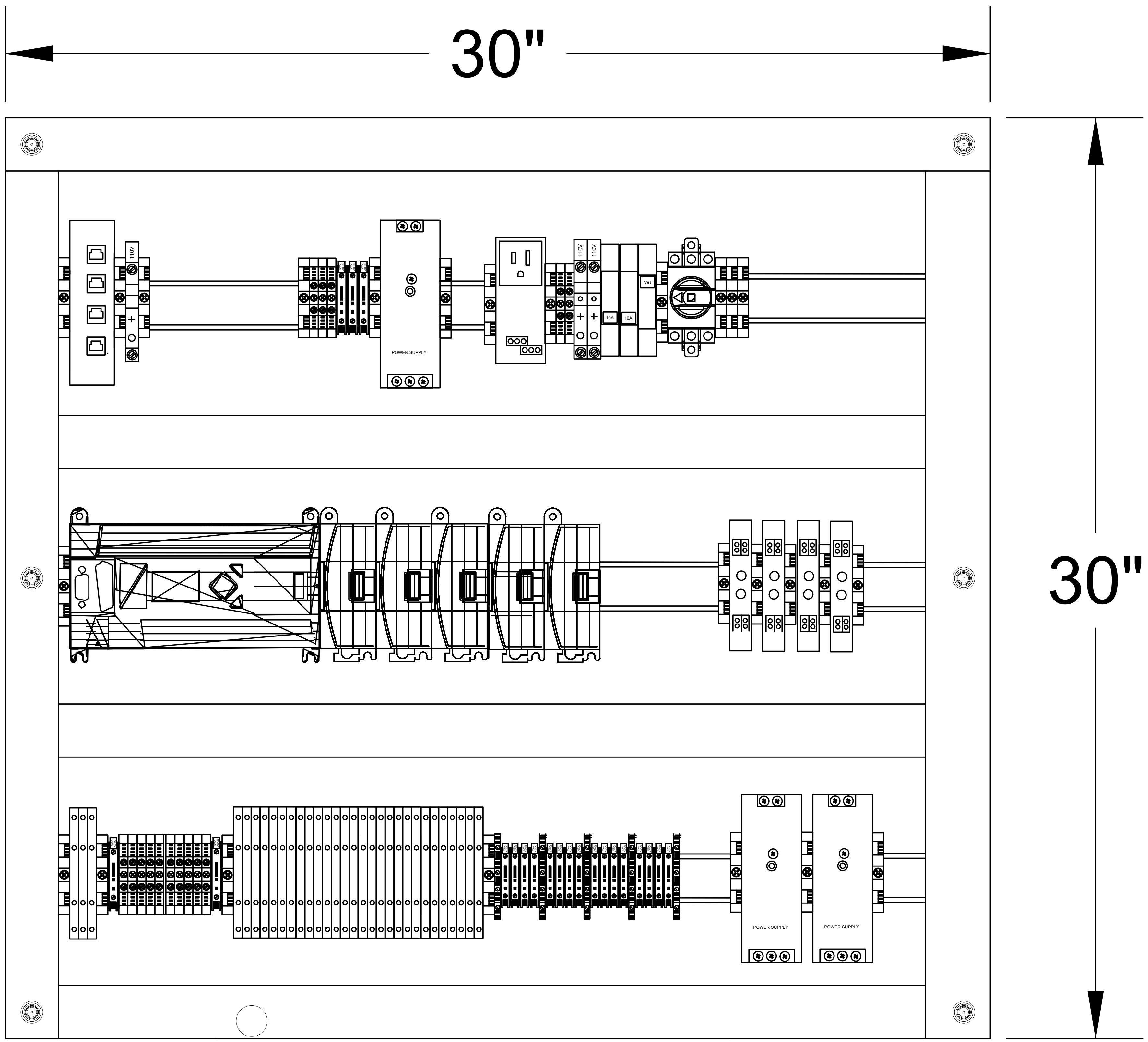
REVISIONS

ZONE	REV.	DESCRIPTION	BY	DATE	APP.

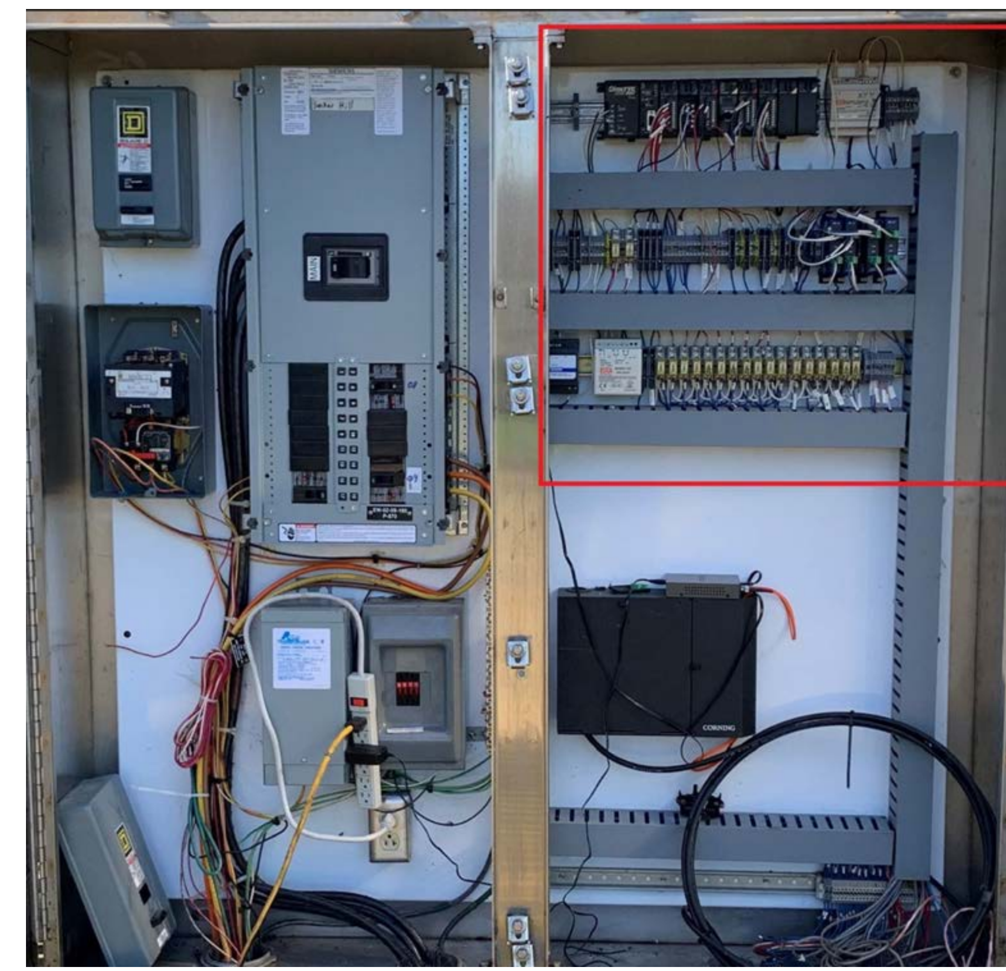
APPROVAL RECOMMENDED DATE
APPROVED DATE
CONTRACT NUMBER

AHTNA GLOBAL, LLC
FORT ORD, CA
BUNKER HILL PLC
ONE LINE DRAWING

SCALE NONE
DRAWING NUMBER S9
SHEET NUMBER 9 OF 18



NOTE: PANEL DRAWING IS FOR BACK PANEL REPLACEMENT OF THE SECTION REDLINED BELOW



LINE IS 2 INCHES AT FULL SIZE (IF NOT 2"-SCALE ACCORDINGLY)

DATE: 01/24/2023
FILE:
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SUBMITTED: DATE:
SUBMITTAL APPROVED: DATE:

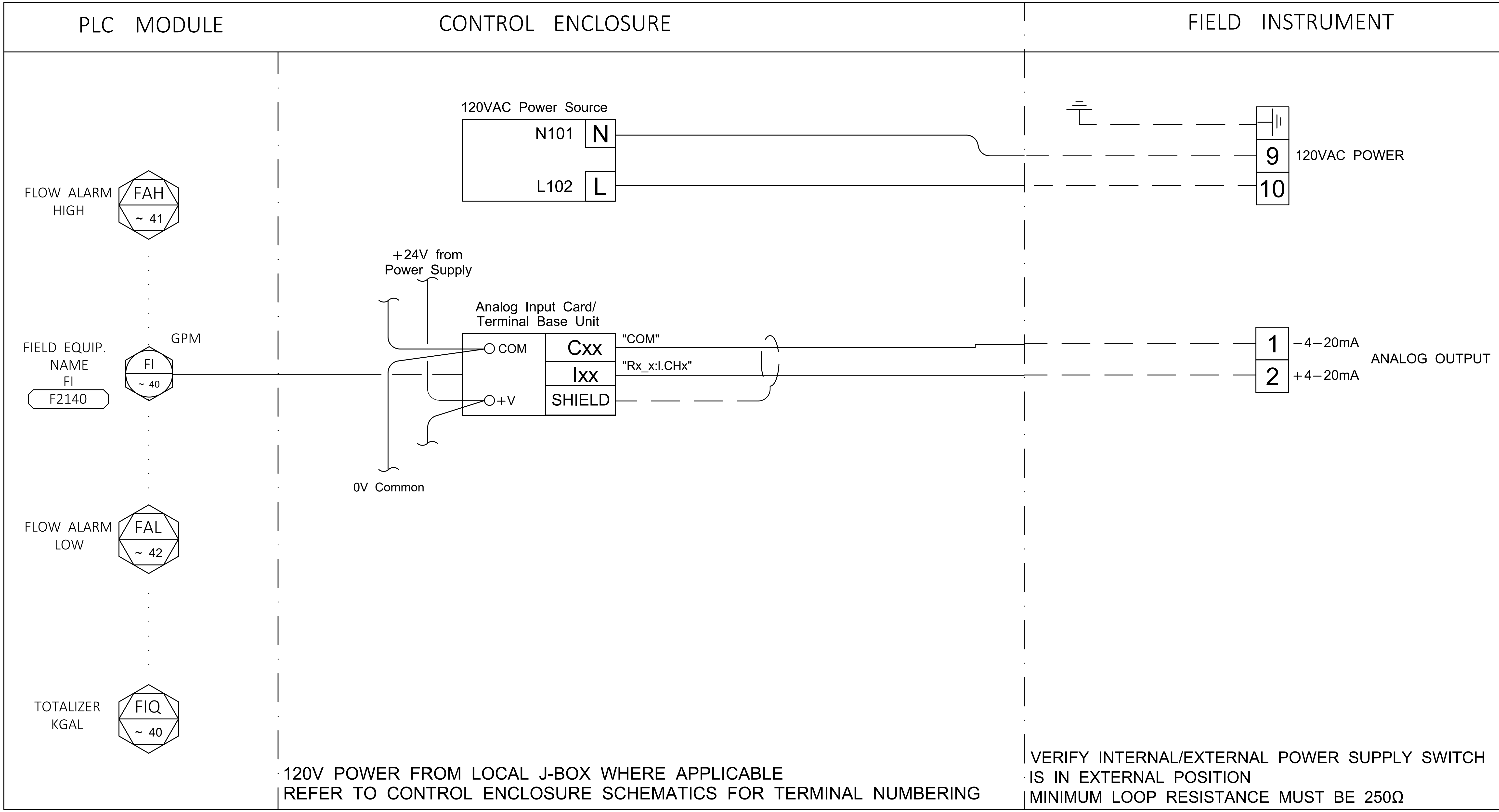
KORE systems Inc

REVISIONS					
ZONE	REV.	DESCRIPTION	BY	DATE	APP.

APPROVAL RECOMMENDED ____ DATE
APPROVED ____ DATE
CONTRACT NUMBER

AHTNA GLOBAL, LLC
FORT ORD, CA
BUNKER HILL PLC
INTERNAL PANEL LAYOUT

SCALE NONE
DRAWING NUMBER S10
SHEET NUMBER 10 OF 18



NOT FOR CONSTRUCTION

LINE IS 2 INCHES AT FULL SIZE (IF NOT 2"-SCALE ACCORDINGLY)

DATE:
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SUBMITTED: DATE:
SUBMITTAL APPROVED: DATE:

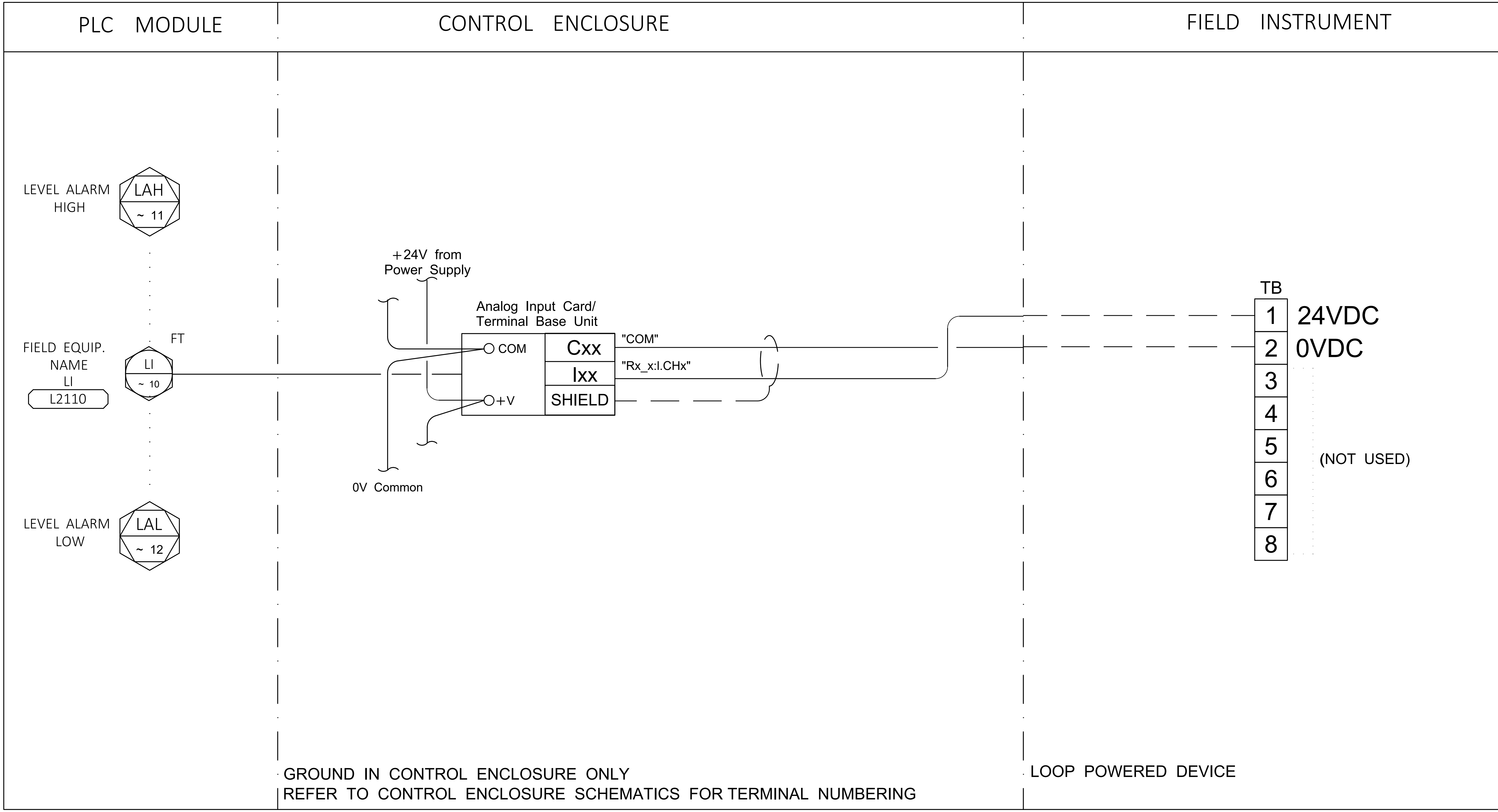
KORE systems Inc

REVISIONS					
ZONE	REV.	DESCRIPTION	BY	DATE	APP.

APPROVAL RECOMMENDED DATE
APPROVED DATE
CONTRACT NUMBER

AHTNA GLOBAL, LLC
FORT ORD, CA
BUNKER HILL PLC
FLOW INSTRUMENT DIAGRAM

SCALE NONE
DRAWING NUMBER ELD01
SHEET NUMBER 11 OF 18



LINE IS 2 INCHES AT FULL SIZE (IF NOT 2"-SCALE ACCORDINGLY)

DATE:
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CHECKED:

SUBMITTED: DATE:
SUBMITTAL APPROVED: DATE:

KORE systems Inc

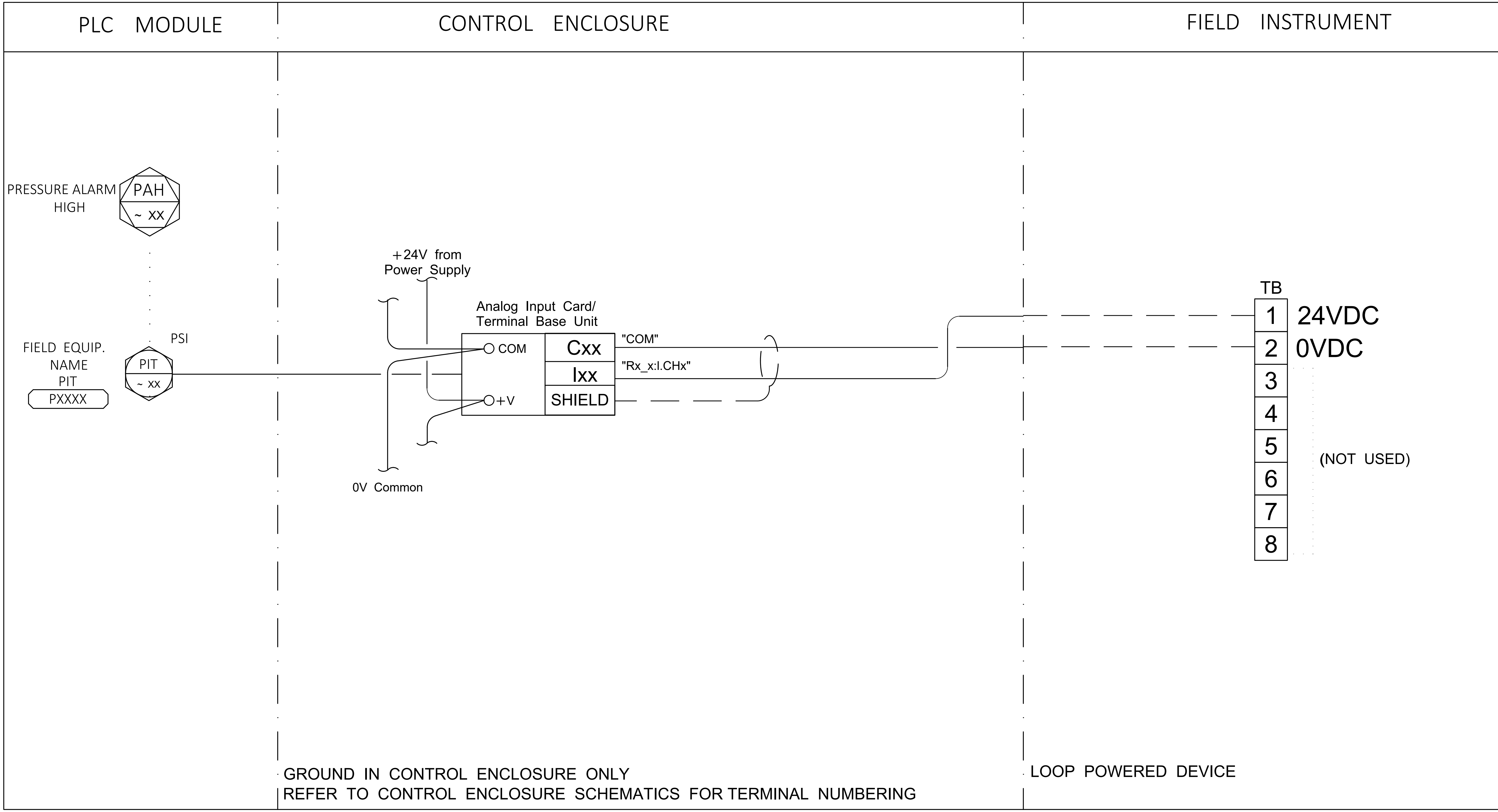
REVISIONS

ZONE	REV.	DESCRIPTION	BY	DATE	APP.

APPROVAL RECOMMENDED DATE
APPROVED DATE
CONTRACT NUMBER

AHTNA GLOBAL, LLC
FORT ORD, CA
BUNKER HILL PLC
LEVEL INSTRUMENT DIAGRAM

SCALE NONE
DRAWING NUMBER ELD02
SHEET NUMBER 12 OF 18



LINE IS 2 INCHES AT FULL SIZE (IF NOT 2"-SCALE ACCORDINGLY)

DATE:
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DESIGNED:
CHECKED:

SUBMITTED: DATE:
SUBMITTAL APPROVED: DATE:

KORE systems Inc

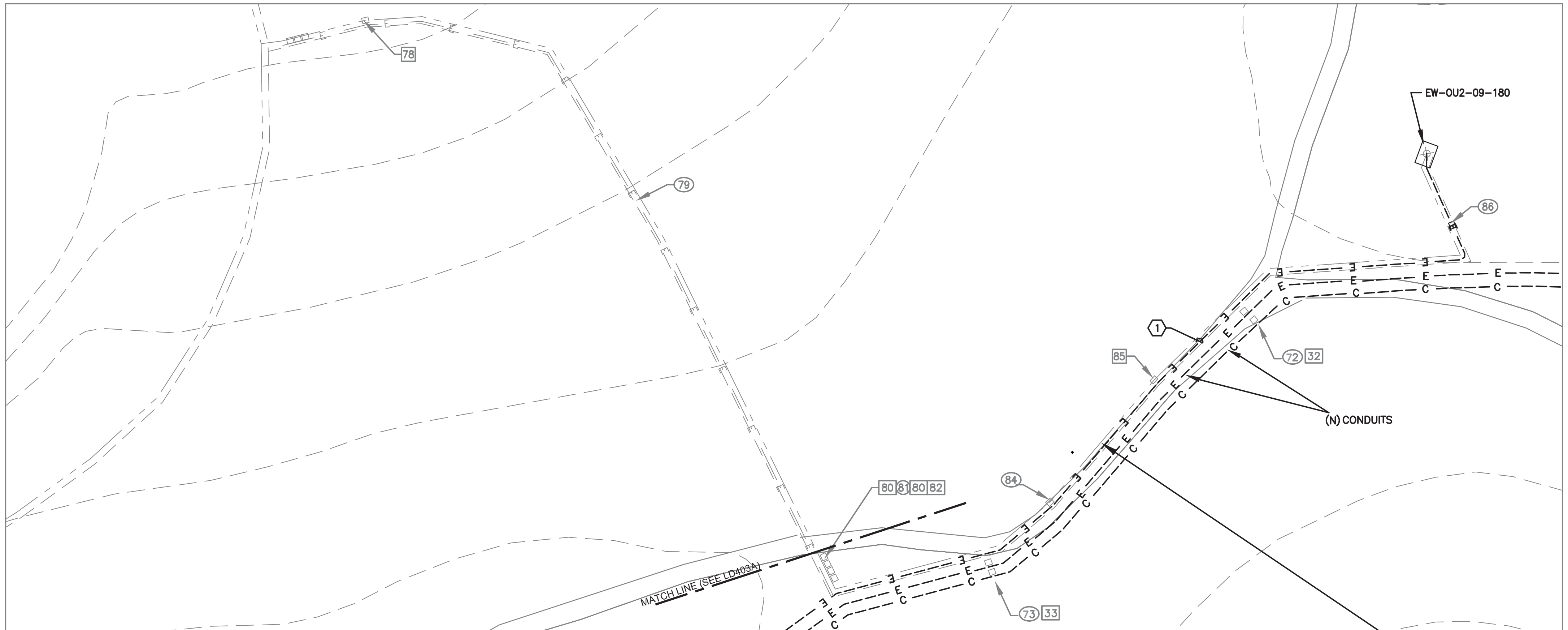
REVISIONS

ZONE	REV.	DESCRIPTION	BY	DATE	APP.

APPROVAL RECOMMENDED DATE
APPROVED DATE
CONTRACT NUMBER

AHTNA GLOBAL, LLC
FORT ORD, CA
BUNKER HILL PLC
PRESSURE INSTRUMENT DIAGRAM

SCALE NONE
DRAWING NUMBER ELD03
SHEET NUMBER 13 OF 18



(E) NO CONTROL CONDUCTORS

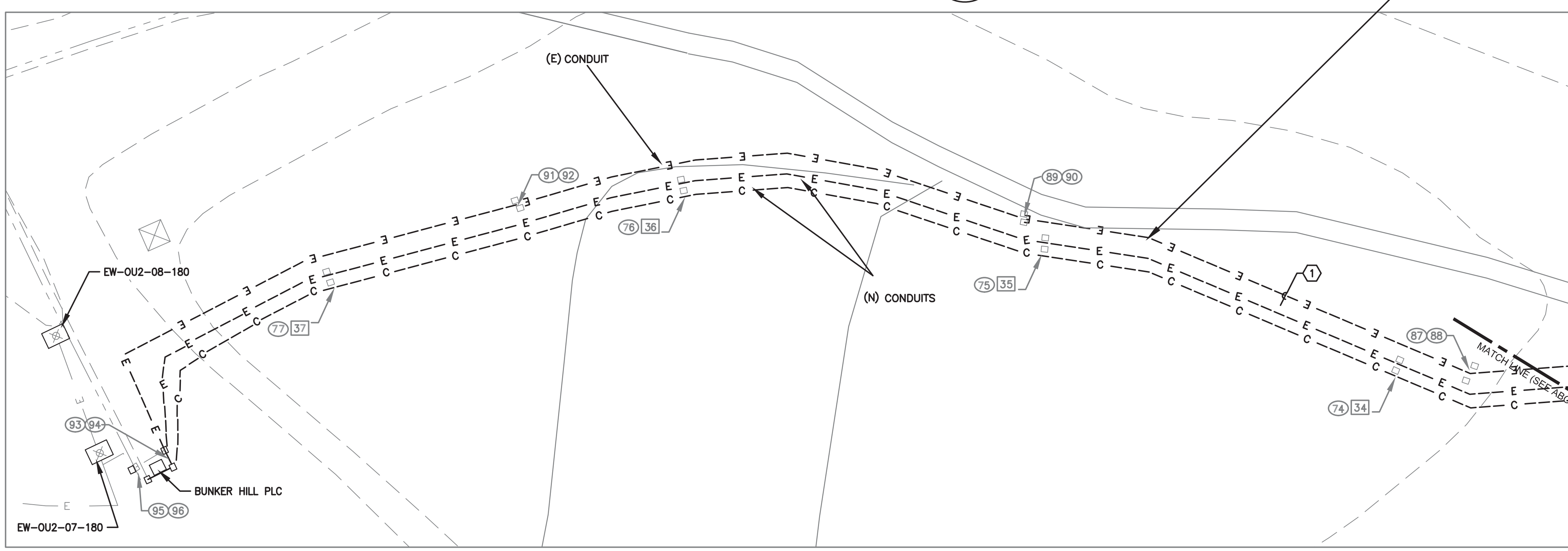
1 BUNKER HILL NETWORK
SCALE 1 : 30

GENERAL NOTES

1. FOR ALL (N) UNDERGROUND METALLIC STRUCTURES PROVIDE CORROSION PROTECTION. THE CONTRACTOR MAY MODIFY THE CATHODIC PROTECTION SYSTEM AS SHOWN IN DETAILS ON E-504 AFTER SITE VERIFICATION AND ANALYSIS.
2. FOR TRAFFIC AND NON-TRAFFIC HANDHOLES SEE DETAIL 1 ON IU501 AND DETAIL 13 ON E-502.
3. SEE CU SHEETS FOR ADDITIONAL TRENCH PROFILES AND DETAILS.

KEYED NOTES

1 ~~(N) CONDUCTORS IN (E) CONDUITS.~~



2 BUNKER HILL NETWORK
SCALE 1 : 30

30 0 30 60
GRAPHIC SCALE IN FEET


KEY PLAN

NOT FOR CONSTRUCTION — PENDING FIELD REVIEW — ALL LENGTHS APPROXIMATE

LINE IS 2 INCHES AT FULL SIZE (IF NOT 2"-SCALE ACCORDINGLY)

DATE: 01/25/2023
FILE:
DRAWN: HR
DESIGNED:
CHECKED:

SUBMITTED: DATE:
SUBMITTAL APPROVED: DATE:

KORE systems Inc

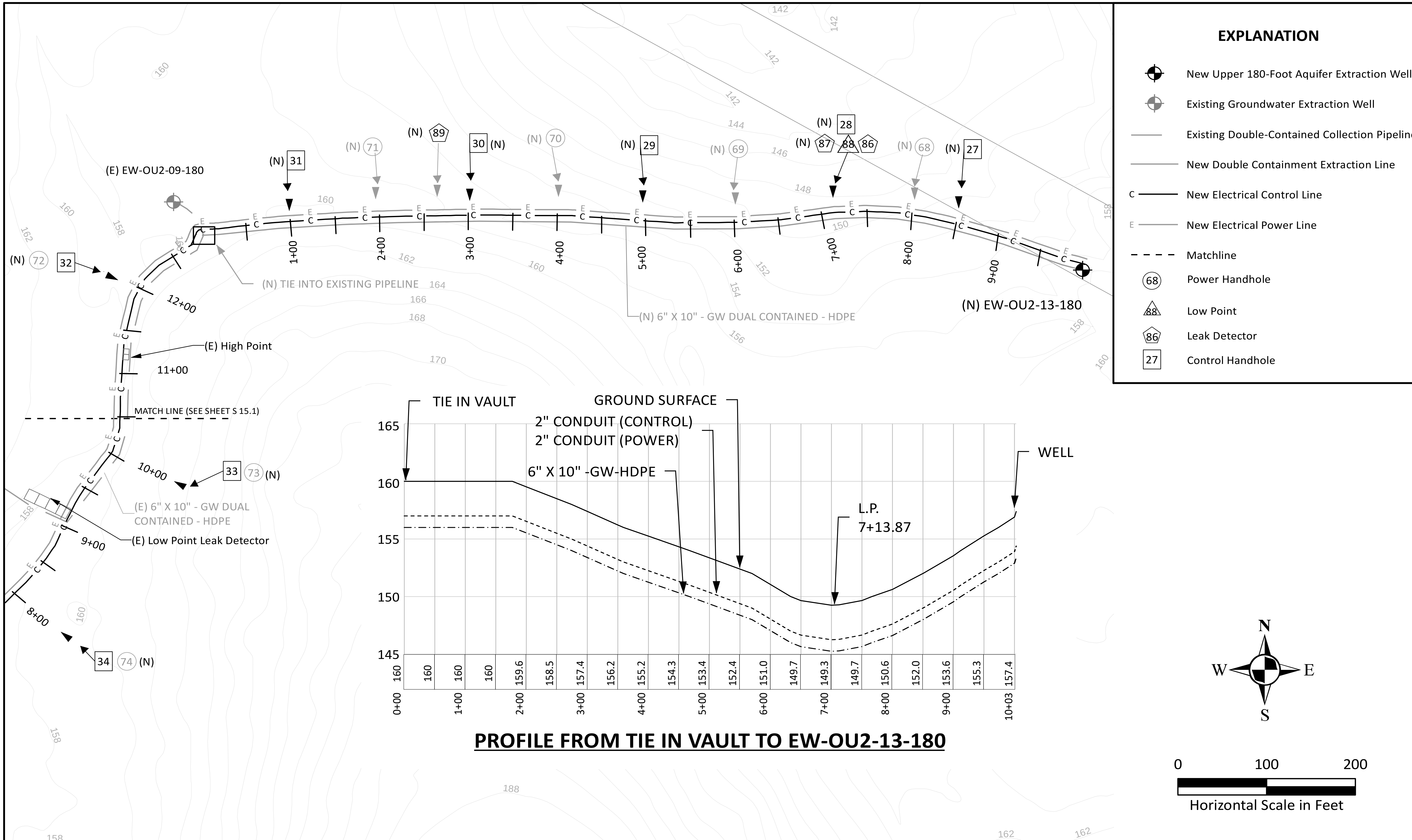
REVISIONS

ZONE	REV.	DESCRIPTION	BY	DATE	APP.
	1				
	2				
	3				
	4				

APPROVAL RECOMMENDED ____ DATE
APPROVED ____ DATE
CONTRACT NUMBER

AHTNA GLOBAL, LLC
FORT ORD, CA
BUNKER HILL NETWORK
CONDUIT ROUTING

SCALE
NOT TO SCALE
DRAWING NUMBER
S14
SHEET NUMBER
14 OF 18



NOT FOR CONSTRUCTION — PENDING FIELD REVIEW — ALL LENGTHS APPROXIMATE

LINE IS 2 INCHES AT FULL SIZE (IF NOT 2"-SCALE ACCORDINGLY)

DATE: 01/25/2023
FILE:
DRAWN: HR
DESIGNED: AHTNA
CHECKED:

SUBMITTED: DATE:
SUBMITTAL APPROVED: DATE:

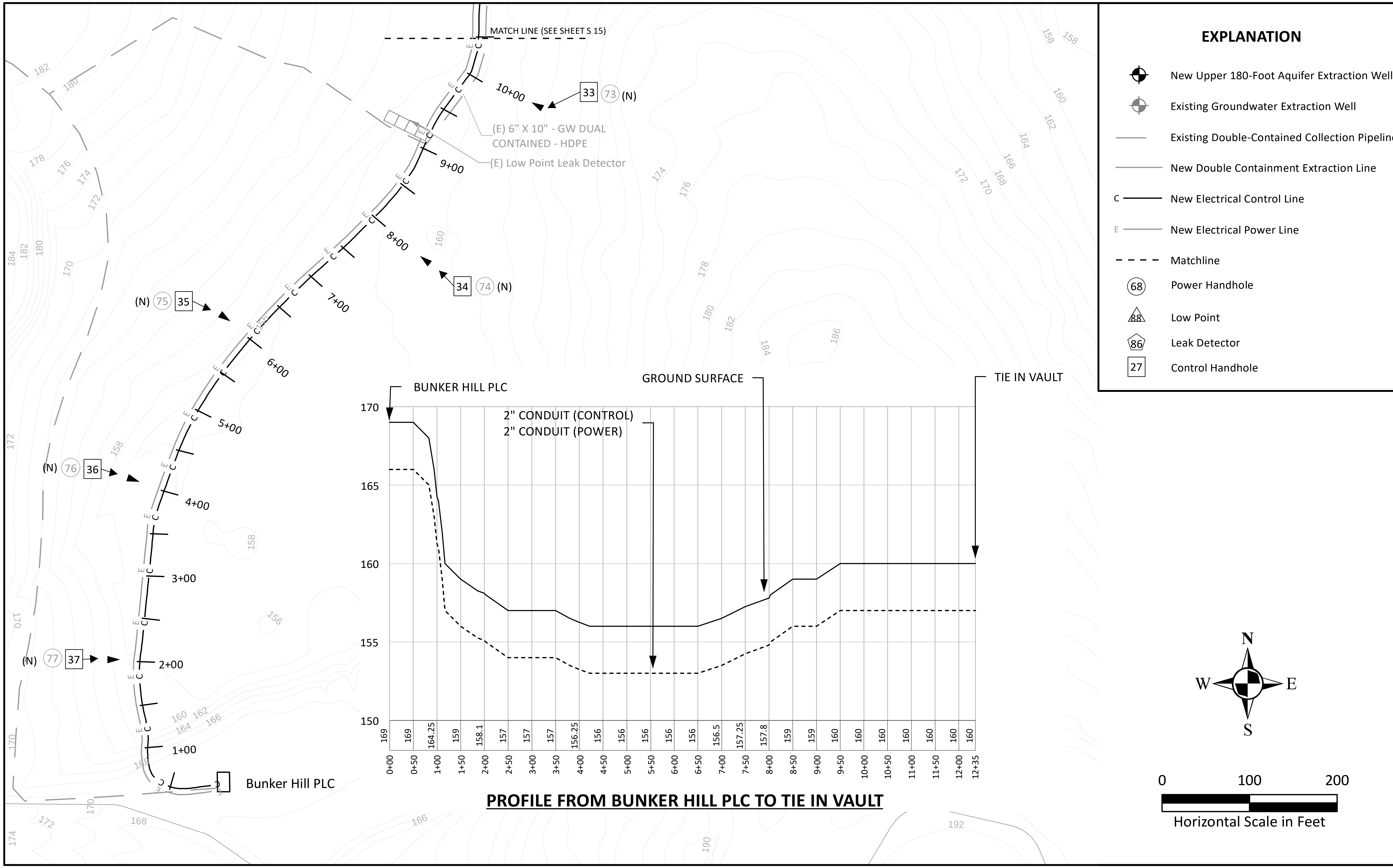
KORE systems Inc

REVISIONS					
ZONE	REV.	DESCRIPTION	BY	DATE	APP.

APPROVAL RECOMMENDED DATE
APPROVED DATE
CONTRACT NUMBER

AHTNA GLOBAL, LLC
FORT ORD, CA
EW-OU2-13-180
CONDUIT ROUTING

SCALE NONE
DRAWING NUMBER S15
SHEET NUMBER 15 OF 18



NOT FOR CONSTRUCTION – PENDING FIELD REVIEW – ALL LENGTHS APPROXIMATE

LINE IS 2 INCHES AT FULL SIZE (IF NOT 2"–SCALE ACCORDINGLY)

DATE: 01/25/2023
FILE:
DRAWN: HR
DESIGNED: AHTNA
CHECKED:

SUBMITTED: DATE:
SUBMITTAL APPROVED: DATE:

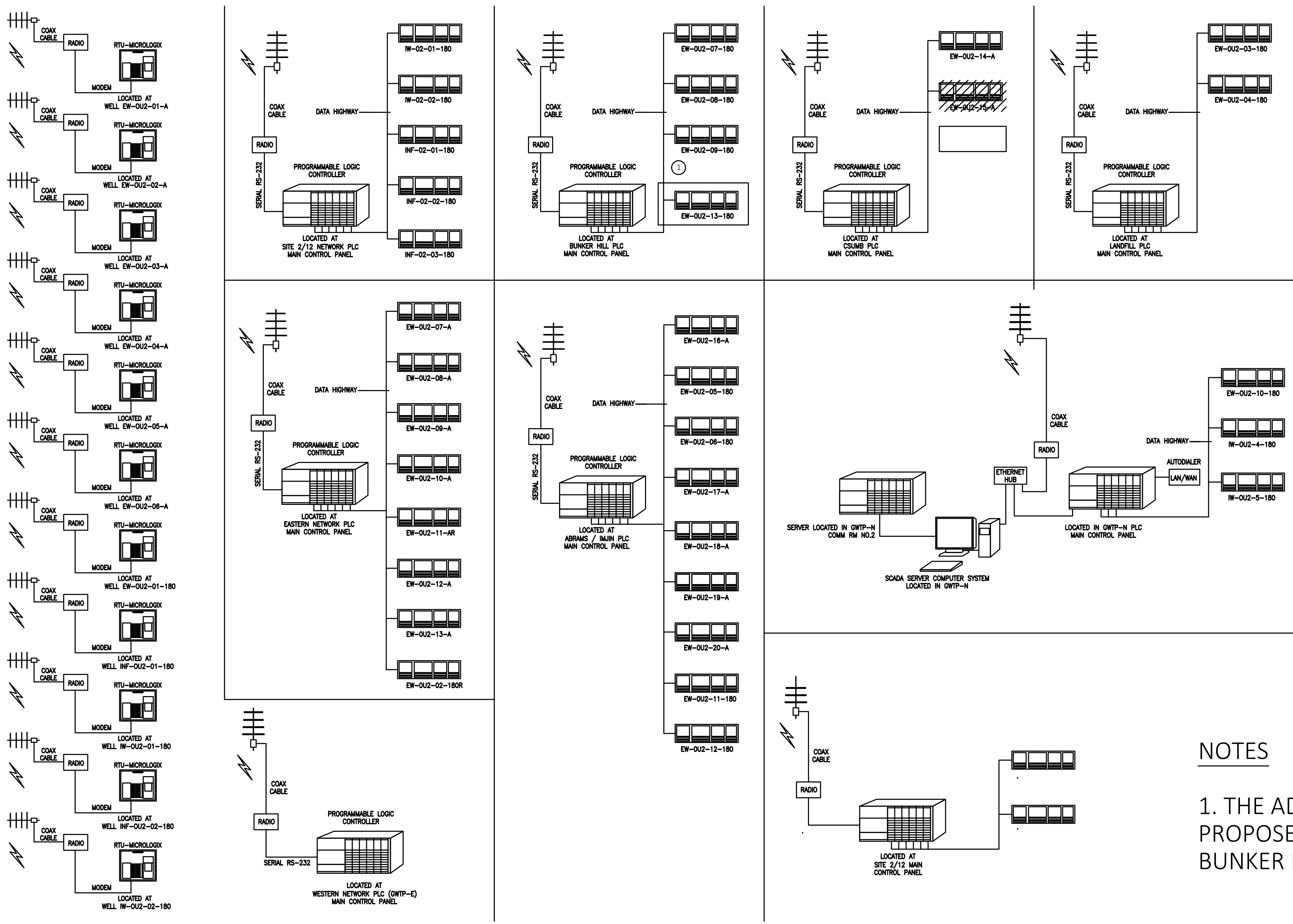
KORE systems Inc

REVISIONS					
ZONE	REV.	DESCRIPTION	BY	DATE	APP.

APPROVAL RECOMMENDED DATE
APPROVED DATE
CONTRACT NUMBER

AHTNA GLOBAL, LLC
FORT ORD, CA
EW–OU2–13–180
CONDUIT ROUTING

SCALE NONE
DRAWING NUMBER S15.1
SHEET NUMBER 15 OF 18



NOTES

1. THE ADDITION OF THE NEW PROPOSED EXTRACTION WELL AT BUNKER HILL.

NOT FOR CONSTRUCTION

LINE IS 2 INCHES AT FULL SIZE (IF NOT 2"-SCALE ACCORDINGLY)

DATE:
FILE:
DRAWN:
DESIGNED:
CHECKED:

SUBMITTED: DATE:
SUBMITTAL APPROVED: DATE:

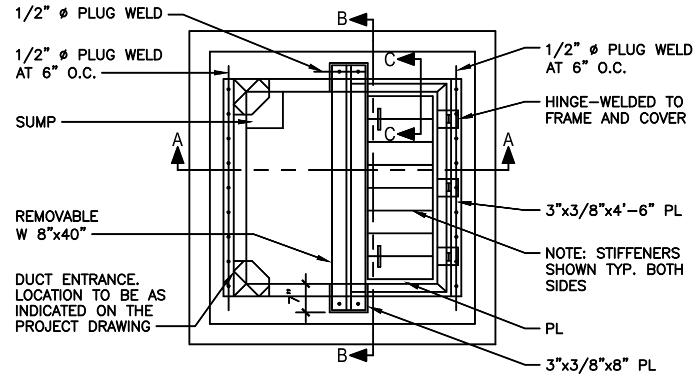
KORE systems Inc

REVISIONS					
ZONE	REV.	DESCRIPTION	BY	DATE	APP.

APPROVAL RECOMMENDED ____ DATE
APPROVED ____ DATE
CONTRACT NUMBER

AHTNA GLOBAL, LCC
FORT ORD, CA
BUNKER HILL PLC
COMMUNICATION HUB

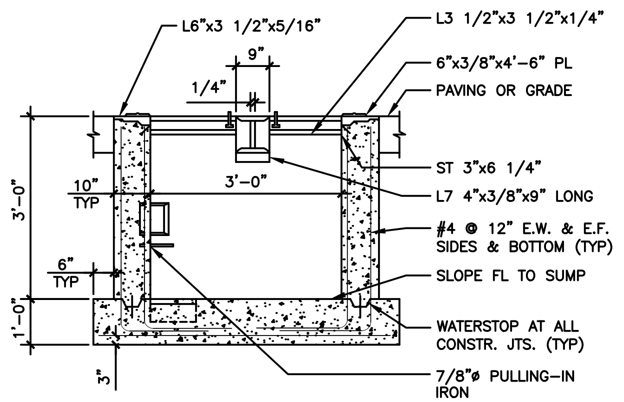
SCALE NONE
DRAWING NUMBER S16
SHEET NUMBER 16 OF 18



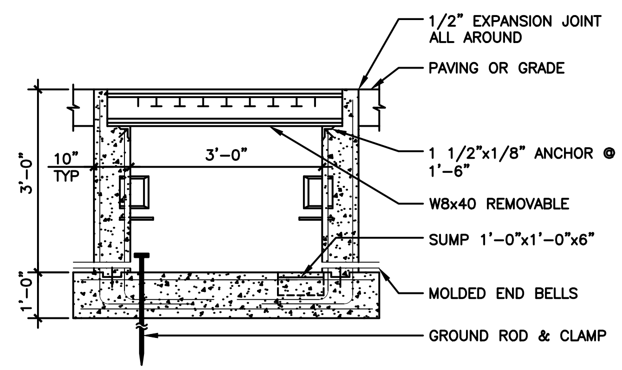
PLAN

NOTES:

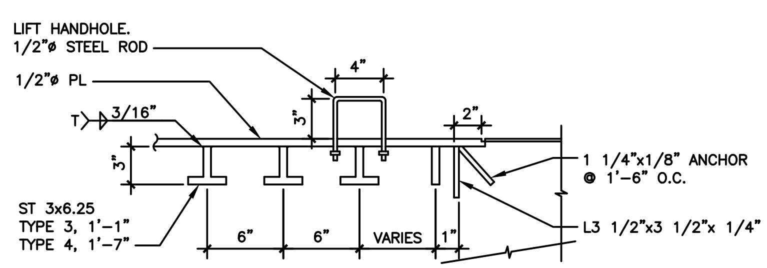
1. ENTRANCE OF DUCTS INTO HANDHOLE MAY BE MADE ON SIDE FACES OR CORNERS AS REQUIRED.
2. FOR DETAILS OF CABLE RACKS, DUCT ENTRANCE AND PULLING-IN IRONS, SEE DETAIL 3, IU501.
3. HANDHOLE AND COVER IS DESIGNED FOR MAXIMUM SINGLE WHEEL LOAD OF 25,000 LB.
4. COVER SHALL BE MADE OF STRUCTURAL STEEL CONFORMING TO ASTM A 36/A 36M.
5. MINIMUM COMPRESSIVE STRENGTH OF CONCRETE SHALL BE 3000 PSI.



SECTION A-A



SECTION B-B



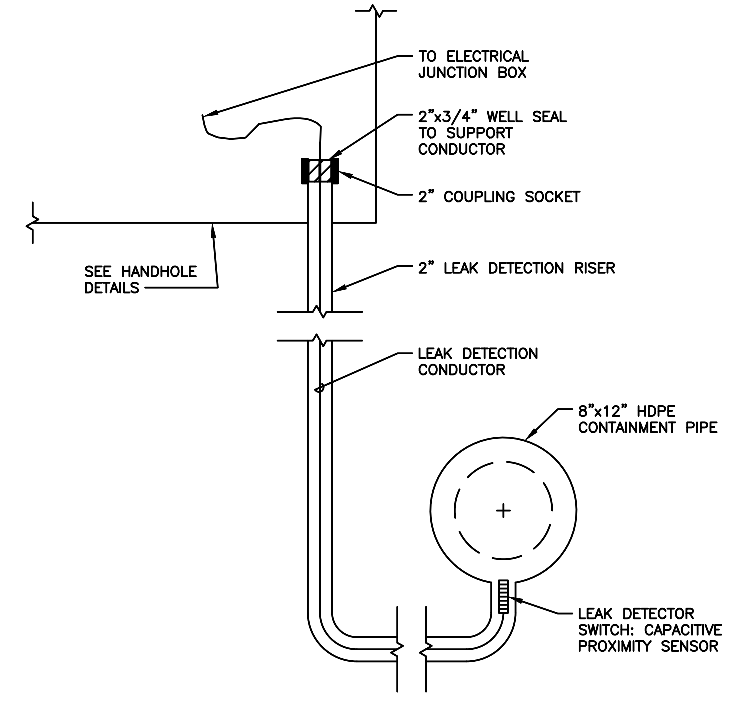
(SEE NOTE 4)

SECTION C-C

1 STANDARD ELECTRICAL/CONTROL HANDHOLE TRAFFIC RATED

NOT TO SCALE

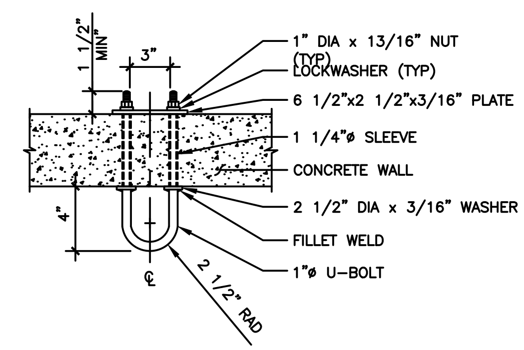
EU401 TO EU408 | IU501
IU101
IU401 TO IU408



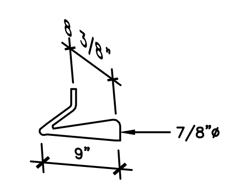
CROSS SECTION

2 LEAK DETECTION STATION

IU406 | IU501 NOT TO SCALE



ALTERED METHOD



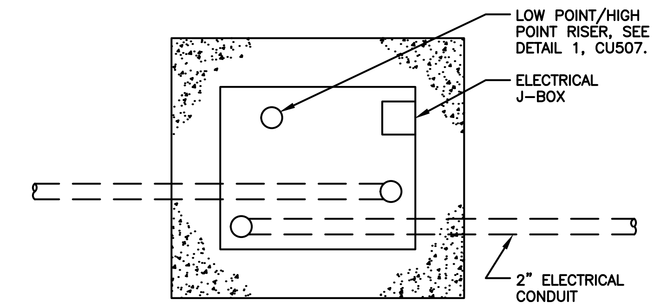
CAST IN PLACE

NOTE:

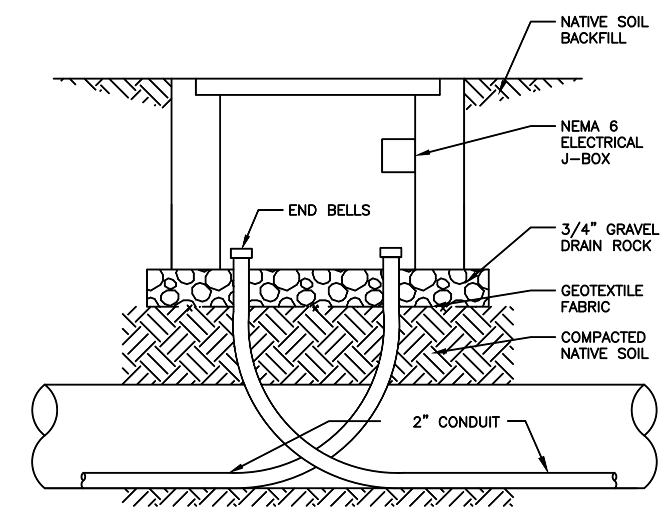
ALL METAL PARTS SHALL BE HOT DIP GALVANIZED

3 PULLING-IN IRON

IU501 | IU501 NOT TO SCALE



PLAN VIEW



CROSS SECTION

NOTES:

1. REFER TO DETAIL 1, THIS PAGE FOR TRAFFIC RATED HANDHOLES OR DETAIL 13, E-502 FOR NON TRAFFIC RATED, AS CONDITIONS DICTATE.

4 HANDHOLE FOR LEAK DETECTION

NOT TO SCALE

IU403 | IU501
IU404

NOT FOR CONSTRUCTION

LINE IS 2 INCHES AT FULL SIZE (IF NOT 2"-SCALE ACCORDINGLY)	DATE: 01/25/2023 FILE: DRAWN: HR DESIGNED: CHECKED:
SUBMITTED: DATE:	
SUBMITTAL APPROVED: DATE:	

KORE systems Inc

REVISIONS

ZONE	REV.	DESCRIPTION	BY	DATE	APP.
	1				
	2				
	3				
	4				

APPROVAL RECOMMENDED ______ DATE

APPROVED ______ DATE

CONTRACT NUMBER

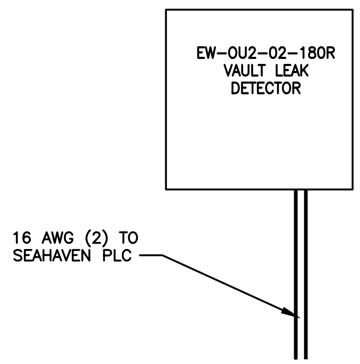
AHTNA GLOBAL, LLC
FORT ORD, CA

BUNKER HILL NETWORK
LEAK DETECTION DETAILS

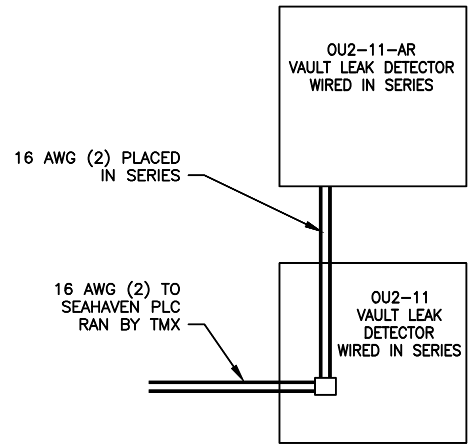
SCALE: NOT TO SCALE

DRAWING NUMBER: S17

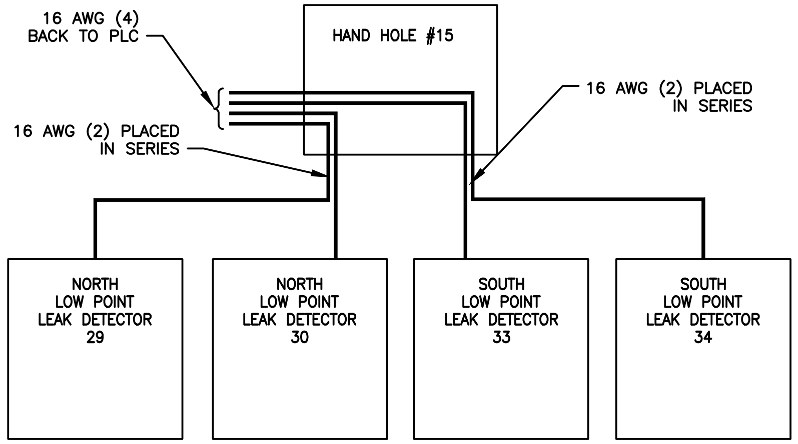
SHEET NUMBER: 17 OF 18



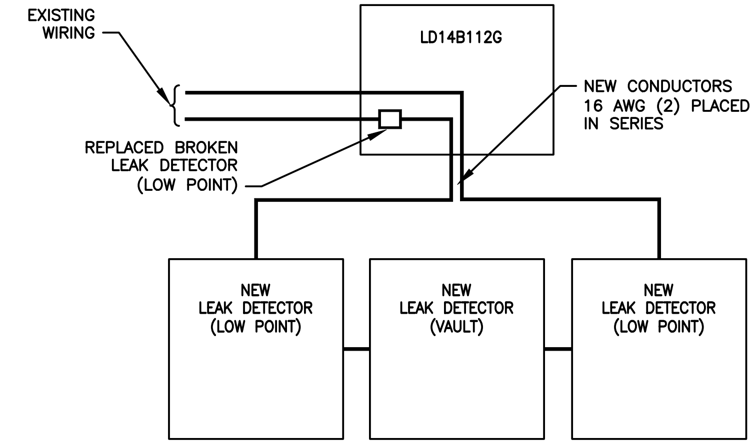
1 CONNECTION SCHEMATIC
LD402 | LD501 NOT TO SCALE



2 CONNECTION SCHEMATIC
LD402 | LD501 NOT TO SCALE

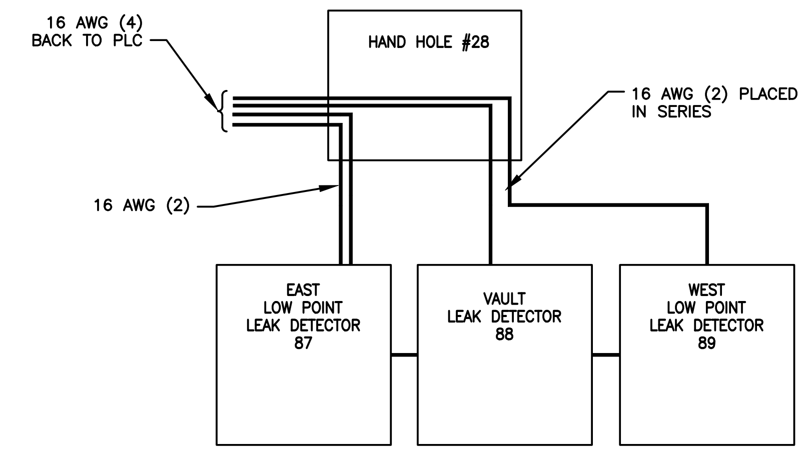


3 CONNECTION SCHEMATIC
LD406 | LD501 NOT TO SCALE

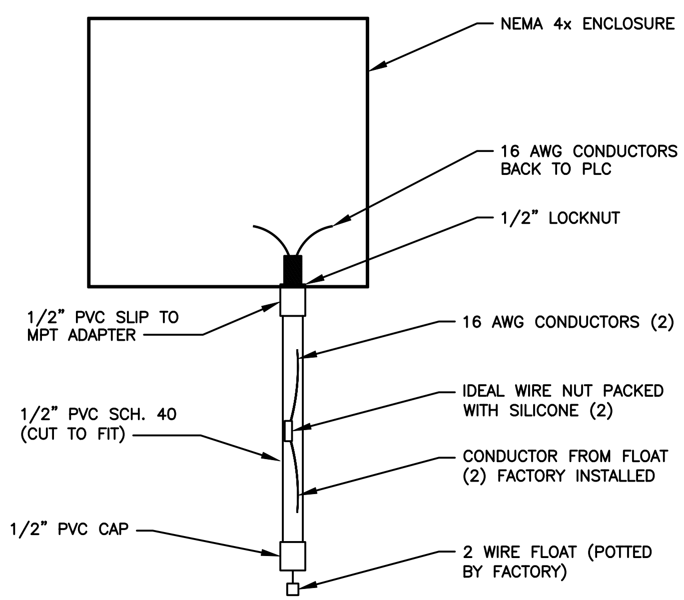


4 CONNECTION SCHEMATIC
LD407 | LD501 NOT TO SCALE

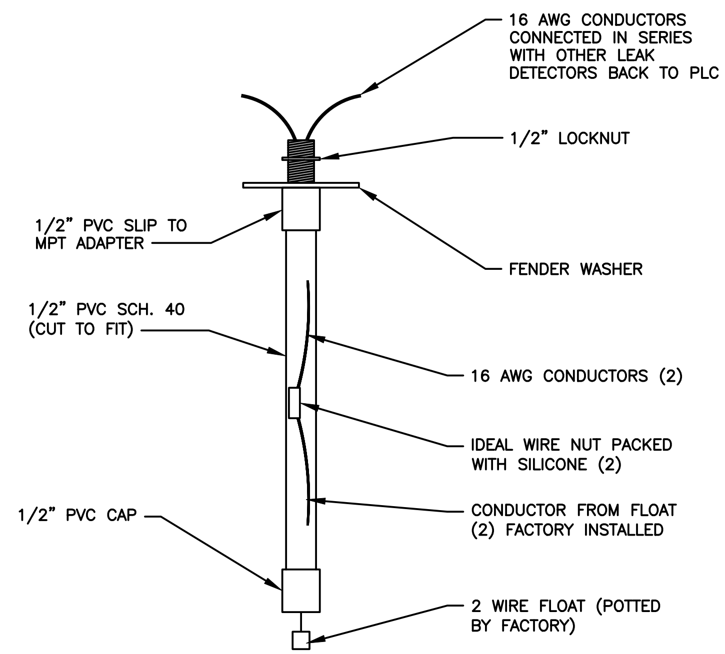
1



7 CONNECTION SCHEMATIC
LD403 | LD501 NOT TO SCALE



5 TYPICAL VAULT LEAK DETECTOR SCHEMATIC
LD501 | LD501 NOT TO SCALE



6 TYPICAL LOW POINT PIPE LEAK DETECTOR SCHEMATIC
LD501 | LD501 NOT TO SCALE

NOTES

1. THE PROPOSED LEAK DETECTORS FOR THE NEW EXTRACTION WELL OU2-13-180.

NOT FOR CONSTRUCTION

LINE IS 2 INCHES AT FULL SIZE (IF NOT 2"-SCALE ACCORDINGLY)

DATE: 01/25/2023
FILE:
DRAWN: HR
DESIGNED: AHTNA
CHECKED:

SUBMITTED: DATE:
SUBMITTAL APPROVED: DATE:

KORE systems Inc

REVISIONS

ZONE	REV.	DESCRIPTION	BY	DATE	APP.

APPROVAL RECOMMENDED DATE
APPROVED DATE
CONTRACT NUMBER

AHTNA GLOBAL, LLC
FORT ORD, CA
EW-OU2-13-180
LEAK DETECTION SCHEMATIC

SCALE NONE
DRAWING NUMBER S18
SHEET NUMBER 18 OF 18

ATTACHMENT D

Boring Logs and Well Construction Diagrams, Wells EW-OU2-09-180 and MW- OU2-64-180 and MW-OU2-66-180

BORING NO. EW-OU2-09-180

Shaw® Shaw Environmental, Inc.

COORDINATES: N. 2137463.33
E. 5749891.44

Datums NAVD88 & NAD 83-Cal Zone 4

PROJECT	Former Fort Ord	PROJECT NUMBER	783751	FIELD GEOLOGIST: W. Werner	TOC ELEV: 152.31[1]
LOCATION	OUCTP	DRILLING METHOD:	Mud Rotary	CHECKED BY: Melinda Montano	GS ELEV: 155.52
DRILL CO.	WDC	Logging: Cuttings, Core 180-220 ft bgs		APPROVED BY: Tim Ault P.G.	DATE BEGAN: 07/20/2010
DRILLER	Cliff Rainbolt	Boring Diameter Pilot 8.5", reamed 17"		TOTAL DEPTH: 227 FEET	DATE FINISHED: 07/29/2010
SCREEN:	Diameter: 10 in.	Length: 40 ft	Type/Size S.Steel, 0.045" slot	Sand Pack: 8x16 (8 Mesh)	Piezo. Elev. 151.43
CASING	Diameter: 10 in.	Length: 175 ft	Type PVC SCH 80	Transition Sand: #60	Note 1: Top of Flange
SUMP	Diameter: 10 in.	Length: 5 ft	Type SS 304		Units: feet

Elevation (ft amsl)	Depth (feet)	Well Completion	Sample	Recovery	USCS Symbol	Profile	Description	Comments
0.00								Drill Rig: Speedstar 40K Geologic Core:94mm punch
-1.00	1.0						Note: Well installation included 1-inch piezometer (not depicted in graphic image) installed external to 10-inch well casing. Casing: Schedule 40, screen 20 slot PVC, Top of screen 175 ft-bgs, Base 215 ft-bgs. 1 foot sump.	20 inch conductor casing set to 20 ft-bgs
-2.00	2.0							
-3.00	3.0							
-4.00	4.0							Hand Auger to 5'
-5.00	5.0							
-6.00	6.0							
-7.00	7.0							
-8.00	8.0							
-9.00	9.0				SW		9': Well Graded Sand. Dark Yellowish Brown 10yr4/4.	
-10.00	10.0							
-11.00	11.0							
-12.00	12.0							Arch to 20'
-13.00	13.0							
-14.00	14.0				SP		14': Poorly Graded Sand. Yellowish Brown 10yr5/4, , 20% Fine, 70% Medium,10% Coarse Sand Slightly Moist	Annular Seal: Grout 5% Bentonite-Cement
-15.00	15.0							
-16.00	16.0							PVC Well Casing 10" Schedule 80
-17.00	17.0							
-18.00	18.0						18': Poorly Graded Sand. Yellowish Brown 10yr5/6, , 10% Medium, 90% Coarse. Slightly Moist	
-19.00	19.0							
-20.00	20.0				SP			Bottom of 20" conductor
-21.00	21.0							Mud Property (Pilot Boring) Marsh cone: 43 seconds
-22.00	22.0							
-23.00	23.0							
-24.00	24.0							
-25.00	25.0				SW		25': Well Graded Sand, Yellowish Brown 10yr5/6. 30% Fine, 40% Medium, 30% Coarse	
-26.00	26.0							
-27.00	27.0							
-28.00	28.0							
-29.00	29.0							
-30.00	30.0							

BORING NO. EW-OU2-09-180

Shaw® Shaw Environmental, Inc.

				COORDINATES: N.	2137463.33
			Datums NAVD88 & NAD 83-Cal Zone 4	E.	5749891.44
PROJECT	Former Fort Ord	PROJECT NUMBER 783751	FIELD GEOLOGIST: W. Werner	TOC ELEV:	152.31[1]
LOCATION	OUCTP	DRILLING METHOD: Mud Rotary	CHECKED BY: Melinda Montano	GS ELEV:	155.52
DRILL CO.	WDC	Logging: Cuttings, Core 180-220 ft bgs	APPROVED BY: Tim Ault P.G.	DATE BEGAN: 07/20/2010	
DRILLER	Cliff Rainbolt	Boring Diameter Pilot 8.5", reamed 17"	TOTAL DEPTH: 227 FEET	DATE FINISHED: 07/29/2010	
SCREEN:	Diameter: 10 in.	Length: 40 ft Type/Size S.Steel, 0.045" slot	Sand Pack: 8x16 (8 Mesh)	Piezo. Elev. 151.43	
CASING	Diameter: 10 in.	Length: 175 ft Type PVC SCH 80	Transition Sand: #60	Note 1: Top of Flange	
SUMP	Diameter: 10 in.	Length: 5 ft Type SS 304		Units: feet	

Elevation (ft amsl)	Depth (feet)	Well Completion	Sample	Recovery	USCS Symbol	Profile	Description	Comments
-31.00	31.0							
-32.00	32.0							
-33.00	33.0							
-34.00	34.0							
-35.00	35.0				SP		35': Poorly Graded Sand, Brownish Yellow 10yr6/6 40% Fine, 50% Medium,10% Coarse. Quartzose.	
-36.00	36.0							
-37.00	37.0							
-38.00	38.0							
-39.00	39.0							
-40.00	40.0							Mud Property (Pilot Boring)
-41.00	41.0							Marsh cone: 35 seconds Mud Weight: 9.1 lb/ft^3
-42.00	42.0				SP		42': Same except: 60% Fine, 40% Medium Sand, Trace Coarse,Trace Silt.	
-43.00	43.0							
-44.00	44.0							Annular Seal: Grout
-45.00	45.0							5% Bentonite-Cement
-46.00	46.0						46': Same except: 40% Fine, 60% Medium Sand.	PVC Well Casing 10"
-47.00	47.0							Schedule 80
-48.00	48.0							
-49.00	49.0							
-50.00	50.0							
-51.00	51.0							
-52.00	52.0				SP		52': Same except, 30% Fine, 70% Medium Sand.	
-53.00	53.0							53' Centralizer
-54.00	54.0							
-55.00	55.0							
-56.00	56.0							
-57.00	57.0							
-58.00	58.0							
-59.00	59.0							
-60.00	60.0				SP		60': Same as above	Mud Property (Pilot Boring) Marsh cone: 34 seconds

BORING NO. EW-OU2-09-180

Shaw® Shaw Environmental, Inc.

COORDINATES: N. 2137463.33
E. 5749891.44

Datums NAVD88 & NAD 83-Cal Zone 4

PROJECT	Former Fort Ord	PROJECT NUMBER 783751		FIELD GEOLOGIST: W. Werner	TOC ELEV: 152.31[1]
LOCATION	OUCTP	DRILLING METHOD: Mud Rotary		CHECKED BY: Melinda Montano	GS ELEV: 155.52
DRILL CO.	WDC	Logging: Cuttings, Core 180-220 ft bgs		APPROVED BY: Tim Ault P.G.	DATE BEGAN: 07/20/2010
DRILLER	Cliff Rainbolt	Boring Diameter Pilot 8.5", reamed 17"		TOTAL DEPTH: 227 FEET	DATE FINISHED: 07/29/2010
SCREEN:	Diameter: 10 in.	Length: 40 ft	Type/Size S.Steel, 0.045" slot	Sand Pack: 8x16 (8 Mesh)	Piezo. Elev. 151.43
CASING	Diameter: 10 in.	Length: 175 ft	Type PVC SCH 80	Transition Sand: #60	Note 1: Top of Flange
SUMP	Diameter: 10 in.	Length: 5 ft	Type SS 304		Units: feet

Elevation (ft amsl)	Depth (feet)	Well Completion	Sample	Recovery	USCS Symbol	Profile	Description	Comments
-61.00	61.0							
-62.00	62.0							
-63.00	63.0							
-64.00	64.0							
-65.00	65.0				SP		65': Poorly Graded Sand, Brownish Yellow 10yr6/6 30% Fine, 70% Medium. Quartzose.	
-66.00	66.0							
-67.00	67.0							
-68.00	68.0							
-69.00	69.0							
-70.00	70.0							
-71.00	71.0							
-72.00	72.0							
-73.00	73.0							
-74.00	74.0							Annular Seal: Grout 5% Bentonite-Cement
-75.00	75.0		Sieve (Field) < 1% fines		SP		75': Poorly Graded Sand, Yellowish Brown 10YR 6/4, 20% Fine, 70% Medium, 10% Coarse	
-76.00	76.0							PVC Well Casing 10" Schedule 80
-77.00	77.0							
-78.00	78.0							
-79.00	79.0							
-80.00	80.0		Sieve (Field) < 1% fines		SP		80': Same as above	
-81.00	81.0							
-82.00	82.0							
-83.00	83.0							
-84.00	84.0							
-85.00	85.0				SP		85': Same as above	
-86.00	86.0							
-87.00	87.0							
-88.00	88.0							
-89.00	89.0							
-90.00	90.0		Sieve (Field) 1.5 fines		SP		90': Same as above	
-91.00	91.0							

BORING NO. EW-OU2-09-180

Shaw® Shaw Environmental, Inc.

COORDINATES: N. 2137463.33
E. 5749891.44

Datums NAVD88 & NAD 83-Cal Zone 4

PROJECT	Former Fort Ord	PROJECT NUMBER	783751	FIELD GEOLOGIST: W. Werner	TOC ELEV: 152.31[1]
LOCATION	OUCTP	DRILLING METHOD:	Mud Rotary	CHECKED BY: Melinda Montano	GS ELEV: 155.52
DRILL CO.	WDC	Logging: Cuttings, Core 180-220 ft bgs		APPROVED BY: Tim Ault P.G.	DATE BEGAN: 07/20/2010
DRILLER	Cliff Rainbolt	Boring Diameter Pilot 8.5", reamed 17"		TOTAL DEPTH: 227 FEET	DATE FINISHED: 07/29/2010
SCREEN:	Diameter: 10 in.	Length: 40 ft	Type/Size S.Steel, 0.045" slot	Sand Pack: 8x16 (8 Mesh)	Piezo. Elev. 151.43
CASING	Diameter: 10 in.	Length: 175 ft	Type PVC SCH 80	Transition Sand: #60	Note 1: Top of Flange
SUMP	Diameter: 10 in.	Length: 5 ft	Type SS 304		Units: feet

Elevation (ft amsl)	Depth (feet)	Well Completion	Sample	Recovery	USCS Symbol	Profile	Description	Comments
-92.00	92.0						92': Same except: Few clay chips (possible clay stringer)	
-93.00	93.0							93' Centralizer
-94.00	94.0							
-95.00	95.0				SP		95': Poorly Graded Sand. Yellowish Brown 10yr6/4 Fine - Medium	
-96.00	96.0							
-97.00	97.0							
-98.00	98.0							
-99.00	99.0							
-100.00	100.0				SP		100': Same as above	Mud Property (Pilot Boring)
-101.00	101.0							Marsh cone: 35 Seconds Mud Weight: 9.0 lb/ft3
-102.00	102.0							
-103.00	103.0							
-104.00	104.0				CH		104': Clay with Fine Sand and Silt. Grey 5y5/1. Soft	
-105.00	105.0							Annular Seal: Grout 5% Bentonite-Cement
-106.00	106.0							
-107.00	107.0							PVC Well Casing 10" Schedule 80
-108.00	108.0							
-109.00	109.0							
-110.00	110.0							
-111.00	111.0						111': Thin sand layer	
-112.00	112.0							
-113.00	113.0							
-114.00	114.0							
-115.00	115.0							
-116.00	116.0							
-117.00	117.0							
-118.00	118.0							
-119.00	119.0							
-120.00	120.0				CH		120': Clay, Grey 5y5/1. <5% Fine Sand.	
-121.00	121.0							
-122.00	122.0				CH		122': Clay, Light Olive Gray 5y6/2.	

BORING NO. EW-OU2-09-180

Shaw® Shaw Environmental, Inc.

COORDINATES: N. 2137463.33
E. 5749891.44

Datums NAVD88 & NAD 83-Cal Zone 4

PROJECT	Former Fort Ord	PROJECT NUMBER 783751		FIELD GEOLOGIST: W. Werner	TOC ELEV: 152.31[1]
LOCATION	OUCTP	DRILLING METHOD: Mud Rotary		CHECKED BY: Melinda Montano	GS ELEV: 155.52
DRILL CO.	WDC	Logging: Cuttings, Core 180-220 ft bgs		APPROVED BY: Tim Ault P.G.	DATE BEGAN: 07/20/2010
DRILLER	Cliff Rainbolt	Boring Diameter Pilot 8.5", reamed 17"		TOTAL DEPTH: 227 FEET	DATE FINISHED: 07/29/2010
SCREEN:	Diameter: 10 in.	Length: 40 ft	Type/Size S.Steel, 0.045" slot	Sand Pack: 8x16 (8 Mesh)	Piezo. Elev. 151.43
CASING	Diameter: 10 in.	Length: 175 ft	Type PVC SCH 80	Transition Sand: #60	Note 1: Top of Flange
SUMP	Diameter: 10 in.	Length: 5 ft	Type SS 304		Units: feet

Elevation (ft amsl)	Depth (feet)	Well Completion	Sample	Recovery	USCS Symbol	Profile	Description	Comments
-123.00	123.0							
-124.00	124.0							
-125.00	125.0							
-126.00	126.0							
-127.00	127.0							
-128.00	128.0							
-129.00	129.0							
-130.00	130.0							
-131.00	131.0							
-132.00	132.0							
-133.00	133.0							133' Centralizer
-134.00	134.0							
-135.00	135.0				CH		135' Clay. Olive Gray - Greenish Gray. Gley1-5/5gy and 5y5/2	
-136.00	136.0							Annular Seal: Grout 5% Bentonite-Cement
-137.00	137.0							
-138.00	138.0							PVC Well Casing 10" Schedule 80
-139.00	139.0							
-140.00	140.0							Mud Property (Pilot Boring) Mud: Weight: 9.0 lb/ft^3 Marsh cone: 33 seconds
-141.00	141.0							
-142.00	142.0							
-143.00	143.0							
-144.00	144.0							
-145.00	145.0							
-146.00	146.0							
-147.00	147.0							
-148.00	148.0							
-149.00	149.0							
-150.00	150.0							
-151.00	151.0							
-152.00	152.0							
-153.00	153.0				CH			Clay <10% (17" Boring)

BORING NO. EW-OU2-09-180

Shaw® Shaw Environmental, Inc.

PROJECT	Former Fort Ord	PROJECT NUMBER	783751	Datums NAVD88 & NAD 83-Cal Zone 4	COORDINATES: N. 2137463.33
					E. 5749891.44
LOCATION	OUCTP	DRILLING METHOD:	Mud Rotary	FIELD GEOLOGIST: W. Werner	TOC ELEV: 152.31[1]
DRILL CO.	WDC	Logging: Cuttings, Core 180-220 ft bgs		CHECKED BY: Melinda Montano	GS ELEV: 155.52
DRILLER	Cliff Rainbolt	Boring Diameter Pilot 8.5", reamed 17"		APPROVED BY: Tim Ault P.G.	DATE BEGAN: 07/20/2010
				TOTAL DEPTH: 227 FEET	DATE FINISHED: 07/29/2010
SCREEN:	Diameter: 10 in.	Length: 40 ft	Type/Size S.Steel, 0.045" slot	Sand Pack: 8x16 (8 Mesh)	Piezo. Elev. 151.43
CASING	Diameter: 10 in.	Length: 175 ft	Type PVC SCH 80	Transition Sand: #60	Note 1: Top of Flange
SUMP	Diameter: 10 in.	Length: 5 ft	Type SS 304		Units: feet

Elevation (ft amsl)	Depth (feet)	Recovery	USCS Symbol	Description	Comments
				153': Clay, Same as above	
-154.00	154.0				Drilling rate increases
-155.00	155.0				
-156.00	156.0		SP	156': Poorly Graded Sand, Yellowish Brown 10yr5/6.	Clay <10% (17" Boring)
-157.00	157.0				
-158.00	158.0		CL	158': Clay. Olive Gray - Greenish Gray. Gley1-5/5gy	Clay 40% (17" boring)
-159.00	159.0		SP	and 5y5/2. Thin layer.	
-160.00	160.0				Top of bentonite seal: 159.5'
-161.00	161.0				
-162.00	162.0				
-163.00	163.0				
-164.00	164.0				
-165.00	165.0		SP	165': Poorly Graded Sand, 10yr5/4, <5% Very Fine, 15% Medium, 80% Coarse.	
-166.00	166.0				166' Top of trans sand
-167.00	167.0				
-168.00	168.0				
-169.00	169.0				169' Top of 8X16 sand
-170.00	170.0				
-171.00	171.0				
-172.00	172.0				Clay decreased (17" boring)
-173.00	173.0				Hard chips in drilling mud 173' Centralizer
-174.00	174.0				
-175.00	175.0		SP	175': Sand, Yellowish Brown, 10yr5/4, 80% Coarse, 20% Very Coarse.	175' Top of screen Clay in ream-mud: 10% (dark gray chips)
-176.00	176.0				
-177.00	177.0				
-178.00	178.0				
-179.00	179.0				
-180.00	180.0			180': Poorly Graded Clayey Sand , Light Olive Brown	Start Punch Core-180 ft-bgs
-181.00	181.0		SC	2.5y5/3, Sand: 10% Medium, 75% Coarse. Clay-silt > 15%Silt	Clay: 5-10 % (17" Boring) (dark gray chips)
-182.00	182.0	60%		182': Well Graded Clayey Sand, Grayish Brown,10yr 5/2, Sand: 20% Medium, 30% Coarse, 30% Very Coarse,	Natural Gamma Trend 70-75 API (Clayey)
-183.00	183.0		SW-SC	5%, Gravel, Layered Clays 15%	
-184.00	184.0				

BORING NO. EW-OU2-09-180

Shaw® Shaw Environmental, Inc.

COORDINATES: N. 2137463.33
E. 5749891.44

Datums NAVD88 & NAD 83-Cal Zone 4

PROJECT	Former Fort Ord	PROJECT NUMBER 783751	FIELD GEOLOGIST: W. Werner	TOC ELEV:	152.31[1]
LOCATION	OUCTP	DRILLING METHOD: Mud Rotary	CHECKED BY: Melinda Montano	GS ELEV:	155.52
DRILL CO.	WDC	Logging: Cuttings, Core 180-220 ft bgs	APPROVED BY: Tim Ault P.G.	DATE BEGAN: 07/20/2010	
DRILLER	Cliff Rainbolt	Boring Diameter Pilot 8.5", reamed 17"	TOTAL DEPTH: 227 FEET	DATE FINISHED: 07/29/2010	
SCREEN:	Diameter: 10 in.	Length: 40 ft Type/Size S.Steel, 0.045" slot	Sand Pack: 8x16 (8 Mesh)	Piezo. Elev. 151.43	
CASING	Diameter: 10 in.	Length: 175 ft Type PVC SCH 80	Transition Sand: #60	Note 1: Top of Flange	
SUMP	Diameter: 10 in.	Length: 5 ft Type SS 304		Units: feet	

Elevation (ft amsl)	Depth (feet)	Well Completion	Sample	Recovery	USCS Symbol	Profile	Description	Comments
-185.00	185.0		Sieve (Field) <1% fines					
-186.00	186.0						186' Poorly Graded Sand with Gravel. Gravel up to 5/8", >15% Gravel	
-187.00	187.0				SP			
-188.00	188.0			80%				
-189.00	189.0							
-190.00	190.0						190' Well Graded Sand with Clay. 10yr5/4. Sand: 40% Coarse , 10% Fine, 40% Medium, 10% Very Coarse, upper 2-feet firm, loose below,	Less Clay (17" Boring) Natural Gamma Trend 65-70 API (silty)
-191.00	191.0							
-192.00	192.0		Sieve (Field) 3.00% Fines					Mud Property (Pilot Boring) Solids: 3 % Marsh cone: 34 seconds Weight: 9.0 lb/ft3 Filter Cake; 4 mm
-193.00	193.0			60%				
-194.00	194.0							
-195.00	195.0				SW		195' to 200' Well Graded Sand. Grayish Brown 10yr5/2. Sand: 30% Fine, 30% Medium, 20% Coarse 15% Very Coarse, Trace Gravel, Clay 5% dark gray.	Clay 5% (17" boring) Dark gray clay
-196.00	196.0							
-197.00	197.0		Sieve (Field) 2% fines					
-198.00	198.0			10%				No clay (17" Boring)
-199.00	199.0							
-200.00	200.0							Mud Property (Pilot Boring) Mud: Marsh Cone 34 sec.
-201.00	201.0							
-202.00	201.0			0%				
-203.00	203.0				SW			
-204.00	204.0							
-205.00	205.0						205' to 210' Poorly Graded Sand. Grayish Brown 2.5Y5/3, Grayish Brown 10YR5/2. 20%Fine, 60% Medium, 15% Coarse and 5% very coarse. Trace Silt, Mica	
-206.00	206.0							
-207.00	207.0		Sieve (Field) 5% fines		SW			
-208.00	208.0			10%				
-209.00	209.0							
-210.00	210.0						210'-215' Poorly Graded Clayey-Silty Sand. Grayish Brown 2.5Y5/3 60%Fine,15% Medium 10% Coarse, 5% Very Coarse. 5-10% Clay-Silt, Some Mica.	
-211.00	211.0							Natural Gasmma Trend: 80 API (Clay)
-212.00	212.0		Sieve Field 5% fines		SW-SC			
-213.00	213.0			10%				Mud Property (17" Boring) Mud: Density 9.0 lb/ft^3 3% solids 1.5% sand Filter cake 3/32"
-214.00	214.0							
-215.00	215.0						215' Possible Gravel stringer	215' End Screen

BORING NO. EW-OU2-09-180

Shaw® Shaw Environmental, Inc.

COORDINATES: N. 2137463.33
E. 5749891.44

Datums NAVD88 & NAD 83-Cal Zone 4

PROJECT	Former Fort Ord	PROJECT NUMBER	783751	FIELD GEOLOGIST: W. Werner	TOC ELEV: 152.31[1]
LOCATION	OUCTP	DRILLING METHOD:	Mud Rotary	CHECKED BY: Melinda Montano	GS ELEV: 155.52
DRILL CO.	WDC	Logging: Cuttings, Core 180-220 ft bgs		APPROVED BY: Tim Ault P.G.	DATE BEGAN: 07/20/2010
DRILLER	Cliff Rainbolt	Boring Diameter Pilot 8.5", reamed 17"		TOTAL DEPTH: 227 FEET	DATE FINISHED: 07/29/2010
SCREEN:	Diameter: 10 in.	Length: 40 ft	Type/Size S.Steel, 0.045" slot	Sand Pack: 8x16 (8 Mesh)	Piezo. Elev. 151.43
CASING	Diameter: 10 in.	Length: 175 ft	Type PVC SCH 80	Transition Sand: #60	Note 1: Top of Flange
SUMP	Diameter: 10 in.	Length: 5 ft	Type SS 304		Units: feet

Elevation (ft amsl)	Depth (feet)	Well Completion	Sample	Recovery	USCS Symbol	Profile	Description	Comments
-216.00	216.0						216'-220' Well Graded clayey-Silty Sand. 60% Fine sand With Coarse to Very Coarse and Gravel throughout. Grain sized up to 3/4". >5 %Clay	
-217.00	217.0							Mud Property (17" Boring) Mud: Density 9.0 lb/ft^3 3% solids 1% sand Filter cake 2/32"
-218.00	218.0			80%	SW-SC			
-219.00	219.0						219' Possible Gravel stringer, quartz sand eith mica.	Sump: welded stainless. 220' Bottom of Sump
-220.00	220.0							
-221.00	221.0						220' to 227 ' backfiller with bentonite chips (tremied)	
-222.00	222.0							
-223.00	223.0							
-224.00	224.0							
-225.00	225.0						225' Same except: With Clay fragments. Multiple thin clay layers from 200' to 225'	
-226.00	226.0							
-227.00	227.0						Total Depth: 227'	

Notes:

1. Mud Property (17" Boring) : Properties measured or observed in drilling mud sampled from well head during reaming of boreole to 17-inches
2. Geophysical logging conducted in 8-inch borehole from ground surface to total depth. Natural Gamma, Caliper, Spontaneous Potential (SP) resistivity (single point, 16-inch and 64 inch normal)
3. Natural Gamma Trend: Visual baseline for natural gamma log over interval of interpreted lithologic zone (e.g. sand, clay, etc).

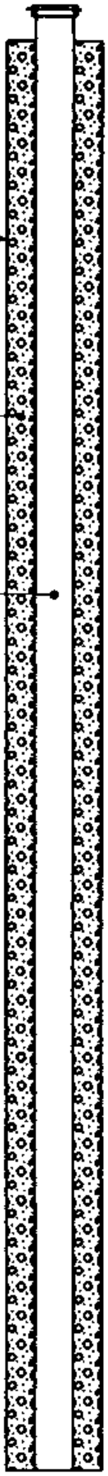
Top of PVC Casing
Elev. 143.35 ft.

Blows/foot	Recovery (inches)	OVA Reading (ppm)	Sample Number	Depth (ft.)	Sample

Equipment Speedstar Mud Rotary
11 3/4"-diameter

Elevation 140.30 ft. GS **Date** 02-12-99

GROUND SURFACE

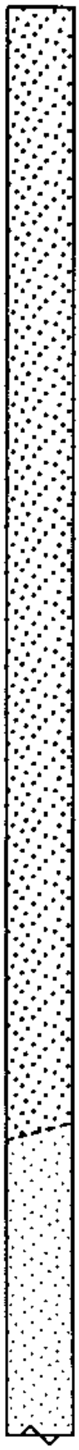


TOP OF CASING at 1.0 ft. above ground surface

11 3/4" DIAMETER BOREHOLE: 0 to 212 ft.

CEMENT/ BENTONITE SEAL: 0 to 164.5 ft.

5" DIAMETER SCHEDULE 80 PVC BLANK CASING: +1.0 to 180 ft.



OVA Reading (ppm)	Depth (ft.)	Description
	0	BROWNISH YELLOW WELL GRADED SAND (SW) (10YR 6/6) loose, dry, 90% fine to coarse sand, 10% silt
	5	@ 5 ft: color change to dark grayish brown (10YR 4/2), loose, moist
		@ 7 ft: color change to dark yellowish brown (10YR 4/4)
	10	@ 10 ft: similar to above
	15	@ 15 ft: color change to dark yellowish brown (10YR 6/4)
0	20	@ 20 ft: color change to yellowish brown (10YR 5/6), wet
	25	@ 25 ft: similar to above
	30	
		LIGHT OLIVE BROWN POORLY GRADED SAND (SP) (2.5Y 5/3) medium dense, wet, 90% fine to medium sand, 10% silt
	35	@ 35 ft: similar to above
0	40	

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Log of Boring and Well Completion MW-OU2-64-180
OU 2 Plume Delineation
Investigation Report
Fort Ord, California

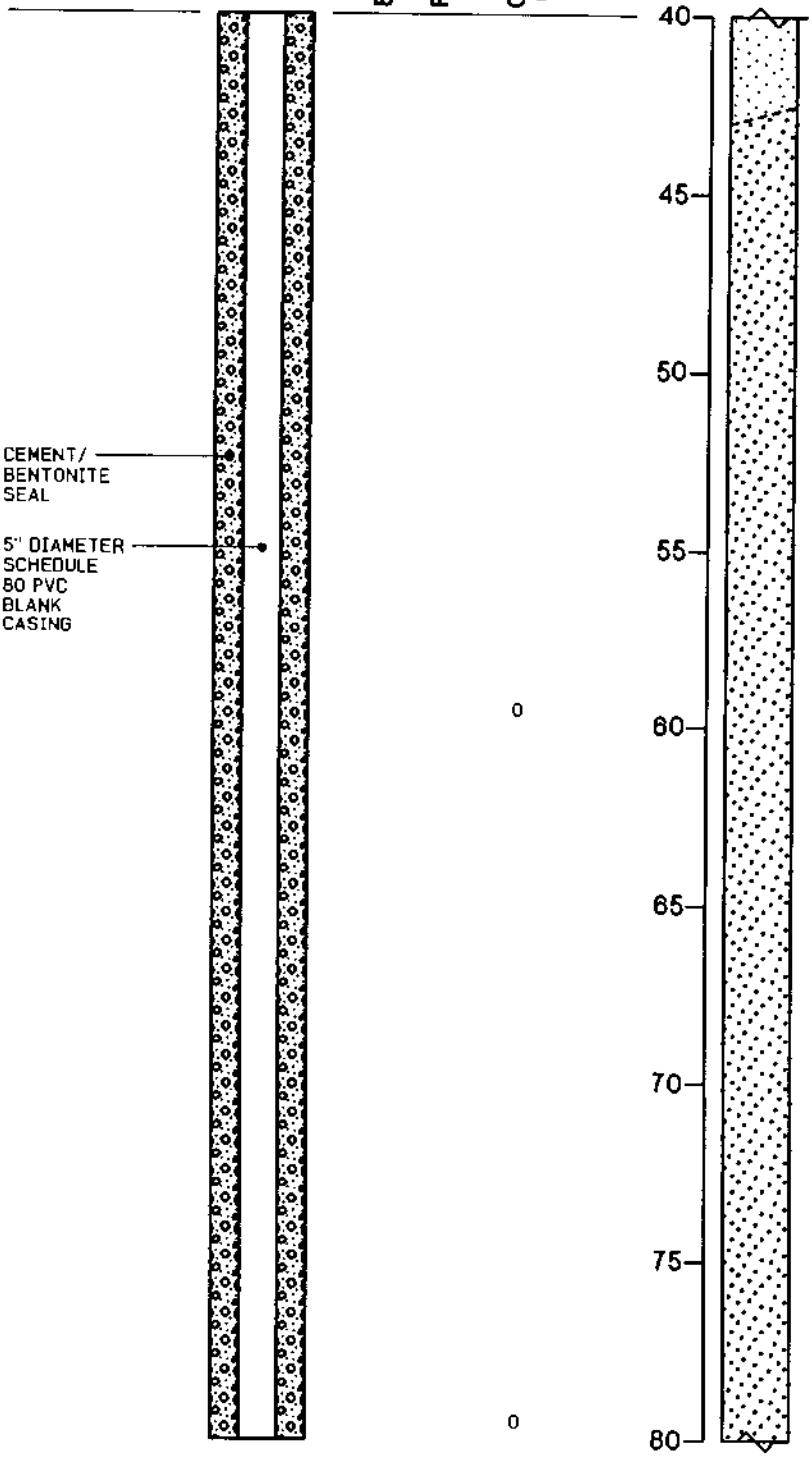
PLATE **1-5**

DRAWN	JOB NUMBER	APPROVED	DATE	REVISED DATE
PCB	42481 00123		3/99	

Equipment Speedstar Mud Rotary
11 3/4"-diameter

Elevation 140.30 ft. GS   Date 02-12-99

Blows/foot	Recovery (inches)	OVA Reading (ppm)	Sample Number	Depth (ft.)	Sample
				40	
				45	
				50	
				55	
		0		60	
				65	
				70	
				75	
		0		80	



@ 40 ft: similar to above

LIGHT OLIVE BROWN WELL GRADED SAND (SW) (2.5Y 5/3)
medium dense, wet, 90% fine to coarse sand, 10% silt

@ 50 ft: similar to above

@ 55 ft: similar to above

@ 60 ft: similar to above

@ 65 ft: similar to above

@ 70 ft: similar to above

@ 75 ft: similar to above, decrease in coarse sand

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Fort Ord, California

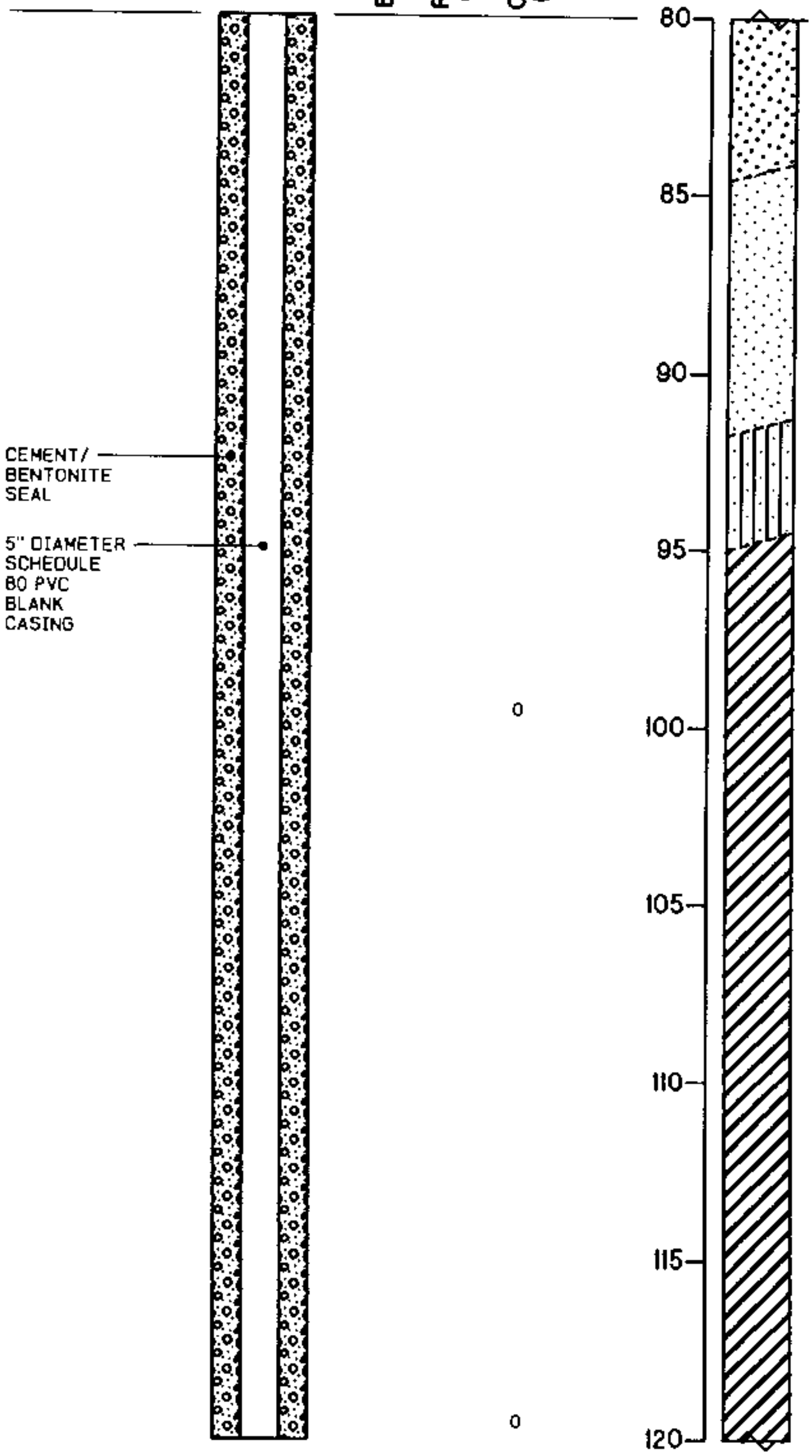
PLATE 1-5

DRAWN	JOB NUMBER	APPROVED	DATE	REVISED DATE
PCB	42481 00123		3/99	

Blows/foot | Recovery (inches) | OVA Reading (ppm) | Sample Number | Depth (ft.) | Sample

Equipment Speedstar Mud Rotary
11 3/4"-diameter

Elevation 140.30 ft. GS Date 02-12-99



@ 80 ft: similar to above

LIGHT OLIVE BROWN POORLY GRADED SAND (SP) (2.5Y 5/3)
medium dense, wet, 90% fine to medium sand, 10% silt

@ 90 ft: similar to above

LIGHT OLIVE BROWN SILTY SAND (SM) (2.5Y 5/3)
medium dense, wet, 60% fine to medium sand, 40% silt

PALE OLIVE SANDY FAT CLAY (CH) (5Y 6/3)
firm, moist, 60% clay, 40% fine sand

@ 97 ft: color change to olive (5Y 5/3), 80% clay, 20% fine sand

@ 100 ft: color change to dark greenish gray (5BG 4/1)

@ 105 ft: similar to above, decrease in fine sand to 10%, trace coarse sand

@ 110 ft: similar to above

@ 115 ft: similar to above, 90% clay, 10% fine sand

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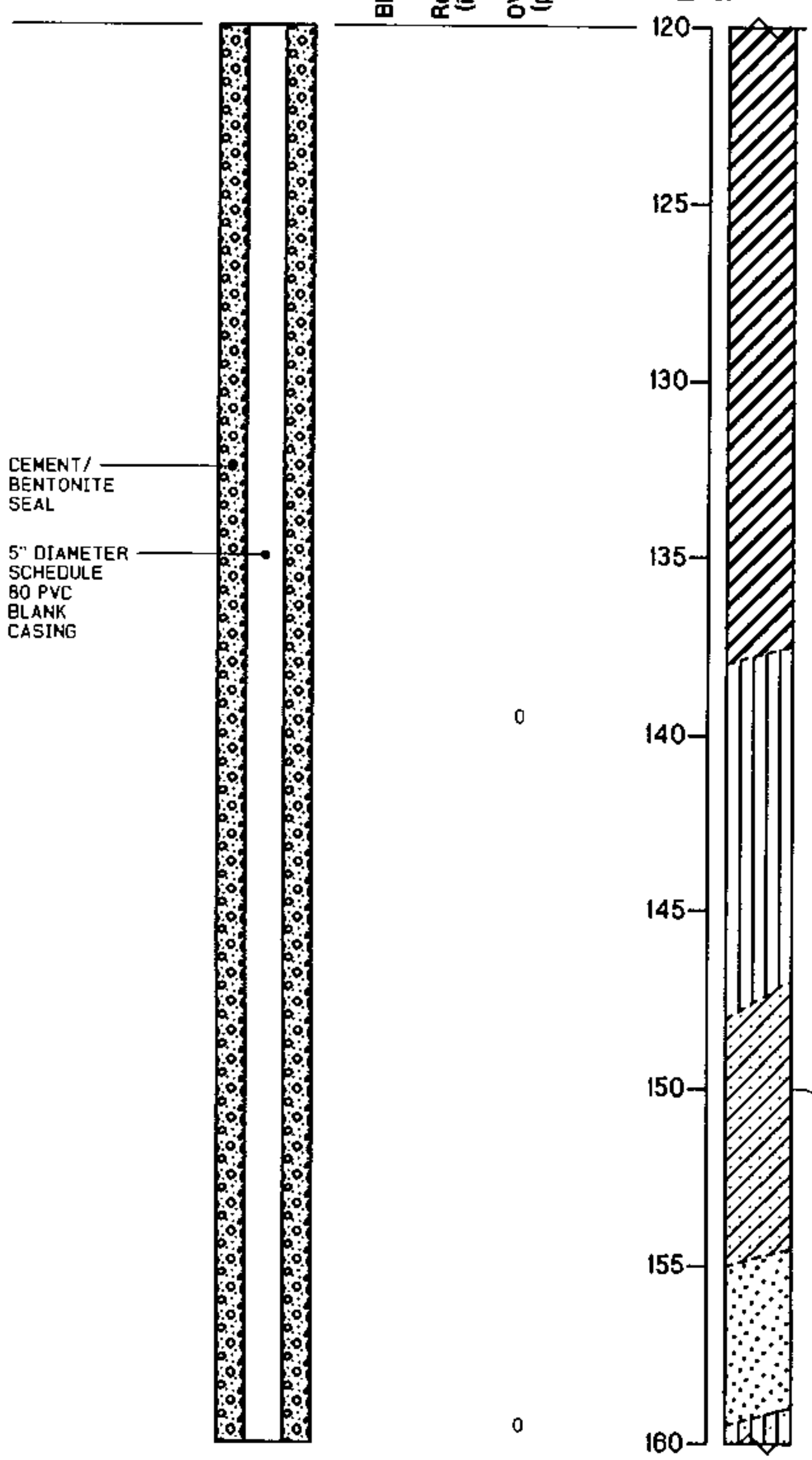
DRAWN	JOB NUMBER	APPROVED	DATE	REVISED DATE
PCB	42481 00123		3/99	

Equipment Speedstar Mud Rotary
11 3/4"-diameter

Elevation 140.30 ft. GS   Date 02-12-99

Blows/foot	Recovery (inches)	OVA Reading (ppm)	Sample Number	Depth (ft.)	Sample



@ 120 ft: similar to above, decrease in sand to 5%

@ 125 ft: color change to olive (5Y 5/3), increase in sand to 10%

@ 130 ft: similar to above

@ 135 ft: similar to above, 80% clay, 20% fine sand

@ 138 ft: Driller notes: drill rods take off, loose drilling
LIGHT OLIVE BROWN SILT (ML) (2.5Y 5/3)
firm, moist, 80% silt, 20% fine sand

@ 145 ft: similar to above

LIGHT OLIVE BROWN CLAYEY SAND (SC) (2.5Y 5/3)
dense, wet, 70% fine to coarse sand, 30% clay

@ 150 ft: similar to above

@ 152 ft: clay decreases to 15%

LIGHT OLIVE BROWN WELL GRADED SAND (SW) (2.5Y 5/3)
dense, wet, 90% fine to coarse sand, 10% silt
Note: lenses of silt and sand from 155 to 160 ft.

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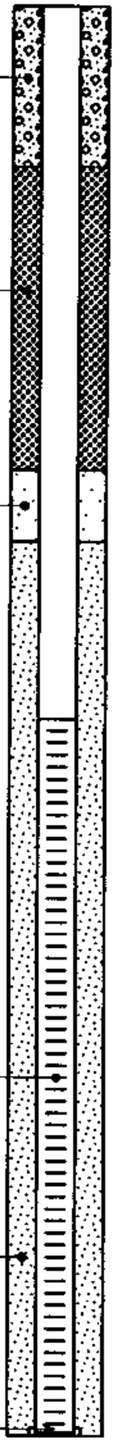
PLATE **1-5**

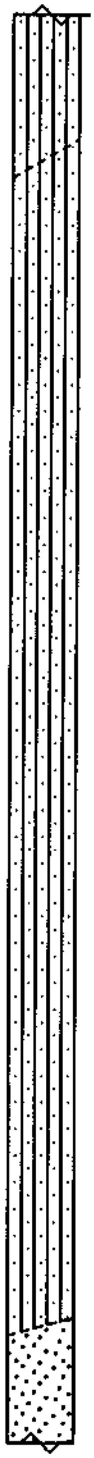
DRAWN	JOB NUMBER	APPROVED	DATE	REVISED DATE
PCB	42481 00123		3/99	

Equipment Speedstar Mud Rotary
11 3/4"-diameter

Elevation 140.30 ft. GS   Date 02-12-99

Blows/foot	Recovery (inches)	OVA Reading (ppm)	Sample Number	Depth (ft.)	Sample
				160	
				165	
				170	
				175	
		0		180	
				185	
				190	
				195	
		0		200	





LIGHT OLIVE BROWN SILTY SAND (SM) (2.5Y 5/3) dense, wet, 65% fine to coarse sand, 35% silt

@ 165 ft: similar to above, decrease in silt to 15%

@ 170 ft: similar to above

@ 175 ft: similar to above, 80% fine to coarse sand, 20% silt, trace gravel

@ 180 ft: similar to above

@ 185 ft: similar to above, increase in silt to 30%

@ 190 ft: similar to above

@ 195 ft: similar to above

@ 197 ft: increase in clay and silt, interbedded clay, silt and sand between 197 and 205 ft.

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PLATE 1-5

DRAWN	JOB NUMBER	APPROVED	DATE	REVISED DATE
PCB	42481 00123		3/99	

Equipment Speedstar Mud Rotary
11 3/4"-diameter
Elevation 140.30 ft. GS Date 02-12-99

Blows/foot	Recovery (inches)	OVA Reading (ppm)	Sample Number	Depth (ft.)	Sample	Description
				200		@ 200 ft: similar to above
						@ 203 ft: similar to above, increase in sand to 35%
				205		LIGHT OLIVE BROWN CLAYEY SAND (SC) (2.5Y 5/3) dense, wet, 60% fine to coarse sand, 30% fat clay, 10% silt
				210		@ 210 ft: similar to above, 75% fine to coarse sand, 25% silt
						@ 212 ft: 80% fine to coarse sand, 20% fat clay *Bottom of boring at 212 ft.* backfilled with #2/10 sand to 208 ft, bentonite pellets to 204 ft.
				215		
		0		220		
				225		
				230		
				235		
		0		240		

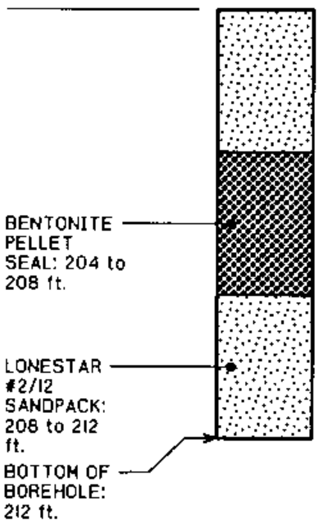

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PLATE 1-5

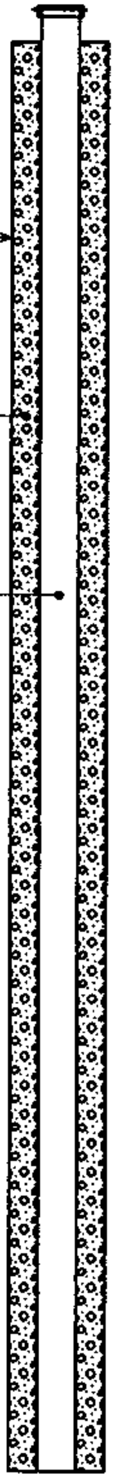
DRAWN	JOB NUMBER	APPROVED	DATE	REVISED DATE
PCB	42481 00123		3/99	

Top of PVC Casing
Elev. 144.27

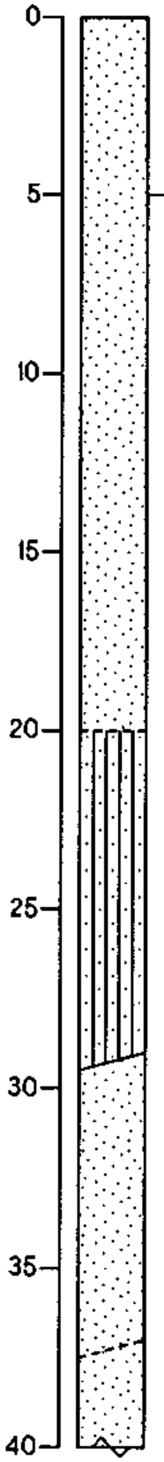
Blows/foot	Recovery (inches)	OVM Reading (ppm)	Sample Number	Depth (ft.)	Sample

Equipment Speedstar SS-15 THH
10"-diameter
Elevation 142.30 ft. GS Date 02-03-99

GROUND SURFACE



OVM Reading (ppm): 0 (at approx. 24 ft), 0 (at approx. 29.5 ft), 0 (at approx. 34.5 ft), 0 (at approx. 39.5 ft)



DARK YELLOWISH BROWN POORLY GRADED SAND (SP)
(10YR 4/4) loose, moist, 95% fine sand, 5% silt

@ 4 ft: color change to 10YR 3/4, 5-10% silt

@ 5 ft: color change to dark yellowish brown (10YR 4/6), 5% silt

@ 7 ft: change to 5-10% silt/fines, trace moist nodules

@ 12 ft: similar to above without nodules

YELLOWISH BROWN SILTY SAND (SM)
(10YR 5/6) medium dense, 80% fine sand, 20% silt

LIGHT YELLOWISH BROWN POORLY GRADED SAND (SP)
(10YR 6/4) medium dense, 90% fine to very fine sand, 10% silt

YELLOWISH BROWN POORLY GRADED SAND (SP)
(10YR 5/6) loose, 95% fine sand, 5% silt

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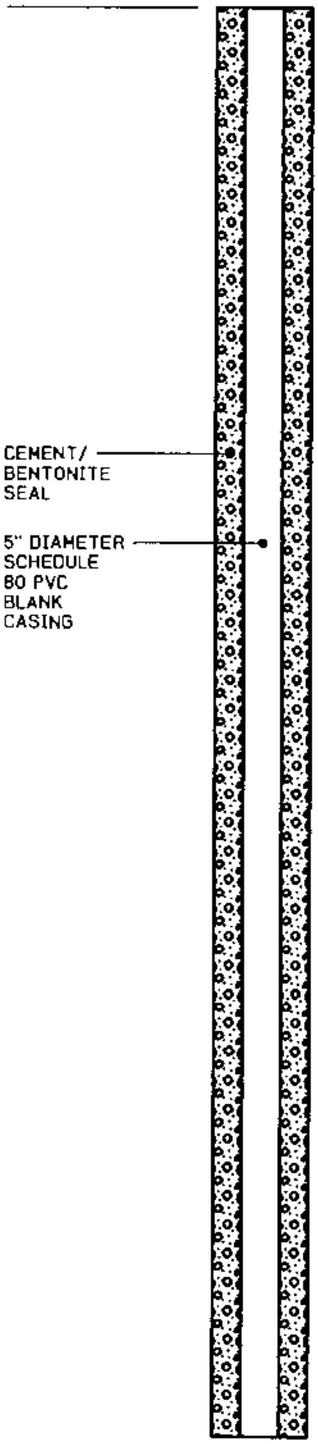
DRAWN	JOB NUMBER	APPROVED	DATE	REVISED DATE
PCB	42481 00123		3/99	

Equipment Speedstar SS-15 THH
10"-diameter

Elevation 142.30 ft. GS Date 02-03-99



Blows/foot	Recovery (inches)	OVM Reading (ppm)	Sample Number	Depth (ft.)	Sample	Description
				40		
		0		45		@ 45 ft: similar to above
		0		50		@ 50 ft: similar to above
						YELLOWISH BROWN POORLY GRADED SAND (SP) (10YR 5/6) medium dense, 90% fine sand, 10% silt
		0		55		
						@ 58 ft: color change to yellowish brown (10YR 5/4)
		0		60		
						@ 64 ft: similar to above
				65		
						YELLOWISH BROWN POORLY GRADED SAND (SP) (10YR 5/6) medium dense, 90% very fine to fine sand, 10% silt
		0				
		0		70		
		0		75		
		0		80		

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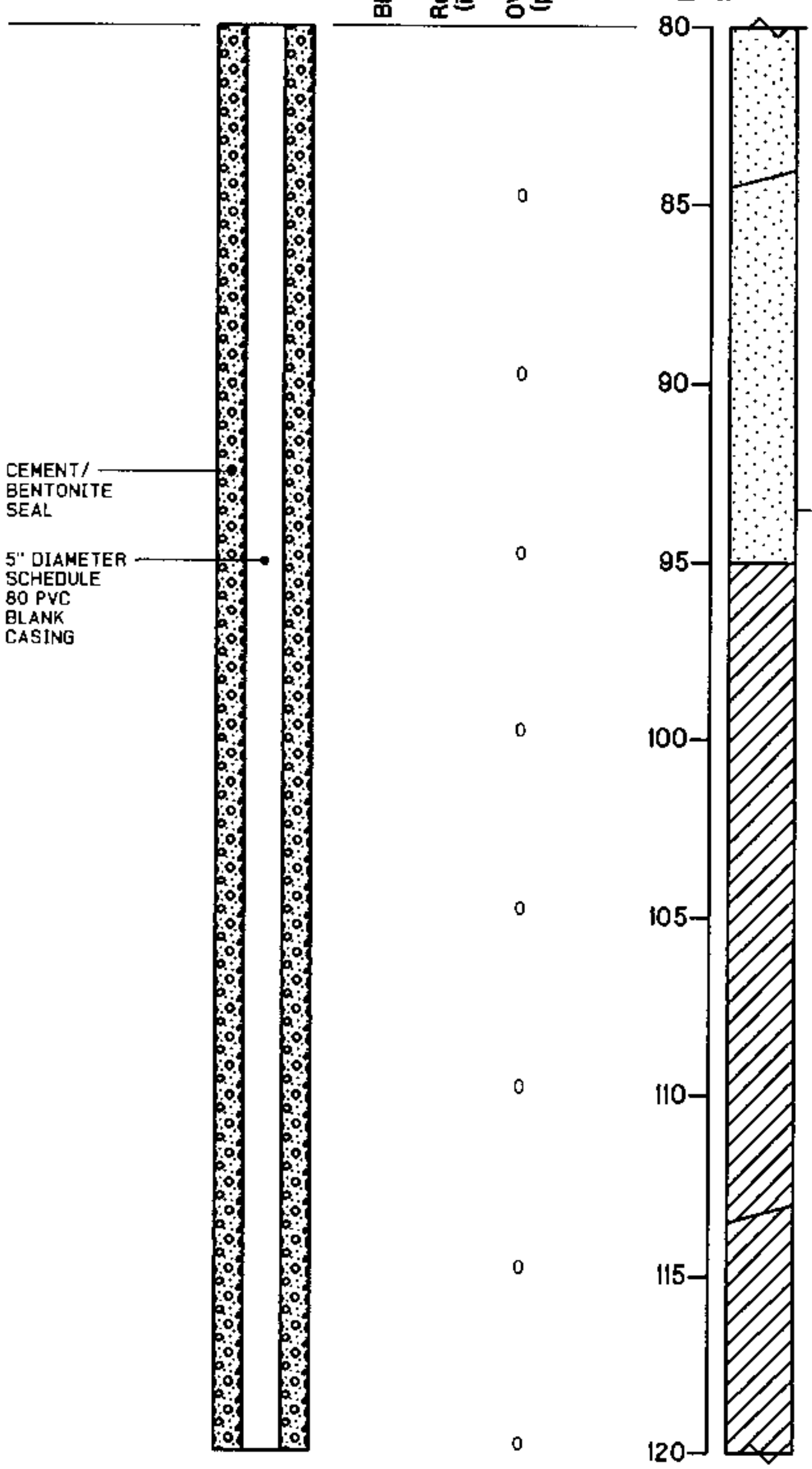
PLATE **1-7**

DRAWN	JOB NUMBER	APPROVED	DATE	REVISED DATE
PCB	42481 00123		3/99	

Equipment Speedstar SS-15 THH
10"-diameter
Elevation 142.30 ft. GS   Date 02-03-99



Blows/foot	Recovery (inches)	OVM Reading (ppm)	Sample Number	Depth (ft.)	Sample	Description
				80		@ 80 ft: color change to light olive brown (2.5Y 5/4)
		0		85		@ 85 ft: color change to dark yellowish brown (10YR 4/6)
		0		90		
						@ 92 ft: similar to above, iron oxide mottle throughout
						YELLOWISH BROWN POORLY GRADED SAND (SP) (10YR 5/4) medium dense, 90% fine to medium sand, 10% silt
		0		95		GRAYISH BROWN LEAN CLAY (CL) (2.5Y 5/2) firm to hard, dry to moist, 80-90% clay, 10-20% silt, dry white nodules near top of unit, calcareous
		0		100		
		0		105		
		0		110		
		0		115		@ 115 ft: color change to dark greenish gray (5G 4/1)
		0		120		

FTO

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OU 2 Plume Delineation
Investigation Report
Fort Ord, California

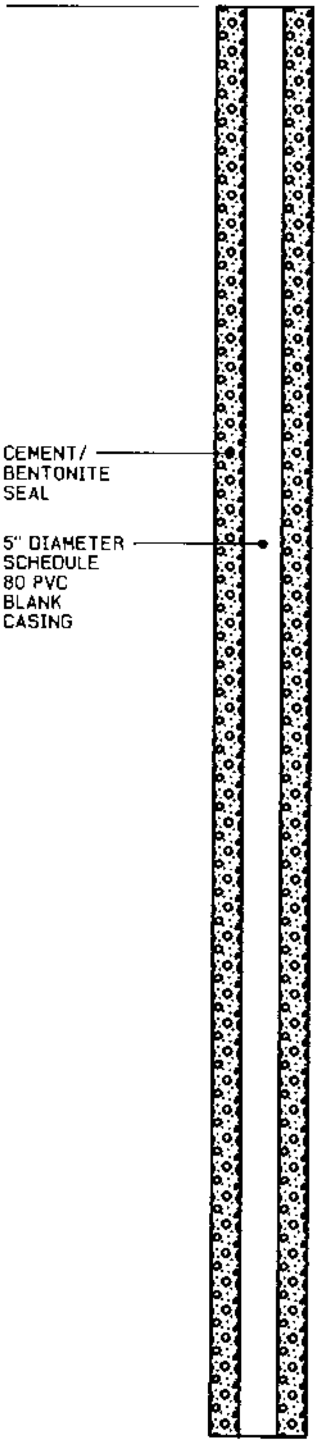
PLATE **1-7**

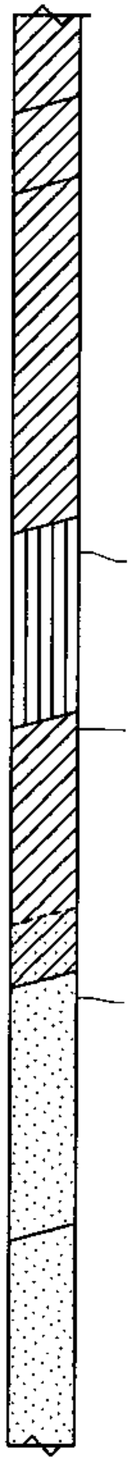
DRAWN	JOB NUMBER	APPROVED	DATE	REVISED DATE
PCB	42481 00123		3/99	

Equipment Speedstar SS-15 THH
10"-diameter

Elevation 142.30 ft. GS   Date 02-03-99

Blows/foot	Recovery (inches)	OVM Reading (ppm)	Sample Number	Depth (ft.)	Sample
				120	
		0		125	
		0		130	
		0		135	
		0		140	
		0		145	
		0		150	
		0		155	
		0		160	





@ 120 ft: color change to olive gray (5Y 5/2) mottled color associated with siltier clay

@ 123 ft: color change to dark greenish gray (5G 4/1)

@ 127 ft: color change to olive brown (2.5Y 4/3)

OLIVE SILTY LEAN CLAY (CL)
(5Y 5/3) firm, 70% clay, 30% silt with dry white calcitic nodules

OLIVE BROWN SILT (ML)
(2.5Y 4/3) firm, 80% silt, 20% clay

@ 139 ft: similar to above

LIGHT OLIVE BROWN LEAN CLAY (CL)
(2.5Y 5/3) hard, 90% clay, 10% silt
Geologist Notes: color variation throughout. Iron oxide mottle around relict grains. 3" thick greenish gray stripe, compressional sedimentary features.

LIGHT YELLOWISH BROWN CLAYEY SAND (SC)
(10YR 6/3) medium dense, 60% sand, 40% clay

YELLOWISH BROWN POORLY GRADED SAND (SP)
(10YR 5/6) medium dense, 90% medium sand, 10% silt

BROWNISH YELLOW POORLY GRADED SAND (SP)
(10YR 6/6) medium dense, 95% fine to medium sand, 5% fines

@ 155 ft: color change to brown (10YR 5/3)

@ 159 ft: similar to above

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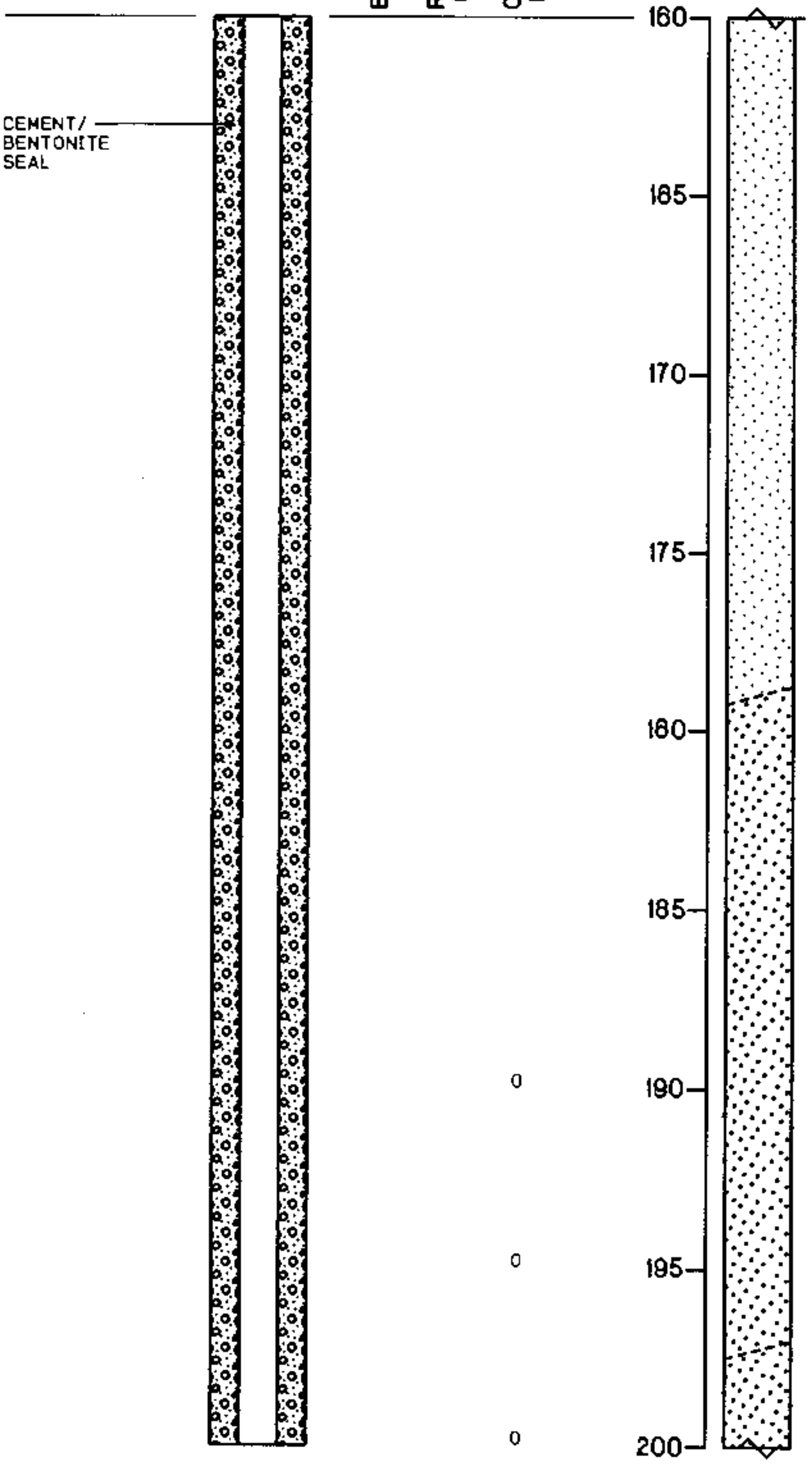
Investigation Report
Fort Ord, California

PLATE **1-7**

DRAWN	JOB NUMBER	APPROVED	DATE	REVISED DATE
PCB	42481 00123		3/99	

Blows/foot	Recovery (inches)	OVM Reading (ppm)	Sample Number	Depth (ft.)	Sample

Equipment Speedstar SS-15 THH
10"-diameter
Elevation 142.30 ft. GS Date 02-03-99



@ 164 ft: no recovery, cuttings similar to above (>80% sand, <20% fines)

@ 169 ft: no recovery, similar to above

@ 174 ft: no recovery

@ 179 ft: coarser cuttings, no recovery

@ 184 ft: no recovery

@ 189 ft: limited recovery
LIGHT YELLOWISH BROWN WELL GRADED SAND WITH GRAVEL (SW)
(10YR 6/4) medium dense, 100% sand, ~15% of grains blue shale - highly weathered

@ 194 ft: similar to above

@ 197 ft: 80% sand (tan, iron oxide shale), 20% silty clay, (from cuttings only)

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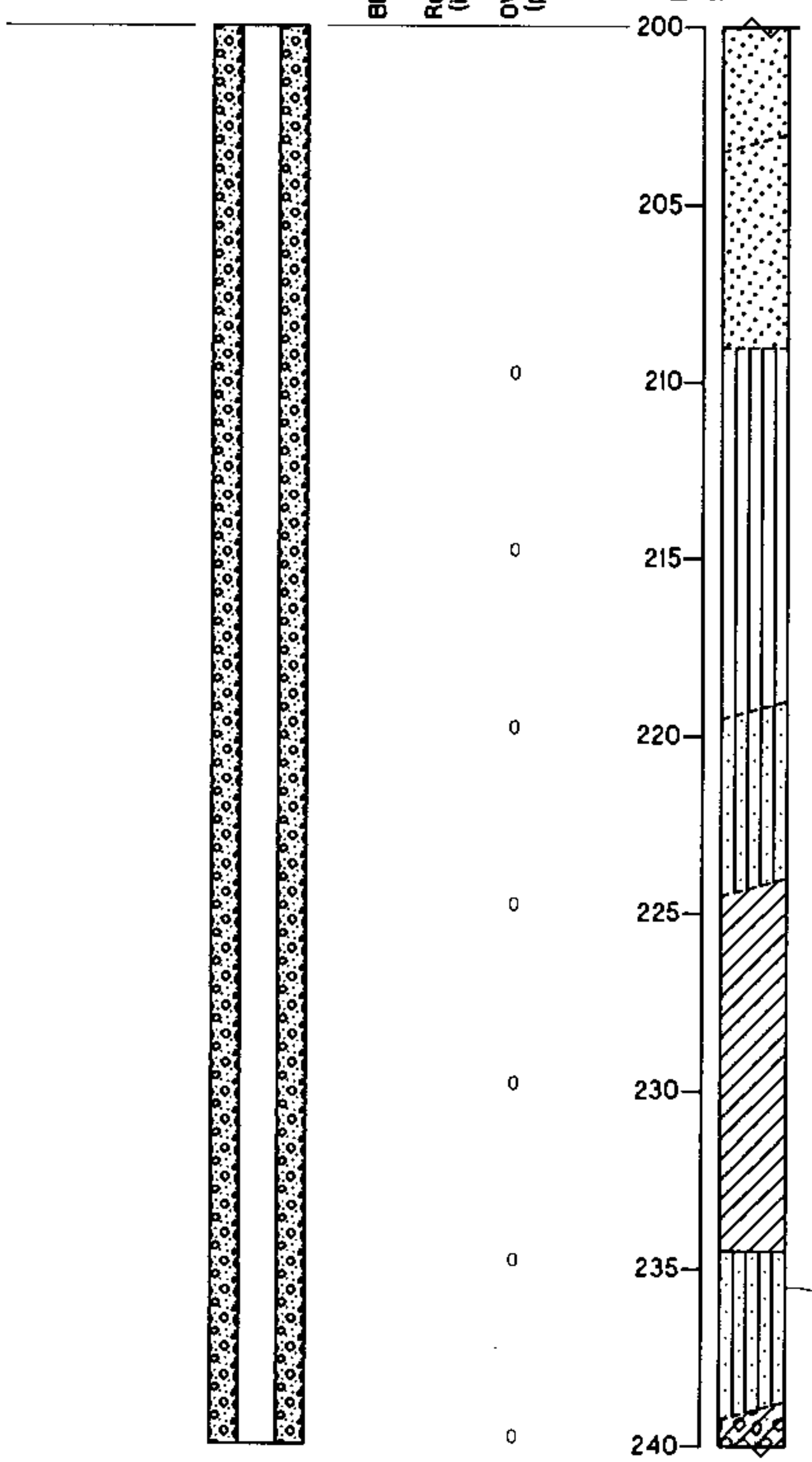
PLATE
1-7

DRAWN	JOB NUMBER	APPROVED	DATE	REVISED DATE
PCB	42481 00123		3/99	

Blows/foot	Recovery (inches)	OVM Reading (ppm)	Sample Number	Depth (ft.)	Sample

Equipment Speedstar SS-15 THH 10"-diameter

Elevation 142.30 ft. GS **Date** 02-03-99



DARK BROWN WELL GRADED SAND (SW)
(7.5YR 4/4) medium dense, 95% sand, 5% silt

@ 204 ft: no recovery, cuttings are light yellowish brown well graded sand (SW) (10YR 6/4) 90% sand, 10% gravel, fines fraction unknown. Some material (20-30% shale) weathered to clay consistency.

BROWN SILT (ML)
(10YR 5/3) firm, 90% silt, 10% sand, mica rich

LIGHT OLIVE BROWN SILT (ML)
(2.5Y 5/3) firm, 90% silt, 10% very fine sand

LIGHT OLIVE BROWN SILTY SAND (SM)
(2.5Y 5/3) firm, 60% fine sand, 30% silt, 10% gravel

LIGHT OLIVE BROWN LEAN CLAY WITH SAND (CL)
(2.5Y 5/6) hard, 80% clay, 20% sand

LIGHT OLIVE BROWN SANDY LEAN CLAY (CL)
(2.5Y 5/3) hard, 50% clay, 30% sand, 20% silt

Variable drill rate. Laminations of fines within coarser unit

LIGHT YELLOWISH BROWN (CLAYEY) SILT (ML)
(2.5Y 6/3) very firm, 70% silt, 30% clay

LIGHT YELLOWISH BROWN SILTY SAND (SM)
(2.5Y 6/3) dense, 70% sand, 20% silt, 10% gravel

LIGHT YELLOWISH BROWN CLAYEY GRAVEL WITH SAND (GC)
(2.5Y 6/3) dense, 40% gravel, 30% sand, 30% clay

FTO

Harding Lawson Associates
Engineering and Environmental Services

Log of Boring and Well Completion MW-OU2-68-180
OU 2 Plume Delineation Investigation Report
Fort Ord, California

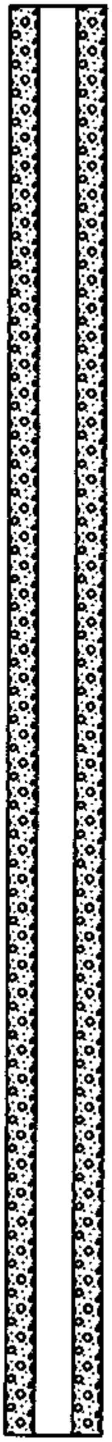
PLATE **1-7**

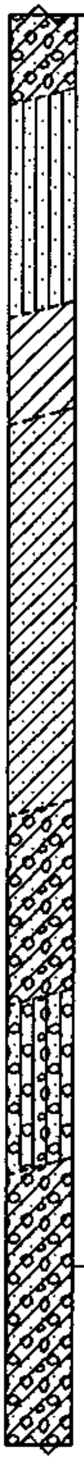
DRAWN	JOB NUMBER	APPROVED	DATE	REVISED DATE
PCB	42481 00123		3/99	

Equipment Speedstar SS-15 THH
10"-diameter

Elevation 142.30 ft. GS   Date 02-03-99

Blows/foot	Recovery (inches)	OVM Reading (ppm)	Sample Number	Depth (ft.)	Sample
				240	
		0		245	
		0		250	
				255	
		0		260	
		0		265	
		0		270	
		0		275	
				280	





LIGHT YELLOWISH BROWN SILTY SAND WITH GRAVEL (SM)
(2.5Y 6/3) dense, 50% sand, 30% gravel, 20% silt

LIGHT YELLOWISH BROWN SANDY LEAN CLAY (CL)
(2.5Y 6/3) hard, 70% clay, 30% sand

@ 254 ft: no recovery (rock in shoe), cuttings are light yellowish brown clayey sand, (SC) (2.5Y 6/3) 80% well graded sand, 20% clay

LIGHT YELLOWISH BROWN CLAYEY SAND WITH GRAVEL (SC)
(2.5Y 6/3) 50% sand, 30% gravel, 20% clay

LIGHT YELLOWISH BROWN CLAYEY GRAVEL (GC)
(2.5Y 6/3) dense, 60-70% gravel, 20-30% clay, 10% sand, (rocks with clay matrix)

LIGHT YELLOWISH BROWN SILTY GRAVEL (GM)
(2.5Y 6/3) dense, 60% gravel, 20% sand, 20% silt, (rocks with silt matrix)
diatomaceous nodules to 1.5 inches long

LIGHT OLIVE BROWN CLAYEY GRAVEL WITH SAND (GC)
(2.5Y 5/3) dense, 50% gravel, 30% clay, 20% sand

@ 275 ft: drill chatters in coarser material

@ 279 ft: no recovery

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Harding Lawson Associates
Engineering and Environmental Services

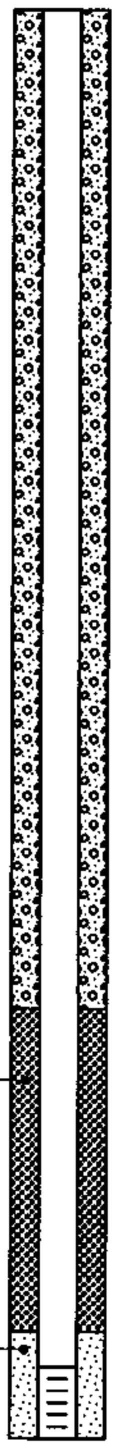
Log of Boring and Well Completion MW-OU2-66-180
OU 2 Plume Delineation
Investigation Report
Fort Ord, California

PLATE **1-7**

DRAWN	JOB NUMBER	APPROVED	DATE	REVISED DATE
PCB	42481 00123		3/99	

Equipment Speedstar SS-15 THH
10"-diameter

Elevation 142.30 ft. GS Date 02-03-99



BENTONITE PELLET SEAL: 308 to 317 ft.

LONESTAR #2/12 SANDPACK: 317 to 339.5 ft.

Blows/foot	Recovery (inches)	OVM Reading (ppm)	Sample Number	Depth (ft.)	Sample	Description
				280		cuttings: ~70% gray sand, ~30% blue clay
		0		285		@ 284 ft: similar to above
						cuttings: LIGHT YELLOWISH BROWN CLAYEY SAND WITH GRAVEL (GC) (2.5Y 6/3) dense, 60% sand, 20% clay, 20% gravel
				290		@ 289 ft: no recovery
		0		295		LIGHT YELLOWISH BROWN CLAYEY GRAVEL (GC) (2.5Y 6/3) dense, 50% gravel, 40% clay, 10% sand
		0		300		cuttings: LIGHT YELLOWISH BROWN CLAYEY GRAVEL WITH SAND (GC) (2.5Y 6/3) 50% gravel, 30% sand, 20% clay
		0		305		cuttings: LIGHT YELLOWISH BROWN CLAYEY SAND WITH GRAVEL (GC) (2.5Y 6/3) 50% sand, 30% gravel, 20% clay
		0		310		cuttings: LIGHT YELLOWISH BROWN CLAYEY GRAVEL WITH SAND (GC) (2.5Y 6/3) dense, 50% gravel, 30% clay, 20% sand
		0		315		cuttings: LIGHT YELLOWISH BROWN CLAYEY SAND WITH GRAVEL (SC) (2.5Y 6/3) dense, 50% sand, 30% gravel, 20% clay
		0		320		cuttings: multi-colored well graded gravel with sand (GW) dense, 60-70% gravel, 20-30% sand, 10% fines

FTO

Harding Lawson Associates
Engineering and Environmental Services

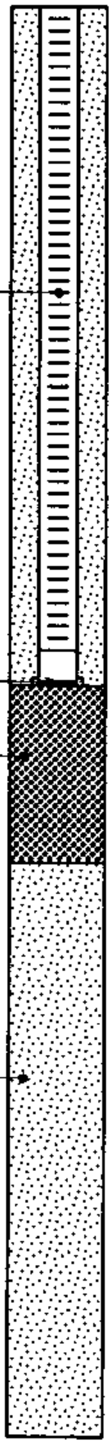
Log of Boring and Well Completion MW-OU2-66-180
OU 2 Plume Delineation
Investigation Report
Fort Ord, California

PLATE **1-7**

DRAWN	JOB NUMBER	APPROVED	DATE	REVISED DATE
PCB	42481 00123		3/99	

Equipment Speedstar SS-15 THH
10"-diameter
Elevation 142.30 ft. GS Date 02-03-99

Blows/foot	Recovery (inches)	OVM Reading (ppm)	Sample Number	Depth (ft.)	Sample
				320	
		0		325	
		0		330	
		0		335	
		0		340	
		0		345	
		0		350	
		0		355	
		0		360	



cuttings: LIGHT YELLOWISH BROWN SILTY SAND WITH GRAVEL (SM)
(2.5Y 6/3) dense, 50% sand, 30% silt, 20% gravel

cuttings: LIGHT YELLOWISH BROWN CLAYEY GRAVEL WITH SAND (GC)
(2.5Y 6/3) 60% gravel, 20% clay, 20% sand

cuttings: LIGHT YELLOWISH BROWN LEAN CLAY (CL)
(10YR 6/4) firm, 60% clay, 40% sand

cuttings: LIGHT YELLOWISH BROWN CLAYEY SAND (SC)
(10YR 6/4) dense, 60% sand, 40% clay

cuttings: LIGHT YELLOWISH BROWN SILTY SAND WITH GRAVEL (SM)
(2.5Y 6/3) dense, 60% sand, 20% silt, 20% gravel

@ 352 ft: similar to above, siltier with depth

@ 356 ft: change to 40% sand, 40% silt, 20% gravel

Bottom of boring at 360 ft.
Continuously cored with 60" tool.

FTO

Harding Lawson Associates
Engineering and Environmental Services

Log of Boring and Well Completion MW-OU2-66-180
OU 2 Plume Delineation
Investigation Report
Fort Ord, California

PLATE **1-7**

DRAWN	JOB NUMBER	APPROVED	DATE	REVISED DATE
PCB	42481 00123		3/99	

ATTACHMENT E

Design Specifications

SECTION 01 33 00: SUBMITTAL PROCEDURES
08/18, CHG 4: 02/21

PART 1 GENERAL

1.1 SUMMARY

1.1.1 Submittal Information

Each submittal is to be complete and in sufficient detail to allow ready determination of compliance with contract requirements.

Units of weights and measures used on all submittals are to be the same as those used in the contract drawings.

1.1.2 Project Type

The Subcontractor/Supplier is to check and approve all items before submittal and stamp, sign, and date indicating action taken. Proposed deviations from the contract requirements are to be clearly identified. Include within submittals items such as: Subcontractor's, manufacturer's, or fabricator's drawings; descriptive literature including (but not limited to) catalog cuts, diagrams, operating charts or curves; test reports; test cylinders; samples; O&M manuals (including parts list); certifications; warranties; and other such required submittals.

1.1.3 Submission of Submittals

Schedule and provide submittals requiring approval before acquiring the material or equipment covered thereby. Pick up and dispose of samples not incorporated into the work in accordance with manufacturer's Safety Data Sheets (SDS) and in compliance with existing laws and regulations.

1.2 DEFINITIONS

1.2.1 Submittal Descriptions (SD)

Submittal requirements are specified in the technical sections. Examples and descriptions of submittals identified by the Submittal Description (SD) numbers and titles follow:

SD-01 Preconstruction Submittals

Submittals that are required prior to or commencing with the start of work on site. Submittals that are required prior to or at the start of construction (work) or the next major phase of the construction on a multiphase contract.

Preconstruction Submittals include schedules and a tabular list of locations, features, and other pertinent information regarding products, materials, equipment, or components to be used in the work.

Certificates Of Insurance

Surety Bonds

List Of Proposed Subcontractors

List Of Proposed Products

Baseline Network Analysis Schedule (NAS)

Submittal Register

Schedule Of Prices Or Earned Value Report

Accident Prevention Plan;

Quality Assurance Project Plan

Work Plan

Quality Control (QC) plan

Environmental Protection Plan

Permits

SD-02 Shop Drawings

Drawings, diagrams and schedules specifically prepared to illustrate some portion of the work.

Diagrams and instructions from a manufacturer or fabricator for use in producing the product and as aids to the Subcontractor for integrating the product or system into the project.

Drawings prepared by or for the Subcontractor to show how multiple systems and interdisciplinary work will be coordinated.

SD-03 Product Data

Catalog cuts, illustrations, schedules, diagrams, performance charts, instructions and brochures illustrating size, physical appearance and other characteristics of materials, systems or equipment for some portion of the work.

Samples of warranty language when the contract requires extended product warranties.

SD-04 Samples

Fabricated or unfabricated physical examples of materials, equipment or workmanship that illustrate functional and aesthetic characteristics of a material or product and establish standards by which the work can be judged.

Color samples from the manufacturer's standard line (or custom color samples if specified) to be used in selecting or approving colors for the project.

Field samples and mock-ups constructed on the project site establish standards ensuring work can be judged. Includes assemblies or portions of assemblies that are to be incorporated into the project and those that will be removed at conclusion of the work.

SD-06 Test Reports

Report signed by authorized official of testing laboratory that a material, product or system identical to the material, product or system to be provided has been tested in accord with specified requirements. Unless specified in another section, testing must have been within three years of date of contract award for the project.

Report that includes findings of a test required to be performed on an actual portion of the work or prototype prepared for the project before shipment to job site.

Report that includes finding of a test made at the job site or on sample taken from the job site, on portion of work during or after installation.

Investigation reports Daily logs and checklists

Final acceptance test and operational test procedure

SD-07 Certificates

Statements printed on the manufacturer's letterhead and signed by responsible officials of manufacturer of product, system or material attesting that the product, system, or material meets specification requirements. Must be dated after award of project contract and clearly name the project.

Document required of Subcontractor, or of a manufacturer, supplier, installer or Subcontractor through Contractor. The document purpose is to further promote the orderly progression of a portion of the work by documenting procedures, acceptability of methods, or personnel qualifications.

SD-08 Manufacturer's Instructions

Preprinted material describing installation of a product, system or material, including special notices and (SDS)concerning impedances, hazards and safety precautions.

SD-09 Manufacturer's Field Reports

Documentation of the testing and verification actions taken by manufacturer's representative at the job site, in the vicinity of the job site, or on a sample taken from the job site, on a portion of the work, during or after installation, to confirm compliance with manufacturer's standards or instructions. The documentation must be signed by an authorized official of a testing laboratory or agency and state the test results; and indicate whether the material, product, or system has passed or failed the test.

Factory test reports.

SD-10 Operation and Maintenance Data

Data provided by the manufacturer, or the system provider, including manufacturer's help and product line documentation, necessary to maintain and install equipment, for operating and maintenance use by facility personnel.

Data required by operating and maintenance personnel for the safe and efficient operation, maintenance and repair of the item.

Data incorporated in an operations and maintenance manual or control system.

SD-11 Closeout Submittals

Documentation to record compliance with technical or administrative requirements or to establish an administrative mechanism.

Special requirements necessary to properly close out a construction contract. For example, Record Drawings and as-built drawings. Also, submittal requirements necessary to properly close out a major phase of construction on a multi-phase contract.

1.2.2 Approving Authority

Office or designated person authorized to approve the submittal.

1.2.3 Work

As used in this section, on-site and off-site construction required by contract documents, including labor necessary to produce submittals, construction, materials, products, equipment, and systems incorporated or to be incorporated in such construction. In exception, excludes work to produce SD-01 submittals.

1.3 SUBMITTALS

Submittals are to be identified for Contractor Quality Control approval or for information only. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-01 Preconstruction Submittals Submittal Register

1.4 SUBMITTAL CLASSIFICATION

1.4.1 Government Approved (G)

Government approval is required for any variations from the Solicitation or the Accepted Proposal and for other items as designated by the Government.

Within the terms of the Contract Clause SPECIFICATIONS AND DRAWINGS FOR CONSTRUCTION, submittals are considered to be "shop drawings."

1.4.2 Design-Build Submittal Classifications

1.4.2.1.1 Variations from the Accepted Design

Designer of Record (DOR) approval is required for any proposed variation from the accepted design that still complies with the contract before the Subcontractor is authorized to proceed with material acquisition or installation. If necessary to facilitate the project schedule, before official submission to the Contractor/Buyer, the Subcontractor and the DOR may discuss with the Contractor/Buyer a submittal proposing a variation. However, the Contractor/Buyer reserves the right to review the submittal before providing an opinion. In any case, the Contractor/Buyer will not formally agree to or provide a preliminary opinion on any variation without the DOR's approval or recommended approval. The Contractor/Buyer reserves the right to reject any design, variation that may affect furniture, furnishings, equipment selections, or operational decisions that were made, based on the reviewed and concurred design.

1.4.2.1.2 Substitutions

Unless prohibited or otherwise provided for elsewhere in the contract, where the Accepted Proposal named products, systems, materials or equipment by manufacturer, brand name, model number, or other specific identification, and the Subcontractor desires to substitute a manufacturer or model after award, submit a requested substitution for Contractor/Buyer concurrence. Include substantiation, through identifying information and the DOR's approval, that the substitute meets the contract requirements and that it is equal in function, performance, quality, and salient features to that in the accepted contract proposal. If the contract otherwise prohibits substitutions of equal named products, systems, materials or equipment by manufacturer, brand name, model number or other specific identification, the request is considered a "variation" to the contract.

1.4.3 For Information Only

For Design-build construction all submittals not requiring DOR or Government approval will be for information only. Within the terms of the Contract Clause SPECIFICATIONS AND DRAWINGS FOR CONSTRUCTION, they are not considered to be "shop drawings."

1.4.4 O&M Data

Submit data specified for a given item within 30 calendar days after the item is delivered to the contract site.

1.6 PREPARATION

1.6.1 Transmittal Form

Use the ENG Form 4025-R transmittal form for submitting both Contractor/Buyer-approved and information-only submittals. Submit in accordance with the instructions on the reverse side of the form. Properly complete this form by filling out all the heading blank spaces and identifying each item submitted. Exercise special care to ensure proper listing of the specification paragraph and sheet number of the contract drawings pertinent to the data submitted for each item.

1.6.2 Identifying Submittals

Identify submittals, except sample installations and sample panels, with the following information permanently adhered to or noted on each separate component of each submittal and noted on transmittal form. Mark each copy of each submittal identically, with the following:

a. Project title and location

b. Construction contract number

c. Dates of the drawings and revisions

d. Name, address, and telephone number of Subcontractor, supplier, manufacturer, and any other Subcontractor associated with the submittal.

e. Section number of the specification by which submittal is required

f. Submittal description (SD) number of each component of submittal

g. For a resubmission, add alphabetic suffix on submittal description, for example, submittal 18 would become 18A, to indicate resubmission

h. Product identification and location in project.

1.6.3 Submittal Format

1.6.3.1 Format of SD-01 Preconstruction Submittals

When the submittal includes a document that is to be used in the project, or is to become part of the project record, other than as a submittal, do not apply the Subcontractor's approval stamp to the document itself, but to a separate sheet accompanying the document.

Provide data in the unit of measure used in the contract documents.

1.6.3.2 Format for SD-02 Shop Drawings

Provide shop drawings not less than 8 1/2 by 11 inches nor more than 30 by 42 inches, except for full-size patterns or templates. Prepare drawings to accurate size, with scale indicated, unless another form is required. Ensure drawings are suitable for reproduction and of a quality to produce clear, distinct lines and letters, with dark lines on a white background.

a. Include the nameplate data, size, and capacity on drawings. Also include applicable federal, military, industry, and technical society publication references.

b. Dimension drawings, except diagrams and schematic drawings. Prepare drawings demonstrating interface with other trades to scale. Use the same unit of measure for shop drawings as indicated on the contract drawings. Identify materials and products for work shown.

Present shop drawings sized 8 1/2 by 11 inches as part of the bound volume for submittals. Present larger drawings in sets. Submit an electronic copy of drawings in PDF format and native electronic format.

1.6.3.2.1 Drawing Identification

Include on each drawing the drawing title, number, date, and revision numbers and dates, in addition to information required in paragraph IDENTIFYING SUBMITTALS.

Number drawings in a logical sequence. Each drawing is to bear the number of the submittal in a uniform location next to the title block. Place the Contractor/Buyer contract number in the margin, immediately below the title block, for each drawing.

Reserve a blank space, no smaller than 3 inches on the right-hand side of each sheet for the Contractor/Buyer disposition stamp.

1.6.3.3 Format of SD-03 Product Data

Present product data submittals for each section as a complete, bound volume. Include a table of contents, listing the page and catalog item numbers for product data.

Indicate, by prominent notation, each product that is being submitted; indicate the specification section number and paragraph number to which it pertains.

1.6.3.3.1 Product Information

Supplement product data with material prepared for the project to satisfy the submittal requirements where product data does not exist. Identify this material as developed specifically for the project, with information and format as required for submission of SD-07 Certificates.

Provide product data in units used in the Contract documents. Where product data are included in preprinted catalogs with another unit, submit the dimensions in contract document units, on a separate sheet.

1.6.3.3.2 Standards

Where equipment or materials are specified to conform to industry or technical-society reference standards of such organizations as the American National Standards Institute (ANSI), ASTM International (ASTM), National Electrical Manufacturer's Association (NEMA), Underwriters Laboratories (UL), or Association of Edison Illuminating Companies (AEIC), submit proof of such compliance. The label or listing by the specified organization will be acceptable evidence of compliance. In lieu of the label or listing, submit a certificate from an independent testing organization, competent to perform testing, and approved by the Contractor/Buyer.
State on the certificate that the item has been tested in accordance with the specified organization's test methods and that the item complies with the specified organization's reference standard.

1.6.3.3.3 Data Submission

Collect required data submittals for each specific material, product, unit of work, or system into a single submittal that is marked for choices, options, and portions applicable to the submittal. Mark each copy of the product data identically. Partial submittals may be accepted for expedition of the construction effort.

Submit the manufacturer's instructions before installation.

1.6.3.4 Format of SD-04 Samples

1.6.3.4.1 Sample Characteristics

Furnish samples in the following sizes, unless otherwise specified or unless the manufacturer has prepackaged samples of approximately the same size as specified:

a. Sample of Equipment or Device: Full size.

b. Sample of Materials Less Than 2 by 3 inches: Built up to 8 1/2 by 11 inches.

c. Sample of Materials Exceeding 8 1/2 by 11 inches: Cut down to 8 1/2 by 11 inches and adequate to indicate color, texture, and material variations.

d. Sample of Linear Devices or Materials: 10-inch length or length to be supplied, if less than 10 inches. Examples of linear devices or materials are conduit and handrails.

1.6.3.4.2 Sample Incorporation

Reusable Samples: Incorporate returned samples into work only if so specified or indicated. Incorporated samples are to be in undamaged condition at the time of use.

Recording of Sample Installation: Note and preserve the notation of any area constituting a sample installation, but remove the notation at the final clean-up of the project.

1.6.3.5 Format of SD-05 Design Data

Provide design data and certificates on 8 1/2 by 11 inch paper. Provide a bound volume for submittals containing numerous pages.

1.6.3.6 Format of SD-06 Test Reports

Provide reports on 8 1/2 by 11 inch paper in a complete bound volume.

By prominent notation, indicate each report in the submittal. Indicate the specification number and paragraph number to which each report pertains.

1.6.3.7 Format of SD-07 Certificates

Provide design data and certificates on 8 1/2 by 11 inch paper. Provide a bound volume for submittals containing numerous pages.

1.6.3.8 Format of SD-08 Manufacturer's Instructions

Present manufacturer's instructions submittals for each section as a complete, bound volume. Include the manufacturer's name, trade name, place of manufacture, and catalog model or number on product data. Also include applicable federal, military, industry, and technical-society publication references. If supplemental information is needed to clarify the manufacturer's data, submit it as specified for SD-07 Certificates.

Submit the manufacturer's instructions before installation.

1.6.3.8.1 Standards

Where equipment or materials are specified to conform to industry or technical-society reference standards of such organizations as the American National Standards Institute (ANSI), ASTM International (ASTM), National Electrical Manufacturer's Association (NEMA), Underwriters Laboratories (UL), or Association of Edison Illuminating Companies (AEIC),

submit proof of such compliance. The label or listing by the specified organization will be acceptable evidence of compliance. In lieu of the label or listing, submit a certificate from an independent testing organization, competent to perform testing, and approved by the Contractor/Buyer.
State on the certificate that the item has been tested in accordance with the specified organization's test methods and that the item complies with the specified organization's reference standard.

1.6.3.9 Format of SD-09 Manufacturer's Field Reports

Provide reports on 8 1/2 by 11 inch paper in a complete bound volume.

By prominent notation, indicate each report in the submittal. Indicate the specification number and paragraph number to which each report pertains.

1.6.3.10 Format of SD-11 Closeout Submittals

When the submittal includes a document that is to be used in the project or is to become part of the project record, other than as a submittal, do not apply the Subcontractor's approval stamp to the document itself, but to a separate sheet accompanying the document.

Provide data in the unit of measure used in the contract documents.

1.6.4 Source Drawings for Shop Drawings

1.6.4.1 Source Drawings

The entire set of source drawing files (DWG) will not be provided to the Subcontractor. Request the specific Drawing Number for the preparation of shop drawings. Only those drawings requested to prepare shop drawings will be provided. These drawings are provided only after award.

1.6.4.2 Terms and Conditions

Data contained on these electronic files must not be used for any purpose other than as a convenience in the preparation of construction data for the referenced project. Any other use or reuse is at the sole risk of the Subcontractor and without liability or legal exposure to the Contractor/Buyer. The Subcontractor must make no claim, and waives to the fullest extent permitted by law any claim or cause of action of any nature against the Contractor/Buyer, its agents, or its subconsultants that may arise out of or in connection with the use of these electronic files. The Subcontractor must, to the fullest extent permitted by law, indemnify and hold the Contractor/Buyer harmless against all damages, liabilities, or costs, including reasonable attorney's fees and defense costs, arising out of or resulting from the use of these electronic files.

These electronic source drawing files are not construction documents. Differences may exist between the source drawing files and the corresponding construction documents. The Contractor/Buyer makes no representation regarding the accuracy or completeness of the electronic source drawing files, nor does it make representation to the compatibility of these files with the Subcontractor hardware or software. The Subcontractor is responsible for determining if any conflict exists. In the event that a conflict arises between the signed and sealed construction documents prepared by the Contractor/Buyer and the furnished source drawing files, the signed and sealed construction documents govern.

Use of these source drawing files does not relieve the Subcontractor of the duty to fully comply with the contract documents, including and without limitation the need to check, confirm and coordinate the work of all contractors for the project. If the Subcontractor uses, duplicates or modifies these electronic source drawing files for use in producing construction data related to this contract, remove all previous indication of ownership (seals, logos, signatures, initials and dates).

1.6.5 Electronic File Format

Provide submittals in electronic format, with the exception of material samples required for SD-04 Samples items. Compile the submittal file as a single, complete document, to include the Transmittal Form described within, and also separately attach the native files which were used to create PDF. The attached files should include the original digital files used to create the submittal. Name the electronic submittal file specifically according to its contents, and coordinate the file naming convention with the Contractor/Buyer. Electronic files must be of sufficient quality that all information is legible. Use PDF as the electronic format, unless otherwise specified or directed by the Contractor/Buyer. Generate PDF files from original documents with bookmarks so that the text included in the PDF file is searchable and can be copied. If documents are scanned, optical character resolution (OCR) routines are required. Index and bookmark files exceeding 30 pages to allow efficient navigation of the file. When required, the electronic file must include a valid electronic signature or a scan of a signature.

E-mail electronic submittal documents smaller than 10MB to an e-mail address as directed by the Contractor/Buyer. Provide electronic documents over 10 MB on an optical disc or through an electronic file sharing system.

1.7 QUANTITY OF SUBMITTALS

1.7.1 Number of SD-01 Preconstruction Submittal Copies

Unless otherwise specified, submit two sets of administrative submittals.

1.7.2 Number of SD-02 Shop Drawing Copies

Submit two copies of submittals of shop drawings requiring review and approval by a QC organization. Submit two copies of shop drawings requiring review and approval by the Contractor/Buyer.

1.7.3 Number of SD-03 Product Data Copies

Submit in compliance with quantity requirements specified for shop drawings.

1.7.4 Number of SD-04 Samples

Submit two samples, or two sets of samples showing the range of variation, of each required item. One approved sample or set of samples will be retained by the approving authority and one will be returned to the Subcontractor/Supplier.

1.7.5 Number of SD-05 Design Data Copies

Submit in compliance with quantity requirements specified for shop drawings.

1.7.6 Number of SD-06 Test Report Copies

Submit in compliance with quantity and quality requirements specified for shop drawings, other than field test results that will be submitted with QC reports.

1.7.7 Number of SD-07 Certificate Copies

Submit in compliance with quantity requirements specified for shop drawings.

1.7.8 Number of SD-08 Manufacturer's Instructions Copies

Submit in compliance with quantity requirements specified for shop drawings.

1.7.9 Number of SD-09 Manufacturer's Field Report Copies

Submit in compliance with quantity and quality requirements specified for shop drawings other than field test results that will be submitted with QC reports.

1.7.10 Number of SD-10 Operation and Maintenance Data Copies

Submit two copies of O&M data to the Contractor/Buyer for review and approval.

1.7.11 Number of SD-11 Closeout Submittals Copies

Unless otherwise specified, submit two sets of administrative submittals.

1.8 INFORMATION ONLY SUBMITTALS

Provide information-only submittals to the Contractor/Buyer a minimum of 14 calendar days prior to the Preparatory Meeting for the associated Definable Feature of Work (DFOW). Normally, submittals for information only will not be returned. However, the Contractor/Buyer reserves the right to return unsatisfactory submittals and require the Subcontractor to resubmit any item found not to comply with the contract. This does not relieve the Subcontractor from the obligation to furnish material conforming to the plans and specifications; will not prevent the Contractor/Buyer from requiring removal and replacement of nonconforming material incorporated in the work; and does not relieve the Subcontractor/Supplier of the requirement to furnish samples for testing by the Contractor/Buyer laboratory or for check testing by the Contractor/Buyer in those instances where the technical specifications so prescribe.

1.8.1 Submittal Management

Prepare and maintain a submittal register, as the work progresses.

Thereafter, the Subcontractor is to track all submittals by maintaining a complete list, including completion of all data columns and all dates on which submittals are received by and returned by the Contractor/Buyer.

1.8.2 Subcontractor Use of Submittal Register

Update with each submittal throughout the contract.

1.8.3 Delivery of Copies

Submit an updated electronic copy of the submittal register to the Contractor/Buyer with each invoice request, unless a paper copy is requested by the Contractor/Buyer.

1.9 VARIATIONS

Variations from contract requirements require Contractor/Buyer approval pursuant to contract Clause FAR 52.236-21 Specifications and Drawings for Construction, and will be considered where advantageous to the Contractor/Buyer.

1.9.1 Considering Variations

Discussion of variations with the Contractor/Buyer before submission of a variation submittal will help ensure that functional and quality requirements are met and minimize rejections and resubmittals. For variations that include design changes or some material or product substitutions, the Contractor/Buyer may require an evaluation and analysis by a licensed professional engineer hired by the Subcontractor.

Specifically point out variations from contract requirements in a variation submittal. Failure to point out variations may cause the Contractor/Buyer to require rejection and removal of such work at no additional cost to the Contractor/Buyer.

1.9.2 Proposing Variations

The Contractor/Buyer will indicate an approval or disapproval of the variation request; and if not approved as submitted, will indicate the Contractor/Buyer's reasons therefore. Any work done before such approval is received is performed at the Subcontractor's risk.

Specifically point out variations from contract requirements in a variation submittal. Failure to point out variations may cause the Contractor/Buyer to require rejection and removal of such work at no additional cost to the Contractor/Buyer.

Check the column "variation" of ENG Form 4025 for submittals that include variations proposed by the Subcontractor. Set forth in writing the reason for any variations and note such variations on the submittal. The Contractor/Buyer reserves the right to rescind inadvertent approval of submittals containing unnoted variations.

1.9.3 Warranting that Variations are Compatible

When delivering a variation for approval, the Subcontractor warrants that this contract has been reviewed to establish that the variation, if incorporated, will be compatible with other elements of work.

1.9.4 Review Schedule Extension

In addition to the normal submittal review period, a period of 14 calendar days will be allowed for the Contractor/Buyer to consider submittals with variations.

1.10 SCHEDULING

Schedule and submit concurrently product data and shop drawings covering component items forming a system or items that are interrelated. Submit pertinent certifications at the same time. No delay damages or time extensions will be allowed for time lost in late submittals.

a. Coordinate scheduling, sequencing, preparing, and processing of submittals with performance of work so that work will not be delayed by submittal processing. The Subcontractor is responsible for additional time required for Contractor/Buyer reviews resulting from required resubmittals. The review period for each resubmittal is the same as for the initial submittal.

b. Submittals required by the contract documents are listed on the submittal register. If a submittal is listed in the submittal register but does not pertain to the contract work, the Subcontractor is to include the submittal in the register and annotate it "N/A" with a brief explanation. Approval by the Contractor/Buyer does not relieve the Subcontractor of supplying submittals required by the contract documents but that have been omitted from the register or marked "N/A."

c. Resubmit the submittal register and annotate it monthly with actual submission and approval dates. When all items on the register have been fully approved, no further resubmittal is required.

d. Except as specified otherwise, allow a review period, beginning with receipt by the approving authority, that includes at least 20 working days for submittals where the Contractor/Buyer is the approving authority. The period of review for submittals with Contractor/Buyer approval begins when the Contractor/Buyer receives the submittal from the QC organization.

1.10.1 Reviewing, Certifying, and Approving Authority

The QC Manager is responsible for reviewing all submittals and certifying that they are in compliance with contract requirements. The approving authority on submittals is the QC Manager unless otherwise specified.

1.10.2 Constraints

Conform to provisions of this section, unless explicitly stated otherwise for submittals listed or specified in this contract.

Submit complete submittals for each definable feature of the work. At the same time, submit components of definable features that are interrelated as a system.

When acceptability of a submittal is dependent on conditions, items, or materials included in separate subsequent submittals, the submittal will be returned without review.

Approval of a separate material, product, or component does not imply approval of the assembly in which the item functions.

1.10.3 QC Organization Responsibilities

a. Review submittals for conformance with project design concepts and compliance with contract documents.

b. Process submittals based on the approving authority indicated in the submittal register.

(1) When the QC manager is the approving authority, take appropriate action on the submittal from the possible actions defined in paragraph APPROVED SUBMITTALS.

(2) When the Contractor/Buyer is the approving authority or when variation has been proposed, forward the submittal to the Contractor/Buyer, along with a certifying statement, or return the submittal marked "not reviewed" or "revise and resubmit" as appropriate. The QC organization's review of the submittal determines the appropriate action.

c. Ensure that material is clearly legible.

d. Stamp each sheet of each submittal with a QC certifying statement or an approving statement, except that data submitted in a bound volume or on one sheet printed on two sides may be stamped on the front of the first sheet only.

(1) When the approving authority is the Contractor/Buyer, the QC organization will certify submittals forwarded to the Contractor/Buyer with the following certifying statement:

"I hereby certify that the (equipment) (material) (article) shown and marked in this submittal is that proposed to be incorporated with Contract Number [______] is in compliance with the contract drawings and specification, can be installed in the allocated spaces, and is submitted for Contractor/Buyer approval.

Certified by Submittal Reviewer ________________________, Date _________
(Signature when applicable)

Certified by QC Manager _________________________________, Date _______"
(Signature)

(2) When approving authority is the QC manager, the QC manager will use the following approval statement when returning submittals to the Subcontractor as "Approved" or "Approved as Noted."

"I hereby certify that the (material) (equipment) (article) shown and marked in this submittal and proposed to be incorporated with Contract Number [______] is in compliance with the contract drawings and specification, can be installed in the allocated spaces, and is approved for use.

Certified by Submittal Reviewer _________________________, Date _______
(Signature when applicable)

Approved by QC Manager ___________________________________, Date ______"

(Signature)

e. Sign the certifying statement or approval statement. The QC organization member designated in the approved QC plan is the person signing certifying statements. The use of original ink for signatures is required. Stamped signatures are not acceptable.

f. Update the submittal register as submittal actions occur, and maintain the submittal register at the project site until final acceptance of all work by the Contractor/Buyer.

g. Retain a copy of approved submittals and approved samples at the project site.

1.11 APPROVING AUTHORITY

When the approving authority is the Contractor/Buyer, the Contractor/Buyer will:

a. Note the date on which the submittal was received from the Subcontractor/Supplier.

b. Review submittals for approval within the scheduling period specified and only for conformance with project design concepts and compliance with contract documents.

c. Identify returned submittals with one of the actions defined in paragraph REVIEW NOTATIONS and with comments and markings appropriate for the action indicated.

Upon completion of review of submittals requiring Contractor/Buyer approval, stamp and date submittals. One copy of the submittal will be retained by the Contractor/Buyer and one copy of the submittal will be returned to the Subcontractor. If the Contractor/Buyer performs a conformance review of other Designer of Record approved submittals, the submittals will be identified and returned, as described above.

1.11.1 Review Notations

Submittals will be returned to the Subcontractor with the following notations:

Submittals marked "approved" or "accepted" authorize proceeding with the work covered.

a. Submittals marked "approved as noted" or "approved, except as noted, resubmittal not required," authorize proceeding with the work covered provided that the Subcontractor takes no exception to the corrections.

b. Submittals marked "not approved," "disapproved," or "revise and resubmit" indicate incomplete submittal or noncompliance with the contract requirements or design concept. Resubmit with appropriate changes. Do not proceed with work for this item until the resubmittal is approved.

c. Submittals marked "not reviewed" indicate that the submittal has been previously reviewed and approved, is not required, does not have evidence of being reviewed and approved by Subcontractor, or is not complete. A submittal marked "not reviewed" will be returned with an explanation of the reason it is not reviewed. Resubmit submittals returned for lack of review by Subcontractor or for being incomplete, with appropriate action, coordination, or change.

d. Submittals marked "receipt acknowledged" indicate that submittals have been received by the Contractor/Buyer. This applies only to "information-only submittals" as previously defined.

1.12 DISAPPROVED SUBMITTALS

Make corrections required by the Contractor/Buyer. If the Subcontractor considers any correction or notation on the returned submittals to constitute a change to the contract drawings or specifications, give notice to the Contractor/Buyer as required under the FAR clause titled CHANGES. The Subcontractor is responsible for the dimensions and design of connection details and the construction of work. Failure to point out variations may cause the Contractor/Buyer to require rejection and removal of such work at the Subcontractor's expense.

If changes are necessary to submittals, make such revisions and resubmit in accordance with the procedures above. No item of work requiring a submittal change is to be accomplished until the changed submittals are approved.

1.13 APPROVED SUBMITTALS

The Contractor/Buyer's approval of submittals is not to be construed as a complete check, and indicates only that the general method of construction, materials, detailing, and other information are satisfactory. The design, general method of construction, materials, detailing, and other information appear to meet the Solicitation and Accepted Proposal.

Approval or acceptance by the Contractor/Buyer for a submittal does not relieve the Subcontractor of the responsibility for meeting the contract requirements or for any error that may exist, because under the Quality Control (QC) requirements of this contract, the Subcontractor is responsible for ensuring information contained within each submittal accurately conforms with the requirements of the contract documents.

After submittals have been approved or accepted by the Contractor/Buyer, no resubmittal for the purpose of substituting materials or equipment will be considered unless accompanied by an explanation of why a substitution is necessary.

1.14 APPROVED SAMPLES

Approval of a sample is only for the characteristics or use named in such approval and is not to be construed to change or modify any contract requirements. Before submitting samples, provide assurance that the materials or equipment will be available in quantities required in the project. No change or substitution will be permitted after a sample has been approved.

Match the approved samples for materials and equipment incorporated in the work. If requested, approved samples, including those that may be damaged in testing, will be returned to the Subcontractor, at its expense, upon completion of the contract. Unapproved samples will also be returned to the Subcontractor at its expense, if so requested.

Failure of any materials to pass the specified tests will be sufficient cause for refusal to consider, under this contract, any further samples of the same brand or make as that material. The Contractor/Buyer reserves the right to disapprove any material or equipment that has previously proved unsatisfactory in service.

Samples of various materials or equipment delivered on the site or in place may be taken by the Contractor/Buyer for testing. Samples failing to meet contract requirements will automatically void previous approvals. Replace such materials or equipment to meet contract requirements.

1.15 WITHHOLDING OF PAYMENT

Payment for materials incorporated in the work will not be made if required approvals have not been obtained. No payment for materials incorporated in the work will be made unless all required DOR approvals or required Contractor/Buyer approvals have been obtained. No payment will be made for any materials incorporated into the work for any conformance review submittals or information-only submittals found to contain errors or deviations from the Solicitation or Accepted Proposal.

1.16 CERTIFICATION OF SUBMITTAL DATA

Certify the submittal data as follows on Form ENG 4025: "I certify that the above submitted items had been reviewed in detail and are correct and in strict conformance with the contract drawings and specifications except as otherwise stated.

______NAME OF SUBCONTRACTOR ____SIGNATURE OF SUBCONTRACTOR

PART 2 PRODUCTS

Not Used

PART 3 EXECUTION

Not Used

-- End of Section --

SECTION 01 42 00: SOURCES FOR REFERENCE PUBLICATIONS
02/19, CHG 1: 08/23

PART 1 GENERAL

1.1 REFERENCES

Various publications are referenced in other sections of the specifications to establish requirements for the work. These references are identified in each section by document number, date and title. The document number used in the citation is the number assigned by the standards producing organization (e.g., ASTM B564 Standard Specification for Nickel Alloy Forgings). However, when the standards producing organization has not assigned a number to a document, an identifying number has been assigned for reference purposes.

1.2 ORDERING INFORMATION

The addresses of the standards publishing organizations whose documents are referenced in other sections of these specifications are listed below, and if the source of the publications is different from the address of the sponsoring organization, that information is also provided.

AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS (AASHTO)
444 North Capital Street, NW, Suite 249 Washington, DC 20001
Ph: 202-624-5800
Fax: 202-624-5806
E-Mail: info@aashto.org
Internet: https://www.transportation.org/

AMERICAN BEARING MANUFACTURERS ASSOCIATION (ABMA)
330 N. Wabash Ave., Suite 2000
Chicago, IL 60611
Ph: 202-367-1155
E-mail: info@americanbearings.org
Internet: https://www.americanbearings.org/

AMERICAN CONCRETE INSTITUTE (ACI)
38800 Country Club Drive Farmington Hills, MI 48331-3439 Ph: 248-848-3700
Fax: 248-848-3701
Internet: https://www.concrete.org/

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)
1899 L Street, NW,11th Floor Washington, DC 20036
Ph: 202-293-8020
Fax: 202-293-9287
E-mail: storemanager@ansi.org Internet: https://www.ansi.org/

AMERICAN SOCIETY OF CIVIL ENGINEERS (ASCE)
1801 Alexander Bell Drive
Reston, VA 20191
Ph: 800-548-2723; 703-295-6300
Internet: https://www.asce.org/

AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)
Two Park Avenue

New York, NY 10016-5990 Ph: 800-843-2763
Fax: 973-882-1717
E-mail: customercare@asme.org Internet: https://www.asme.org/

AMERICAN WATER WORKS ASSOCIATION (AWWA)
6666 W. Quincy Avenue Denver, CO 80235 USA
Ph: 303-794-7711 or 800-926-7337
Fax: 303-347-0804
Internet: https://www.awwa.org/

AMERICAN WELDING SOCIETY (AWS) 8669 NW 36 Street, #130
Miami, FL 33166-6672
Ph: 800-443-9353
Internet: https://www.aws.org/

ASTM INTERNATIONAL (ASTM)
100 Barr Harbor Drive, P.O. Box C700 West Conshohocken, PA 19428-2959 Ph: 610-832-9500
Fax: 610-832-9555
E-mail: service@astm.org Internet: https://www.astm.org/

ELECTRONIC COMPONENTS INDUSTRY ASSOCIATION (ECIA)
310 Maxwell Road, Suite 200
Alpharetta, GA 30009
Ph: 678-393-9990
Fax: 678-393-9998
E-mail: emikoski@ecianow.org Internet: https://www.ecianow.org

ELECTRONIC INDUSTRIES ALLIANCE (EIA)
EIA has become part of the ELECTRONIC COMPONENTS INDUSTRY ASSOCIATION (ECIA)

EUROPEAN COMMITTEE FOR STANDARDIZATION (CEN/CENELEC)
CEN-CENELEC Management Centre Rue de la Science 23
B - 1040 Brussels, Belgium Ph: 32-2-550-08-11
Fax: 32-2-550-08-19
Internet: https://www.cen.eu/

FORESTRY SUPPLIERS INC. (FSUP)
205 West Rankin Street
P.O. Box 8397
Jackson, MS 39284-8397
Ph: 800-752-8460
Internet: https://www/forestry-suppliers.com

GEOLOGICAL SOCIETY OF AMERICA (GeoSA)
P.O. Box 9140
Boulder, CO 80301-9140
Ph: 303-357-1000
Fax: 303-357-1070
E-mail: gsaservice@geosociety.org Internet: http://www.geosociety.org

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)
445 and 501 Hoes Lane
Piscataway, NJ 08854-4141
Ph: 732-981-0060 or 800-701-4333

Fax: 732-981-9667
E-mail: onlinesupport@ieee.org Internet: https://www.ieee.org/

INTERNATIONAL CODE COUNCIL (ICC)
500 New Jersey Avenue, NW
6th Floor, Washington, DC 20001 Ph: 800-786-4452 or 888-422-7233
Fax: 202-783-2348
E-mail: order@iccsafe.org Internet: https://www.iccsafe.org/

INTERNATIONAL ELECTRICAL TESTING ASSOCIATION (NETA)
3050 Old Centre Ave. Suite 101
Portage, MI 49024
Ph: 269-488-6382
Fax: 269-488-6383
Internet: https://www.netaworld.org/

INTERNATIONAL ELECTROTECHNICAL COMMISSION (IEC)
3, rue de Varembe, 1st floor
P.O. Box 131
CH-1211 Geneva 20, Switzerland Ph: 41-22-919-02-11
Fax: 41-22-919-03-00
E-mail: info@iec.ch
Internet: https://www.iec.ch/

INTERNATIONAL ORGANIZATION FOR STANDARDIZATION (ISO)
ISO Central Secretariat BIBC II
Chemin de Blandonnet 8
CP 401 - 1214 Vernier, Geneva Switzerland
Ph: 41-22-749-01-11
E-mail: central@iso.ch Internet: https://www.iso.org

INTERNATIONAL SOCIETY OF AUTOMATION (ISA)
67 T.W. Alexander Drive PO Box 12277
Research Triangle Park, NC 27709 Ph: 919-549-8411
Fax: 919-549-8288
E-mail: info@isa.org
Internet: https://www.isa.org/

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)
1300 North 17th Street, Suite 900
Arlington, VA 22209
Ph: 703-841-3200
Internet: https://www.nema.org

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)
1 Batterymarch Park
Quincy, MA 02169-7471
Ph: 800-344-3555
Fax: 800-593-6372
Internet: https://www.nfpa.org

NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY (NIST)
100 Bureau Drive
Gaithersburg, MD 20899
Ph: 301-975-2000
Internet: https://www.nist.gov/

TELECOMMUNICATIONS INDUSTRY ASSOCIATION (TIA)
1320 North Courthouse Rosd, Suite 200
Arlington, VA 22201
Ph: 703-907-7700
Fax: 703-907-7727
E-mail: marketing@tiaonline.org Internet:
https://www.tiaonline.org/

U.S. ARMY CORPS OF ENGINEERS (USACE)
CRD-C DOCUMENTS available on Internet:
http://www.wbdg.org/ffc/army-coe/standards Order Other Documents from:
Official Publications of the Headquarters, USACE E-mail:
hqpublications@usace.army.mil
Internet: http://www.publications.usace.army.mil/ or
https://www.hnc.usace.army.mil/Missions/Engineering-Directorate/TECHINFO/

U.S. DEPARTMENT OF DEFENSE (DOD)
Order DOD Documents from:
Room 3A750-The Pentagon 1400 Defense Pentagon
Washington, DC 20301-1400
Ph: 703-571-3343
Fax: 215-697-1462
E-mail: customerservice@ntis.gov Internet: https://www.ntis.gov/
Obtain Military Specifications, Standards and Related Publications from:
Acquisition Streamlining and Standardization Information System (ASSIST)
Department of Defense Single Stock Point (DODSSP) Document Automation and Production Service (DAPS) Building 4/D
700 Robbins Avenue
Philadelphia, PA 19111-5094
Ph: 215-697-6396 - for account/password issues
Internet: https://assist.dla.mil/online/start/; account registration required
Obtain Unified Facilities Criteria (UFC) from: Whole Building Design Guide (WBDG)
National Institute of Building Sciences (NIBS) 1090 Vermont Avenue NW, Suite 700
Washington, DC 20005
Ph: 202-289-7800
Fax: 202-289-1092
Internet:
https://www.wbdg.org/ffc/dod/unified-facilities-criteria-ufc

U.S. ENVIRONMENTAL PROTECTION AGENCY (EPA)
1200 Pennsylvania Avenue, N.W. Washington, DC 20004
Ph: 202-564-4700
Internet: https://www.epa.gov
--- Some EPA documents are available only from: National Technical Information Service (NTIS) 5301 Shawnee Road
Alexandria, VA 22312
Ph: 703-605-6060 or 1-800-363-2068
Fax: 703-605-6880
TDD: 703-487-4639
E-mail: info@ntis.gov
Internet: https://www.ntis.gov/

U.S. GENERAL SERVICES ADMINISTRATION (GSA)
General Services Administration 1800 F Street, NW
Washington, DC 20405
Ph: 1-844-472-4111
Internet: https://www.gsaelibrary.gsa.gov/ElibMain/home.do Obtain documents from:
Acquisition Streamlining and Standardization Information System (ASSIST)
Internet: https://assist.dla.mil/online/start/; account registration required

U.S. NATIONAL ARCHIVES AND RECORDS ADMINISTRATION (NARA)
8601 Adelphi Road
College Park, MD 20740-6001 Ph: 866-272-6272
Internet: https://www.archives.gov/ Order documents from:
Superintendent of Documents
U.S. Government Publishing Office (GPO) 732 N. Capitol Street, NW
Washington, DC 20401
Ph: 202-512-1800 or 866-512-1800
Bookstore: 202-512-0132 Internet: https://www.gpo.gov/

UNDERWRITERS LABORATORIES (UL)
2600 N.W. Lake Road Camas, WA 98607-8542
Ph: 877-854-3577 or 360-817-5500
E-mail: CustomerExperienceCenter@ul.com Internet: https://www.ul.com/
UL Directories available through IHS at https://ihsmarkit.com/

PART 2 PRODUCTS

Not used

PART 3 EXECUTION

Not used

-- End of Section --

SECTION 03 30 53: MISCELLANEOUS CAST-IN-PLACE CONCRETE
05/14

PART 1 GENERAL

1.1 SUMMARY

Perform all work in accordance with ACI 318.

1.2 UNIT PRICES

1.2.1 Concrete Payment

Payment will cover all costs associated with manufacturing, furnishing, delivering, placing, finishing, and curing of concrete for the various items of the schedule, including the cost of all formwork. Payment for concrete work, for which payment is made as a lump sum, including but not limited to grout, preformed expansion joints, field-molded sealants, waterstops, reinforcing steel bars or wire reinforcement, is to be included in this unit price payment item.

1.2.2 Measurement

Concrete will be measured for payment on the basis of the actual volume of concrete within the pay lines and design dimensions of the structures as indicated. Measurement of concrete placed against the sides of any excavation without the use of intervening forms will be made only within the pay lines of the structure. No deductions will be made for rounded or beveled edge, for space occupied by metal work, for electrical conduits or timber, or for voids or embedded items that are either less than 5 cubic feet in volume or 1 square foot in cross section.

1.2.3 Unit of Measure

Unit of measure: cubic yard.

1.3 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN CONCRETE INSTITUTE (ACI)

ACI 117	(2010; Errata 2011) Specifications for Tolerances for Concrete Construction and Materials and Commentary
ACI 301	(2016) Specifications for Structural Concrete
ACI 302.1R	(2015) Guide for Concrete Floor and Slab Construction
ACI 304R	(2000; R 2009) Guide for Measuring, Mixing Transporting, and Placing Concrete
ACI 305R	(2020) Guide to Hot Weather Concreting
ACI 306R	(2016) Guide to Cold Weather Concreting

ACI 318	(2014; Errata 1-2 2014; Errata 3-5 2015; Errata 6 2016; Errata 7-9 2017) Building Code Requirements for Structural Concrete (ACI 318-14) and Commentary (ACI 318R-14)
ACI 347R	(2014; Errata 1 2017) Guide to Formwork for Concrete
ACI SP-66	(2004) ACI Detailing Manual

ASTM INTERNATIONAL (ASTM)

ASTM A615/A615M	(2022) Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement
ASTM A1064/A1064M	(2022) Standard Specification for Carbon-Steel Wire and Welded Wire Reinforcement, Plain and Deformed, for Concrete
ASTM C31/C31M	(2022) Standard Practice for Making and Curing Concrete Test Specimens in the Field
ASTM C33/C33M	(2018) Standard Specification for Concrete Aggregates
ASTM C39/C39M	(2021) Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens
ASTM C94/C94M	(2022a) Standard Specification for Ready-Mixed Concrete
ASTM C143/C143M	(2020) Standard Test Method for Slump of Hydraulic-Cement Concrete
ASTM C150/C150M	(2022) Standard Specification for Portland Cement
ASTM C172/C172M	(2017) Standard Practice for Sampling Freshly Mixed Concrete
ASTM C173/C173M	(2016) Standard Test Method for Air Content of Freshly Mixed Concrete by the Volumetric Method
ASTM C231/C231M	(2022) Standard Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method
ASTM C260/C260M	(2010a; R 2016) Standard Specification for Air-Entraining Admixtures for Concrete
ASTM C309	(2019) Standard Specification for Liquid Membrane-Forming Compounds for Curing Concrete
ASTM C494/C494M	(2019; E 2022) Standard Specification for Chemical Admixtures for Concrete
ASTM C595/C595M	(2021) Standard Specification for Blended Hydraulic Cements
ASTM C618	(2023; E 2023) Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete
ASTM C685/C685M	(2017) Standard Specification for Concrete Made by Volumetric Batching and Continuous Mixing

ASTM C920	(2018) Standard Specification for Elastomeric Joint Sealants
ASTM C989/C989M	(2022) Standard Specification for Slag Cement for Use in Concrete and Mortars
ASTM C1064/C1064M	(2017) Standard Test Method for Temperature of Freshly Mixed Hydraulic-Cement Concrete
ASTM C1157/C1157M	(2020a) Standard Performance Specification for Hydraulic Cement
ASTM C1260	(2021) Standard Test Method for Potential Alkali Reactivity of Aggregates (Mortar-Bar Method)
ASTM C1567	(2022) Standard Test Method for Potential Alkali-Silica Reactivity of Combinations of Cementitious Materials and Aggregate (Accelerated Mortar-Bar Method)
ASTM C1602/C1602M	(2022) Standard Specification for Mixing Water Used in Production of Hydraulic Cement Concrete
ASTM D75/D75M	(2019) Standard Practice for Sampling Aggregates
ASTM D98	(2015) Calcium Chloride
ASTM D412	(2016; R 2021) Standard Test Methods for Vulcanized Rubber and Thermoplastic Elastomers - Tension
ASTM D471	(2016a) Standard Test Method for Rubber Property - Effect of Liquids
ASTM D1752	(2018) Standard Specification for Preformed Sponge Rubber, Cork and Recycled PVC Expansion Joint Fillers for Concrete Paving and Structural Construction
ASTM E96/E96M	(2022a; E 2023) Standard Test Methods for Gravimetric Determination of Water Vapor Transmission Rate of Materials
ASTM E1155	(2020) Standard Test Method for Determining Floor Flatness and Floor Levelness Numbers
ASTM E1155M	(2014) Standard Test Method for Determining Floor Flatness and Floor Levelness Numbers (Metric)
ASTM E1643	(2018a) Standard Practice for Selection, Design, Installation, and Inspection of Water Vapor Retarders Used in Contact with Earth or Granular Fill Under Concrete Slabs
ASTM E1745	(2017; R 2023) Standard Specification for Water Vapor Retarders Used in Contact with Soil or Granular Fill under Concrete Slabs
ASTM E1993/E1993M	(1998; R 2020) Standard Specification for Bituminous Water Vapor Retarders Used in Contact with Soil or Granular Fill Under Concrete Slabs

U.S. ARMY CORPS OF ENGINEERS (USACE)

COE CRD-C 513	(1974) Corps of Engineers Specifications for Rubber Waterstops
COE CRD-C 572	(1974) Corps of Engineers Specifications for Polyvinylchloride Waterstops

U.S. NATIONAL ARCHIVES AND RECORDS ADMINISTRATION (NARA)

40 CFR 247	Comprehensive Procurement Guideline for Products Containing Recovered Materials

1.4 SUBMITTALS

Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Installation Drawings;

SD-03 Product Data

Air-Entraining Admixture Accelerating Admixture
Water-Reducing or Retarding Admixture Curing Materials
Expansion Joint Filler Strips, Premolded Joint Sealants - Field Molded Sealants Waterstops
Mix Design Data; Ready-Mix Concrete
Curing Compound
Mechanical Reinforcing Bar Connectors

SD-06 Test Reports

Aggregates
Concrete Mixture Proportions; Compressive Strength Testing; Slump; Air Content Water

SD-07 Certificates

Cementitious Materials Pozzolan
Fly Ash
CPG for recycled materials or appropriate Waiver Form
Aggregates
Delivery Tickets

SD-08 Manufacturer's Instructions

Curing Compound

1.5 QUALITY ASSURANCE

Indicate specific locations of [Concrete Placement] [Forms] [Steel Reinforcement] [Accessories] [Expansion Joints] [Construction Joints] [Contraction Joints] [Control Joints] on installation drawings and include, but not be limited to, square feet of concrete placements, thicknesses and widths, plan dimensions, and arrangement of cast-in-place concrete section.

1.5.1 Regulatory Requirements

The state statutory and regulatory requirements: [CA] form a part of this specification to the extent referenced. Submit CPG for recycled materials or appropriate Waiver Form.

PART 2 PRODUCTS

2.1 SYSTEM DESCRIPTION

The Contractor/Buyer retains the option to sample and test aggregates and concrete to determine compliance with the specifications. Provide facilities and labor as may be necessary to assist the Contractor/Buyer in procurement of representative test samples. Obtain samples of aggregates at the point of batching in accordance with ASTM D75/D75M. Sample concrete in accordance with ASTM C172/C172M. Determine slump and air content in accordance with ASTM C143/C143M and ASTM C231/C231M, respectively, when cylinders are molded. Prepare, cure, and transport compression test specimens in accordance with ASTM C31/C31M. Test compression test specimens in accordance with ASTM C39/C39M. Take samples for strength tests not less than once each shift in which concrete is produced. Provide a minimum of five specimens from each sample; two to be tested at 28 days (90 days if pozzolan is used) for acceptance, two will be tested at 7 days for information and one held in reserve.

2.1.1 Strength

Acceptance test results are the average strengths of two specimens tested at 28 days (90 days if pozzolan is used). The strength of the concrete is considered satisfactory so long as the average of three consecutive acceptance test results equal or exceed the specified compressive strength, f'c, but not more than 20 percent, and no individual acceptance test result falls below f'c by more than 500 psi.

2.1.2 Construction Tolerances

Apply a Class "C" finish to all surfaces except those specified to receive a Class "D" finish. Apply a Class "D" finish to all post-construction surfaces which will be permanently concealed. Surface requirements for the classes of finish required are as specified in ACI 117.

2.1.3 Concrete Mixture Proportions

Concrete mixture proportions are the responsibility of the Subcontractor. Mixture proportions must include the dry weights of cementitious material(s); the nominal maximum size of the coarse aggregate; the specific gravities, absorptions, and saturated surface-dry weights of fine and coarse aggregates; the quantities, types, and names of admixtures; and quantity of water per yard of concrete. Provide materials included in the mixture proportions of the same type and from the same source as will be used on the project. The specified compressive strength f'c is 3,000 psi at 28 days (90 days if pozzolan is used). The maximum nominal size coarse aggregate is ¾-inch, in accordance with ACI 304R. The air content must be between 4.5 and 7.5 percent with a slump between 2 and 5 inches. The maximum water-cementitious material ratio is 0.50. Submit the applicable test reports and mixture proportions that will produce concrete of the quality required, ten days prior to placement of concrete.

2.2 MATERIALS

Submit manufacturer's literature from suppliers which demonstrates compliance with applicable specifications for the specified materials.

2.2.1 Cementitious Materials

Submit Manufacturer's certificates of compliance, accompanied by mill test reports, attesting that the concrete materials meet the requirements of the specifications in accordance with the Special Clause "CERTIFICATES OF COMPLIANCE". Also, certificates for all material conforming to EPA's Comprehensive Procurement Guidelines (CPG), in accordance with 40 CFR 247. Provide cementitious materials that conform to the appropriate specifications listed:

2.2.1.1 Portland Cement

ASTM C150/C150M, Type I or II with tri-calcium aluminates (C_3A) content less than 10 percent and a maximum cement-alkali content of 0.80 percent Na_2O (sodium oxide) equivalent.

2.2.1.3 Pozzolan

Provide pozzolan that conforms to ASTM C618, Class F, including requirements of Tables 1A and 2A.

2.2.2 Aggregates

For fine and coarse aggregates meet the quality and grading requirements of ASTM C33/C33M and test and evaluate for alkali-aggregate reactivity in accordance with ASTM C1260. Perform evaluation of fine and coarse aggregates separately and in combination, matching the proposed mix design proportioning. All results of the separate and combination testing must have a measured expansion less than 0.08 percent at 28 days after casting. If the test data indicates an expansion of 0.08 percent or greater, reject the aggregate(s) or perform additional testing using ASTM C1260 and ASTM C1567. Perform the additional testing using ASTM C1260 and ASTM C1567 using the low alkali Portland cement in combination with ground granulated blast furnace (GGBF) slag, or Class F fly ash. Use GGBF slag in the range of 40 to 50 percent of the total cementitious material by mass. Use Class F fly ash in the range of 25 to 40 percent of the total cementitious material by mass]. Submit certificates of compliance and test reports for aggregates showing the material(s) meets the quality and grading requirements of the specifications under which it is furnished.

2.2.3 Admixtures

Provide admixtures, when required or approved, in compliance with the appropriate specification listed. Retest chemical admixtures that have been in storage at the project site, for longer than 6 months or that have been subjected to freezing, at the expense of the Subcontractor at the request of the Contractor/Buyer and will be rejected if test results are not satisfactory.

2.2.3.1 Air-Entraining Admixture

Provide air-entraining admixture that meets the requirements of ASTM C260/C260M.

2.2.3.2 Accelerating Admixture

Provide calcium chloride meeting the requirements of ASTM D98. Other accelerators must meet the requirements of ASTM C494/C494M, Type C or E.

]2.2.3.3 Water-Reducing or Retarding Admixture

Provide water-reducing or retarding admixture meeting the requirements of ASTM C494/C494M, Type A, B, or D. [High-range water reducing admixture Type F [or G] may be used only when approved, approval being contingent upon particular placement requirements as described in the Subcontractor's Quality Control Plan.]

2.2.4 Water

Mixing and curing water in compliance with the requirements of ASTM C1602/C1602M; free of injurious amounts of oil, acid, salt, or alkali. Submit test report showing water complies with ASTM C1602/C1602M.

2.2.5 Reinforcing Steel

Provide reinforcing bars conforming to the requirements of ASTM A615/A615M, Grade 60, deformed. Provide welded steel wire reinforcement conforming to the requirements of ASTM A1064/A1064M. Detail reinforcement not indicated in accordance with ACI 301 and ACI SP-66. Provide mechanical reinforcing bar connectors in accordance with ACI 301 and provide 125 percent minimum yield strength of the reinforcement bar.

2.2.6 Expansion Joint Filler Strips, Premolded

Expansion joint filler strips, premolded of sponge rubber conforming to ASTM D1752, Type I.

2.2.7 Joint Sealants - Field Molded Sealants

Conform to ASTM C920, Type M, Grade NS, Class 25, use NT for vertical joints and Type M, Grade P, Class 25, use T for horizontal joints. Provide polyethylene tape, coated paper, metal foil, or similar type bond breaker materials. The backup material needs to be compressible, non shrink, nonreactive with the sealant, and a nonabsorptive material such as extruded butyl or polychloroprene foam rubber. Immediately prior to installation of field-molded sealants, clean the joint of all debris and further cleaned using water, chemical solvents, or other means as recommended by the sealant manufacturer or directed.

2.2.8 Formwork

Design and engineer the formwork as well as its construction in accordance with ACI 301 Section 2 and 5 and ACI 347R. Fabricate of wood, steel, or other approved material. Submit formwork design prior to the first concrete placement.

2.2.9 Form Coatings

Provide form coating in accordance with ACI 301.

2.2.11 Curing Materials

Provide curing materials in accordance with ACI 301, Section 5.

2.3 READY-MIX CONCRETE

Provide ready-mix concrete with mix design data conforming to ACI 301 Part 4. Submit delivery tickets in accordance with ASTM C94/C94M for each ready-mix concrete delivery, include the following additional information:

a. Type and brand cement

b. Cement content in 94-pound bags per cubic yard of concrete

c. Maximum size of aggregate

d. Amount and brand name of admixture

e. Total water content expressed by water cementitious material ratio

2.4 ACCESSORIES

2.4.1 Waterstops

2.4.1.1 PVC Waterstop

Polyvinylchloride waterstops conforming to COE CRD-C 572.

2.4.1.2 Rubber Waterstop

Rubber waterstops conforming to COE CRD-C 513.

2.4.1.3 Thermoplastic Elastomeric Rubber Waterstop

Thermoplastic elastomeric rubber waterstops conforming to ASTM D471.

2.4.1.4 Hydrophilic Waterstop

Swellable strip type compound of polymer modified chloroprene rubber that swells upon contact with water conforming to ASTM D412 as follows: Tensile strength 420 psi minimum; ultimate elongation 600 percent minimum. Minimum hardness of 50 on the type A durometer and the volumetric expansion ratio in distilled water at 70 degrees F; 3 to 1 minimum.

2.4.2 Curing Compound

Provide curing compound conforming to ASTM C309. Submit manufactures instructions for placing curing compound.

PART 3 EXECUTION

3.1 PREPARATION

Prepare construction joints to expose coarse aggregate. The surface must be clean, damp, and free of laitance. Construct ramps and walkways, as necessary, to allow safe and expeditious access for concrete and workers. Remove snow, ice, standing or flowing water, loose particles, debris, and foreign matter. Satisfactorily compact earth foundations. Make spare vibrators available. Placement cannot begin until the entire preparation has been accepted by the Contractor/Buyer.

3.1.1 Embedded Items

Secure reinforcement in place after joints, anchors, and other embedded items have been positioned. Arrange internal ties so that when the forms are removed the metal part of the tie is not less than 2 inches from concrete surfaces permanently exposed to view or exposed to water on the finished structures. Prepare embedded items so they are free of oil and other foreign matters such as loose coatings or rust, paint, and scale. The embedding of wood in concrete is permitted only when specifically authorized or directed. Provide all equipment needed to place, consolidate, protect, and cure the concrete at the placement site and in good operating condition.

3.1.2 Formwork Installation

Forms must be properly aligned, adequately supported, and mortar-tight. Provide smooth form surfaces, free from irregularities, dents, sags, or holes when used for permanently exposed faces. Chamfer all exposed joints and edges, unless otherwise indicated.

3.1.4 Production of Concrete

3.1.4.1 Ready-Mixed Concrete

Provide ready-mixed concrete conforming to ASTM C94/C94M except as otherwise specified.

3.1.4.2 Concrete Made by Volumetric Batching and Continuous Mixing Conform

to ASTM C685/C685M.

3.1.5 Waterstops

Install and splice waterstops as directed by the manufacturer.

3.2 CONVEYING AND PLACING CONCRETE

Convey and place concrete in accordance with ACI 301, Section 5.

3.2.1 Cold-Weather Requirements

Place concrete in cold weather in accordance with ACI 306R

3.2.2 Hot-Weather Requirements

Place concrete in hot weather in accordance with ACI 305R

3.3 FINISHING

3.3.1 Temperature Requirement

Do not finish or repair concrete when either the concrete or the ambient temperature is below 50 degrees F.

3.3.2 Finishing Formed Surfaces

Remove all fins and loose materials, and surface defects including filling of tie holes. Repair all honeycomb areas and other defects. Remove all unsound concrete from areas to be repaired. Ream or chip surface defects greater than ½-inch in diameter and holes left by removal of tie rods in all surfaces not to receive additional concrete and fill with dry-pack mortar. Brush-coat the prepared area with an approved epoxy resin or latex bonding compound or with a neat cement grout after dampening and filling with mortar or concrete. Use a blend of Portland cement and white cement in mortar or concrete for repairs to all surfaces permanently exposed to view so that the final color when cured is the same as adjacent concrete.

3.4 CURING AND PROTECTION

Cure and protect in accordance with ACI 301, Section 5.

3.5 FORM WORK

Provide form work in accordance with ACI 301, Section 2 and Section 5.

3.5.1 Removal of Forms

Remove forms in accordance with ACI 301, Section 2.

a. Provide form release agent that is colorless, biodegradable, and water-based, with a zero VOC content.
b. Provide product that does not bond with, stain, or adversely affect concrete surfaces and does not impair subsequent treatments of concrete surfaces.
c. Provide form release agent that reduces formwork moisture absorption, and does not contain diesel fuel, petroleum-based lubricating oils, waxes, or kerosene. Submit documentation indicating type of biobased material in product and biobased content. Indicate relative dollar value of biobased content products to total dollar value of products included in project.
d. Submit manufacturer's product data on formwork release agent for use on each form-facing material.

3.6 STEEL REINFORCING

Reinforcement must be free from loose, flaky rust and scale, and free from oil, grease, or other coating which might destroy or reduce the reinforcement's bond with the concrete.

3.6.1 Fabrication

Shop fabricate steel reinforcement in accordance with ACI 318 and ACI SP-66. Provide shop details and bending in accordance with ACI 318 and ACI SP-66.

3.6.2 Splicing

Perform splices in accordance with ACI 318 and ACI SP-66.

3.6.3 Supports

Secure reinforcement in place by the use of metal or concrete supports, spacers, or ties.

3.7 EMBEDDED ITEMS

Before placing concrete, take care to determine that all embedded items are firmly and securely fastened in place. Provide embedded items free of oil and other foreign matter, such as loose coatings of rust, paint and scale. Embedding of wood in concrete is permitted only when specifically authorized or directed.

3.8 TESTING AND INSPECTING

Report the results of all tests and inspections conducted at the project site informally at the end of each shift. Submit written reports weekly. Deliver within three days after the end of each weekly reporting period.

3.8.1 Field Testing Technicians

The individuals who sample and test concrete must have demonstrated a knowledge and ability to perform the necessary test procedures equivalent to the ACI minimum guidelines for certification of Concrete Field Testing Technicians, Grade I.

3.8.2 Preparations for Placing

Inspect foundation or construction joints, forms, and embedded items in sufficient time prior to each concrete placement to certify that it is ready to receive concrete.

3.8.3 Sampling and Testing

e. Obtain samples and test concrete for quality control during placement. Sample fresh concrete for testing in accordance with ASTM C172/C172M. Make six test cylinders.

f. Test concrete for compressive strength at 7 and 28 days for each design mix and for every 100 cubic yards of concrete. Test two cylinders at 7 days; two cylinders at 28 days; and hold two cylinders in reserve. Conform test specimens to ASTM C31/C31M. Perform compressive strength testing conforming to ASTM C39/C39M.

g. Test slump at the site of discharge for each design mix in accordance with ASTM C143/C143M. Check slump once during each shift that concrete is produced.

h. Test air content for air-entrained concrete in accordance with ASTM C231/C231M. Test concrete using lightweight or extremely porous aggregates in accordance with ASTM C173/C173M. Check air content at least once during each shift that concrete is placed.

i. Determine temperature of concrete at time of placement in accordance with ASTM C1064/C1064M. Check concrete temperature at least once during each shift that concrete is placed.

3.8.4 Action Required

3.8.4.1 Placing

Do not begin placement until the availability of an adequate number of acceptable vibrators, which are in working order and have competent operators, has been verified. Discontinue placing if any lift is inadequately consolidated.

3.8.4.2 Air Content

Whenever an air content test result is outside the specification limits, adjust the dosage of the air-entrainment admixture prior to delivery of concrete to forms.

3.8.4.3 Slump

Whenever a slump test result is outside the specification limits, adjust the batch weights of water and fine aggregate prior to delivery of concrete to the forms. Make the adjustments so that the water-cementitious material ratio does not exceed that specified in the submitted concrete mixture proportion and the required concrete strength is still met.

-- End of Section --

SECTION 26 05 00.00 40: COMMON WORK RESULTS FOR ELECTRICAL
11/20

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI C12.1 (2014; Errata 2016) Electric Meters - Code for Electricity Metering

AMERICAN SOCIETY OF CIVIL ENGINEERS (ASCE)

ASCE 7-16 (2017; Errata 2018; Supp 1 2018) Minimum Design Loads and Associated Criteria for Buildings and Other Structures

ASTM INTERNATIONAL (ASTM)

ASTM D709 (2017) Standard Specification for Laminated Thermosetting Materials

ELECTRONIC INDUSTRIES ALLIANCE (EIA)

EIA 480 (1981) Toggle Switches INSTITUTE OF

ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE C2 (2023) National Electrical Safety Code

IEEE C57.12.28 (2014) Standard for Pad-Mounted Equipment - Enclosure Integrity

IEEE C57.12.29 (2014) Standard for Pad-Mounted Equipment - Enclosure Integrity for Coastal Environments

IEEE Stds Dictionary (2009) IEEE Standards Dictionary: Glossary of Terms & Definitions INTERNATIONAL CODE

COUNCIL (ICC)

ICC/ANSI A117.1 (2009) Accessible and Usable Buildings and Facilities

INTERNATIONAL ELECTRICAL TESTING ASSOCIATION (NETA)

NETA ATS (2021) Standard for Acceptance Testing Specifications for Electrical Power Equipment and Systems

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

ANSI C12.7	(2022) Requirements for Watthour Meter Sockets
ANSI C80.1	(2020) American National Standard for Electrical Rigid Steel Conduit (ERSC)
ANSI C80.3	(2020) American National Standard for Electrical Metallic Tubing (EMT)
ANSI Z535.1	(2017) Safety Colors
ANSI/NEMA OS 1	(2013; R 2020) Sheet-Steel Outlet Boxes, Device Boxes, Covers, and Box Supports
ANSI/NEMA OS 2	(2013; R 2020) Nonmetallic Outlet Boxes, Device Boxes, Covers, and Box Supports
NEMA 250	(2020) Enclosures for Electrical Equipment (1000 Volts Maximum)
NEMA AB 3	(2013) Molded Case Circuit Breakers and Their Application
NEMA FB 1	(2014) Standard for Fittings, Cast Metal Boxes, and Conduit Bodies for Conduit, Electrical Metallic Tubing, and Cable
NEMA FU 1	(2012) Low Voltage Cartridge Fuses
NEMA ICS 1	(2022) Standard for Industrial Control and Systems: General Requirements
NEMA ICS 6	(1993; R 2016) Industrial Control and Systems: Enclosures
NEMA KS 1	(2013) Enclosed and Miscellaneous Distribution Equipment Switches (600 V Maximum)
NEMA PB 1	(2011) Panelboards
NEMA RN 1	(2005; R 2013) Polyvinyl-Chloride (PVC) Externally Coated Galvanized Rigid Steel Conduit and Intermediate Metal Conduit
NEMA ST 20	(2014) Dry-Type Transformers for General Applications
NEMA TC 2	(2020) Standard for Electrical Polyvinyl Chloride (PVC) Conduit
NEMA TC 3	(2021) Polyvinyl Chloride (PVC) Fittings for Use With Rigid PVC Conduit and Tubing
NEMA VE 1	(2017) Metal Cable Tray Systems
NEMA WD 1	(1999; R 2020) Standard for General Color Requirements for Wiring Devices

NEMA WD 6	(2021) Wiring Devices Dimensions Specifications

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2023) National Electrical Code
NFPA 70E	(2024) Standard for Electrical Safety in the Workplace

TELECOMMUNICATIONS INDUSTRY ASSOCIATION (TIA)

TIA-222	(2018H; Add 1 2019) Structural Standard for Antenna Supporting Structures and Antennas and Small Wind Turbine Support Structures

UNDERWRITERS LABORATORIES (UL)

UL 1	(2005; Reprint Jan 2022) UL Standard for Safety Flexible Metal Conduit
UL 4	(2004; Reprint Mar 2021) UL Standard for Safety Armored Cable
UL 5	(2016; Reprint Jul 2022) UL Standard for Safety Surface Metal Raceways and Fittings
UL 5A	(2015; Reprint Aug 2020) Nonmetallic Surface Raceways and Fittings
UL 6	(2022) UL Standard for Safety Electrical Rigid Metal Conduit-Steel
UL 20	(2018; Reprint May 2023) UL Standard for Safety General-Use Snap Switches
UL 44	(2018; Reprint May 2021) UL Standard for Safety Thermoset-Insulated Wires and Cables
UL 50	(2015) UL Standard for Safety Enclosures for Electrical Equipment, Non-Environmental Considerations
UL 67	(2018; Reprint May 2023) UL Standard for Safety Panelboards
UL 83	(2017; Reprint Mar 2020) UL Standard for Safety Thermoplastic-Insulated Wires and Cables
UL 198M	(2018; Reprint May 2023) UL Standard for Mine-Duty Fuses
UL 360	(2013; Reprint Apr 2023) UL Standard for Safety Liquid-Tight Flexible Metal Conduit
UL 486A-486B	(2018; Reprint May 2021) UL Standard for

	Safety Wire Connectors
UL 486C	(2018; Reprint May 2021) UL Standard for Safety Splicing Wire Connectors
UL 489	(2016; Rev 2019) UL Standard for Safety Molded-Case Circuit Breakers, Molded-Case Switches and Circuit-Breaker Enclosures
UL 498	(2017; Reprint May 2023) UL Standard for Safety Attachment Plugs and Receptacles
UL 506	(2017; Reprint Jan 2022) UL Standard for Safety Specialty Transformers
UL 514A	(2013; Reprint Jun 2022) UL Standard for Safety Metallic Outlet Boxes
UL 514B	(2012; Reprint May 2020) Conduit, Tubing and Cable Fittings
UL 514C	(2014; Reprint Feb 2020) UL Standard for Safety Nonmetallic Outlet Boxes, Flush-Device Boxes, and Covers
UL 651	(2011; Reprint May 2022) UL Standard for Safety Schedule 40, 80, Type EB and A Rigid PVC Conduit and Fittings
UL 797	(2007; Reprint Apr 2023) UL Standard for Safety Electrical Metallic Tubing -- Steel
UL 817	(2015; Reprint May 2023) UL Standard for Safety Cord Sets and Power-Supply Cords
UL 869A	(2006; Reprint Jun 2020) Reference Standard for Service Equipment
UL 870	(2016; Reprint Mar 2019) UL Standard for Safety Wireways, Auxiliary Gutters, and Associated Fittings
UL 943	(2016; Reprint Feb 2018) UL Standard for Safety Ground-Fault Circuit-Interrupters
UL 1242	(2006; Reprint Apr 2022) UL Standard for Safety Electrical Intermediate Metal Conduit -- Steel
UL 1283	(2017) UL Standard for Safety Electromagnetic Interference Filters
UL 1449	(2021; Reprint Dec 2022) UL Standard for Safety Surge Protective Devices
UL 1561	(2011; Reprint Jun 2015) Dry-Type General Purpose and Power Transformers
UL 1569	(2018) UL Standard for Safety Metal-Clad

	Cables
UL 4248-1	(2022) UL Standard for Safety Fuseholders - Part 1: General Requirements
UL 4248-12	(2018; Reprint Feb 2022) UL Standard for Safety Fuseholders - Part 12: Class R

1.2 DEFINITIONS

a. Unless otherwise specified or indicated, electrical and electronics terms used in these specifications, and on the drawings, are as defined in IEEE Stds Dictionary.

b. The technical sections referred to herein are those specification sections that describe products, installation procedures, and equipment operations and that refer to this section for detailed description of submittal types.

1.3 SUBMITTALS

Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings Marking Strips;

SD-03 Product Data

Conduits and Raceways; Wire and Cable;

Splices and Connectors;

Outlet Boxes, Pull Boxes and Junction Boxes; Circuit Breakers;

Panelboards;

Dry-Type Distribution Transformers;

Device Plates;

SD-06 Test Reports

Continuity Test;

Phase-Rotation Tests;

Insulation Resistance Test;

600-Volt Wiring Test;

Transformer Tests;

Ground-Fault Receptacle Test; Insulation-Resistance Test;

SD-08 Manufacturer's Instructions

1.4 QUALITY CONTROL

1.4.1 Regulatory Requirements

In each of the publications referred to herein, consider the advisory provisions to be mandatory, as though the word, "shall" had been substituted for "should" wherever it appears. Interpret references in these publications to the "authority having jurisdiction," or words of similar meaning, to mean the Contractor/Buyer. Ensure equipment, materials, installation, and workmanship are in accordance with the mandatory and advisory provisions of NFPA 70, [IEEE C2] unless more stringent requirements are specified or indicated.

1.4.2 Standard Products

Provide materials and equipment that are products of manufacturers regularly engaged in the production of such products which are of equal material, design and workmanship. Provide products which have been in satisfactory commercial or industrial use for 2 years prior to bid opening. Ensure the 2-year period includes applications of equipment and materials under similar circumstances and of similar size. Ensure the product has been on sale on the commercial market through advertisements, manufacturers' catalogs, or brochures during the 2-year period. Where two or more items of the same class of equipment are required, these items must be products of a single manufacturer.

PART 2 PRODUCTS

2.1 EQUIPMENT

Provide the standard cataloged materials and equipment of manufacturers regularly engaged in the manufacture of the products. For material, equipment, and fixture lists submittals, show manufacturer's style or catalog numbers, specification and drawing reference numbers, warranty information, and fabrication site.

Provide factory-applied finish on electrical equipment in accordance with the following:

a. NEMA 250 corrosion-resistance test and the additional requirements as specified herein.

b. Interior and exterior steel surfaces of equipment enclosures: thoroughly cleaned followed by a rust-inhibitive phosphatizing or equivalent treatment prior to painting.

c. Exterior surfaces: free from holes, seams, dents, weld marks, loose scale or other imperfections.

d. Interior surfaces: receive not less than one coat of corrosion-resisting paint in accordance with the manufacturer's standard practice.

e. Exterior surfaces: primed, filled where necessary, and given not less than two coats baked enamel with semigloss finish.

f. Equipment located indoors: ANSI Light Gray, and equipment located outdoors: ANSI[Light Gray][Dark Gray].

g. Provide manufacturer's coatings for touch-up work and as specified in paragraph FIELD APPLIED MOUNTING.

2.1.1 Conduits and Raceways

2.1.1.1 Rigid Steel Conduit

Provide hot dipped galvanized rigid steel conduit complying with NEMA RN 1, ANSI C80.1, UL 6 and UL 5 as applicable. Except where installed underground, or in corrosive areas, provide polyvinylchloride (PVC), or protect from corrosion by painting with bitumastic coating or wrapping with corrosion inhibiting tape..

Use threaded fittings for rigid steel conduit.

Use solid gaskets. Ensure conduit fittings with blank covers have gaskets, except in clean, dry areas or at the lowest point of a conduit run where drainage is required.

Provide covers with captive screws and are accessible after the work has been completed.

2.1.1.2 Electrical Metallic Tubing (EMT)

Ensure EMT is in accordance with UL 797, UL 5, and ANSI C80.3 and is zinc coated steel. Provide zinc-coated couplings and connectors that are raintight, [gland] compression type with insulated throat. Crimp, spring, or setscrew type fittings are not acceptable.

2.1.1.3 Flexible Metallic Conduit

Ensure flexible metallic conduit is galvanized steel and complies with UL 1 and UL 360.

Ensure fittings for flexible metallic conduit are specifically designed for such conduit.

Provide liquid-tight flexible metallic conduit with a protective jacket of PVC extruded over a flexible interlocked galvanized steel core to protect wiring against moisture, oil, chemicals, and corrosive fumes.

Ensure fittings for liquid-tight flexible metallic conduit are specifically designed for such conduit.

2.1.1.4 Intermediate Metal Conduit

Ensure intermediate metal conduit is galvanized steel and complies with UL 1242, NEMA RN 1, ANSI C80.1, UL 6 and UL 5 as applicable.

2.1.1.5 Rigid Nonmetallic Conduit

Ensure rigid nonmetallic conduit complies with NEMA TC 2, NEMA TC 3, and UL 651 as applicable with a wall thickness not less than Schedule 40.

2.1.1.6 Surface Metal Raceway

Ensure surface metal raceways and multi-outlet assemblies conform to NFPA 70, and have receptacles conforming to NEMA WD 1, Type [5-15R] [5-20R].

UL 5, two-piece painted steel, totally enclosed, snap-cover type. Provide multiple outlet-type raceway with grounding-type receptacle where indicated.

2.1.1.7 Surface Nonmetallic Raceway

UL 5A, nonmetallic totally enclosed, snap-cover type. Provide multiple outlet-type raceway with grounding-type receptacle where indicated.

2.1.2 Wireways

Ensure wireways and auxiliary gutters are a minimum 4 by 4-inch trade size conforming to UL 870.

UL 870. Material: steel epoxy painted 16 gauge for heights and depths up to 6 by 6 inches, and 14 gauge for heights and depths up to 12 by 12 inches. Provide in length required for the application with[hinged-][screw-] cover NEMA[1][3R][12] enclosure per NEMA ICS 6.

]2.1.4 Outlet Boxes, Pull Boxes and Junction Boxes

Ensure outlet boxes for use with conduit systems are in accordance with NEMA FB 1 UL 514A, UL 514B, UL 514C and [ANSI/NEMA OS 1] [ANSI/NEMA OS 2] and are not less than 1½ inches deep. Furnish all pull and junction boxes with screw-fastened covers.

2.1.5 Panelboards

Provide panelboards in accordance with NEMA PB 1, UL 67, and UL 50. Ensure panelboards for use as service equipment are also in accordance with UL 869A. Ensure panelboards have current rating, number of phases, and number of wires as indicated or specified herein. Ensure panelboards are rated for 277/480-volt, three-phase, 60-hertz. Ensure each panelboard, as a complete unit, has a short-circuit current rating equal to or greater than the integrated equipment rating indicated, but in no case less than 10,000 amperes symmetrical.

Provide panelboards with bolt-on circuit breakers only. Use of plug-in style breaker is not permitted. Ensure panelboards are designed such that individual breakers can be removed without disturbing adjacent units or without loosening or removing supplemental insulation supplied as means of obtaining required clearance. Provide main lugs or main circuit breakers mounted["above"][or]["below"] branch breakers with current ratings as indicated. Use of sub-feed breakers is not acceptable unless specifically indicated otherwise. Where "space only" is indicated, make provisions for future installation of breakers.

Submit detail drawings and manufacturer's standard product data for panelboards. Detail drawings consist of fabrication and assembly drawings for all parts of the work in sufficient detail to verify conformity with all requirements. Ensure drawings for panelboards indicate details of bus layout, overall physical features, dimensions, ratings, service requirements, and weights of equipment.

Provide[[tinned] copper][aluminum] buses of the rating indicated, with main lugs or main circuit breaker. Provide all panelboards for use on grounded ac systems with a separate grounding bus in accordance with UL 67 bonded to the panelboard enclosure. Provide three-phase, four-wire and single-phase, three-wire panelboards with an isolated full-capacity bus providing spaces for single-pole circuit breaker switches and spaces indicated as spare.

Provide bus bar connections to the branch circuit breakers that are the "distributed phase" or "phase sequence" type. Ensure single-phase, three-wire panelboard busing is such that when any two adjacent single-pole breakers are connected to opposite phases, two-pole breakers can be installed in any location. Ensure that three-phase, four-wire panelboard busing is such that when any three adjacent single-pole breakers are individually connected to each of the three different phases, two- or three-pole breakers can be installed at any location. Ensure current-carrying parts of the bus assembly are plated.

Support bus bars on bases independent of circuit breakers. Design main buses and back pans so that breakers may be changed without machining, drilling, or tapping.

2.1.5.1 Circuit Breakers

Provide circuit breakers that conform to UL 489 and NEMA AB 3 [and as specified in Section 26 05 71.00 40 LOW VOLTAGE OVERCORRECT PROTECTIVE DEVICES]with frame a trip ratings as indicated.

Provide bolt-on type, molded-case, manually operated, trip-free circuit breakers, with inverse-time thermal-overload protection and instantaneous magnetic short-circuit protection. Completely enclose circuit breakers in a molded case, with a factory-sealed, calibrated sensing element to prevent tampering. Plug-in type, tandem, and half-size circuit breakers are not permitted.

Provide inverse-time-delay thermal-overload protection and instantaneous magnetic short-circuit protection. Provide an instantaneous [thermal-magnetic][electronic][solid-state] tripping element that is adjustable and accessible from the front of the breaker on frame sizes larger than [100][250][_____] ampere.[Provide circuit breakers with frame sizes [100][250][_____] ampere and larger with [electronic][solid-state] trip units equipped with adjustable long-time[,][short-time][and][ground-fault] settings in addition to instantaneous.]

Provide sufficient interrupting capacity of the panel and lighting branch circuit breakers to successfully interrupt the maximum short-circuit current imposed on the circuit at the breaker terminals. Provide circuit breaker interrupting capacities with a minimum of 10,000 A and that conform to NEMA AB 3. Series rating of circuit breakers or overcurrent protective devices to achieve indicated interrupt rating is [not]permitted.

Provide the common-trip-type multipole circuit breakers having a single operating handle and a two-position on/off indication. Provide circuit breakers with temperature compensation for operation in an ambient temperature of 104 degrees F. Provide circuit breakers that have root mean square (rms) symmetrical interrupting ratings sufficient to protect the circuit being supplied. Interrupting ratings may have selective-type tripping (time delay, magnetic, thermal, or ground fault).

Provide a phenolic-composition breaker body capable of having such accessories as handle-extension, handle-locking, and padlocking devices attached where required to meet lock-out/tag-out requirements of NFPA 70E.

2.1.6 Dry-Type Distribution Transformers

2.1.6.1 General Requirements

Ensure that general purpose dry-type transformers with windings 600 volts or less are two-winding, 60 hertz, and self-cooled in accordance with UL

506 and UL 1561. Ensure windings have a minimum of two 2-1/2-percent taps above and below nominal voltage.

Provide transformers in NEMA[1][3R][_____] enclosure. Transformer insulation system:

a. 220 degrees C insulation system for transformers 15 kVA and greater, with temperature rise not exceeding[150][115][80] degrees C under full-rated load in maximum ambient of 40 degrees C.

b. 180 degrees C insulation for transformers rated 10 kVA and less, with temperature rise not exceeding[150][115][80] degrees C under full-rated load in maximum ambient of 40 degrees C.

2.1.6.2 Transformer Factory Tests

Submittal: include routine NEMA ST 20 transformer test results on each transformer and also provide the results of NEMA "design" and "prototype" tests that were made on transformers electrically and mechanically equal to those specified.

2.2 MATERIALS

2.2.1 Wire And Cable

Provide wires and cables in accordance with applicable requirements of NFPA 70 and UL for type of insulation, jacket, and conductor specified or indicated. Do not use wires and cables manufactured more than 12 months prior to date of delivery to site.

Provide minimum conductor size in accordance with the following:

a. Branch circuits: No. 12 AWG.

b. Class 1 remote-control and signal circuits: No. 14 AWG.

c. Class 2 low-energy, remote-control and signal circuits: No. 16 AWG.

d. Class 3 low-energy, remote-control, alarm and signal circuits: No. 22 AWG.

Ensure connectors used in wire systems comply with UL 486A-486B and UL 486C as applicable.

Ensure conductors installed in plenums are marked plenum rated.

2.2.1.1 Insulation

Unless specified or indicated otherwise or required by NFPA 70, provide power and lighting wires rated for 600-volts,[Type THWN/THHN conforming to UL 83][or][Type[XHHW][or][RHW] conforming to UL 44], except that grounding wire may be type TW conforming to UL 83; remote-control and signal circuits: Type TW or TF, conforming to UL 83. Where lighting fixtures require 90-degree Centigrade (C) conductors, provide only conductors with 90-degree C insulation or better.

2.2.2 Device Plates Provide the following:

a. UL listed, one-piece device plates for outlets to suit the devices installed.

b. For metal outlet boxes, plates on unfinished walls: zinc-coated sheet steel or cast metal having round or beveled edges.

c. For nonmetallic boxes and fittings, other suitable plates may be provided.

g. Sectional type device plates are not permitted.

h. Plates installed in wet locations: gasketed and UL listed for "wet locations."

2.2.3 Switches

2.2.3.1 Safety Switches

Ensure safety switches comply with NEMA KS 1, and are the heavy-duty type with enclosure, voltage, current rating, number of poles, and fusing as indicated on the drawings. Ensure fused switch fuse holders comply with UL 4248-1. Ensure switch construction is such that, when the switch handle in the "ON" position, the cover or door cannot be opened. Cover release device is coin proof and so constructed that an external tool is used to open the cover. Make provisions to lock the handle in the "OFF" position. Ensure the switch is not capable of being locked in the "ON" position.

Provide switches of the quick-make, quick-break type and terminal lugs for use with copper conductors.

Ensure safety color coding for identification of safety switches conforms to ANSI Z535.1.

2.2.3.2 Toggle Switches

Ensure toggle switches comply with EIA 480, NEMA WD 1, and UL 20 control Light Emitting Diode (LED), and fluorescent lighting fixtures and are the heavy duty, general purpose, noninterchangeable flush-type.

Provide commercial grade toggle switches, [single] [double]-pole, [three] [four]-way two-position devices rated 20 amperes at 120/277 volts, 60 hertz alternating current (ac) only.

Ensure all toggle switches are products of the same manufacturer.

2.2.4 Fuses

NEMA FU 1. Provide complete set of fuses for each fusible[switch][panel][and control center]. Coordinate time-current characteristics curves of fuses serving motors or connected in series with circuit breakers[or other circuit protective devices] for proper operation. Submit coordination data for approval. Provide fuses with a voltage rating not less than circuit voltage.

2.2.4.1 Fuseholders

Provide in accordance with UL 4248-1.

2.2.4.2 Cartridge, Current Limiting Type (Class R)

UL 198M, Class[RK-1][RK-5][time-delay type]. Provide only Class R associated fuseholders in accordance with UL 4248-12.

2.2.4.3 Cartridge Fuses, High-Interrupting Capacity, Current Limiting Type (Classes J, L, and CC)

UL 198M, Class J for zero to 600 amperes, Class L for 601 to 6,000 amperes, and Class CC for zero to 30 amperes.

2.2.4.4 Cartridge Fuses, Current Limiting Type (Class T)

UL 198M, Class T for zero to 1,200 amperes, 300 volts; and zero to 800 amperes, 600 volts.

2.2.5 Receptacles Provide the following:

a. [UL 498, hard use (also designated heavy-duty),][UL 498, hospital grade,] grounding-type.

b. Ratings and configurations: as indicated.

c. Bodies: [white][ivory][brown] as per NEMA WD 1.

d. Face and body: thermoplastic supported on a metal mounting strap.

e. Dimensional requirements: per NEMA WD 6.

f. Screw-type, side-wired wiring terminals or of the solderless pressure type having suitable conductor-release arrangement.

g. Grounding pole connected to mounting strap.

h. The receptacle: containing triple-wipe power contacts and double or triple-wipe ground contacts.

2.2.5.1 Switched Duplex Receptacles

Provide separate terminals for each ungrounded pole. Top receptacle: switched when installed.

2.2.5.2 Weatherproof Receptacles

Provide receptacles, UL listed for use in "wet locations." Include cast metal box with gasketed, hinged, lockable and weatherproof while-in-use, [polycarbonate, UV resistant/stabilized][die-cast metal/aluminum] cover plate.

2.2.5.3 Ground-Fault Circuit Interrupter Receptacles

UL 943, duplex type for mounting in standard outlet box. Provide device capable of detecting current leak of 6 milliamperes or greater and tripping per requirements of UL 943 for Class A ground-fault circuit interrupter devices. Provide screw-type, side-wired wiring terminals or pre-wired (pigtail) leads.

2.2.6 Manufacturer's Nameplate

Ensure each item of equipment has a nameplate bearing the manufacturer's name, address, model number, and serial number securely affixed in a conspicuous place; the nameplate of the distributing agent is not acceptable.

2.2.7 Warning Signs

Provide warning signs for the enclosures of electrical equipment including substations, pad-mounted transformers, pad-mounted switches, generators, and switchgear having a nominal rating exceeding 600 volts.

a. Enclosure integrity to conform with [IEEE C57.12.28][IEEE C57.12.29], such as for pad-mounted transformers[and pad-mounted SF6 switches]. Provide self-adhesive warning signs on the outside of the high voltage compartment door(s). Provide decal signs with nominal dimensions of 7 by 10 inches. Print the legend "DANGER HIGH VOLTAGE" in two lines of nominal 2-inch high letters. Show the word "DANGER" in white letters on a red background and the words "HIGH VOLTAGE" in black letters on a white background.[Use Panduit decal No. PPSO710D72 or approved equal.]

b. When such equipment is guarded by a fence, mount signs on the fence. Provide metal signs having nominal dimensions of 14 by 10 inches with the legend "DANGER HIGH VOLTAGE KEEP OUT" printed in three lines of nominal 3-inch high white letters on a red and black field.

2.2.9 Surge Protective Devices

Provide parallel type surge protective devices (SPD) which comply with UL 1449 at the service entrance[, load centers] [, panelboards] [, MCC] [and] [_____]. Provide surge protectors in a NEMA[1][______] enclosure per NEMA ICS 6. Use Type 1 or Type 2 SPD and connect on the load side of a dedicated circuit breaker.

Provide the following modes of protection:

FOR SINGLE PHASE AND THREE PHASE WYE CONNECTED SYSTEMS-
Phase to phase (L-L)
Each phase to neutral (L-N) [Neutral to ground (N-G)]
[Phase to ground (L-G)]

[FOR DELTA CONNECTIONS-
Phase to phase (L-L) Phase to ground (L-G)

] SPDs at the service entrance: provide with a minimum surge current rating of 80,000 amperes for L-L mode minimum and 40,000 amperes for other modes (L-N, L-G, and N-G)[and downstream SPDs rated 40,000 amperes for L-L mode minimum and 20,000 amperes for other modes (L-N, L-G, and N-G)].

[Provide SPDs per NFPA 780 for the lightning protection system.

Maximum L-N, L-G, and N-G Voltage Protection Rating:

[600V for 120V, single phase system] [600V for 120/240V, single phase system] [600V for 208Y/120V, three phase system] [1,200V for 480Y/277V, three phase system] Maximum L-L Voltage

Protection Rating:

[1,200V for 120V, single phase system]
[1,200V for 120/240V, single phase system]

[1,200V for 208Y/120V, three phase system]
[1,200V for 480Y/277V, three phase system]

][Provide SPDs. Maximum L-N, L-G, and N-G Voltage Protection Rating:
[700V for 120V, single phase system]
[700V for 120/240V, single phase system]
[700V for 208Y/120V, three phase system]
[1,200V for 480Y/277V, three phase system]

Maximum L-L Voltage Protection Rating:
[1,200V for 120V, single phase system]
[1,200V for 120/240V, single phase system]
[1,200V for 208Y/120V, three phase system]
[2,000V for 480Y/277V, three phase system]

] The minimum MCOV (Maximum Continuous Operating Voltage) rating for L-N and L-G modes of operation: 120% of nominal voltage for 240 volts and below; 115% of nominal voltage above 240 volts to 480 volts.

PART 3 EXECUTION

3.1 PREPARATION

Submit manufacturer's instructions including special provisions required to install equipment components and system packages. Special provisions include impedances, hazards and safety precautions.

Protect metallic materials against corrosion. Provide equipment enclosures with the standard finish by the manufacturer when used for most indoor installations. Do not use aluminum when in contact with earth or concrete and, where connected to dissimilar metal, protect by using approved fittings and treatment. Except where other equivalent protective treatment is specifically approved in writing, provide hot-dip galvanized ferrous metals for items such as, anchors, bolts, braces, boxes, bodies, clamps, fittings, guards, nuts, pins, rods, shims, thimbles, washers, and miscellaneous items not made of corrosion-resistant steel.

3.2 INSTALLATION

3.2.1 Underground Service

Underground service conductors and associated conduit: continuous from service entrance equipment to outdoor power system connection.

3.2.2 Hazardous Locations

Perform work in hazardous locations, as defined by NFPA 70, in strict accordance with NFPA 70 for particular "Class," "Division," and "Group" of hazardous locations involved. Provide conduit and cable seals where required by NFPA 70. Provide conduit with tapered threads.

3.2.3 Service Entrance Identification

Service entrance disconnect devices, switches, and enclosures: labeled and identified as such.

3.2.4 Labels

Wherever work results in service entrance, disconnect devices in more than one enclosure, as permitted by NFPA 70, label each enclosure, new and existing, as one of several enclosures containing service entrance disconnect devices. Label, at minimum: indicate number of service disconnected devices housed by enclosure and indicate total number of enclosures that contain service disconnect devices. Provide laminated plastic labels conforming to paragraph FIELD FABRICATED NAMEPLATES. Use lettering of at least 0.25 inch in height, and engrave on black-on-white matte finish. Service entrance disconnect devices in more than one enclosure: provided only as permitted by NFPA 70.

3.2.5 Wiring Methods

Provide insulated conductors installed in rigid steel conduit, IMC, rigid nonmetallic conduit, or EMT, except where specifically indicated or specified otherwise or required by NFPA 70 to be installed otherwise. Grounding conductor: separate from electrical system neutral conductor. Provide insulated green equipment grounding conductor for circuit(s) installed in conduit and raceways.[Shared neutral, or multi-wire branch circuits, are not permitted with arc-fault circuit interrupters.] Minimum conduit size: 1/2 inch in diameter for low voltage lighting and power circuits. Vertical distribution in multiple story buildings made with metal conduit in fire-rated shafts, with metal conduit extending through shafts for minimum distance of 6 inches.

3.2.5.1 Pull Wire

Install pull wires in empty conduits. Pull wire: plastic having minimum 200-pound force tensile strength. Leave minimum 36 inches of slack at each end of pull wire.

3.2.7 Conduits, Raceways and Fittings

Ensure that conduit runs between outlet and outlet, between fitting and fitting, or between outlet and fitting does not contain more than the equivalent of three 90-degree bends, including those bends located immediately at the outlet or fitting.

Do not install crushed or deformed conduit. Avoid trapped conduit runs where possible. Take care to prevent the lodgment of foreign material in the conduit, boxes, fittings, and equipment during the course of construction. Clear any clogged conduit of obstructions or replace conduit.

3.2.7.1 Rigid Steel Conduit

Make field-made bends and offsets with approved Hickey bending tool or conduit bending machine. Use long radius conduit for elbows larger than 2½ inches.

Provide a flush coupling for all conduit stubbed-up through concrete floors for connections to free-standing equipment with the exception of motor-control centers, cubicles, and other such items of equipment, when the floor slab is of sufficient thickness. Otherwise, provide a floor box set flush with the finished floor. For conduits installed for future use, terminate with a coupling and plug; set flush with the floor.

3.2.7.2 Electrical Metallic Tubing (EMT)

Ground EMT in accordance with NFPA 70, using pressure grounding connectors especially designed for EMT.

3.2.7.3 Flexible Metallic Conduit

Use flexible metallic conduit to connect recessed fixtures from outlet boxes in ceilings, transformers, and other approved assemblies.

Use bonding wires in flexible conduit as specified in NFPA 70, for all circuits. Flexible conduit is not considered a ground conductor.

Make electrical connections to vibration-isolated equipment with flexible metallic conduit.

Use liquid-tight flexible metallic conduit in wet and oily locations and to complete the connection to motor-driven equipment.

Provide flexible steel conduit between 3 and 6 feet in length for equipment subject to vibration, noise transmission, or movement; and for motors. Install flexible conduit to allow 20 percent slack. Minimum flexible steel conduit size: ½-inch diameter. Provide liquid-tight flexible[nonmetallic] conduit in wet and damp locations for equipment subject to vibration, noise transmission, movement, or motors. Provide separate ground conductor across flexible connections.

3.2.7.4 Intermediate Conduit

Make all field-made bends and offsets with approved Hickey bending tool or conduit bending machine. Use intermediate metal conduit only for indoor installations.

3.2.7.5 Rigid Nonmetallic Conduit

Install a green insulated copper grounding conductor in conduit with conductors and solidly connect to ground at each end. Size grounding wires in accordance with NFPA 70.

3.2.7.6 Underground Conduit

Plastic-coated rigid steel; plastic-coated steel IMC; PVC, Type EPC-40[; or fiberglass.

3.2.7.7 Conduit for Circuits Rated Greater Than 600 Volts

Rigid metal conduit or IMC only.

3.2.7.8 Conduit Support

Support conduit by pipe straps, wall brackets, threaded rod conduit hangers, or ceiling trapeze. Fasten by wood screws to wood; by toggle bolts on hollow masonry units; by concrete inserts or expansion bolts on concrete or brick; and by machine screws, welded threaded studs, or spring-tension clamps on steel work. Threaded C-clamps may be used on rigid steel conduit only. Do not weld conduits or pipe straps to steel structures. Do not exceed one-fourth proof test load for load applied to fasteners.

3.2.7.9 Directional Changes in Conduit Runs

Make changes in direction of runs with symmetrical bends or cast-metal fittings. Make field-made bends and offsets with hickey or conduit-bending machine. Do not install crushed or deformed conduits. Avoid trapped conduits. Prevent plaster, dirt, or trash from lodging in conduits, boxes, fittings, and equipment during construction. Free clogged conduits of obstructions.

3.2.8 Wiring

Color code feeder and branch circuit conductors as follows:

CONDUCTOR	COLOR AC
Phase A	Black (208VAC); Brown (480VAC)
Phase B	Red (208VAC); Orange (480VAC)
Phase C	Blue (208VAC); Yellow (480VAC)
Neutral	White (208VAC); Natural Gray (480VAC)
Equipment Grounds	[Green] [Green with Yellow

Use conductors up to and including AWG No. 2 that are manufactured with colored insulating materials. For conductors larger than AWG No. 2, have ends identified with color plastic tape in outlet, pull, or junction boxes.

Splice in accordance with the NFPA 70. Provide conductor identification within each enclosure where a tap, splice, or termination is made and at the equipment terminal of each conductor. Match terminal and conductor identification as indicated.

Where several feeders pass through a common pull box, tag the feeders to clearly indicate the electrical characteristics, circuit number, and panel designation.

3.2.9 Wiring Devices

3.2.9.1 Wall Switches and Receptacles

Install wall switches and receptacles so that when device plates are applied, the plates are aligned vertically to within [_____] [1/16] inch.

Bond ground terminal of each flush-mounted receptacle to the outlet box with an approved green bonding jumper when used with dry wall type construction.

3.2.9.2 Device Plates

Ensure device plates for switches are suitably engraved with a description of the loads when not within sight of the loads controlled.

Mark device plates and receptacle cover plates for receptacles other than 125-volt, single-phase, duplex, convenience outlets. Show the circuit number, voltage, frequency, phasing, and amperage available at the receptacle. Use self-adhesive labels having [______] [1/4] inch embossed letters.

Similarly mark device plates for convenience outlets indicating the supply panel and circuit number.

3.2.10 Splices and Connectors

Make all splices in AWG No. 8 and smaller with approved [insulated electrical type] [indentor crimp-type connectors and compression tools].

Make all splices in AWG No. 6 and larger with [indentor crimp-type connectors and compression tools][insulated electrical lugs type] . Wrap joints with an insulating tape that has an insulation and temperature rating equivalent to that of the conductor.

3.2.11 Conductor Identification

Provide conductor identification within each enclosure where tap, splice, or termination is made. For conductors No. 6 AWG and smaller diameter, provide color coding by factory-applied, color-impregnated insulation. For conductors No. 4 AWG and larger diameter, provide color coding by plastic-coated, self-sticking markers; colored nylon cable ties and plates; or heat shrink-type sleeves.

3.2.11.1 Marking Strips

Provide marking strips in accordance with the following:

a. Provide white or other light-colored plastic marking strips, fastened by screws to each terminal block, for wire designations.

b. Use permanent ink for the wire numbers

c. Provide reversible marking strips to permit marking both sides or provide two marking strips with each block.

d. Size marking strips to accommodate the two sets of wire numbers.

e. Assign a device designation in accordance with NEMA ICS 1 to each device to which a connection is made. Mark each device terminal to which a connection is made with a distinct terminal marking corresponding to the wire designation used on the Subcontractor's schematic and connection diagrams.

f. The wire (terminal point) designations used on the Subcontractor's wiring diagrams and printed on terminal block marking strips may be according to the Subcontractor's standard practice; however, provide additional wire and cable designations for identification of remote (external) circuits for the Contractor/Buyer's wire designations.

g. Prints of the marking strips drawings submitted for approval will be so marked and returned to the Subcontractor for addition of the designations to the terminal strips and tracings, along with any rearrangement of points required.

3.2.12 Safety Switches

Securely fasten switches to the supporting structure or wall, utilizing a minimum of [four] [_____] ¼-inch bolts. Do not use sheet metal screws and small machine screws for mounting. Do not mount switches in an inaccessible location or where the passageway to the switch may become obstructed. Mounting height [______] [5] feet above floor level, when possible.

3.2.13 Boxes and Fittings

Provide pull boxes where necessary in the conduit system to facilitate conductor installation. For conduit runs longer than [______] [100] feet or with more than three right-angle bends, install a pull box at a convenient intermediate location.

Securely mount boxes and enclosures to the building structure using supports that are independent of the conduit entering or leaving the boxes.

3.2.14 Covers and Device Plates

Install with edges in continuous contact with finished wall surfaces without use of mats or similar devices. Plaster fillings are not permitted. Install plates with alignment tolerance of 1/16 inch. Use of sectional-type device plates are not permitted. Provide gasket for plates installed in wet locations.

3.2.15 Panelboards

Securely mount panelboards so that the top operating handle does not exceed [_] [72]-inches above the finished floor. Do not mount equipment within
36-inches of the front of the panel. Ensure directory card information is complete and legible.

3.2.16 Dry-Type Distribution Transformers

Connect dry-type transformers with flexible metallic conduit.

Mount all dry-type transformers on vibration isolators

]3.2.18 Surge Protective Devices

Connect the surge protective devices in parallel to the power source, keeping the conductors as short and straight as practically possible. Maximum allowed lead length is 3 feet.

3.2.19 Field Fabricated Nameplates

Ensure nameplates conform to ASTM D709. Provide laminated plastic nameplates for each equipment enclosure, relay, switch, and device, as specified or as indicated on the drawings. Each nameplate inscription identifies the function and, when applicable, the position. Provide nameplates that are melamine plastic, 0.125-inch thick, white with [black] [_____] center core and a matte finish surface [with square corners]. Accurately align lettering and engrave into the core. Minimum size of nameplates is 1 by 2.5 inches. Lettering is a minimum of 0.25-inch high normal block style.

3.2.20 Identification Plates and Warnings

Provide identification plates for lighting and power panelboards, motor control centers, all line voltage heating and ventilating control panels, fire detector and sprinkler alarms, doorbells, pilot lights, disconnect switches, manual starting switches, and magnetic starters. Attach identification plates to process control devices and pilot lights.

Install identification plates for all line voltage enclosed circuit breakers, identifying the equipment served, voltage, phase(s) and power source. For circuits 480 volts and above, install conspicuously located warning signs in accordance with OSHA requirements.

3.3 FIELD FABRICATED NAMEPLATE MOUNTING

Provide number, location, and letter designation of nameplates as indicated. Fasten nameplates to the device with a minimum of two sheet-metal screws or two rivets.

3.4 WARNING SIGN MOUNTING

Provide the number of signs required to be readable from each accessible side. Space the signs in accordance with NFPA 70E.

3.5 FIELD APPLIED MOUNTING

Paint electrical equipment as required to match finish of adjacent surfaces or to meet the indicated or specified safety criteria. [Where field painting of enclosures for panelboards, load centers or the like is specified to match adjacent surfaces, to correct damage to the manufacturer's factory applied coatings, or to meet the indicated or specified safety criteria, provide manufacturer's recommended coatings and apply in accordance to manufacturer's instructions.]

3.6 FIELD QUALITY CONTROL

After completion of the installation and splicing, and prior to energizing the conductors, perform wire and cable continuity and insulation tests as herein specified before the conductors are energized.

Provide all necessary test equipment, labor, and personnel to perform the tests, as specified herein.

Isolate completely all wire and cable from all extraneous electrical connections at cable terminations and joints. Use substation and switchboard feeder breakers, disconnects in combination motor starters, circuit breakers in panel boards, and other disconnecting devices to isolate the circuits under test.

Perform insulation-resistance test on each field-installed conductor with respect to ground and adjacent conductors. Applied potential is 500 volts dc for 300 volt rated cable and 1000 volts dc for 600 volt rated cable. Take readings after 1 minute and until the reading is constant for 15 seconds. Minimum insulation-resistance values is not less than 25 Megohms for 300 volt rated cable and 100 Megohms for 600 volt rated cable. For circuits with conductor sizes AWG No. 8 and smaller insulation resistance testing is not required.

Perform continuity test to insure correct cable connection end-to-end (i.e., correct phase conductor, grounded conductor, and grounding conductor wiring). Repair and verify any damages to existing or new electrical equipment resulting from mis-wiring. Receive approval for all repairs prior to commencement of the repair.

Conduct phase-rotation tests on all three-phase circuits using a phase-rotation indicating instrument. Perform phase rotation of electrical connections to connected equipment in a clockwise direction, facing the source.

Perform 600-volt wiring test on wiring rated 600 volt and less to verify that no short circuits or accidental grounds exist. Perform insulation resistance tests on wiring No. 6 AWG and larger diameter using instrument which applies voltage of approximately 500 volts to provide direct reading of resistance. Minimum resistance: 250,000 ohms.

Perform the standard, not optional, transformer tests in accordance with the Inspection and Test Procedures for transformers, dry type, air-cooled, 600 volt and below; as specified in NETA ATS. Measure primary and secondary voltages for proper tap settings. Tests need not be performed by a recognized independent testing firm or independent electrical consulting firm.

Perform ground-fault receptacle test for ground-fault receptacles with a "load" (such as a plug-in light) to verify that the "line" and "load" leads are not reversed.

Submit test reports in accordance with referenced standards in this section.

Final acceptance requires the successful performance of wire and cable under test. Do not energize any conductor until the final test reports are reviewed and approved.

-- End of Section --

SECTION 26 05 26.00 40: GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS
08/19

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN WELDING SOCIETY (AWS)

AWS A3.0M/A3.0	(2020) Standard Welding Terms and Definitions
AWS A5.8/A5.8M	(2019) Specification for Filler Metals for Brazing and Braze Welding
AWS B2.1/B2.1M	(2021) Specification for Welding Procedure and Performance Qualification

ASTM INTERNATIONAL (ASTM)

ASTM B3	(2013) Standard Specification for Soft or Annealed Copper Wire
ASTM B8	(2011; R 2017) Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft
ASTM B187/B187M	(2020) Standard Specification for Copper, Bus Bar, Rod and Shapes and General Purpose Rod, Bar and Shapes

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE 81	(2012) Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Ground System
IEEE C2	(2023) National Electrical Safety Code

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

ANSI/NEMA GR 1	(2007) Grounding Rod Electrodes and Grounding Rod Electrode Couplings

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2023) National Electrical Code

TELECOMMUNICATIONS INDUSTRY ASSOCIATION (TIA)

TIA-607	(2019d) Generic Telecommunications Bonding and Grounding (Earthing) for Customer

Premises

U.S. DEPARTMENT OF DEFENSE (DOD)

MIL-STD-889	(2021; Rev D) Galvanic Compatibility of Electrically Conductive Materials

UNDERWRITERS LABORATORIES (UL)

UL 467	(2022) UL Standard for Safety Grounding and Bonding Equipment
UL 546	(2008) UL Outline of Investigation for Conductor Termination Compounds

1.2 SUBMITTALS

Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-11 Closeout Submittals Record Drawings

1.3 QUALITY CONTROL

1.3.1 Regulatory Requirements

In each of the publications referred to herein, consider the advisory provisions to be mandatory, as though the word, "shall" had been substituted for "should" wherever it appears. Interpret references in these publications to the "authority having jurisdiction," or words of similar meaning, to mean the Contractor/Buyer. Ensure equipment, materials, installation, and workmanship are in accordance with the mandatory and advisory provisions of NFPA 70, IEEE C2 unless more stringent requirements are specified or indicated.

1.3.2 Standard Products

Provide materials and equipment that are products of manufacturers regularly engaged in the production of such products which are of equal material, design and workmanship. Provide products which have been in satisfactory commercial or industrial use for 2 years prior to bid opening. Ensure the 2-year period includes applications of equipment and materials under similar circumstances and of similar size. Ensure the product has been on sale on the commercial market through advertisements, manufacturers' catalogs, or brochures during the 2-year period. Where two or more items of the same class of equipment are required, these items must be products of a single manufacturer.

PART 2 PRODUCTS

Submit material, equipment, and fixture lists for grounding systems, including manufacturer's style or catalog numbers, specification and drawing reference numbers, warranty information, and fabrication site information.

2.1 MATERIALS

2.1.1 Ground Rods

Provide ground rods of [copper][copper-clad steel] conforming to UL 467 and ANSI/NEMA GR 1. Ensure ground rods are not less than ¾ inch in diameter and 10 feet in length.

Where ground rod length is greater than 10 feet, provide sectional type ground rods with each section 10 feet in length. Join sectional type ground rods using [threaded brass couplings][exothermic welding completely around both rod/coupling joints][threaded couplings that are welded at the threaded joints]. Ensure ground rods have cone-shaped point on the end of the first section driven into the ground.

Provide ground rods and ground rod sections die-stamped near the top with the name or trademark of the manufacturer and the length of the segment in feet.

2.1.2 Ground Wires

2.1.2.1 Bare

Provide annealed bare copper, Class "B" stranded ground and bond wires in accordance with ASTM B8 for wires #4 AWG and larger and solid in accordance with ASTM B3 for wires #6 AWG and smaller. Provide conductors with 98 percent conductivity and sized wires in accordance with the requirements of NFPA 70 and NFPA 780.

2.1.2.2 Insulated

Ensure insulated conductors conform to the requirements of Section 26 05 00.00 40 COMMON WORK RESULTS FOR ELECTRICAL.

Where installed in conduit as part of a complete circuit provide conductors with green insulation for sizes #8 AWG and smaller and with green phase tape at each end and in each junction box for sizes #6 AWG and larger.

2.1.2.3 Straps/Jumpers

Provide copper bonding straps and jumpers with a cross-sectional area of not less than [No. 6 AWG][as indicated]. Ensure bonding straps and jumpers for shock-mounted devices with [pivot] [hinged] [swivel] joints are made of [flat] [tinned-copper] [woven-wire braid] [flexible stranded] wire.

2.1.3 Connectors and Fasteners

2.1.3.1 Exothermic Welds

Ensure the molds, materials and powder charges used to make exothermic welds are the standard product of a single manufacturer and listed by the manufacturer for use on the specific type, size, quantity and configuration of conductors to which the weld is applied.

2.1.3.2 Irreversible Compression Lugs

Provide irreversible compression lug type connectors manufactured from tin-plated copper and installed using a hydraulic compression tool and die to apply correct, uniformly distributed, circumferential pressure. Ensure tools and dies are as recommended by the irreversible compression lug type connector manufacturer. Use an embossing die code or other standard method to provide visible indication that a connector has been adequately compressed onto the conductor. Apply irreversible compression lug type connectors in strict accordance with the manufacturer's written instructions and published installation instructions. Use 2-hole lug type connectors for connections to NEMA cable pads and bus bars, and single-hole connectors otherwise.

2.1.3.3 Mechanical

Provide split bolt and clamp style mechanical type connectors manufactured from [copper,][copper alloy,][or][bronze,] listed by the manufacturer as suitable for direct burial use. Ensure mechanical type connectors are applied in strict accordance with the manufacturer's published installation instructions.

2.1.3.4 Fasteners

Provide bolts, nuts, washers, lock washers, and associated fasteners used for grounding and bonding connections manufactured of [copper][bronze][tin plated tempered brass][stainless steel]. Where fasteners contact dissimilar metals, apply conductive oxide-inhibiting compound.

2.1.5 Conductive Corrosion Inhibiting Compounds

Provide conductive corrosion inhibiting compounds UL Listed in accordance with UL 546, listed by the manufacturer as suitable for the application, and suitable for all aluminum and copper conductor/connector applications. Ensure conductive corrosion inhibiting compounds inhibit oxidation at the conductor/connector interface and have no deleterious effect on the conductor/connector metal or EPDM, natural rubber, or polyethylene insulating materials.[

Provide gritted conductive corrosion inhibiting compound that are non-petroleum based and non-toxic, and contain conductive grit. Ensure gritted conductive corrosion inhibiting compound is specified by the manufacturer for application to the conductor/connector interface of compression connectors.][

Provide non-gritted conductive corrosion inhibiting compound that are non-petroleum based and non-toxic and contain no grit filler. Ensure non-gritted conductive corrosion inhibiting compound is specified by the manufacturer for application to the conductor/connector interface of mechanical connectors such as bolted joints, flat-to-flat contact surfaces, terminal and lug tongues, and grooves of bolted parallel connectors or clamps.]

2.1.6 Ground Buses

Provide [electro-tin plated,]solid copper ground buses conforming to ASTM B187/B187M with minimum dimensions of 0.25 inch thick, 4 inches wide, and 12 inches in length or as indicated. Ensure ground buses are equipped with two UL Recognized red 1000V rated insulated standoffs and stainless steel mounting brackets.

Provide Telecommunications Main Ground Buses and Telecommunications Ground Buses in meeting the standards of TIA-607.

Provide grounding buses with predrilled NEMA hole configuration as indicated.

PART 3 EXECUTION

3.1 INSTALLATION

Install grounding systems in accordance with NFPA 70, NFPA 780 and IEEE C2, and as indicated.

Bond exposed non-current-carrying metallic parts of electrical equipment and metallic raceway systems to ground.

Bond grounding conductors in metallic and non-metallic raceways to ground. Make ground connections at equipment and to ground rods as indicated. Interconnect all grounding media in or on the structure to provide a common ground potential. This includes lightning protection, electrical service, telecommunications system grounds, as well as underground metallic piping systems.

Bond wiring system neutrals to ground in accordance with the requirements of NFPA 70. Where ground fault protection is employed, ensure that connection of ground and neutral does not interfere with correct operation of fault protection. [

Counterpoise ground systems consist of a series of ground rods with a direct buried grounding conductor loop, configured to minimize the number of dead-ends, interconnecting the individual ground rods. Provide ground rods in the locations indicated.]

3.1.1 Ground Rods

[Install ground rods using a water jetting procedure.]

[Install ground rods so that the top of the rod is [4] [_____] inches above grade.

][Install ground rods so that the top of the rod is not less than [18] [______] inches below finished grade.

]3.1.2 Conductors

Install bare or insulated conductors as indicated. Install bare conductors where not specifically identified as bare or insulated except where installed in conduit with associated phase conductors. Install insulated conductors in conduit with insulation of the same material as the associated phase conductors with which it is installed.

Provide straps/jumpers across joints subject to vibration. Install strap/jumper such that vibration will not change its electrical characteristics. Apply strap/jumper to the metallic structure on each side of the joint; do not penetrate any adjacent parts. Install straps/jumpers in areas that are accessible for maintenance. Install strap/jumper such that it does not restrict the movement of the metallic structures to which it is connected. Install strap/jumper such that it does not weaken the metallic structures to which it is attached. Do not connect two or more straps/jumpers in series.

3.1.3 Counterpoise

Install No. [4/0] [______] AWG bare copper counterpoise grounding conductor direct buried outside of the structure drip line, within 24 to 72 inches of the structure foundation, with a minimum of 18 inches of earth cover. Install counterpoise grounding conductor in earth undisturbed by excavation, not earth fill, and do not locate beneath roof overhang, or wholly under paved areas or roadways where rainfall cannot penetrate to keep soil moist in the vicinity of the conductor.

Install ground rods vertically into the earth not less 10 feet with top of ground rod not less than [18] [______] inches below finished grade. Bond ground rods to counterpoise grounding conductor at intervals no less than 20 linear feet nor greater than 40 linear feet of ground counterpoise cable.

3.1.4 Ground Buses

Install ground busses in accordance with manufacturer's instructions.

3.1.5 Building Grounds

Install No. [4/0] [______] AWG bare copper ground conductor from [concrete encased foundation rebar][and][every corner column and intermediate exterior column] to counterpoise. [Connect conductors to rebar using [mechanical connectors manufactured for such purpose][exothermic welds]. Install one conductor a minimum of every [60] [____] feet of concrete foundation perimeter.]Connect ground conductors to [columns and]counterpoise using [mechanical connectors manufactured for such purpose][exothermic welds].

3.1.6 Equipment Grounding

Install ground systems for power, telecommunications, and instrumentation. Independently connect each system to the building counterpoise.

3.1.6.1 Equipment and Enclosure Bonding

Bond each metallic enclosure and all electrical equipment to ground. Make at least one copper connection from the system ground point to one or more enclosures in the area such that all enclosures and equipment provide a low-impedance path to ground when properly bonded together.

[In addition to the green colored equipment grounding conductor required in each raceway and sized in accordance with Table 250.122 of NFPA 70, bond each panelboard, switchboard enclosure, transformer housing, motor housing, disconnect, starter, and other electrical equipment, to the grounding system with a stranded copper conductor, routed external to the feeder raceway.

] Individually and directly connect indoor substations, transformers, switchboard frames, switchgear assemblies, motors, motor control centers, air compressors, air handlers, refrigerated air dryers, generators, frames and tracks of cranes, and [_____] to the building ground. Ensure the current-carrying capacity of the grounding conductor is the same as the current-carrying capacity of the power conductors for circuits utilizing power lines size No. [2] [_____] AWG and smaller. For circuits with power wiring larger than No. [2] [______] AWG, ensure the grounding conductor is in accordance with NFPA 70.

3.1.6.2 Bonding of Conduit and Raceway Systems

Bond all metal conduit, fittings, junction boxes, outlet boxes, armored and metal sheathed cable, and other raceways. Ensure adequate electrical contact at the joints and terminations. Ensure metallic raceway systems have electrical continuity with equipment. Individually and directly connect equipment to the building ground, independent of the raceway system.

For rigid metal conduit and terminations, ensure threaded connections are wrench-tight with no exposed threads. Ream all ends of the conduit to remove burrs and rough edges. Bond conduits entering boxes and enclosures to the box with [bonding-type locknuts, one outside and one inside.] [locknuts and grounding-type bushings.] Locknuts that gouge into the metal box when tightened are not acceptable.

Conduit systems that are interrupted by PVC dielectric links are bonded separately on either side of the link. Do not jumper the dielectric link.

Install flexible metal conduit with an integral grounding conductor.

3.1.6.3 Cable Tray Bonding

Bond cable tray sections together. Cable tray sections in tandem assembly are considered as having electrical continuity when these sections are bonded with the appropriate bolts. Install bond straps across expansion joints. Bond cable trays to the building ground system.

3.1.7 Bonding Materials And Methods

Accomplish bonding of metal surfaces by [brazing] [welding] [clamping] [structural joining methods].

3.1.7.1 Brazing

Ensure brazing solder conforms to AWS A5.8/A5.8M [_____].

3.1.7.2 Welding

Weld using the exothermic process with procedures conforming to AWS A3.0M/A3.0, AWS B2.1/B2.1M, and manufacturer's recommendation. Where dissimilar metals are to be joined via exothermic weld, follow the weld kit manufacturer's recommendations and published instructions. Ensure connections between dissimilar metals do not produce galvanic action in accordance with MIL-STD-889.

Use welding processes of the exothermic fusion type that makes a connection without corroding or loosening. Ensure process joins all strands and does not cause the parts to be damaged or weakened. Completed connection or joint is equal or larger in size than the conductors joined and has the same current-carrying capacity as the largest conductor. Paint the buried ground connections with a bitumastic paint.

3.1.7.3 Clamping

In external locations, use clamping only where a disconnect type of connection is required. Connection device may utilize [spring-loaded jaws] [threaded fasteners]. Construct device such that positive contact pressure is maintained at all times. Use machine bolts with [tooth-type] [spring-type] lock washers.

3.1.7.4 Cleaning of Bonding Surfaces

Thoroughly clean surfaces that comprise the bond before joining. Apply an appropriate abrasive with gentle and uniform pressure to ensure a smooth and uniform surface. Do not remove excessive metal from the surface. Clean clad metals in such a manner that the cladding material is not penetrated by the cleaning process. Then clean bare metal with an appropriate solvent to remove any grease, oil, dirt, corrosion preventives, and other contaminants. Bond to the cleaned area within one hour after cleaning. Seal joint and refinish the exposed surfaces within two hours of exposure to prevent oxidation. When additional time is required, apply a corrosion preventive compound until the area can be refinished.

3.1.7.5 Protection of Finished Bonds

Protect finished bonds by painting to match the original finish after the bond is made.

3.2 FIELD QUALITY CONTROL

Submit written results of each test to Contractor/Buyer for review and approval. Document each location where test is performed, the field conditions at the time of the test, the measured results of the test, and whether the measured results "PASSED" or "FAILED" relative to specified pass/fail performance criteria.

Perform rework to correct FAILED conditions at no additional cost to the Contractor/Buyer.

3.2.1 Ground Isolation Test

Test ground systems for isolation from other ground systems.

3.2.2 Equipment Continuity Test

Test connection from electrical distribution equipment including panelboards, switchboards, transformers, substations, and motor control centers to counterpoise. Measure and record the circuit resistance between electrical equipment ground connections and the counterpoise. The circuit resistance shall not exceed [5][ ] Ohms.

3.3 CLOSEOUT ACTIVITIES

Submit record drawings indicating the location of ground rods, mats, grids, building ground bus, supplementary grounding electrodes, steel building columns, and other metal structures connected to the grounding system.

-- End of Section --

SECTION 26 28 00.00 10: MOTOR CONTROL CENTERS, SWITCHBOARDS AND PANELBOARDS
08/22

PART 1 GENERAL

1.1 SUMMARY

These specifications include the design, fabrication, assembly, wiring, testing, and delivery of the items of equipment and accessories and spare parts listed in the Schedule and shown on the drawings.

1.2 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI C12.1	(2014; Errata 2016) Electric Meters - Code for Electricity Metering

AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)

ASME B1.1	(2003; R 2018) Unified Inch Screw Threads (UN and UNR Thread Form)
ASME B1.20.1	(2013; R 2018) Pipe Threads, General Purpose (Inch)

ASTM INTERNATIONAL (ASTM)

ASTM A780/A780M	(2020) Standard Practice for Repair of Damaged and Uncoated Areas of Hot-Dip Galvanized Coatings
ASTM B187/B187M	(2020) Standard Specification for Copper, Bus Bar, Rod and Shapes and General Purpose Rod, Bar and Shapes
ASTM B317/B317M	(2007; R 2015; E 2016) Standard Specification for Aluminum-Alloy Extruded Bar, Rod, Tube, Pipe, Structural Profiles, and Profiles for Electrical Purposes (Bus Conductor)
ASTM D877	(2002; R 2007) Standard Test Method for Dielectric Breakdown Voltage of Insulating Liquids Using Disk Electrodes
ASTM D923	(2007) Standard Practice for Sampling Electrical Insulating Liquids
ASTM D924	(2008) Standard Test Method for Dissipation Factor (or Power Factor) and Relative Permittivity (Dielectric Constant) of Electrical Insulating Liquids

ASTM D971	(2020) Standard Test Method for Interfacial Tension of Insulating Liquids Against Water by the Ring Method
ASTM D974	(2014; E 2016) Standard Test Method for Acid and Base Number by Color-Indicator Titration
ASTM D1500	(2012; R 2017) Standard Test Method for ASTM Color of Petroleum Products (ASTM Color Scale)
ASTM D1524	(2015; R 2022) Standard Test Method for Visual Examination of Used Electrical Insulating Liquids in the Field
ASTM D1533	(2012) Standard Test Method for Water in Insulating Liquids by Coulometric Karl Fischer Titration

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE 81	(2012) Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Ground System
IEEE C2	(2023) National Electrical Safety Code
IEEE C37.04	(2018; Erta 2019; Corr 2021) Ratings and Requirements for AC High-Voltage Circuit Breakers with Rated Maximum Voltage Above 1000 V Corrigendum 1
IEEE C57.13	(2016) Standard Requirements for Instrument Transformers

INTERNATIONAL ELECTRICAL TESTING ASSOCIATION (NETA)

NETA ATS	(2021) Standard for Acceptance Testing Specifications for Electrical Power Equipment and Systems

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA C12.4	(1984; R 2011) Registers - Mechanical Demand
NEMA ICS 1	(2022) Standard for Industrial Control and Systems: General Requirements
NEMA ICS 2	(2000; R 2020) Industrial Control and Systems Controllers, Contactors, and Overload Relays Rated 600 V
NEMA ICS 4	(2015) Application Guideline for Terminal Blocks
NEMA ICS 6	(1993; R 2016) Industrial Control and Systems: Enclosures

NEMA PB 1	(2011) Panelboards
NEMA PB 2	(2011) Deadfront Distribution Switchboards
NEMA ST 20	(2014) Dry-Type Transformers for General Applications
NEMA/ANSI C12.10	(2011; R 2021) Physical Aspects of Watthour Meters - Safety Standard
NEMA/ANSI C12.11	(2006; R 2019) Instrument Transformers for Revenue Metering, 10 kV BIL through 350 kV BIL (0.6 kV NSV through 69 kV NSV)

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2023) National Electrical Code

U.S. DEPARTMENT OF DEFENSE (DOD)

DOD 8510.01	(2022) Risk Management Framework (RMF) for DoD Systems
DODI 8500.01	(2014) Cybersecurity UNDERWRITERS

LABORATORIES (UL)

UL 44	(2018; Reprint May 2021) UL Standard for Safety Thermoset-Insulated Wires and Cables
UL 50	(2015) UL Standard for Safety Enclosures for Electrical Equipment, Non-Environmental Considerations
UL 67	(2018; Reprint May 2023) UL Standard for Safety Panelboards
UL 467	(2022) UL Standard for Safety Grounding and Bonding Equipment
UL 489	(2016; Rev 2019) UL Standard for Safety Molded-Case Circuit Breakers, Molded-Case Switches and Circuit-Breaker Enclosures
UL 508	(2018; Reprint Jul 2021) UL Standard for Safety Industrial Control Equipment
UL 845	(2021) UL Standard for Safety Motor Control Centers
UL 891	(2019) UL Standard for Safety Switchboards
UL 1063	(2017; Reprint Jun 2022) UL Standard for Safety Machine-Tool Wires and Cables

1.3 SUBMITTALS

Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings;

Shop Drawings;

Switchboards; Panelboards;

SD-03 Product Data Equipment;

Required Settings Request For Settings

SD-06 Test Reports

Acceptance Checks And Tests;

1.4 DELIVERY, STORAGE, AND HANDLING

Ship the equipment as completely assembled and wired as feasible so as to require a minimum of installation work. Properly match mark each shipping section to facilitate reassembly,.

Carefully pack and ship separately any relay or other device which cannot withstand the hazards of shipment when mounted in place on the equipment. Mark these devices with the number of the panel which they are to be mounted on and fully identified. Wrap all finished painted surfaces and metal work or otherwise protect from damage during shipment. Prepare all parts for shipment so that slings for handling may be attached readily while the parts are in a railway car or transport truck. Carefully package and clearly mark all spare parts and accessories.

1.5 MAINTENANCE

1.5.1 Accessories and Tools

Furnish a complete set of accessories and special tools unique to equipment provided and required for erecting, handling, dismantling, testing and maintaining the apparatus.

1.5.2 Extra Materials

Furnish spare parts as specified below. All spare parts must be of the same material and workmanship, must meet the same requirements, and must be interchangeable with the corresponding original parts furnished.

SPARE PARTS	
Amount	Description
2 of each type and size	Fuses
1	Circuit breaker auxiliary switch
2 for each size ac contactor	Operating coils
1 for each size dc contactor	Operating coil

SPARE PARTS	
Amount	Description
2 Complete sets for each size ac contactor	3-pole stationary and moving contact assemblies
1 Complete set for each size dc contactor	2-pole stationary and moving contact assemblies
3 of each type and rating	Contactor overload relays, each relay with a complete set of contact blocks
1 Spare set for each heater rating provided	Heater elements
2 for each type	Indicating lamp assemblies
1 of each type and rating	Control transformer
1 of each type and rating	Control relay
1 of each type	Contactor auxiliary contact
1 for each type and rating	Circuit Breaker
1 for each type and rating	Motor Circuit Protector

PART 2 PRODUCTS

2.1 MATERIALS AND EQUIPMENT

Provide materials and equipment which are standard products of a manufacturer regularly engaged in their manufacture and that essentially duplicate items that have been in satisfactory use for at least 2 years prior to bid opening and that conform to the requirements of these specifications. Provide high quality materials, free from defects and imperfections, of recent manufacture, and of the classification and grades designated. All materials, supplies, and articles not manufactured by the Subcontractor must be the products of other recognized reputable manufacturers.

2.1.1 Rules

Provide equipment conforming to the requirements of NFPA 70 unless more stringent requirements are indicated herein or shown. NEMA rated and UL listed equipment has been specified when available. Provide equipment meeting NEMA and UL construction and rating requirements as specified. No equivalent will be acceptable. Immediately notify the Contractor/Buyer of any requirements of the specifications or Subcontractor proposed materials or assemblies that do not comply with UL or NEMA. International Electrotechnical Commission (IEC) rated equipment will not be considered an acceptable alternative to specified NEMA ratings.

2.1.2 Coordination

The general arrangement of the motor control centers, switchboards and panelboards is shown on the contract drawings. Any modifications of the equipment arrangement or device requirements as indicated will be subject to the approval of the Contractor/Buyer. If any conflicts occur necessitating departures from the drawings, submit details of and reasons for departures for approval prior to implementing any change. Completely assemble all equipment at the factory. The motor control centers and switchboards may be disassembled into sections, if necessary, for convenience of handling, shipping, and installation.

2.2 NAMEPLATES

Provide nameplates made of laminated sheet plastic or of anodized aluminum approximately 1/8-inch thick, engraved to provide white letters on a black background. Fasten the nameplates to the panels in proper positions with anodized round-head screws. Lettering must be minimum ½ inch high. Provide nameplate designations in accordance with lists on the drawings, and as a minimum provide nameplates for the following equipment:

a. Individual items of equipment mounted in the Motor Control Centers

b. Switchboards

[d. Individually-mounted circuit breakers in Switchboard]

[e. Group-mounted circuit breakers in Switchboard]

f. Panelboards

[g. Individually-mounted circuit breakers in Panelboard]

Provide equipment of the withdrawal type with nameplates mounted on the removable equipment in locations visible when the equipment is in place.

2.3 CONNECTIONS

Furnish all bolts, studs, machine screws, nuts, and tapped holes in accordance with ASME B1.1. Provide sizes and threads of all conduit and fittings, tubing and fittings, and connecting equipment in accordance with ASME B1.20.1. Provide ferrous fasteners that have rust-resistant finish and equip all bolts and screws with approved locking devices. Manufacturer's standard threads and construction may be used on small items which, in the opinion of the Contractor/Buyer, are integrally replaceable, except that threads for external connections to these items must meet the above requirements.

2.4 MOLDED CASE CIRCUIT BREAKERS

Provide molded case circuit breakers conforming to the applicable requirements of UL 489 and UL 489. Provide circuit breakers that are manually-operated, that are the quick-make, quick-break, common trip type, and that are of the automatic-trip type unless otherwise specified or indicated on the drawings. Operate all poles of each breaker simultaneously by means of a common handle. Provide operating handles that clearly indicate whether the breakers are in "On," "Off," or "Tripped" position and have provisions for padlocking in the "Off" position. Provide personnel safety line terminal shields for each breaker. Furnish circuit breakers that are products of only one manufacturer, and are interchangeable when of the same frame size. [Where indicated on the drawings, provide circuit breakers with shunt trip devices.] [Where indicated on the drawings, provide circuit breakers with bell alarm contacts that close on automatic operation only. Provide contacts that are suitable for [125] [_____] volts dc and reset when the breaker is reset.]

2.4.1 Trip Units

Except as otherwise noted, provide combination thermal and instantaneous magnetic or solid state trip units for the circuit breakers, of frame sizes and the trip unit ratings as shown on the drawings. The Contractor/Buyer reserves the right to change the indicated trip ratings, within frame limits, of the trip devices at the time the shop drawings are submitted for approval. Submit copies of outline drawings of all equipment to be furnished under this contract, together with weights and overall dimensions, within 30 calendar days after date of receipt of notice to proceed, for the approval of the Contractor/Buyer. Provide interchangeable breaker trip units and instantaneous magnetic trip units that are adjustable on frame sizes larger than 150 amperes. Set nonadjustable instantaneous magnetic trip units at approximately 10 times the continuous current ratings of the circuit breakers. [Solid state trip units, where indicated, must also have adjustable [long time pick-up and delay],[short time pick-up and delay], [and ground fault pick-up and delay].]

2.4.2 480-Volt AC Circuits

Furnish circuit breakers for 480-volt or 277/480-volt ac circuits that are rated 600 volts ac, and that have an UL listed minimum interrupting capacity of [14,000] [________________________________] symmetrical amperes at [600] [____________________________________] volts ac.

2.4.3 120/240-Volt AC Circuits

Circuit breakers for 120-volt ac circuits rated less than 120/240 or 240 volts ac are not permitted, and must have a UL listed minimum interrupting capacity of [10,000] [_____] symmetrical amperes.

2.4.4 125-Volt DC Circuits

Circuit breakers for 125-volt dc circuits must be two-pole rated 125/250 or
250 volts dc, and must have an UL listed minimum interrupting capacity of [5,000] [10,000] [_____] amperes dc.

2.5 WIRING

Provide control wire consisting of stranded tinned copper switchboard wire with 600-volt flame-retardant insulation Type SIS meeting UL 44 or Type MTW meeting UL 1063, and passing the VW-1 flame tests included in those standards. Provide hinge wire consisting of Class K stranding. Current transformer secondary leads smaller than No. 10 AWG is not permitted. The minimum size of control wire is to be No. 14 AWG. Furnish power wiring for 480-volt circuits and below that is the same type as control wiring and a minimum size of No. 12 AWG. Give special attention to wiring and terminal arrangement on the terminal blocks to permit the individual conductors of each external cable to be terminated on adjacent terminal points.

2.6 CONTROL SWITCHES

2.6.1 General

All control switches must be of the rotary switchboard type with handles on the front and the operating contact mechanisms on the rear of the panels.

Provide each switch with ample contact stages to perform the functions of the control system and provide with at least two spare contacts. Provide self-aligning contacts that operate with a wiping action. Provide a positive means of maintaining high pressure on closed contacts. Compression springs or pivotal joints must not carry current. All control switches must be suitable for operation on 600-volt AC or 250-volt DC circuits. All such switches must be capable of satisfactorily withstanding a life test of at least 10,000 operations with rated current flowing in the switch contacts. Provide switches capable of continuously carrying 20 amperes without exceeding a temperature rise of 30 degrees C. The single-break inductive load interrupting rating of switches must not be less than 1.5 amperes for 125 volts DC or 10 amperes for 115 volts AC.

2.6.2 Switch Features

a. Provide control and instrument switches that are suitable for the intended use and that have the features shown on the schematic diagrams and switch development drawings. Provide switches that have handles as shown or approved and are black in color unless otherwise specified.

b. Control switches for electrically-operated circuit breakers must be 3-position momentary-contact type with spring return to neutral position, and must have modern-black, heavy duty pistol grip handles. Provide circuit breaker control switches that have mechanical operation indicators to show the last manual operation of the switches and slip contacts.

c. Provide control switches for instrument and meter transfer switches and for selector switches that are the maintained contact type with the required number of positions and that have round notched or knurled handles. Connect ammeter and voltmeter switches to read all three phase ammeter switches. Do not open the secondary circuits of the current transformer at any time.

c. Provide each control switch with an escutcheon clearly marked to show each operating position. Engrave the switch identifications on the escutcheon plates or on separate nameplates. The escutcheon and nameplate markings are subject to approval.

2.7 TERMINAL BLOCKS

Furnish control circuit terminal blocks for control wiring that are molded or fabricated type with barriers, rated not less than 600 volts. Provide terminals that are removable binding, fillister, or washer head screw type, or of the stud type with contact and locking nuts. The terminals must be no less than No. 10 in size and have sufficient length and space for connecting at least two indented terminals for 10 AWG conductors to each terminal. The terminal arrangement is subject to the approval of the Contractor/Buyer and provide no less than four (4) spare terminals or 10 percent, whichever is greater, on each block or group of blocks. Modular, pull apart, terminal blocks will be acceptable provided they are of the channel or rail-mounted type. Submit data showing that the proposed alternate will accommodate the specified number of wires, are of adequate current-carrying capacity, and are constructed to assure positive contact between current-carrying parts.

2.7.1 Types of Terminal Blocks

2.7.1.1 Short-Circuiting Type

Furnish short-circuiting type terminal blocks for all current transformer secondary leads and have provision for shorting together all leads from each current transformer without first opening any circuit. Provide terminal blocks meeting the requirements of paragraph CONTROL CIRCUIT TERMINAL BLOCKS above.

2.7.1.2 Load Type

Provide load terminal blocks rated no less than 600 volts and of adequate capacity for the conductors for NEMA Size 3 and smaller motor controllers and for other power circuits except those for feeder tap units. Provide terminals that are either the stud type with contact nuts and locking nuts or the removable screw type, having length and space for at least two indented terminals of the size required on the conductors to be terminated. For conductors rated more than 50 amperes, provide screws with hexagonal heads. Conducting parts between connected terminals must have adequate contact surface and cross-section to operate without overheating. Place the circuit designation or wire number on or near the terminal in permanent contrasting color for each connected terminal.

2.7.2 Marking Strips

Provide white or other light-colored plastic marking strips, fastened by screws to each terminal block, for wire designations. Make wire numbers with permanent ink. Use reversible marking strips to permit marking both sides, or furnish two marking strips with each block. Marking strips must accommodate the two sets of wire numbers. For each device to which a connection is made, assign a device designation in accordance with NEMA ICS 1 and mark each device terminal to which a connection is made with a distinct terminal marking corresponding to the wire designation used on the Subcontractor's schematic and connection diagrams. The wire (terminal point) designations used on the Subcontractor's wiring diagrams and printed on terminal block marking strips may be according to the Subcontractor's standard practice; however, provide additional wire and cable designations for identification of remote (external) circuits for the Contractor/Buyer's wire designations. Show the general arrangement and overall dimensions of the motor control centers, switchboards, and panelboards. Show space requirements, details of any floor supports to be embedded in concrete and provisions for conduits for external cables. Prints of drawings submitted for approval will be so marked and returned to the Subcontractor for addition of the designations to the terminal strips and tracings, along with any rearrangement of points required.

2.10 SWITCHBOARDS

Provide dead-front switchboards conforming to NEMA PB 2 and label under UL 891. Provide completely enclosed self-supporting metal structures with the required number of vertical panel sections, buses, molded-case circuit breakers, [and other devices] as shown on the drawings. Provide switchboards that are fully rated for a short-circuit current of [14,000] [22,000] [65,000] [_____] symmetrical amperes RMS AC.

2.10.1 Enclosure

Provide NEMA type [2] [3R] switchboard enclosure, built with selected smooth sheet steel panels of no less than No. 14 gage. Exposed panels on the front and ends must have bent angle or channel edges with all corner seams welded and ground smooth. Do not drill or weld the front outside surfaces for the purpose of attaching wires or mounting devices if such holes or fastenings will be visible from the front. Make the front panels in sections flanged on four sides and attach to the framework by screws and arrange for ready removal for inspection or maintenance. [Provide rear access to the bus and device connections.] Provide ventilating openings as required and preferably of the grille type. Provide all ventilating openings with corrosion-resistant insect-proof screens on the inside. [Provide each switchboard with a channel iron base at front, rear, and sides, with exposed ends covered by welded steel plates. Provide grout holes. Bolt the switchboard sections to the base.] [Mount switchboards as shown on the drawings and furnish mounting materials as indicated.] Treat all interior and exterior steel parts to inhibit corrosion and paint as specified in paragraph PAINTING.

2.10.2 Bus

Provide buses that are copper [or aluminum] and [all bolted splices and connections between buses and for extensions or taps for equipment] that are tin or silver-plated [throughout]. Provide copper [or aluminum] bars and shapes for bus conductors conforming to the applicable requirements of ASTM B187/B187M [, and ASTM B317/B317M]. Bolt all splices for field assembly with at least two bolts and employ the use of "Belleville" washers in the connection. Horizontal and vertical power buses have minimum current ratings as shown on the drawings. Insulate the buses for no less than 600 volts. Braze, pressure-weld or bolt shop splices and tap connections. Bolt all splices for field assembly. Mount the buses on insulating supports of wet process porcelain, glass polyester, or suitable molded material, and brace to withstand no less than [14,000] [22,000] [65,000] [_____] symmetrical amperes ac.

2.10.3 Grounding Bus

Mount a copper [or aluminum] ground bus, rated no less than 300 amps, extending the entire length of the assembled structure, near the bottom of enclosure. Provide a full clamp-type solderless copper or copper alloy lug for No. 2/0 AWG stranded copper cable at each end of the bus for connection to the station grounding system.

2.10.4 Components

Equip each switchboard with molded-case circuit breakers conforming to paragraph MOLDED CASE CIRCUIT BREAKERS and with frame sizes, trip ratings, and terminal connectors for attachment of outgoing power cables as shown on the drawings. Stationary mount the circuit breakers individually, as shown on the drawings, that are operable and removable from the front. Where shown on the drawings, enclose circuit breakers in individual compartments. [Provide the group-mounted circuit breakers complete with bus work in an integrated assembly on the switchboard and conform to the applicable requirements of paragraph PANELBOARDS.]

2.11 PANELBOARDS

Provide panelboards consisting of assemblies of molded-case circuit breakers with buses and terminal lugs for the control and protection of branch circuits to motors, heating devices and other equipment operating at

480 volts ac or less. Provide UL 67 labeled panelboards. "Loadcenter" type panels are not acceptable. Design panelboards for installation in surface-mounted or flush-mounted cabinets accessible from the front only, as shown on the drawings. Provide panelboards that are fully rated for a short-circuit current of [14,000] [22,000] [___________] symmetrical amperes RMS ac.

2.11.1 Enclosure

Furnish enclosures meeting the requirements of UL 50. Fabricate all cabinets from sheet steel of no less than No 10 gage if flush-mounted or mounted outdoors, and no less than No 12 gage if surface-mounted indoors, with full seam-welded box ends. Hot-dip galvanize cabinets mounted outdoors or flush-mounted after fabrication. Paint cabinets in accordance with paragraph PAINTING. Provide outdoor cabinets of NEMA 3R raintight and [conduit hubs welded to the cabinet] [a removable steel plate ¼ inch thick in the bottom for field drilling for conduit connections.]
Form-flange edges of cabinets or fit with structural shapes welded or riveted to the sheet steel, for supporting the panelboard front. Fabricate all cabinets so that no part of any surface on the finished cabinet deviates from a true plane by more than 1/8 inch. Provide holes in the back of indoor surface-mounted cabinets, with outside spacers and inside stiffeners, for mounting the cabinets with a ½-inch clear space between the back of the cabinet and the wall surface. Mount flush doors on hinges that expose only the hinge roll to view when the door is closed. Fit each door with a combined catch and lock, except provide doors over 24 inches long with a three-point latch having a knob with a T-handle, and a cylinder lock. Provide two keys with each lock, and key all locks alike. Provide finished-head cap screws for mounting the panelboard fronts on the cabinets. Provide enclosure nameplates in accordance with paragraph NAMEPLATES. Provide directory holders, containing a neatly typed or printed directory under a transparent cover, on the inside of panelboard doors.

2.11.2 Buses

Provide dead-front type panelboards with buses and circuit breakers mounted on a plate or base for installation as a unit in a cabinet. Provide buses that are copper [or aluminum] [and are tin or silver-plated throughout].

Provide copper [or aluminum] bars and shapes for bus conductors conforming to the applicable requirements of ASTM B187/B187M[, and ASTM B317/B317M]. Provide sizes of buses and the details of panelboard construction meeting or exceeding the requirements of NEMA PB 1. Make suitable provisions for mounting the bus within panelboards and adjusting their positions in the cabinets. Provide terminal lugs required to accommodate the conductor sizes shown on the drawing for all branch circuits larger than No. 10 AWG. Provide a grounding bus with a lug suitable for 1/0 AWG wire for each panelboard.

2.11.3 Components

Equip each branch circuit, and the main buses where so specified or shown on the drawings, with molded-case circuit breakers having overcurrent trip ratings as shown on the drawings. Provide circuit breakers designed for bolted connection to buses in a panelboard assembly, and meeting the requirements of paragraph MOLDED CASE CIRCUIT BREAKERS. Circuit breakers of the same frame size and rating must be interchangeable. [Furnish bell alarm contacts as indicated on the drawings and wire to terminal blocks mounted in the cabinet. Furnish terminal blocks conforming to requirements of paragraph TERMINAL BLOCKS.]

2.12 FACTORY TESTS

Each item of equipment supplied under this contract must be given the manufacturer's routine factory tests and tests as specified below, to ensure successful operation of all parts of the assemblies. The Contractor/Buyer will witness all tests required herein unless waived in writing, and no equipment will be shipped until it has been approved for shipment by the Contractor/Buyer.

a. Submit copies of manufacturer's routine factory test procedures and production line tests for all motor control centers and switchboards, within a minimum of 14 calendar days prior to the proposed date of tests. Notify the Contractor/Buyer a minimum of 14 calendar days prior to the proposed date of the tests so that arrangements can be made for the Contractor/Buyer to be present at the tests.

b. Use factory test equipment and the test methods conforming to the applicable NEMA Standards, and are subject to the approval of the Contractor/Buyer. Submit complete reproducible copies of the factory inspection results and complete reproducible copies of the factory test results in booklet form, including all plotted data curves, all test conditions, a listing of test equipment complete with calibration certifications, and all measurements taken.

c. Report must be signed and dated by the Subcontractor's and Contractor/Buyer's Representatives. Reports of all witnessed tests must be signed by witnessing representatives of the Subcontractor and Contractor/Buyer. The Subcontractor is responsible for the cost of performing all tests and include in the prices bid in the schedule for equipment.

2.12.1 Motor Control Centers Tests

2.12.1.1 Dielectric Tests

Completely assemble each motor control center and perform dielectric tests in accordance with NEMA ICS 1.

2.12.1.2 Operational Tests

Check the correctness of operation of each air circuit breaker [or motor circuit protector] and magnetic contactor and of all control devices, accessories and indicating lamps. Make these checks rated voltage with power supplies to the main buses. Also check all magnetic contactors for proper operation with power at 90 percent of rated voltage.

2.12.1.3 Short Circuit Tests

If the unit is not UL labeled for the specified short circuit, the Subcontractor may submit design tests demonstrating that satisfactory short-circuit tests, as specified in NEMA ICS 2, have been made on a motor control center of similar type of construction and having the same available short circuit current at the motor terminals, including any motor contributions, as the motor control centers specified to be furnished under these specifications.

2.12.2 Switchboards Tests

2.12.2.1 Production Tests

Completely assemble each switchboard and give applicable production tests for assembled switchboard as specified in NEMA PB 2.

2.12.2.2 Short Circuit Tests

If the unit is not UL labeled for the specified short circuit, the Subcontractor may submit design tests demonstrating that satisfactory short-circuit tests have been made on a switchboard of similar type of construction and of the same short-circuit rating as the switchboards specified to be furnished under these specifications.

2.12.3 Panelboards Tests

Assemble each panelboard with cabinet and front to the extent necessary to check the fit and provisions for installing all parts in the field. Give each panelboard a dielectric test in accordance with NEMA PB 1. Operate all circuit breakers to check mechanical adjustments. Check all doors and locks for door clearances and fits and the performance of lock and latches.

2.13 PAINTING

Clean interior and exterior steel surfaces of equipment enclosures thoroughly and then apply a rust-inhibitive phosphatizing or equivalent treatment prior to painting. Exterior surfaces must be free from holes, seams, dents, weld marks, loose scale or other imperfections. Apply no less than one coat of corrosion-resisting paint in accordance with the manufacturer's standard practice to exterior surfaces. Prime exterior, fill where necessary, and give no less than two coats baked enamel with semigloss finish. Equipment located indoors must be ANSI Light Gray, [and equipment located outdoors must be ANSI [Light Grey] [Dark Gray].] Perform all touch-up work with manufacturer's coatings as supplied under paragraph SPARE PARTS.

PART 3 EXECUTION

3.1 INSTALLATION

Conform to IEEE C2, NFPA 70, and to the requirements specified herein. Provide new equipment and materials unless indicated or specified otherwise.

3.2 GROUNDING

NFPA 70 and IEEE C2, except that grounds and grounding systems with a resistance to solid earth ground not exceeding [25][_____] ohms.

3.2.1 Grounding Electrodes

Provide driven ground rods as specified in Section 33 71 02 UNDERGROUND ELECTRICAL DISTRIBUTION. Connect ground conductors to the upper end of the ground rods by exothermic weld or compression connector. Provide compression connectors at equipment end of ground conductors.

3.2.2 Equipment Grounding

Provide bare copper cable not smaller than No. 4/0 AWG not less than 24 inches below grade connecting to the indicated ground rods. When work in addition to that indicated or specified is directed to obtain the specified ground resistance, the provision of the contract covering "Changes" applies.

3.2.3 Connections

Make joints in grounding conductors and loops by exothermic weld or compression connector. Install exothermic welds and compression connectors as specified in Section 33 71 02 UNDERGROUND ELECTRICAL DISTRIBUTION.

3.2.4 Grounding and Bonding Equipment

UL 467, except as indicated or specified otherwise.

3.3 INSTALLATION OF EQUIPMENT AND ASSEMBLIES

Install and connect equipment furnished under this section as indicated on project drawings, the approved shop drawings, and as specified herein.

3.3.1 Switchboards

NEMA PB 1.

3.3.2 Panelboards

NEMA PB 2.

3.3.3 Field Applied Painting

Where field painting of enclosures is required to correct damage to the manufacturer's factory applied coatings, provide manufacturer's recommended coatings and apply in accordance with manufacturer's instructions.

3.3.4 Galvanizing Repair

Repair damage to galvanized coatings using ASTM A780/A780M, zinc rich paint, for galvanizing damaged by handling, transporting, cutting, welding, or bolting. Do not heat surfaces that repair paint has been applied to.

3.3.5 Field Fabricated Nameplate Mounting

Provide number, location, and letter designation of nameplates as indicated. Fasten nameplates to the device with a minimum of two sheet-metal screws or two rivets.

3.5.1 Performance of Acceptance Checks and Tests

Perform in accordance with the manufacturer's recommendations

3.5.1.1 Circuit Breakers - Low Voltage - Power

a. Visual and Mechanical Inspection

1. Compare nameplate data with specifications and approved shop drawings.

2. Inspect physical and mechanical condition.

3. Inspect anchorage, alignment, and grounding.

4. Verify that all maintenance devices are available for servicing and operating the breaker.

5. Inspect arc chutes.

6. Inspect moving and stationary contacts for condition, wear, and alignment.

7. Verify that primary and secondary contact wipe and other dimensions vital to satisfactory operation of the breaker are correct.

8. Perform all mechanical operator and contact alignment tests on both the breaker and its operating mechanism.

9. Inspect all bolted electrical connections for high resistance using low-resistance ohmmeter, verifying tightness of accessible bolted electrical connections by calibrated torque-wrench method, or performing thermographic survey.

10. Verify cell fit and element alignment.

11. Verify racking mechanism.

12. Confirm correct application of manufacturer's recommended lubricants.

b. Electrical Tests

1. Perform contact-resistance tests on each breaker.

2. Perform insulation-resistance tests.

3. Adjust Breaker(s) for final settings in accordance with Contractor/Buyer provided settings.

4. Determine long-time minimum pickup current by primary current injection.

5. Determine long-time delay by primary current injection.

6. Determine short-time pickup and delay by primary current injection.

7. Determine ground-fault pickup and delay by primary current injection.

8. Determine instantaneous pickup value by primary current injection.

9. Activate auxiliary protective devices, such as ground-fault or

undervoltage relays, to ensure operation of shunt trip devices; Check the operation of electrically-operated breakers in their cubicle.

10. Verify correct operation of any auxiliary features such as trip and pickup indicators, zone interlocking, electrical close and trip operation, trip-free, and anti-pump function.

11. Verify operation of charging mechanism.

3.5.1.2 Current Transformers

a. Visual and Mechanical Inspection

1. Compare equipment nameplate data with specifications and approved shop drawings.

2. Inspect physical and mechanical condition.

3. Verify correct connection.

4. Verify that adequate clearances exist between primary and secondary circuit.

5. Inspect all bolted electrical connections for high resistance using low-resistance ohmmeter, verifying tightness of accessible bolted electrical connections by calibrated torque-wrench method, or performing thermographic survey.

6. Verify that all required grounding and shorting connections provide good contact.

b. Electrical Tests

1. Perform resistance measurements through all bolted connections with low-resistance ohmmeter, if applicable.

2. Perform insulation-resistance tests.

3. Perform polarity tests.

4. Perform ratio-verification tests.

3.5.1.3 Grounding System

a. Visual and Mechanical Inspection

1. Inspect ground system for compliance with contract plans and specifications.

3.5.1.4 Switches, Air, Low-Voltage

a. Visual and Mechanical Inspection

1. Compare equipment nameplate data with drawings and specifications.

2. Inspect physical and mechanical condition.

3. Inspect anchorage, alignment, grounding, and required clearances.

4. Verify the unit is clean.

5. Verify correct blade alignment, blade penetration, travel stops, and mechanical operation.

6. Verify that fuse sizes and types are in accordance with drawings, short-circuit studies, and coordination study.

7. Verify that each fuse has adequate mechanical support and contact integrity.

8. Inspect all bolted electrical connections for high resistance using low-resistance ohmmeter, verifying tightness of accessible bolted electrical connections by calibrated torque-wrench method, or performing thermographic survey.

9. Verify operation and sequencing of interlocking systems.

10. Verify correct phase barrier installation.

11. Verify correct operation of all indicating and control devices.

12. Verify appropriate lubrication on moving current-carrying parts and on moving and sliding surfaces.

b. Electrical Tests

1. Perform resistance measurements through bolted connections with a low-resistance ohmmeter, in accordance with Section 7.5.1.1.A.8.1 of NETA ATS.

2. Measure contact resistance across each switchblade and fuseholder.

3. Perform insulation-resistance tests for one minute on each pole, phase-to-phase and phase-to-ground with switch closed, and across each open pole. Apply voltage in accordance with manufacturer’s published data. In the absence of manufacturer’s data, use Table 100.1 of NETA ATS.

4. Measure fuse resistance.

5. Verify cubicle space heater operation.

6. Perform ground fault test in accordance with Section 7.14 of NETA ATS.

7. Perform tests on other protective devices in accordance with Section 7.9 of NETA ATS.

3.5.1.5 Switches, Air, Medium-Voltage, Metal-Enclosed

a. Visual and Mechanical Inspection

1. Compare equipment nameplate data with drawings and specifications.

2. Inspect physical and mechanical condition.

3. Inspect anchorage, alignment, grounding, and required clearances.

4. Verify the unit is clean.

5. Verify correct blade alignment, blade penetration, travel stops, arc interrupter operation, and mechanical operation.

6. Verify that fuse sizes and types are in accordance with drawings, short-circuit study, and coordination study.

7. Verify that expulsion-limiting devices are in place on all fuses having expulsion-type elements.

8. Verify that each fuseholder has adequate mechanical support and contact integrity.

9. Inspect all bolted electrical connections for high resistance using low-resistance ohmmeter, verifying tightness of accessible bolted electrical connections by calibrated torque-wrench method, or performing thermographic survey.

10. Verify operation and sequencing of interlocking systems.

11. Verify correct phase barrier installation.

12. Verify correct operation of all indicating and control devices.

13. Verify appropriate lubrication on moving current-carrying parts and on moving and sliding surfaces.

b. Electrical Tests

1. Perform resistance measurements through bolted connections with a low-resistance ohmmeter in accordance with Section 7.5.1.2.A.9.1 of NETA ATS.

2. Measure contact resistance across each switchblade assembly and fuseholder.

3. Perform insulation-resistance tests for one minute on each pole, phase-to-phase and phase-to-ground with switch closed, and across each open pole. Apply voltage in accordance with manufacturer’s published data. In the absence of manufacturer’s data, use Table 100.1 of NETA ATS.

4. Perform a dielectric withstand voltage test on each pole with switch closed. Test each pole-to-ground with all other poles grounded. Test voltage will be in accordance with manufacturer’s published data. In the absence of manufacturer’s data, use Table 100.2 of NETA ATS.

5. Measure fuse resistance.

6. Verify cubicle space heater operation.

7. Perform online partial-discharge survey in accordance with Section 11 of NETA ATS.

3.5.1.6 Circuit Breakers

3.5.1.6.1 Circuit Breakers, Air, Insulated-Case/Molded-Case

a. Visual and Mechanical Inspection

1. Compare equipment nameplate data with drawings and specifications.

2. Inspect physical and mechanical condition.

3. Inspect anchorage and alignment.

4. Verify the unit is clean.

5. Operate the circuit breaker to insure smooth operation.

6. Inspect all bolted electrical connections for high resistance using low-resistance ohmmeter, verifying tightness of accessible bolted electrical connections by calibrated torque-wrench method, or performing thermographic survey.

7. Inspect operating mechanism, contacts, and arc chutes in unsealed nits.

8. Perform adjustments for final protective device settings in accordance with the coordination study.

b. Electrical Tests

1. Perform resistance measurements through bolted connections with a low-resistance ohmmeter in accordance with Section 7.6.1.1.A.6.1 of NETA ATS.

2. Perform insulation-resistance tests for one minute on each pole, phase-to-phase and phase-to-ground with the circuit breaker closed, and across each open pole. Apply voltage in accordance with manufacturer’s published data. In the absence of manufacturer’s data, use Table 100.1 of NETA ATS.

3. Perform a contact/pole-resistance test.

4. Perform insulation-resistance tests on all control wiring with respect to ground. Applied potential will be 500 volts dc for 300-volt rated cable and 1000 volts dc for 600-volt rated cable. Test duration will be one minute. For units with solid-state components, follow manufacturer’s recommendation.

5. Determine long-time pickup and delay by primary current injection.

6. Determine short-time pickup and delay by primary current injection.

7. Determine ground-fault pickup and time delay by primary current injection.

8. Determine instantaneous pickup by primary current injection.

9. Test functions of the trip unit by means of secondary injection.

10. Perform minimum pickup voltage tests on shunt trip and close coils in accordance with manufacturer’s published data.

11. Verify correct operation of auxiliary features such as trip and pickup indicators, zone interlocking, electrical close and trip operation, trip-free, anti-pump function, and trip unit battery condition. Reset all trip logs and indicators.

12. Verify operation of charging mechanism.

3.5.1.6.2 Circuit Breakers, Low-Voltage Power

a. Visual and Mechanical Inspection

1. Compare equipment nameplate data with drawings and specifications.

2. Inspect physical and mechanical condition.

3. Inspect anchorage, alignment, and grounding.

4. Verify that all maintenance devices are available for servicing and operating the breaker.

5. Verify the unit is clean.

6. Verify the arc chutes are intact.

7. Inspect moving and stationary contacts for condition and alignment.

8. Verify that primary and secondary contact wipe and other dimensions vital to satisfactory operation of the breaker are correct.

9. Perform all mechanical operator and contact alignment tests on both the breaker and its operating mechanism in accordance with manufacturer's published data.

10. Inspect all bolted electrical connections for high resistance using low-resistance ohmmeter, verifying tightness of accessible bolted electrical connections by calibrated torque-wrench method, or performing thermographic survey

11. Verify cell fit and element alignment.

12. Verify racking mechanism operation.

13. Verify appropriate lubrication on moving current-carrying parts and on moving and sliding surfaces.

14. Perform adjustments for final protective device settings in accordance with coordination study provided by end user.

15. Record as-found and as-left operation counter readings.

b. Electrical Tests

1. Perform resistance measurements through bolted connections with a low-resistance ohmmeter in accordance with Section 7.6.1.2.A.10.1 of NETA ATS.

2. Perform insulation-resistance tests for one minute on each pole,

phase-to-phase and phase-to-ground with the circuit breaker closed, and across each open pole. Test voltage will be in accordance with manufacturer’s published data. In the absence of manufacturer’s data, use Table 100.1 of NETA ATS.

3. Perform a contact/pole-resistance test.

4. Perform insulation-resistance tests on all control wiring with respect to ground. Applied potential will be 500 volts dc for 300-volt rated cable and 1000 volts dc for 600-volt rated cable. Test duration will be one minute. For units with solid-state components, follow manufacturer’s recommendation.

5. Determine long-time pickup and delay by primary current injection.

6. Determine short-time pickup and delay by primary current injection.

7. Determine ground-fault pickup and delay by primary current injection.

8. Determine instantaneous pickup value by primary current injection.

9. Test functions of the trip unit by means of secondary injection.

10. Perform minimum pickup voltage tests on shunt trip and close coils in accordance with manufacturer’s published data. In the absence of manufacturer’s data, use Table 100.20 of NETA ATS.

11. Verify correct operation of any auxiliary features such as trip and pickup indicators, zone interlocking, electrical close and trip operation, trip-free, anti-pump function, and trip unit battery condition. Reset all trip logs and indicators.

12. Verify operation of charging mechanism.

3.5.1.6.3 Circuit Breakers, Air, Medium-Voltage

a. Visual and Mechanical Inspection

1. Compare equipment nameplate data with drawings and specifications.

2. Inspect physical and mechanical condition.

3. Inspect anchorage, alignment, and grounding.

4. Verify that all maintenance devices are available for servicing and operating the breaker.

5. Verify the unit is clean.

6. Verify the arc chutes are intact.

7. Inspect moving and stationary contacts for condition and alignment.

8. If recommended by manufacturer, slow close/open breaker and check for binding, friction, contact alignment, and penetration. Verify that

contact sequence is in accordance with manufacturer’s published data. In the absence of manufacturer’s data, use IEEE C37.04.

9. Perform all mechanical operation tests on the operating mechanism in accordance with manufacturer’s published data.

10. Inspect all bolted electrical connections for high resistance using low-resistance ohmmeter, verifying tightness of accessible bolted electrical connections by calibrated torque-wrench method, or performing thermographic survey

11. Verify cell fit and element alignment.

12. Verify racking mechanism operation.

13. Inspect puffer operation.

14. Verify appropriate lubrication on moving current-carrying parts and on moving and sliding surfaces.

15. Perform contact-timing test.

16. Perform mechanism-motion analysis.

17. Perform trip/close coil current signature analysis.

18. Record as-found and as-left operation-counter readings.

b. Electrical Tests

1. Perform resistance measurements through bolted connections with a low-resistance ohmmeter. See Section 7.6.1.3.A.10.1 of NETA ATS.

2. Perform insulation-resistance tests for one minute on each pole, phase-to-phase and phase-to-ground with circuit breaker closed, and across each open pole. Apply voltage in accordance with manufacturer’s published data. In the absence of manufacturer’s data, use Table 100.1 of NETA ATS.

3. Perform a contact/pole-resistance test.

4. Perform insulation-resistance tests on all control wiring with respect to ground. Applied potential will be 500 volts dc for 300-volt rated cable and 1000 volts dc for 600-volt rated cable. Test duration will be on minute. For units with solid-state components or control devices that cannot tolerate the applied voltage, follow manufacturer’s recommendation.

5. With breaker in the test position, make the following tests:

(a) Trip and close breaker with the control switch.

(b) Trip breaker by operating each of its protective relays.

(c) Verify mechanism charge, trip-free, and anti-pump functions.

6. Perform minimum pickup voltage tests on trip and close coils in accordance with manufacturer’s published data. In the absence of manufacturer’s data, use Table 100.20 of NETA ATS.

7. Perform power-factor or dissipation-factor tests with breaker in both the open and closed positions.

8. Perform power-factor or dissipation-factor tests on each bushing equipped with a power-factor/capacitance tap. In the absence of a power-factor/ capacitance tap, perform hot-collar tests. These tests will be in accordance with the test equipment manufacturer’s published data.

9. Perform a dielectric withstand voltage test on each phase with the circuit breaker closed and the poles not under test grounded. Apply voltage in accordance with manufacturer’s published data. In the absence of manufacturer’s data, use Table 100.19 of NETA ATS.

10. Measure blowout coil circuit resistance.

11. Verify operation of heaters.

12. Test instrument transformers in accordance with Section 7.10 of NETA ATS.

3.5.1.6.4 Circuit Breakers, Oil, Medium- and High-Voltage

a. Visual and Mechanical Inspection

1. Visual and Mechanical Inspection

2. Inspect physical and mechanical condition.

3. Inspect anchorage, alignment, grounding, and required clearances.

4. Verify that all maintenance devices such as special tools and gauges specified by the manufacturer are available for servicing and operating the breaker.

5. Verify correct oil level in all tanks and bushings.

6. Verify that breather vents are clear.

7. Verify the unit is clean.

8. Inspect hydraulic system and air compressor in accordance with manufacturer’s published data.

9. Test alarms and pressure-limit switches for pneumatic and hydraulic operators as recommended by the manufacturer.

10. Perform mechanical operation tests on the operating mechanism in accordance with manufacturer’s published data.

11. While performing internal inspection:

(a) Remove oil. Lower tanks or remove manhole covers as necessary. Inspect bottom of tank for broken parts and debris.

(b) Inspect lift rod and toggle assemblies, contacts, interrupters, bumpers, dashpots, bushing current transformers, tank liners, and gaskets.

(c) Verify that contact sequence is in accordance with manufacturer’s published data. In the absence of manufacturer’s data, use IEEE C37.04.

(d) Fill tank(s) with filtered oil.

12. Inspect bolted electrical connections for high resistance using one or more of the following methods:

(a) Use of low-resistance ohmmeter in accordance with Section 7.6.2.B.1 of NETA ATS.

(b) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method in accordance with manufacturer’s published data. In the absence of manufacturer’s data, use Table 100.12 of NETA ATS.

(c) Perform thermographic survey in accordance with Section 9 of NETA ATS.

14. Verify racking mechanism operation.

15. Perform contact-timing test.

16. Perform mechanism-motion analysis.

17. Perform trip/close coil current signature analysis.

18. Verify appropriate lubrication on moving current-carrying parts and on moving and sliding surfaces.

19. Record as-found and as-left operation counter readings.

b. Electrical Tests

1. Perform resistance measurements through bolted connections with a low-resistance ohmmeter in accordance with Section 7.6.2.A.12.1 of NETA ATS.

2. Perform insulation-resistance tests for one minute on each pole, phase-to-phase and phase-to-ground with circuit-breaker closed, and across each open pole. Test voltage will be in accordance with manufacturer’s published data. In the absence of manufacturer’s data, use Table 100.1 of NETA ATS.

3. Perform a static contact/pole resistance test.

4. Perform a dynamic contact/pole resistance test.

5. Perform insulation-resistance tests on all control wiring with respect to ground. Applied potential will be 500 volts dc for 300-volt rated cable and 1000 volts dc for 600-volt rated cable. Test duration will be one minute. For units with solid-state components, follow manufacturer’s recommendation.

6. Remove a sample of insulating liquid in accordance with ASTM D923. Sample will be tested in accordance with the referenced standard.

(a) Dielectric breakdown voltage: ASTM D877

(b) Color: ASTM D1500

(c) Power factor: ASTM D924

(d) Interfacial tension: ASTM D971

(e) Visual condition: ASTM D1524

(f) Neutralization number (acidity): ASTM D974

(g) Water content: ASTM D1533

7. Perform minimum pickup voltage tests on trip and close coils in accordance with manufacturer’s published data. In the absence of manufacturer’s data, use Table 100.20 of NETA ATS.

8. Verify correct operation of any auxiliary features such as electrical close and trip operation, trip-free, anti-pump function.

9. Trip circuit breaker by operation of each protective device. Reset all trip logs and indicators.

10. Perform power-factor or dissipation-factor tests on each pole with breaker open and each phase with breaker closed. Determine tank loss index.

11. Perform power-factor or dissipation-factor tests on each bushing equipped with a power-factor/capacitance tap. In the absence of a power-factor/capacitance tap, perform hot-collar tests. These tests will be in accordance with the test equipment manufacturer’s published data.

12. Perform a dielectric withstand voltage test in accordance with manufacturer’s published data.

13. Verify operation of heaters.

14. Test instrument transformers in accordance with Section 7.10 of NETA ATS.

3.5.1.6.5 Circuit Breakers, Vacuum, Medium-Voltage

a. Visual and Mechanical Inspection

1. Compare equipment nameplate data with drawings and specifications.

2. Inspect physical and mechanical condition.

3. Inspect anchorage, alignment, and grounding.

4. Verify that all maintenance devices such as special tools and gauges specified by the manufacturer are available for servicing and operating the breaker.

5. Verify the unit is clean.

6. Perform all mechanical operation tests on the operating mechanism in accordance with manufacturer’s published data.

7. Measure critical distances such as contact gap as recommended by manufacturer.

8. Inspect bolted electrical connections for high resistance using one or more of the following methods:

    (a) Use of low-resistance ohmmeter in accordance with Section 7.6.3.B.1 of NETA ATS.

    (b) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method in accordance with manufacturer’s published data. In the absence of manufacturer’s data, use Table 100.12 of NETA ATS.

    (c) Perform thermographic survey in accordance with Section 9 of NETA ATS.

9. Verify cell fit and element alignment.

10. Verify racking mechanism operation.

11. Verify appropriate lubrication on moving, current-carrying parts and on moving and sliding surfaces.

12. Perform contact-timing test.

13. Perform trip/close coil current signature analysis.

14. Perform mechanism motion analysis.

15. Record as-found and as-left operation counter readings.

b. Electrical Tests

1. Perform resistance measurements through bolted connections with a low-resistance ohmmeter in accordance with Section 7.6.3.A.8.1 of NETA ATS.

2. Perform insulation-resistance tests for one minute on each pole, phase-to-phase and phase-to-ground with the circuit breaker closed, and across each open pole. Test voltage will be in accordance with manufacturer’s published data. In the absence of manufacturer’s data, use Table 100.1 of NETA ATS.

3. Perform insulation-resistance tests on all control wiring with respect to ground. Applied potential will be 500 volts dc for 300-volt rated cable and 1000 volts dc for 600-volt rated cable. Test duration will be one minute. For units with solid-state components, follow manufacturer’s recommendation.

4. Perform a contact/pole-resistance test.

5. Perform minimum pickup voltage tests on trip and close coils in accordance with manufacturer’s published data. In the absence of manufacturer’s data, use Table 100.20 of NETA ATS.

6. Verify correct operation of any auxiliary features such as electrical close and trip operation, trip-free, and anti-pump function.

7. Trip circuit breaker by operation of each protective device. Reset all trip logs and indicators.

8. Perform power-factor or dissipation-factor tests on each pole with the breaker open and each phase with the breaker closed.

9. Perform power-factor or dissipation-factor tests on each bushing equipped with a power-factor/capacitance tap. In the absence of a power-factor/capacitance tap, perform hot-collar tests. These tests will be in accordance with the test equipment manufacturer’s published data.

10. Perform magnetron atmospheric condition (MAC) test on each vacuum interrupter.

11. Perform vacuum bottle integrity (dielectric withstand voltage) test across each vacuum bottle with the breaker in the open position in strict accordance with manufacturer’s published data.

12. Perform a dielectric withstand voltage test in accordance with manufacturer’s published data. In the absence of manufacturer’s data, use Table 100.19 of NETA ATS.

13. Verify operation of heaters.

14. Test instrument transformers in accordance with Section 7.10 of NETA ATS.

3.5.1.6.6 Circuit Breakers, SF6

a. Visual and Mechanical Inspection

1. Compare equipment nameplate data with drawings and specifications.

2. Inspect physical and mechanical condition.

3. Inspect anchorage, alignment, and grounding.

4. Verify that all maintenance devices such as special tools and gauges specified by the manufacturer are available for servicing and operating the breaker.

5. Verify the unit is clean.

6. When provisions are made for sampling, remove a sample of SF6 gas and test in accordance with Table 100.13 of NETA ATS. Do not break seal or distort “sealed-for-life” interrupters.

7. Inspect operating mechanism and/or hydraulic or pneumatic system and SF6 gas-insulated system in accordance with manufacturer’s published data.

8. Test for SF6 gas leaks in accordance with manufacturer’s published data.

9. Verify correct operation of alarms and pressure-limit switches for pneumatic, hydraulic, and SF6 gas pressure in accordance with manufacturer’s published data.

10. If recommended by manufacturer, slow close/open breaker and check for binding, friction, contact alignment, and penetration. Verify that contact sequence is in accordance with manufacturer’s published data. In the absence of manufacturer’s data, refer to IEEE C37.04.

11. Perform all mechanical operation tests on the operating mechanism in accordance with the manufacturer’s published data.

12. Inspect all bolted electrical connections for high resistance using one or more of the following methods:

    (a) Use of a low-resistance ohmmeter in accordance with Section 7.6.4.B.1 of NETA ATS.

    (b) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method in accordance with manufacturer’s published data. In the absence of manufacturer’s data, use Table 100.12 of NETA ATS.

    (c) Perform a thermographic survey in accordance with Section 9 of NETA ATS.

13. Verify the appropriate lubrication on moving current-carrying parts and on moving and sliding surfaces.

14. Perform contact-timing test.

15. Perform trip/close coil signature analysis.

16. Perform mechanism motion analysis.

17. Record as-found and as-left operation counter readings.

b. Electrical Tests

1. Perform resistance measurements through all bolted connections with a low-resistance ohmmeter in accordance with Section 7.6.4.A.12.1 of NETA ATS.

2. Perform insulation-resistance tests in accordance with Table 100.1 of NETA ATS from each pole-to-ground with breaker closed and across open poles at each phase. For single-tank breakers, perform insulation resistance tests in accordance with Table 100.1 from pole-to-pole.

3. Perform a contact/pole-resistance test.

4. Perform insulation-resistance tests on all control wiring with respect to ground. Applied potential will be 500 volts dc for 300-volt rated cable and 1000 volts dc for 600-volt rated cable. Test duration will be one minute. For units with solid-state components or for control devices that cannot tolerate the voltage, follow manufacturer's recommendation.

5. Perform minimum pickup voltage tests on trip and close coils in accordance with manufacturer's published data.

6. Verify correct operation of any auxiliary features such as electrical close and trip operation, trip-free, and anti-pump function. Reset all trip logs and indicators.

7. Trip circuit breaker by operation of each protective device.

8. Perform power-factor or dissipation-factor tests on each pole with the breaker open and on each phase with the breaker closed.

9. Perform power-factor or dissipation-factor tests on each bushing equipped with a power-factor/capacitance tap. In the absence of a power-factor/capacitance tap, perform hot-collar tests. These tests will be in accordance with the test equipment manufacturer's published data.

10. Perform a dielectric withstand voltage test in accordance with manufacturer's published data.

11. Verify operation of heaters.

12. Test instrument transformers in accordance with Section 7.10 from NETA ATS.

3.5.1.7 Motor Control, Motor Starters, Low-Voltage

a. Visual and Mechanical Inspection

1. Compare equipment nameplate data with drawings and specifications.

2. Inspect physical and mechanical condition.
3. Inspect anchorage, alignment, and grounding.

4. Verify the unit is clean.

5. Inspect contactors.

(a) Verify mechanical operation.

(b) Verify contact gap, wipe, alignment, and pressure are in accordance with manufacturer’s published data.

6. Motor-Running Protection

(a) Verify overload element rating/motor protection settings are correct for application.

(b) If motor-running protection is provided by fuses, verify correct fuse rating.

7. Inspect all bolted electrical connections for high resistance using low-resistance ohmmeter, verifying tightness of accessible bolted electrical connections by calibrated torque-wrench method, or performing thermographic survey.

8. Verify appropriate lubrication on moving current-carrying parts and on moving and sliding surfaces.

b. Electrical Tests

1. Perform resistance measurements through bolted connections with a low-resistance ohmmeter in accordance with Section 7.16.1.1.A.7.1 from NETA ATS.

2. Perform insulation-resistance tests for one minute on each pole, phase-to-phase and phase-to-ground with starter closed, and across each open pole. Test voltage will be in accordance with manufacturer’s published data or Table 100.1 from NETA ATS.

3. Perform insulation-resistance tests on all control wiring with respect to ground. Applied potential will be 500 volts dc for 300-volt rated cable and 1000 volts dc for 600-volt rated cable. Test duration will be one minute. For units with solid-state components, follow manufacturer’s recommendation.

4. Test motor protection devices in accordance with manufacturer’s published data. In the absence of manufacturer’s data, use Section 7.9 from NETA ATS.

5. Test circuit breakers in accordance with Section 7.6.1.1 from NETA ATS.

6. Perform operational al tests by initiating control devices.

3.5.1.8 Motor Control, Motor Starters, Medium-Voltage

a. Visual and Mechanical Inspection

1. Compare equipment nameplate data with drawings and specifications.
2. Inspect physical and mechanical condition.
3. Inspect anchorage, alignment, and grounding.
4. Verify the unit is clean.
5. Inspect all bolted electrical connections for high resistance using low-resistance ohmmeter, verifying tightness of accessible bolted electrical connections by calibrated torque-wrench method, or performing thermographic survey.
6. Test electrical and mechanical interlock systems for correct operation and sequencing.
7. Verify correct barrier and shutter installation and operation.
8. Exercise active components and confirm correct operation of indicating devices.
9. Inspect contactors.
    (a) Verify mechanical operation.
    (b) Verify contact gap, wipe, alignment, and pressure are in accordance with manufacturer's published data.
10. Verify overload protection rating is correct for its application. Set adjustable or programmable devices according to the protective device coordination study.
11. Verify appropriate lubrication on moving current-carrying parts and on moving and sliding surfaces.

b. Electrical Tests

1. Perform resistance measurements through bolted connections with a low-resistance ohmmeter in accordance with Section 7.16.1.2.A.5.1 from NETA ATS.
2. Perform insulation-resistance tests on contactor(s) for one minute, phase-to-ground and phase-to-phase with the contactor closed, and across each open contact. Test voltage will be in accordance with manufacturer's published data, or Table 100.1 from NETA ATS.
3. Perform insulation-resistance tests on all control wiring with respect to ground. Applied potential will be 500 volts dc for 300-volt rated cable and 1000 volts dc for 600-volt rated cable. Test duration will be one minute. For units with solid-state components, follow manufacturer's recommendation.
4. Perform magnetron atmospheric condition (MAC) test on each vacuum interrupter.
5. Perform a dielectric withstand voltage test in accordance with manufacturer's published data. In the absence of manufacturer's data, use Table 100.9 from NETA ATS.

6. Perform vacuum bottle integrity test (dielectric withstand voltage) across each vacuum bottle with the contacts in the open position in strict accordance with manufacturer's published data.

7. Perform contact resistance tests.

8. Measure blowout coil circuit resistance.

9. Measure resistance of power fuses.

10. Energize contactor using an auxiliary source. Adjust armature to minimize operating vibration.

11. Test control power transformers in accordance with Section 7.1.B.8 from NETA ATS.

12. Test starting transformers, in accordance with Section 7.2.1 from NETA ATS.

13. Test starting reactors, in accordance with 7.20.3 from NETA ATS.

14. Test motor protection devices in accordance with manufacturer's published data. In the absence of manufacturer's data, test in accordance with Section 7.9 from NETA ATS.

15. Standard Commissioning Specifications for Electrical Power Equipment & Systems.

16. Verify operation of cubicle space heater.

17. Test instrument transformers in accordance with Section 7.10 from NETA ATS.

18. Test metering devices in accordance with Section 7.11 from NETA ATS.

3.5.2 Follow-Up Verification

Upon completion of acceptance checks, settings, and tests, show by demonstration in service that circuits and devices are in good operating condition and properly performing the intended function. Trip circuit breakers by operation of each protective device. Test each item to perform its function not less than three times. As an exception to requirements stated elsewhere in the contract, provide the Contractor/Buyer 5 working days advance notice of the dates and times for checks, settings, and tests.

-- End of Section --

SECTION 26 29 23: ADJUSTABLE SPEED DRIVE (ASD) SYSTEMS UNDER 600 VOLTS

02/20, CHG 1: 05/21

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

EUROPEAN COMMITTEE FOR STANDARDIZATION (CEN/CENELEC)

EN 61800-3	(2017) Requirements for the Control of Electromagnetic Interference Characteristics of Subsystems and Equipment

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE 519	(2022) Standard for Harmonic Control in Electrical Power Systems
IEEE C62.41.1	(2002; R 2008) Guide on the Surges Environment in Low-Voltage (1000 V and Less) AC Power Circuits
IEEE C62.41.2	(2002) Recommended Practice on Characterization of Surges in Low-Voltage (1000 V and Less) AC Power Circuits

INTERNATIONAL ELECTROTECHNICAL COMMISSION (IEC)

IEC 61000-3-12	(2012) Electromagnetic Compatibility (EMC) - Part 3-12: Limits - Limits for harmonic currents produced by equipment connected to public low-voltage systems with input current >16 A and </=75 A per phase

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA 250	(2020) Enclosures for Electrical Equipment (1000 Volts Maximum)
NEMA ICS 1	(2022) Standard for Industrial Control and Systems: General Requirements
NEMA ICS 3.1	(2019) Guide for the Application, Handling, Storage, Installation and Maintenance of Medium-Voltage AC Contactors, Controllers and Control Centers
NEMA ICS 6	(1993; R 2016) Industrial Control and Systems: Enclosures
NEMA ICS 7	(2020) Adjustable-Speed Drives

NEMA ICS 7.2	(2015) Application Guide for AC Adjustable Speed Drive Systems
NEMA ICS 61800-2	(2005) Adjustable Speed Electrical Power Drive Systems Part 2: General Requirements - Rating Specifications for Low Voltage Adjustable Frequency A.C. Power Drive Systems
NEMA MG 1	(2021) Motors and Generators NATIONAL FIRE

PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2023) National Electrical Code

U.S. NATIONAL ARCHIVES AND RECORDS ADMINISTRATION (NARA)

47 CFR 15	Radio Frequency Devices UNDERWRITERS

LABORATORIES (UL)

UL 489	(2016; Rev 2019) UL Standard for Safety Molded-Case Circuit Breakers, Molded-Case Switches and Circuit-Breaker Enclosures
UL 61800-5-1	(2016) Adjustable Speed Electrical Power Drive Systems - Part 5-1: Safety Requirements - Electrical, Thermal and Energy

1.2 SYSTEM DESCRIPTION

1.2.1 Performance Requirements

1.2.1.1 Electromagnetic Interference Suppression

Computing devices, as defined by 47 CFR 15 and EN 61800-3 rules and regulations, must be certified to comply with the requirements for class A computing devices and labeled.

1.2.1.2 Electromechanical and Electrical Components

Ensure electrical and electromechanical components of the Adjustable Speed Drive (ASD) do not cause electromagnetic interference to adjacent electrical or electromechanical equipment while in operation.

1.2.2 Electrical Requirements

1.2.2.1 Power Line Surge Protection

IEEE C62.41.1 and IEEE C62.41.2, IEEE 519, IEC 61000-3-12 Control panel must have surge protection, included within the panel to protect the unit from damaging transient voltage surges. Surge protective device must be mounted near the incoming power source and properly wired to all three phases and ground. Fuses must not be used for surge protection.

1.2.2.2 Sensor and Control Wiring Surge Protection

I/O functions as specified must be protected against surges induced on control and sensor wiring installed outdoors and as shown. Test the inputs and outputs in both normal mode and common mode using the following two waveforms:

a. A 10 microsecond by 1000 microsecond waveform with a peak voltage of 1500 volts and a peak current of 60 amperes.

b. An 8 microsecond by 20 microsecond waveform with a peak voltage of 1000 volts and a peak current of 500 amperes.

1.3 SUBMITTALS

Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Schematic Diagrams; Interconnecting Diagrams; Installation

Drawings;

As-Built Drawings; SD-03 Product Data

Adjustable Speed Drives; Wires and Cables

Equipment Schedule SD-06 Test Reports

ASD Test

Performance Verification Tests Endurance Test

SD-07 Certificates

Testing Agency's Field Supervisor NETA Certificate;

SD-08 Manufacturer's Instructions Installation instructions

SD-09 Manufacturer's Field Reports

Standard Products

SD-10 Operation and Maintenance Data Adjustable Speed Drives, Data

Package 4

1.4 QUALITY ASSURANCE

1.4.1 Schematic Diagrams

Submit diagrams showing circuits and device elements for each replaceable module. Schematic diagrams of printed circuit boards are permitted to group functional assemblies as devices, provided that sufficient information is provided for government maintenance personnel to verify proper operation of the functional assemblies.

1.4.2 Interconnecting Diagrams

Show interconnections between equipment assemblies, and external interfaces, including power and signal conductors. Include for enclosures and external devices.

1.4.3 Installation Drawings

Show floor plan of each site, with ASD's and motors indicated. Indicate ventilation requirements, adequate clearances, and cable routes. Submit drawings for Contractor/Buyer approval prior to equipment construction or integration. Immediately record modifications to original drawings made during installation for inclusion into the as-built drawings.

1.4.4 Equipment Schedule

Provide schedule of equipment supplied. Schedule must provide a cross reference between manufacturer data and identifiers indicated in shop drawings. Schedule must include the total quantity of each item of equipment supplied and data indicating compatibility with motors being driven. For complete assemblies, such as ASD's, provide the serial numbers of each assembly, and a sub-schedule of components within the assembly. Provide recommended spare parts listing for each assembly or component.

1.4.5 Installation Instructions

Provide installation instructions issued by the manufacturer of the equipment, including notes and recommendations, prior to shipment to the site. Provide operation instructions prior to acceptance testing.

1.4.6 Standard Products

Provide materials and equipment that are products of manufacturers regularly engaged in the production of such products which are of equal material, design and workmanship and:

a. Have been in satisfactory commercial or industrial use for 2 years prior to bid opening including applications of equipment and materials under similar circumstances and of similar size.

b. Have been on sale on the commercial market through advertisements, manufacturers' catalogs, or brochures during the 2-year period.

c. Where two or more items of the same class of equipment are required, provide products of a single manufacturer; however, the component parts of the item need not be the products of the same manufacturer unless stated in this section.

1.5 DELIVERY AND STORAGE

Store delivered equipment to protect from the weather, humidity and temperature variations, dirt and dust, or other contaminants.

1.6 WARRANTY

The complete system must be warranted by the manufacturer for a period of one year. Repair or replace any component failing to perform its function as specified and documented at no additional cost to the Contractor/Buyer. Items repaired or replaced must be warranted for an additional period of at least one year from the date that it becomes functional again, as specified in FAR 52.246-21 Warranty of Construction.

1.7 MAINTENANCE

1.7.1 Spare Parts

Manufacturers provide spare parts in accordance with recommended spare parts list.

1.8.2 Operation and Maintenance Data

Provide service and maintenance information including preventive maintenance, assembly, and disassembly procedures. Include electrical drawings from electrical general sections. Provide additional information necessary to provide complete operation, repair, and maintenance information, detailed to the smallest replaceable unit. Include copies of as-built submittals. Provide routine preventative maintenance instructions, and equipment required. Provide instructions on how to modify program settings, and modify the control program. Provide instructions on drive adjustment, trouble-shooting, and configuration. Provide instructions on process tuning and system calibration.

1.8.3 Maintenance Support

During the warranty period, provide on-site, on-call maintenance services by drive manufacturer's personnel on the following basis: The service must be on a per-call basis with 36 hour response. Subcontractor is responsible for the maintenance of all hardware and software of the system during the warranty period. Various personnel of different expertise must be sent on-site depending on the nature of the maintenance service required. Costs must include travel, local transportation, living expenses, and labor rates of the service personnel while responding to the service request. The provisions of this Section are not in lieu of, nor relieve the Subcontractor of, warranty responsibilities covered in this specification. Should the result of the service request be the uncovering of a system defect covered under the warranty provisions, all costs for the call, including the labor necessary to identify the defect, must be borne by the Subcontractor.

1.8.4 Technical Support

Provide the ASDs with manufacturer's technical telephone support in English, readily available during normal working hours.

PART 2 PRODUCTS

2.1 ADJUSTABLE SPEED DRIVES (ASD)

Provide adjustable speed drive to control the speed of induction motor(s). The ASD must include the following minimum functions, features and ratings.

a. Input circuit breaker per UL 489 with a minimum of 10,000 amps symmetrical interrupting capacity and door interlocked external operator.

b. A converter stage per UL 61800-5-1 must change fixed voltage, fixed frequency, ac line power to a fixed dc voltage. The converter must utilize a full wave bridge design incorporating diode rectifiers. Silicon Controlled Rectifiers (SCR) are not acceptable. The converter must be insensitive to three phase rotation of the ac line and must not cause displacement power factor of less than .95 lagging under any speed and load condition.

c. An inverter stage must change fixed dc voltage to variable frequency, variable ac voltage for application to a standard NEMA MG 1 Part 30 motor designed for use with adjustable frequency power supplies. Switch the inverter to produce a sine coded pulse width modulated (PWM) output waveform.

d. The ASD shall be capable of supplying 110 percent of rated full load current for one minute at maximum ambient temperature.

e. The ASD must be designed to operate from a [_____] volt, plus or minus 10 percent, three phase, 60 Hz supply, and control motors with a corresponding voltage rating.

f. Acceleration and deceleration time must be independently adjustable from one second to 60 seconds.

[Adjust decelerating time by[providing an external dynamic braking resistor designed to meet NEMA ICS 61800-2 to be capable of decelerating six times the motor inertia with no more than 150 percent of rated current with the motor at its base speed.][providing an ASD with a regenerative braking designed to return some of braking energy from the motor to the AC power distribution system.][providing each of several ASD used in a process with a common DC bus tie designed to share the regenerative energy between tied in parallel controls.]]Required deceleration time may be achieved using not only dynamic braking resistor but with other methods described in NEMA ICS 7.2-2015 paragraph 5.2.5.

g. Adjustable full-time current limiting must limit the current to a preset value which must not exceed 110 percent of the controller rated current. The current limiting action must maintain the V/Hz ratio constant so that variable torque can be maintained. Short time starting override must allow starting current to reach 175 percent of controller rated current to maximum starting torque.

h. The controllers must be capable of producing an output frequency over the range of 3 Hz to 60 Hz (20 to one speed range), without low speed cogging. Over frequency protection must be included such that a failure in the controller electronic circuitry must not cause frequency to exceed 110 percent of the maximum controller output frequency selected.

i. Minimum and maximum output frequency must be adjustable over the following ranges: 1) Minimum frequency 3 Hz to 50 percent of maximum selected frequency; 2) Maximum frequency 40 Hz to 60 Hz.

j. The controller efficiency at any speed must not be less than 96 percent.

k. The controllers must be capable of being restarted into a motor coasting in the forward direction without tripping.

l. Protection of power semiconductor components must be accomplished without the use of fast acting semiconductor output fuses. Subjecting the controllers to any of the following conditions must not result in component failure or the need for fuse replacement:

(1) Short circuit at controller output

(2) Ground fault at controller output

(3) Open circuit at controller output

(4) Input undervoltage

(5) Input overvoltage

(6) Loss of input phase

(7) AC line switching transients

(8) Instantaneous overload

(9) Sustained overload exceeding 115 percent of controller rated current

(10) Over temperature

(11) Phase reversal

m. Solid state motor overload protection must [be included such that current exceeding an adjustable threshold must activate a 60 second timing circuit. Should current remain above the threshold continuously for the timing period, the controller will automatically shut down.][have [sensor in each phase,][[Class 10] [Class 20] [Class 10/20 selectable] tripping characteristic selected to protect motor against voltage and current unbalance and single phasing,] [Class II ground-fault protection, with start and run delays to prevent nuisance trip on staring,] [analog communication module,][[NC] [NO] isolated overload alarm contact,] [external overload, reset push button].]

n. Include slip compensation circuit that will sense changing motor load conditions and adjust output frequency to provide speed regulation of NEMA MG 1 Part 30 designed for use with adjustable frequency power supplies motors to within plus or minus 0.5 percent of maximum speed without the necessity of a tachometer generator.

o. The ASD must be factory set for manual restart after the first protective circuit trip for malfunction (overcurrent, undervoltage, overvoltage or overtemperature) or an interruption of power. The ASD must be capable of being set for automatic restart after a selected time delay. If the drive faults again within a specified time period (adjustable 0-60 seconds), a manual restart will be required.[Provide Bidirectional Autospeed Search capable of starting the ASD into rotating loads spinning in either direction and returning motor to set speed in proper direction, without causing damage to drive, motor, or load.]

p. The ASD must include external fault reset capability. All the necessary logic to accept an external fault reset contact must be included.

q. Provide critical speed lockout circuitry to prevent operating at frequencies with critical harmonics that cause resonant vibrations.

The ASD must have a minimum of three user selectable bandwidths.

r. Provide properly sized [NEMA][IEC] rated by-pass and isolation contactors to enable operation of motor in the event of ASD failure[and for safety transfers motor between power converter output and bypass circuit using a field-selectable automatic and manual bypass mode]. Install mechanical and electrical interlocks between the by-pass and isolation contactors. Provide a selector switch and transfer delay timer. Motor overload and short circuit protective features must remain in use during the bypass mode.

s. Each individual ASD must meet the following Total Harmonic Distortion (THD) requirements at the input terminals to the factory assembly of the ASD or at the load disconnecting means serving the ASD and filter assembly. These measurements should be taken with the drive set at 90 percent frequency (rpms) and the motor under a minimum of 50 percent demand.

(1) The Voltage THD should not exceed 2.0 percent THD.

(2) The Current THD should not exceed 15.0 percent THD.

(3) If the standard factory ASD does not meet or exceed these requirements the factory must install appropriate equipment (Harmonic Traps, Filters, different Drive technology, etc.) to mitigate the distortion to assure performance of the VFD is within the limits.

(4) These tests should be performed at the Manufacturers Laboratory facilities and submitted as part of the Product Data Submittals, in order to prevent the necessity of adding mitigation equipment in the field. If the requirements listed above are met, IEEE 519 will also be met.

t. t. Minimum Operating Conditions. Designed and constructed ASD's to operate within the following service conditions:

(1) Ambient Temperature Rating: 0 to 120 degrees F.

(2) Non-condensing relative humidity rating: less than 95 percent.

(3) Ambient rating: Not exceed 3,300 feet.

2.1.1 ASD for Industrial Application

Provide the following operator control and monitoring devices mounted on the front panel of the ASD:

a. Manual speed potentiometer.

b. Hand-Off-Auto (HOA) switch.

c. Power on light.

d. Drive run power light.

e. Local display[capable of including ASD status, frequency, motor RPM, phase current, fault diagnostic in descriptive text, and all programmed parameters].

2.2 ENCLOSURES

Provide equipment enclosures conforming to NEMA 250, NEMA ICS 7, and NEMA ICS 6, with a heater if located outdoors. An HMCP device shall provide the disconnecting means. The operating handle shall protrude through the door, but the disconnect shall not be mounted on the door. The handle shall indicate ON, OFF, and tripped conditions. The handle shall have provisions to accommodate a minimum of three padlocks in the OFF position. Interlocks shall prevent unauthorized opening or closing of the ASD door with the disconnect handle in the ON position. The door handle interlock should have provisions to be defeated by qualified maintenance personnel.

2.3 WIRES AND CABLES

All wires and cables must conform to NEMA 250, NEMA ICS 7, NFPA 70.

2.4 NAMEPLATES

Provide manufacturer's standard, permanent nameplates for internal areas of enclosures.

2.5 SOURCE QUALITY CONTROL

2.5.1 ASD Test Plan

To ensure quality, each ASD must be subject to a series of in-plant quality control inspections before approval for shipment from the manufacturer's facilities. Provide test plans.

2.5.2 ASD Test Report

To ensure quality, each ASD must be subject to a series of in-plant quality control inspections before approval for shipment from the manufacturer's facilities. Provide test reports.

PART 3 EXECUTION

3.1 INSTALLATION

Per NEMA ICS 3.1, install equipment in accordance with the approved manufacturer's printed installation drawings, instructions, wiring diagrams, and as indicated on project drawings and the approved shop drawings. A field representative of the drive manufacturer must supervise the installation of all equipment, and wiring.

3.2 GROUNDING

Per NEMA ICS 7.2, ASD must be solidly grounded to the main distribution.

3.3 FIELD QUALITY CONTROL

Specified products must be tested as a system for conformance to specification requirements prior to scheduling the acceptance tests. Conduct performance verification tests in the presence of Contractor/Buyer representative, observing and documenting complete compliance of the system to the specifications. Submit a signed copy of the test results, certifying proper system operation before scheduling tests.

3.3.1 ASD Test

A proposed test plan must be submitted to the Contractor/Buyer at least 28 calendar days prior to proposed testing for approval. The tests must conform to NEMA ICS 1, NEMA ICS 7, and all manufacturer's safety regulations. The Contractor/Buyer reserves the right to witness all tests and review any documentation. Inform the Contractor/Buyer at least 14 working days prior to the dates of testing. Perform the ASD test [with the assistance of a factory-authorized service representative][engaging a qualified testing agency's field supervisor currently certified by NETA to supervise on-site testing].

3.3.2 Performance Verification Tests

"Performance Verification Test" plan must provide the step by step procedure required to establish formal verification of the performance of the ASD. Compliance with the specification requirements must be verified by inspections, review of critical data, demonstrations, and tests. The Contractor/Buyer reserves the right to witness all tests, review data, and request other such additional inspections and repeat tests as necessary to ensure that the system and provided services conform to the stated requirements. Inform the Contractor/Buyer 14 calendar days prior to the date the test is to be conducted.

3.3.3 Endurance Test

Immediately upon completion of the performance verification test, the endurance test must commence. The system must be operated at varying rates for not less than 192 consecutive hours, at an average effectiveness level of 0.9998, to demonstrate proper functioning of the complete PCS. Continue the test on a day-to-day basis until performance standard is met. The Subcontractor is not allowed in the building during the endurance test. The system must respond as designed.

3.4 DEMONSTRATION

3.4.1 Training

Coordinate training requirements with the Contractor/Buyer. Provide video tapes, if available, of all training provided to the Contractor/Buyer for subsequent use in training new personnel. Provide all training aids, texts, and expendable support material for a self-sufficient presentation shall be provided, the amount of which to be determined by the Contractor/Buyer.

3.4.1.1 Engineering/Maintenance Personnel Training

Accomplish the training program as specified. Training must be conducted on site at a location designated by the Contractor/Buyer. Provide a training session to train four [] engineering personnel in the functional operations of the system. This training must include:

a. System overview

b. General theory of operation

c. System operation

d. System configuration

e. Alarm formats

f. Failure recovery procedures

g. Troubleshooting and repair

h. Maintenance and calibration

i. System programming and configuration

-- End of Section --

SECTION 27 21 10.00 40: FIBER OPTIC DATA TRANSMISSION SYSTEM

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PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ELECTRONIC COMPONENTS INDUSTRY ASSOCIATION (ECIA)

ECIA EIA/ECA 310-E	(2005) Cabinets, Racks, Panels, and Associated Equipment

ELECTRONIC INDUSTRIES ALLIANCE (EIA)

ANSI/TIA-455-80C	(2003) FOTP-80 - IEC 60793-1-144 Optical fibres Part 1-44: Measurement Methods and Test Procedures - Cut-off Wavelength

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE C2	(2023) National Electrical Safety Code
IEEE C62.41.1	(2002; R 2008) Guide on the Surges Environment in Low-Voltage (1000 V and Less) AC Power Circuits
IEEE C62.41.2	(2002) Recommended Practice on Characterization of Surges in Low-Voltage (1000 V and Less) AC Power Circuits

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA 250	(2020) Enclosures for Electrical Equipment (1000 Volts Maximum)

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2023) National Electrical Code

TELECOMMUNICATIONS INDUSTRY ASSOCIATION (TIA)

TIA-232	(1997f; R 2012) Interface Between Data Terminal Equipment and Data Circuit-Terminating Equipment Employing Serial Binary Data Interchange
TIA-455-13	(1996a; R 2012) FOTP-13 Visual and Mechanical Inspection of Fiber Optic Components, Devices, and Assemblies
TIA-455-58	(2001b) FOTP-58 Core Diameter Measurement of Graded-Index Optical Fibers

TIA-455-78-B	(2020c) FOTP-78 Optical Fibres - Part 1-40: Measurement Methods and Test Procedures - Attenuation
TIA-455-82	(2020c) FOTP-82 Fluid Penetration Test for Fluid-Blocked Fiber Optic Cable
TIA-455-91	(1986; R 1996) FOTP-91 Fiber Optic Cable Twist-Bend Test
TIA-455-104	(2016b) Standard for FOTP-104 Fiber Optic Cable Cyclic Flexing Test
TIA-455-177	(2020c) FOTP-177 IEC-60793-1-43: Measurement Methods and Test Procedures - Numerical Aperture
TIA-485	(1998a; R 2012) Electrical Characteristics of Generators and Receivers for Use in Balanced Digital Multipoint Systems
TIA-606	(2021d) Administration Standard for Telecommunications Infrastructure
TIA/EIA-455-25	(2016d) FOTP-25 Impact Testing of Optical Fiber Cables
TIA/EIA-455-41	(1993a; R 2013) FOTP-41 Compressive Loading Resistance of Fiber Optic Cables
TIA/EIA-455-81	(2000b) FOTP-81 Compound Flow (Drip) Test for Filled Fiber Optic Cable
TIA/EIA-455-88	(2001) FOTP-88 Fiber Optic Cable Bend Test
TIA/EIA-455-171	(2001a) FOTP-171 - Attenuation by Substitution Measurement for Short-Length Multimode Graded-Index and Single-Mode Optical Fiber Cable Assemblies
TIA/EIA-455-204	(2000) Standard for Measurement of Bandwidth on Multimode Fiber

U.S. NATIONAL ARCHIVES AND RECORDS ADMINISTRATION (NARA)

47 CFR 15	Radio Frequency Devices UNDERWRITERS

LABORATORIES (UL)

UL 1666	(2007; Reprint Sep 2021) UL Standard for Safety Test for Flame Propagation Height of Electrical and Optical-Fiber Cables Installed Vertically in Shafts

1.2 SUBMITTALS

Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-06 Test Reports

Test Procedures and Reports Power Attenuation Test Analog Video

Signal Test Digital Video Signal Test

Optical Time Domain Reflectometer Tests

SD-07 Certificates

Labeling Format

SD-08 Manufacturer's Instructions Manufacturer's Instructions

Manufacturer's Recommendations

SD-10 Operation and Maintenance Data Operating Instructions

1.3 MAINTENANCE MATERIAL SUBMITTALS

PART 2 PRODUCTS

2.1.1 Environmental Requirements

Rate equipment and cables for continuous outdoor operation under ambient environmental conditions of [minus 40] [minus [____]] to plus [166] [________________________] and humidity of up to 100 percent condensing or as normally encountered for the installed location. Rate all equipment and cable for continuous operation under the ambient environmental temperature, pressure, humidity, and vibration conditions specified or normally encountered for the installed location. Install cables in ducts, plenums, and other air-handling spaces per NFPA 70. Ensure cables installed in plenums are plenum-rated cables listed for the use. Ensure cables installed in risers are riser-rated cables listed for the use unless the installed cable is identified as a permitted substitution for the required riser-rated cable type.

2.1.2 Hazardous Environment

Rate the system components and wiring located in areas where fire or explosion hazards may exist with the proper Classes, Divisions, and Groups. Also rate the components and wiring for the operating temperatures.
Install according to Chapter 5 of NFPA 70 and as shown.

2.1.3 Electrical Requirements

Operate the equipment from a voltage source as shown, plus or minus 10 percent, and 60 Hz, plus or minus 2 percent.

2.1.4 Input Line Surge Protection

Protect inputs and outputs against surges induced on wiring and cables including wiring and cables installed outdoors. For components requiring protection, select surge protection devices based on voltages and current ratings of components to be protected. Protect communications equipment against surges induced on any communications circuit. Install surge protection circuits at each end of cables and conductors (except non-conductive FO cables which serve as communications circuits from consoles to field equipment and between field equipment). Furnish protection at equipment. Install additional triple electrode gas surge protectors rated for the application on each conductive wire line and coaxial circuit within 3-feet of the building cable entrance. Do not use fuses for surge protection. Test the inputs and outputs in both normal mode and common mode using the following two waveforms:

a. A 10 microsecond rise time by 1000 microsecond pulse width waveform with a peak voltage of 1500 volts and a peak current of 60 amperes.

b. An 8 microsecond rise time by 20 microsecond pulse width waveform with a peak voltage of 1000 volts and a peak current of 500 amperes.

2.1.5 Power Line Surge Protection

Protect equipment connected to AC circuits from power line surges. Select surge protection devices based on voltages and current ratings of components to be protected. Provide equipment that meets the requirements of IEEE C62.41.1 and IEEE C62.41.2. Do not use fuses for surge protection.

2.2 COMPONENTS

2.2.1 FO Modems

Select FO modems to meet FO system requirements. Ensure the modems allow full duplex, asynchronous, point-to-point digital communication for the system being installed.

2.2.1.1 FO Modem Operating Wavelength

Center the operating wavelength on [850] [1300] [1550] nanometers (nm).

2.2.1.2 FO Modem Inputs and Outputs

Provide FO modems that accept inputs and provide outputs compatible with [TIA-232] [TIA-485] [20 mA current loop] [T1] [10 Base-F]. Digital data rates through each link are [9.6 KBPS] [19.2 KBPS] [38.4 KBPS] [1.54 MBPS] [10 MBPS].

2.2.2 FO Transmitter And Receiver Modules

Ensure FO transmitter/receiver pairs have signal-to-noise power ratio of 40 dB or better after photo detection at the receiver. Transmitter power output and receiver sensitivity cannot drift more than plus or minus 2 dB over their operational life.

2.2.2.1 Analog FO Transmitter and Receiver Modules

Ensure FO transmitter/receiver pairs used to pass analog video signals accept inputs and provide outputs that have a bandwidth of 6 MHz or greater.

2.2.2.2 Digital FO Transmitter and Receiver Modules

Ensure FO transmitter/receiver pairs used to pass digital signals accept inputs and provide outputs compatible with [TIA-232] [TIA-485] [20 mA current loop] [T1] [10 Base-F]. Digital data rates through each link are [9.6 KBPS] [19.2 KBPS] [38.4 KBPS] [1.54 MBPS] [10 MBPS]. House FO transmitter and receiver modules [in field equipment enclosures where possible] [in new enclosures] [as shown]. Provide FO transmitter and receiver modules compatible with each other, the FO cable, and connectors.

2.2.2.3 FO Transmitter Module

Provide a FO transmitter module that accepts electronic signals and modulates a light source. Couple the light source into an FO cable. Center the operating wavelength on [850] [1300] [1550] [850 and 1300] [1300 and 1550] nanometers.

2.2.2.4 FO Receiver Module

Ensure the FO receiver module receives light from the FO cable and converts this light into an electronic signal identical to the electronic signal applied to the FO transmitter module. Ensure the operating wavelength is the same as the transmitter.

2.2.3 FO Digital Repeaters

Use FO digital repeaters to extend the range of the FO data transmission system when necessary to meet the requirements of paragraph SYSTEM REQUIREMENTS. For simplex circuits, the repeater consists of an FO receiver connected to an FO transmitter. For Duplex circuits, the repeater consists of a pair of FO receivers that are connected to a pair of FO transmitters. The FO receivers receive the optical signal and drive the transmitters. The transmitters regenerate the optical signal at the transmission rate specified. Ensure the FO repeater is mechanically and optically compatible with the remainder of the FO system.

2.2.4 FO Analog Repeaters

Use FO analog repeaters to extend the range of the FO data transmission system when necessary to meet the requirements of paragraph SYSTEM REQUIREMENTS. For simplex circuits, the repeater consists of an FO receiver connected to an FO transmitter. For duplex circuits, the repeater consists of a pair of FO receivers that are connected to a pair of FO transmitters. The FO receivers receives the optical signal and drive the transmitters. Ensure the FO repeater is mechanically and optically compatible with the remainder of the FO system.

2.2.5 Transceivers for Lan Applications

Provide transceivers for FO LAN applications that are active units, and compatible with the LAN cards, modems and repeaters used in the system. Provide indicators for power, collision detection, receive, transmit, and status. Derive power for transceivers from the Attachment Unit Interface (AUI) port of LAN equipment or from a dedicated power supply. Ensure transceiver loss characteristics are less than 1.0 db. Provide low loss connectors that are compatible with LAN equipment. Include circuitry so when a device is disconnected, other devices on the LAN continue to operate without any disruption.

2.2.6 FO Switches

Provide single pole, double throw FO switches with switching speed less than 15 milliseconds, and insertion loss less than 1.5 dB. Provide crosstalk attenuation between FO outputs at 40 dB or greater. FO switches are latching or non-latching, as shown.

2.2.7 FO Splitter/Combiner

For FO splitter/combiner units, provide full-duplex communications in a multi-point configuration. Ensure each unit has one input port module and up to four output port modules. Ensure FO splitter/combiner units are mechanically and optically compatible with the remainder of the FO system. The splitter/combiner allows a mixed configuration of port module operating wavelengths and single-mode or multimode FO cables. Ensure each port module has a separate FO cable input and output. Connect port modules using an electronic data bus. Port module FO transmitters regenerate the optical signal at the transmission rate specified. Rack mount port modules in a 19-inch rack complying with ECIA EIA/ECA 310-E. Ensure the total propagation delay through the splitter/combiner is less than 100 nanoseconds.

2.2.8 Fiber Optic Digital Repeaters (FODR)

FODRs combine the features specified for Fiber Optic Digital Repeaters and Local Area Network (LAN) transceivers. FODRs regenerate the optical signal at the transmission rate specified. Ensure the FODRs are mechanically and optically compatible with the remainder of the Fiber Optic System. Ensure FODRs restore the optical signals amplitude, timing and waveform and provide an electrical interface to the transmission media. Ensure the electrical interface is identical to all other network interfaces as specified.

Submit a manufacturer's certificate of the Fiber Optic System indicating compliance with transmission and reliability requirements. Where equipment or materials are specified to conform to the standards or publications and requirements of CFR, ANSI, IEEE, NEMA, NFPA, EIA, or UL, furnish certificates attesting that the items identified conform to the specified requirements.

2.2.9 Data Transmission Converter

Use data transmission converters to connect equipment using TIA-485 data transmission when necessary and as shown. Install converters that operate full duplex and support two wire circuits at speeds up to 2 megabytes per second and have a built in 120 Ohm terminating resistor. Ensure converters are mechanically, electrically, and optically compatible with the system.

2.2.10 Enclosures

Ensure enclosures conform to the requirements of NEMA 250 for the types specified. Use the manufacturer's standard finish color, unless otherwise indicated. Repair and refinish damaged surfaces using original type finish.

2.2.10.1 Exterior

Ensure enclosures installed outdoors meet the requirements of NEMA 250 Type 4 unless otherwise specified or shown.

2.2.10.2 Corrosive Environment

For enclosures in a corrosive environment, meet the requirements of NEMA

250, Type 4X.

2.2.11 Tamper and Physical Protection Provisions

Provide enclosures and fittings of every description having hinged doors or removable covers that contain the FO circuits, connections, splices, or power supplies, with cover-operated, corrosion-resistant tamper switches, arranged to initiate an alarm signal when the door or cover is moved. Mechanically mount tamper switches to maximize the defeat time when enclosure covers are opened or removed. Ensure the enclosure and the tamper switch function together to not allow direct line of sight to any internal components and tampering with the switch or the circuits before the switch activates.

Ensure tamper switches are inaccessible until the switch is activated; have mounting hardware concealed so that the location of the switch cannot be observed from the exterior of the enclosure; are connected to circuits which are under electrical supervision at all times, irrespective of the protection mode in which the circuit is operating; are spring-loaded and held in the closed position by the door cover; and are wired so that they break the circuit when the door or cover is disturbed.

Ensure tamper switches located in enclosures which open to make routine maintenance adjustments to the system and to service the power supplies are push/pull-set, automatic reset type.

2.2.11.1 Enclosure Covers

Covers of pull and junction boxes provided to facilitate installation of the system need not be provided with tamper switches if they contain no splices, connections or power supplies, but are protected by [security screws] [tack welding or brazing] to hold the covers in place. Affix zinc labels to such boxes indicating they contain no connections. Do not indicate with these labels that the box is part of a security system. Clean and repair damage to the enclosure or its cover's surface protection using the same type of surface protection as the original enclosure. Secure the conduit enclosures constructed of fiberglass with tamper proof security servers.

2.2.11.2 Conduit-Enclosure Connections

Protect conduit enclosure connections by tack welding or brazing the conduit to the enclosure. Apply tack welding or brazing in addition to standard conduit-enclosure connection methods as described in NFPA 70. Clean and repair any damage to the enclosure or its cover's surface protection using the same type of surface protection as the original enclosure. Secure conduit enclosures constructed of fiberglass with tamper proof security screws.

2.2.11.3 Locks and Key-Lock-Operated Switches

2.2.12 Optical Fibers

2.2.12.1 General

Coat optical fibers with a suitable material to preserve the intrinsic strength of the glass. The outside diameter of the glass-cladded fiber is nominally 125 microns, and concentric with the fiber core. Ensure optical fibers meet TIA-455-78-B, and TIA-455-177.

2.2.12.2 50 Micron Multimode Fibers

Use conductors that are multimode, graded index, solid glass waveguides with a nominal core diameter of 50 microns. Ensure the fiber has transmission windows centered at 850 and 1300 nanometer wavelengths, with a numerical aperture minimum of 0.20. The attenuation at 850 nanometers is 3.5 dB/Km or less. The attenuation at 1300 nanometers is 1.5 dB/Km or less. For both transmission windows, the minimum bandwidth is 500 MHz-Km. Certify the fibers to meet TIA/EIA-455-204 and TIA-455-58.

2.2.12.3 62.5 Micron Multimode Fibers

Use conductors that are multimode, graded index, solid glass waveguides with a nominal core diameter of 62.5 microns. Ensure the fiber has transmission windows centered at 850 and 1300 nanometer wavelengths, with a numerical aperture minimum of 0.275. The attenuation at 850 nanometers is
3.5 dB/Km or less. The attenuation at 1300 nanometers is 1.5 dB/Km or less. The minimum bandwidth is 160 MHz-Km at 850 nanometers and 500 MHz-Km at 1300 nanometers. Certify FO cable to meet TIA/EIA-455-204 and TIA-455-58.

2.2.12.4 8.3 Micron Single-Mode Fibers

Use conductors that are single-mode, solid glass waveguides with a nominal core diameter of 8.3 microns. Ensure the fiber has a transmission windows centered at 1310 and 1550 nanometer wavelengths with a numerical aperture minimum of 0.10. The attenuation for inside cable at 1310 and 1550 nanometers is 1.0 dB/Km or less. The attenuation for outside cable at 1310 and 1550 nanometers is 0.5 dB/Km or less. Certify the fibers to meet ANSI/TIA-455-80C.

2.2.13 Cross-Connects

2.2.13.1 Patch Panels

Install patch panels as a complete system of components by a single manufacturer; provide termination, splice storage, routing, radius limiting, cable fastening, storage, and cross-connection. Ensure patch panel connectors and couplers are the same type and configuration as used elsewhere in the system. Patch panels are [a 19-inch rack mount type] [wall mounted] [as shown].

2.2.13.2 Patch Cords

Provide patch cord cable assemblies consisting of factory connector-terminated flexible optical fiber cable with connectors of the same type as used elsewhere in the system. Optical fiber is the same type as used elsewhere in the system. Install patch cords as complete assemblies from manufacturer's standard products.

2.3 SYSTEM REQUIREMENTS

2.3.1 Signal Transmission Code Format

Ensure FO equipment uses the same transmission code format from the beginning of a circuit to the end of that circuit. Different transmission code formats may be used for different circuits as required to interconnect supported equipment.

2.3.2 Flux Budget/Gain Margin

Provide FO links with a minimum gain margin of 6 dB. The flux budget is the difference between the transmitter output power and the receiver input power required for signal discrimination when both are expressed in dBm. Ensure the flux budget is equal to the sum of losses (such as insertion losses, connector and splice losses, and transmission losses) plus the gain margin. When a repeater or other signal regenerating device is inserted to extend the length of an FO circuit, both the circuit between the transmitter and the repeater-receiver, and the circuit between the repeater-transmitter and the receiver are considered independent FO links for gain margin calculations.

2.3.3 Receiver Dynamic Range

Ensure the dynamic range of receivers is large enough to accommodate both the worst-case, minimum receiver flux density, and the maximum possible receiver flux density, with a range of at least 15 dB. Where required, use optical attenuators to force the FO link power to fall within the receiver dynamic range.

2.4 ACCESSORIES

2.4.1 FO Connectors

Use field installable, self-aligning and centering FO connectors. Match FO connectors with the fiber core and cladding diameters. Provide FO cable connectors at field equipment [of the type to match the field equipment connectors] [of type [_____]] [as shown]. Provide FO connectors at terminal head end equipment [of the type to match terminal head equipment connectors] [of type [_____]] [as shown]. Connector insertion loss is nominally 0.3 dB and maximum loss less than 0.7 dB.

2.4.2 Mechanical Splices

Mechanical splices are suitable for installation in the field. External power sources are not required to complete a mechanical splice. Use self-aligning mechanical splices for optimum signal coupling. Do not use mechanical splices for exterior applications where they may be buried underground or laced to aerial messenger cables. Mechanical splices may be used for interior locations and within enclosures. Protect the spliced fibers from moisture and prevent physical damage with splice closures. Use the splice closure to provide strain relief for the cable and the fibers at the splice points.

2.4.3 Fusion Splices

Use a portable, fully automatic, and compact fusion splicer, suitable for fusion splicing all types of telecommunication grade optical fibers and individual fibers as well as cables containing multiple optical fibers. Ensure the fusion splicer is capable of operation under various environmental conditions (e.g., temperature, humidity, altitude, etc.) for all types of optical cable deployments. Start the automatic splicing process by pressing one button and can be interrupted at any time. Alternatively, make available semi-automatic (step-by-step) or manual splicing by menu selection. Conduct communication with the fusion splicer through a language unspecific keyboard with universal symbols and display the dialogue with the splicer on the device screen.

2.4.4 Conduit, Fittings And Enclosures

Ensure conduit, fittings, and enclosures are as specified as shown.

2.4.5 Fan-Out Kits

For all loose-tube optical fibers, furnish and install fan-out kits using furcating tubes for connectorization. Incorporate strain relief for loose-tube optical fiber furcating tubes if the connectorization is not contained within a protective enclosure such as a patch panel. For tight-buffered optical fibers, furnish and install fan-out kits using furcating tubes and which incorporate strain relief, if the connectorization is not contained within a protective enclosure such as a patch panel. Furcating tubes required to incorporate strain relief also provide increased pullout protection. Tubes are comprised of an inner tube, surrounded by a layer of nonconductive strength members, then surrounded by an enclosing outer jacket layer. [Color code fan-out kits to match the industry fiber color scheme.] Length of furcating tube is [24] [36]-inches minimum when installation is complete. Rate fan-out kits for the ambient conditions of the location as specified in paragraph ENVIRONMENTAL REQUIREMENTS. Provide terminations for each fiber, regardless whether fiber is active or spare.

2.5 CABLE CONSTRUCTION

2.5.1 General

Ensure the cable contains a minimum of two FO fibers for each link circuit. The number of fibers in each cable is [______] [as shown]. Protect each fiber by a protective tube. Ensure cables have a jacketed strength member, and an exterior jacket. Ensure cable and fiber protective covering are free from holes, splits, blisters, and other imperfections. Insulation and jacketing material for interior cables cannot contain any polyvinyl chloride (PVC) compounds. Use a covering that is flame retardant, moisture resistant, non-nutrient to fungus, ultraviolet light resistant as specified, and nontoxic. Do not transmit mechanical stress present in cable to the optical fibers. Ensure strength members are non-metallic and an integral part of the cable construction. Ensure the combined strength of all the strength members is sufficient to support the stress of installation and to protect the cable in service. For exterior cables, select a minimum storage temperature range of minus 104 to plus 167 degrees F. A minimum storage temperature of plus 14 to plus 167 degrees F is required for interior cables. Ensure all optical fiber cables and all optical fiber raceways furnished meet the requirement of NFPA 70. Apply a flooding compound into the interior of the fiber tubes, into the interstitial spaces between the tubes, to the core covering, and between the core covering and jacket of all cable to be installed aerially, underground, and in locations susceptible to moisture. Ensure flooded cables comply with TIA/EIA-455-81 and TIA-455-82. Provide cables from the same manufacturer, of the same cable type, of the same size, and of the same optical characteristics. Ensure each fiber and protective coverings is continuous with no factory splices. Certify by the manufacturer, optic cable assemblies, including jacketing and fibers, to have a minimum life of
30 years. Ensure cables meet UL 1666. Certify FO cable to meet the

following: TIA-455-13, TIA/EIA-455-25, TIA/EIA-455-41, TIA-455-177, TIA-455-78-B, TIA/EIA-455-88, TIA-455-91, TIA-455-104, and TIA/EIA-455-171.

2.5.2 Exterior Cable

2.5.2.1 Duct Cable

Surround the optical fibers by a tube buffer, contained in a channel or otherwise loosely packaged to provide clearance between the fibers and inside of the container, and extruded from a material having a coefficient of friction sufficiently low to allow the fiber free movement. Select cable with the following characteristics:

a. Cable outer jacket: Medium density polyethylene material with orange pigment added for ease of identification.

b. Tensile strength: Withstand an installation tensile load of not less than 608 pounds and not less than 135 pounds continuous tensile load.

c. Impact and Crush resistance: Withstand an impact of 1.7 lbs/in as a minimum, and have a crush resistance of 317 psi as a minimum.

2.5.3 Pigtail Cables

Use flexible fiber pigtail cables for connections to equipment having the same physical and operational characteristics as the parent cable. Ensure the cable jacket is FCP, which complies with NFPA 70 for OFNP applications. Maximum dB loss for pigtail cable is 3.5 dB/km at 850 nanometers, and 1.0 dB/km at 1300 nanometers, and [_____] dB/Km at 1550 nanometers.

PART 3 EXECUTION

3.1 INSTALLATION

Install system components and appurtenances in accordance with the manufacturer's instructions and as shown. Provide interconnections, services, and adjustments required for a complete and operable data transmission system.

Where installation procedures, or any part thereof, are required to be in accordance with the manufacturer's recommendations of the material being installed, submit printed copies of these recommendations prior to installation. Installation of the item is not allowed to proceed until the recommendations are received and approved.

3.1.1 Interior Work

Install conduits, tubing and cable trays for interior FO cable as shown. Ensure cable installation and applications meet the requirements of NFPA 70, Article 770. Properly support and secure cables not installed in conduits or wireways. If installed in plenums or other spaces used for environmental air, comply with NFPA 70 requirements for this type of installation.

3.1.2 Exterior Work Underground

Except as otherwise specified, install conduits, ducts, and manholes for underground FO cable systems as specified as shown.

a. Minimum burial depth for cable is 24 inches. Burial depth specified takes precedence over any requirements specified elsewhere.

b. Where direct burial cable passes under sidewalks, roads, or other paved areas, place the cable in a 1-inch zinc-coated rigid conduit or larger as required to limit conduit fill to 80 percent or less.

c. Place buried cables below a plastic warning tape buried in the same trench or slot. Place the warning tape 12 inches above the cable. Continuously imprint the warning tape with the words "WARNING - COMMUNICATIONS CABLE BELOW" at not more than 48-inch intervals. Use warning tape that is acid and alkali resistant polyethylene film, 3 inches wide with a minimum thickness of 0.004-inch, with a minimum strength of 1750 psi lengthwise and 1500 psi crosswise.

d. Transitions from underground cable to aerial cable are as shown.

e. For cables installed in ducts and conduit, use a cable lubricant compatible with the cable sheathing material on all cables pulled. Attach pulling fixtures to the cable strength members. If indirect attachments are used, match the grip diameter and length to the cable diameter and characteristics. If an indirect attachment is used on cables having only central strength members, reduce the pulling forces to ensure that the fibers are not damaged from forces being transmitted to the strength member. During pulling, continuously monitor the cable pull line tension using dynamometers or load-cell instruments. Do not exceed the maximum tension specified by the cable manufacturer. Ensure the mechanical stress placed upon the cable during installation is such that the cable is not twisted or stretched. Use a cable feeder guide between the cable reel and the face of the duct or conduit to protect the cable and guide it into the duct or conduit as it is un-spooled from the reel. As the cable is un-spooled from the reel, inspect it for jacket defects or damage. Do not kink or crush the cable. Do not exceed the minimum bend radius of the cable during installation. Hand feed and guide cable through each manhole and apply additional lubricant at all intermediate manholes. When practicable, use the center pulling technique to lower pulling tension. That is, pull the cable from the center point of the cable run towards the end termination points. The method may require the cable to be pulled in successive pulls. If the cable is pulled out of a junction box or manhole, protect the cable from dirt and moisture by laying the cable on a ground covering.

3.1.3 Service Loops

Ensure each FO cable has service loops of not less than 9.8-feet in length at each end. House the service loops in a service loop enclosure.

3.1.4 Metallic Sheath Grounding

Ground the FO cable with metallic sheath that enter buildings at a point as close as practicable to the building point of entrance. Ensure FO cable with metallic sheath routed in the trench with a power cable has the metallic sheath grounded at the cable termination points.

3.1.5 Splices

3.1.5.1 General

No splices are permitted unless the length of cable being installed exceeds the maximum standard cable length available from a manufacturer or unless FO pigtails are used to connect transmitters, receivers, or other system components for terminations to the fiber. Make splices using the method recommended by the cable manufacturer. Place splices in a splice enclosure and encapsulate with an epoxy, ultraviolet light cured splice encapsulant or otherwise protected against infiltration of moisture or contaminants.
Field test FO splices at the time of splicing. Ensure fusion splices have a nominal splice loss of [0.15] [_____] dB for multimode and for single mode cable fusion splices and a maximum fusion splice loss not more than 0.3 dB loss.

3.1.5.2 Mechanical Splices

Install mechanical splices with a nominal splice loss of [0.15] [_____] dB for multimode fiber mechanical splices and [0.2] [_____] dB for single mode fiber mechanical splices with a maximum mechanical splice loss not more than [0.3] [_______________________________________] dB loss for multimode and single mode fiber mechanical splices. Install no more than 1 splice per 0.62 mile in any of the FO cables excluding terminations. Locate field splices in cable boxes.
Provide sufficient cable in each splicing location to properly rack and splice the cables, and to provide extra cable for additional splices. Protect cable ends with end caps except during actual splicing. During the splicing operations, provide means to protect the unspliced portions of the cable and its fibers from the intrusion of moisture and other foreign matter.

3.1.6 Connectors

Prior to and during installation of connectors, perform appropriate cleaning to ensure that any contaminant particulates larger than 0.06 micron in size are removed. Connectors are as specified in paragraph FO CONNECTORS. Connectors or splices which leave residue on the connector ferrule or optical connector "lens", are not permitted. Ensure fibers at each end of the cable have jumpers or pigtails installed of not less than 3 feet in length. For fibers at both ends of the cable, have connectors installed on the jumpers. Ensure the mated connector pair loss does not exceed [0.7] [_____] dB. The pull strength between the connector and the attached fiber cannot be less than 50 pounds.

3.1.7 Identification and Labeling

Provide identification tags or labels for each cable. For markers, tags and labels, use indelible ink or etching which does not fade in sunlight, or in buried or underground applications. Use markers, tags, and labels that do not become brittle or deteriorate for a period of 20 years due to moisture, sunlight, soil minerals, chemicals or other environmental elements. Label all termination blocks and panels with cable number or pair identifier for cables in accordance with TIA-606 and as specified on drawings. Identify the labeling format and provide a complete record to the Contractor/Buyer with the final documentation. Identify each cable with type of signal being carried and termination points.

3.1.8 Enclosure Sizing and Cable

Size termination enclosures to accommodate the FO equipment to be installed. Sizing includes sufficient space for service loops to be provided and to accommodate a neat layout of equipment and the bend radii of fibers and cables terminated inside the enclosure.

3.1.9 Enclosure Penetrations

Install enclosure penetrations from the bottom. Seal penetrations with rubber silicone sealant to preclude the entry of water. Internally seal conduits rising from underground.

3.2 FIELD QUALITY CONTROL

3.2.1 General

Provide personnel, equipment, instrumentation, and supplies necessary to perform testing.

3.2.2 Field Test

Verify the complete operation of the data transmission system in conjunction with field testing associated with systems supported by the fiber optic data transmission system as specified in Section [_____] prior to formal acceptance testing. Include a flux density test in field tests. Perform these tests on each link and repeated from the opposite end of each link.

3.2.2.1 Optical Time Domain Reflectometer Tests

Perform optical time domain reflectometer tests using the FO test procedures of TIA-455-78-B. Perform an optical time domain reflectometer test on all fibers of the FO cable on the reel prior to installation. Calibrate the optical time domain reflectometer to show anomalies of 0.2 dB as a minimum. Furnish photographs of the traces to the Contractor/Buyer. Perform an optical time domain reflectometer test on all fibers of the FO cable after it is installed. Calibrate the optical time domain reflectometer to show anomalies of 0.2 dB as a minimum. If the optical time domain reflectometer test results show anomalies greater than 1 dB, the FO cable segment is unacceptable to the Contractor/Buyer. Replace the unsatisfactory segments of cable with a new segment of cable. Then test the new segment of cable to demonstrate acceptability. Furnish photographs of the traces to the Contractor/Buyer for each link.

3.2.2.2 Power Attenuation Test

Perform power attenuation test at each light wavelength of the transmitter to be used on the circuit being tested. Measure the flux at the FO receiver end and compare to the flux injected at the transmitter end. Add a jumper at each end of the circuit under test so that end connector loss is validated. Rotational optimization of the connectors is not permitted. If the circuit loss exceeds the calculated circuit loss by more than 2 dB, the circuit is unsatisfactory. Examine the circuit to determine the problem. Notify the Contractor/Buyer of the problem and propose procedures to eliminate the problem. Prepare and submit a report documenting the results of the test.

3.2.2.3 Gain Margin Test

Test and verify that each circuit has a gain margin which exceeds the circuit loss by at least the minimum gain margin specified in paragraph FLUX BUDGET/GAIN MARGIN.

3.2.2.4 Analog Video Signal Test

Test analog video circuits. Ensure the monitor or automated test set is stable. If the result is unsatisfactory, examine the circuit to determine the problem. Notify the Contractor/Buyer of the problem and of the procedures proposed to eliminate the problem. Prepare and submit a report documenting the results of the test.

3.2.2.5 Digital Video Signal Test

Test digital video circuits. Ensure the monitor or automated test set is stable. If the result is unsatisfactory, examine the circuit to determine the problem. Notify the Contractor/Buyer of the problem and of the procedures proposed to eliminate the problem. Prepare and submit a report documenting the results of the test.

3.2.2.6 Performance Verification Test and Endurance Test

Test the FO data transmission system as a part of the completed [UMCS] [IDS] [ESS] [CCTV] [_____] during the Performance Verification Test and Endurance Test.

3.3 CLOSEOUT ACTIVITIES

3.3.1.1.1 Operation and Maintenance Data

Deliver a draft copy of the operation and maintenance data.

3.3.1.1.2 Maintenance Manual

Include the maintenance descriptions for all equipment including inspection, periodic preventative maintenance, fault diagnosis, and repair or replacement of defective components.

3.3.1.1.3 Operator's Manual

Ensure the operator's manual fully explains procedures and instructions for operation of the system. This includes an operator's manual for any FO systems in which system operators control any function of the system.

3.3.2 Training

Conduct a training course for designated personnel in the maintenance of the FO system. Orient the training to the specific system being installed under this specification. Furnish all training materials and supplies.

3.3.2.1 System Maintenance Training Course

Provide two copies of operating instructions outlining the step-by-step procedures required for system operation including description of each subsystem in its operating mode. Instructions includes the manufacturer's name, service manual, parts list, and a brief description of equipment, components, and their basic operating features. Provide two copies of the maintenance instructions listing regular maintenance procedures, possible system failures, a troubleshooting guide for repairs, and simplified diagrams for the system as installed. A video describing operating and maintenance instructions may be included.

Provide a system maintenance course taught at the project site after completion of the endurance test for a period of 1 training day. A maximum of five personnel designated by the Contractor/Buyer will attend the course. A training day consists of 8 hours of classroom or lab instruction, including two 15 minute breaks and excluding lunchtime during the daytime shift in effect at the facility. Training includes:

a. Physical layout of the system and each piece of hardware.

b. Troubleshooting and diagnostics procedures.

c. Repair instructions.

d. Preventative maintenance procedures and schedules.

e. Calibration procedures.

-- End of Section --

SECTION 31 00 00: EARTHWORK
08/23

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS (AASHTO)

AASHTO T 180	(2017) Standard Method of Test for Moisture-Density Relations of Soils Using a 4.54-kg (10-lb) Rammer and a 457-mm (18-in.) Drop AMERICAN WATER WORKS

ASSOCIATION (AWWA)

AWWA C600	(2017) Installation of Ductile-Iron Mains and Their Appurtenances

AMERICAN WELDING SOCIETY (AWS)

AWS D1.1/D1.1M	(2020; Errata 1 2021) Structural Welding Code - Steel

ASTM INTERNATIONAL (ASTM)

ASTM C33/C33M	(2018) Standard Specification for Concrete Aggregates
ASTM C117	(2017) Standard Test Method for Materials Finer than 75-um (No. 200) Sieve in Mineral Aggregates by Washing
ASTM C136/C136M	(2019) Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates
ASTM C150/C150M	(2022) Standard Specification for Portland Cement
ASTM C260/C260M	(2010a; R 2016) Standard Specification for Air-Entraining Admixtures for Concrete
ASTM C618	(2023; E 2023) Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete
ASTM C989/C989M	(2022) Standard Specification for Slag Cement for Use in Concrete and Mortars
ASTM D698	(2012; E 2014; E 2015) Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/cu. ft. (600 kN-m/cu. m.))

ASTM D1140	(2017) Standard Test Methods for Determining the Amount of Material Finer than 75-µm (No. 200) Sieve in Soils by Washing
ASTM D1556/D1556M	(2015; E 2016) Standard Test Method for Density and Unit Weight of Soil in Place by Sand-Cone Method
ASTM D1557	(2012; E 2015) Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft3) (2700 kN-m/m3)
ASTM D2167	(2015) Density and Unit Weight of Soil in Place by the Rubber Balloon Method
ASTM D2216	(2019) Standard Test Methods for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass
ASTM D2321	(2020) Standard Practice for Underground Installation of Thermoplastic Pipe for Sewers and Other Gravity-Flow Applications
ASTM D2487	(2017; E 2020) Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System)
ASTM D2974	(2020; E 2020) Moisture, Ash, and Organic Matter of Peat and Other Organic Soils
ASTM D4253	(2016; E 2019) Standard Test Methods for Maximum Index Density and Unit Weight of Soils Using a Vibratory Table
ASTM D4254	(2016) Standard Test Methods for Minimum Index Density and Unit Weight of Soils and Calculation of Relative Density
ASTM D4318	(2017; E 2018) Standard Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils
ASTM D4829	(2021) Standard Test Method for Expansion Index of Soils
ASTM D4832	(2016; E 2018) Standard Test Method for Preparation and Testing of Controlled Low Strength Material (CLSM) Test Cylinders
ASTM D5268	(2019) Topsoil Used for Landscaping Purposes
ASTM D6023	(2016) Standard Test Method for Density (Unit Weight), Yield, Cement Content, and Air Content (Gravimetric) of Controlled Low-Strength Material (CLSM)

ASTM D6103/D6103M	(2017; E 2021) Standard Test Method for Flow Consistency of Controlled Low Strength Material (CLSM)
ASTM D6938	(2017a) Standard Test Method for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth)
ASTM D8167/D8167M	(2023) Standard Test Method for In-Place Bulk Density of Soil and Soil-Aggregate by a Low-Activity Nuclear Method (Shallow Depth)

U.S. ARMY CORPS OF ENGINEERS (USACE)

EM 385-1-1	(2014) Safety -- Safety and Health Requirements Manual

U.S. ENVIRONMENTAL PROTECTION AGENCY (EPA)

EPA 600/4-79/020	(1983) Methods for Chemical Analysis of Water and Wastes
EPA SW-846.3-3	(1999, Third Edition, Update III-A) Test Methods for Evaluating Solid Waste: Physical/Chemical Methods

U.S. GENERAL SERVICES ADMINISTRATION (GSA)

CID A-A-203	(Rev C; Notice 3) Paper, Kraft, Untreated

1.2 DEFINITIONS

1.2.1 Structural Fill

Soil material placed to support buildings, walls, pads, and other similar facilities.

1.2.2 Embankment Fill

Soil material placed to construct embankment.

1.2.3 Porous Fill

Free-draining material placed for subsurface drainage, as a capillary break, or another specific purpose.

1.2.4 Topsoil

Surface layer of primarily organic soil capable of supporting vegetation growth.

1.2.5 Utility Bedding Material

Fill placed to directly support pipes, conduits, cables, and appurtenant structures. Bedding may also be used to provide a cushion between utilities and bedrock, obstacles, obstructions and other unyielding materials.

1.2.6 Satisfactory Materials

Satisfactory materials for fill, backfill, and/or any in-situ soils to remain in place comprise any materials classified by ASTM D2487 as [GW], [GP], [GM], [GP-GM], [GW-GM], [GC], [GP-GC], [GM-GC], [SW], [SP], [SM], [SW-SM], [SC], [SW-SC], [SP-SM], [SP-SC]. Maximum particle size to be no greater than 3 inches] in any dimension.

1.2.7 Unsatisfactory Materials

Materials which do not comply with the requirements for satisfactory materials are unsatisfactory. Unsatisfactory materials also include man-made fills; trash; refuse; backfills from previous construction; roots and other organic matter or frozen material. Notify the Contractor/Buyer when encountering any contaminated materials.

1.2.8 Cohesionless Materials

Cohesionless materials include materials classified in ASTM D2487 as GW, GP, SW, and SP. Materials classified as GM and SM will be identified as cohesionless only when the fines are non-plastic. Perform testing, required for classifying materials, in accordance with ASTM D4318, ASTM C117, ASTM C136/C136M and ASTM D1140.

1.2.9 Cohesive Materials

Cohesive materials include materials classified as GC, SC, ML, CL, MH, and CH. Materials classified as GM and SM will be identified as cohesive only when the fines are plastic. Perform testing, required for classifying materials, in accordance with ASTM D4318, ASTM C117, ASTM C136/C136M and ASTM D1140.

1.2.10 Hard/Unyielding Materials

Hard/Unyielding materials comprise weathered rock, dense consolidated deposits, or conglomerate materials which are not included in the definition of "rock". These materials usually require the use of heavy excavation equipment, ripper teeth, or jack hammers for removal.

1.2.11 Unstable Material

Unstable materials are too weak to adequately support the utility pipe, conduit, equipment, or appurtenant structure. Satisfactory material may become unstable due to ineffective drainage, dewatering, becoming frozen, excessive loading.

1.2.12 Expansive Soils

Expansive soils are defined as soils that have an expansion index greater than 20 when tested in accordance with ASTM D4829.

1.2.13 Rock

Solid homogeneous interlocking crystalline material with firmly cemented, laminated, or foliated masses or conglomerate deposits, neither of which can be removed without systematic drilling and blasting, drilling and the use of expansion jacks or feather wedges, or the use of backhoe-mounted pneumatic hole punchers or rock breakers; also large boulders, buried masonry, or concrete other than pavement exceeding 1/2 cubic yard in volume. Removal of hard material will not be considered rock excavation because of intermittent drilling and blasting that is performed merely to increase production.

1.2.14 Degree of Compaction (Proctor)

Degree of compaction required, except as noted in the second sentence, is expressed as a percentage of the maximum density obtained by the test procedure presented in [ASTM D1557] [ASTM D698] abbreviated as a percent of laboratory maximum density. Since ASTM D1557 applies only to soils that have 30 percent or less by weight of their particles retained on the ¾-inch sieve, express the degree of compaction for material having more than 30 percent by weight of their particles retained on the ¾-inch sieve as a percentage of the maximum density in accordance with AASHTO T 180-21 paragraph 1.5, Note 1.

1.2.15 Degree of Compaction (Relative Density)

Degree of compaction required for soils with less than 5 percent passing the No. 200 sieve, is expressed as a relative percentage of the maximum index density/dry unit weight and minimum index density/dry unit weight, obtained by the test procedures in accordance with ASTM D4253 and ASTM D4254, respectively, abbreviated as a percent of laboratory relative density.

1.2.16 Borrow

Soil brought to the project site from an external location for the purposes of project construction.

1.2.17 Subgrade

Earth materials directly below foundations and directly below granular base materials in building slab and pavement areas including shoulders.

1.3 CRITERIA FOR BIDDING

Base bids on the following criteria:

a. Surface elevations are as indicated.

b. Pipes or other artificial obstructions, except those indicated, will not be encountered.

c. Ground water elevation is 100 feet below existing surface elevation.

d. Material character is indicated by the boring logs.

e. Hard materials will not be encountered in the excavations.

1.4 SUBMITTALS

Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-03 Product Data

Geotextiles

SD-06 Test Reports

Pipe Pressure Test Report;

Borrow Soil Test Report

1.5 QUALITY CONTROL

1.5.1 Qualified Technician

Provide a Qualified Technician to inspect, monitor, sample, and performing field testing. The technician qualifications need to be one of the following: a current National Institute for Certification in Engineering Technologies (NICET) Level II minimum certification in Construction Materials Testing Soils; a Geologist-in-Training with minimum one-year experience; an Engineer-in-Training with minimum one-year experience; a Registered Geologist; or a Professional Engineer.

1.5.2 Lab Validation

Perform testing by a Corps validated commercial testing laboratory or Subcontractor established testing laboratory approved by the Contractor/Buyer. Submit testing laboratory validation for the testing to be performed. Do not permit work requiring testing until approved by the Contractor/Buyer.

1.5.3 Preconstruction Meeting

Conduct a preconstruction meeting at least five business days prior to the start of earthwork operations on the project. The preconstruction meeting is to be arranged by the Subcontractor and is to follow the written agenda submitted prior to the meeting. The purpose of this meeting is to review the requirements of this specification and the associated plans. The following individuals must be in attendance at this meeting: Subcontractor's Project Manager and Project Superintendent, earthwork subcontractor's Project Manager and Site Foreman, and Contractor/Buyer Construction Manager and Engineering Technician.

The minutes of this meeting are to be recorded by the Subcontractor and published via email within 48 hours to all attendees. The minutes must be re-published within 48 hours via email pending any subsequent comments from the attendees.

PART 2 PRODUCTS

2.1 SOIL MATERIALS

2.1.1 Structural Fill

Materials classified as [GW], [GP], [GM], [GC], [GW-GM], [GW-GC], [GP-GM], [GP-GC], [GC-GM], [SW], [SP], [SM], [SW-SM], [SC], [SW-SC], [SP-SM], or [SP-SC], in accordance with ASTM D2487. Select material type appropriate for the intended purpose.

2.1.2 Embankment Fill

Materials classified as [GW], [GP], [GM], [GC], [GW-GM], [GW-GC], [GP-GM], [GP-GC], [GC-GM], [SW], [SP], [SM], [SW-SM], [SC], [SW-SC], [SP-SM], [SP-SC], [CL], or [CH] in accordance with ASTM D2487. Select material type appropriate for the intended purpose.

2.1.3 Topsoil

Material suitable for topsoil obtained from excavations is defined as: Natural, friable soil representative of productive, well-drained soils in the area, free of subsoil, stumps, rocks larger than 1 inch diameter, brush, weeds, toxic substances, and other material detrimental to plant growth.

2.1.4 Utility Bedding Material

Except as specified otherwise in the individual piping section, provide bedding for buried piping in accordance with [AWWA C600] [ASTM D2321]. Install bedding for plastic piping to spring line of pipe. Utility bedding material may include the following:

2.1.4.1 Sand

Clean, coarse-grained sand classified as SW or SP by ASTM D2487 for bedding and backfill.

2.2 BURIED WARNING AND IDENTIFICATION MARKERS

Provide [polyethylene plastic] [and] [metallic core or metallic-faced, acid- and alkali-resistant, polyethylene plastic] warning tape manufactured specifically for warning and identification of buried utility lines.

Provide tape on rolls, 3 inches minimum width, color coded as specified below for the intended utility with warning and identification imprinted in bold black letters continuously over the entire tape length. Warning and identification to read, "CAUTION, BURIED (intended service) LINE BELOW" or similar wording. Provide permanent color and printing, unaffected by moisture or soil.

Warning Tape Color Codes	
Red	Electric
Yellow	Gas, Oil; Dangerous Materials
Orange	Telephone and Other Communications
Blue	Water Systems
Green	Sewer Systems
White	Steam Systems
Gray	Compressed Air

2.2.1 Warning Tape for Metallic Piping

Provide acid and alkali-resistant polyethylene plastic tape conforming to the width, color, and printing requirements specified above, with a minimum thickness of 0.003 inch and a minimum strength of 1500 psi lengthwise, and 1250 psi crosswise, with a maximum 350 percent elongation.

2.2.2 Detectable Warning Tape for Non-Metallic Piping

Provide polyethylene plastic tape conforming to the width, color, and printing requirements specified above, with a minimum thickness of 0.004 inch, and a minimum strength of 1500 psi lengthwise and 1250 psi crosswise. Manufacture tape with integral wires, foil backing, or other means of enabling detection by a metal detector when tape is buried up to 3 feet deep. Encase metallic element of the tape in a protective jacket or provide with other means of corrosion protection.

2.2.3 Detection Wire for Non-Metallic Piping

Insulate a single strand, solid copper detection wire with a minimum of 12 AWG.

2.2.4 Bedding Material

Provide bedding material consisting of sand, gravel, or crushed rock, well graded, or poorly graded with a maximum particle size of 2 inches. Compose material of tough, durable particles. Allow fines passing the No. 200 standard sieve with a plasticity index less than 6.

2.3 GEOTEXTILE

Provide a pervious sheet of polyester, nylon, glass or polypropylene ultraviolet resistant filaments woven, spun bonded, fused, or otherwise manufactured into a non-raveling fabric with uniform thickness and strength. Fabric must have manufacturer certified minimum average roll properties that conform with SECTION 31 05 19.13. Submit a sample and material product data for all Geotextiles utilized.

PART 3 EXECUTION

3.1 PROTECTION

Perform all work specified in accordance with applicable requirements of the Corps of Engineers publication EM 385-1-1 Safety and Health Requirements Manual.

Use equipment of type and size appropriate for the site conditions (soil character and moisture content). Maintenance of exposed subgrades and fills is the responsibility of the Subcontractor. The Subcontractor is required to prevent damage by ineffective drainage, dewatering, and heavy loads and equipment by implementing precautionary measures. Repair or replace any defects or damage.

3.1.1 Underground Utilities

Location of the existing utilities indicated is approximate. Physically verify the location and elevation of the existing utilities indicated prior to starting construction. The Subcontractor is responsible for protecting utilities from damage during construction.

3.1.2 Drainage and Dewatering

Provide for the collection and disposal of surface and subsurface water encountered during construction.

3.1.2.1 Drainage

Provide for the collection and disposal of surface and subsurface water encountered during construction. Throughout construction grade the construction area to provide positive surface water runoff away from the construction activity or provide temporary ditches, swales, and other drainage features and equipment as required to keep soils from becoming unstable, prevent erosion, or undermining of foundations. Remove unstable material from working platforms for equipment operation and soil support for subsequent construction features and provide new material as specified herein. It is the responsibility of the Subcontractor to assess the site conditions to employ necessary measures to permit construction to proceed.

3.1.3 Protection of Graded Surfaces

Protect newly backfilled, graded, and topsoiled areas from traffic, erosion, and settlements that may occur. Repair or reestablish damaged grades, elevations, or slopes.

3.1.4 Government Furnished Borrow Area(s)

Obtain approved borrow materials from Operable Unit 2 Landfills. The rights-of-way and earth materials for constructing the work have been furnished, without cost, to the Subcontractor at locations as specified. Submit a Borrow Plan to the Contractor/Buyer of intention to use the specified Government-furnished borrow areas.

3.1.4.1 Drainage of Borrow Excavations

Provide adequate drainage of borrow area. Ensure that borrow operations result in minimum detrimental effects on natural environmental conditions.

3.1.4.2 Borrow Area Closure

Complete borrow areas final grading, so that slopes are not steeper than 3 vertical on 1 horizontal, except as otherwise indicated. Avoid abrupt changes in grade. Distribute stripped material and stockpiles of unstable materials over the disturbed borrow area, as directed. Final grade the borrow area to drain.

3.2 SURFACE PREPARATION

3.2.1 Clearing and Grubbing

Clear and grub as specified in Section 31 11 00 CLEARING AND GRUBBING. Remove trees, stumps, logs, shrubs, brush and vegetation and other items that would interfere with construction operations. Remove stumps entirely. Grub out matted roots and roots over 3 inches in diameter to at least 18 inches below existing surface.

3.2.2 Stripping

Strip site where indicated on the plans. Strip existing surface materials to a depth of 6 inches below the existing ground surface in areas designated as Clear and Grub on the plans. Strip existing surficial soils to a depth of 3 inches in all other areas. All stripped materials not suitable for reuse as topsoil will be wasted in specified disposal area.

Strip suitable soil from the site where excavation or grading is indicated and stockpile separately from other excavated material. Protect topsoil and keep in segregated piles until needed.

3.3.4 Stockpiling Operations

Place and grade stockpiles of satisfactory, unsatisfactory, and wasted materials as specified. Keep stockpiles in a neat and well drained condition, giving due consideration to drainage at all times. Clear, grub, and seal by rubber-tired equipment, the ground surface at stockpile locations; separately stockpile excavated satisfactory and unsatisfactory materials. Protect stockpiles of satisfactory materials from contamination which may destroy the quality and fitness of the stockpiled material. Do not create stockpiles that could endanger a partly finished structure, impair the efficiency or appearance of any structure, or be detrimental to the completed work in any way. If the Subcontractor fails to protect the stockpiles, and any material becomes unsatisfactory, remove and replace such material with satisfactory material from approved sources.

3.3 EXCAVATION

Excavate to contours, elevation, and dimensions indicated. Excavate soil disturbed or weakened by Subcontractor's operations, and soils softened or made unstable for subsequent construction due to exposure to weather. Use material removed from excavations meeting the specified requirements in the construction of fills, embankments, subgrades, shoulders, bedding (as backfill), and for similar purposes to minimize surplus material and to minimize additional material to brought on site. Do not excavate below indicated depths except to remove unstable material as determined by the Contractor/Buyer. Remove and replace excavations below the grades shown with appropriate materials as directed by the Contractor/Buyer.

If at any time during excavation, including excavation from borrow areas, the Subcontractor encounters material that may be classified as rock or as hard/unyielding material, uncover such material, and notify the Contractor/Buyer. Do not proceed with the excavation of this material until the Contractor/Buyer has classified the materials as common excavation or rock excavation. Failure on the part of the Subcontractor to uncover such material, notify the Contractor/Buyer, and allow sufficient time for classification and delineation of the undisturbed surface of such material will cause the forfeiture of the Subcontractor's right of claim to any classification or volume of material to be paid for other than that allowed by the Contractor/Buyer for the areas of work in which such deposits occur.

3.3.1 Trench Excavation Requirements

Excavate the trench as recommended by the manufacturer of the pipe to be installed. Slope trench walls below the top of the pipe, or make vertical, and of such width as recommended by the manufacturer. Provide vertical trench walls where no manufacturer installation instructions are available. Do not exceed the trench width of 24 inches below the top pipe plus pipe outside diameter (O.D.) for pipes of less than 24 inches inside diameter. Where recommended trench widths are exceeded, provide redesign, stronger pipe, or special installation procedures. The Subcontractor is responsible for the cost of redesign, stronger pipe, or special installation procedures without any additional cost to the

Contractor/Buyer.

3.3.1.1 Bottom Preparation

Grade the bottoms of trenches accurately to provide uniform bearing and support for the bottom quadrant of each section of the pipe. Excavate bell holes to the necessary size at each joint or coupling to eliminate point bearing. Remove stones of 1 inch or greater in any dimension, or as recommended by the pipe manufacturer, whichever is smaller, to avoid point bearing.

3.3.1.2 Removal of Unyielding Material

Where unyielding material is encountered in the bottom of the trench,, remove such material 2 inches below the required grade and replaced with suitable materials as provided in paragraph FILLING AND COMPACTION.

3.3.1.3 Removal of Unstable Material

Where unstable material is encountered in the bottom of the trench, remove such material to the depth directed and replace it to the proper grade with suitable material as provided in paragraph FILLING AND COMPACTION. When removal of unstable material is required due to the Subcontractor's fault or neglect in performing the work, the Subcontractor is responsible for excavating the resulting material and replacing it without additional cost to the Contractor/Buyer.

3.3.1.4 Excavation for Appurtenances

Provide excavation for manholes, catch-basins, inlets, or similar structures sufficient to leave at least 12 inches clear between the outer structure surfaces and the face of the excavation or support members or of sufficient size to permit the placement and removal of forms for the full length and width of structure footings and foundations as shown.

3.3.1.5 Water Lines

Excavate trenches to a depth that provides a minimum cover of 3 feet from the existing ground surface, or from the indicated finished grade, whichever is lower, to the top of the pipe.

3.3.1.6 Cleaning

Clean inside of the pipeline casing of dirt, weld splatters, and other foreign matter which would interfere with insertion of the piped utilities by attaching a pipe cleaning plug to the boring rig and passing it through the pipe.

3.3.1.7 End Seals

After installation of piped utilities in pipeline casing, provide watertight end seals at each end of pipeline casing between pipeline casing and piping utilities. Provide watertight segmented elastomeric end seals.

3.3.2 Underground Utilities

Excavation made with power-driven equipment is not permitted within 2 feet of known utility or subsurface construction. For work immediately adjacent to or for excavations exposing a utility or other buried obstruction, excavate by hand. Start hand excavation on each side of the indicated obstruction and continue until the obstruction is uncovered or until clearance for the new grade is assured. Support uncovered lines or other existing work affected by the contract excavation until approval for backfill is granted by the Contractor/Buyer.] Report damage to utility lines or subsurface construction immediately to the Contractor/Buyer.

3.4 SUBGRADE PREPARATION

3.4.1 General Requirements

Shape subgrade to line, grade, and cross section as indicated. Remove unsatisfactory and unstable material in surfaces to receive fill or in excavated areas, and replace with structural fill. Do not place material on surfaces that are muddy, frozen, contain frost, or otherwise containing unstable material. Scarify the surface to a depth of 4 inches prior to placing fill. Step or bench sloped surfaces steeper than 1 vertical to 4 horizontal prior to scarifying. Place 4 inches of loose fill and blend with scarified material. When subgrade is part fill and part excavation or natural ground, scarify to a depth of 8 inches.

3.4.2 Subgrade Filter Fabric

Place filter fabric as indicated directly on prepared subgrade free of vegetation, stumps, rocks larger than 2 inch diameter and other debris which may puncture or otherwise damage the fabric. Repair damaged fabric by placing an additional layer of fabric to cover the damaged area a minimum of 3 feet overlap in all directions. Overlap fabric at joints a minimum of 3 feet. Obtain approval of filter fabric installation before placing fill or backfill. Place fill or backfill on fabric in the direction of overlaps and compact as specified herein. Follow manufacturer's recommended installation procedures.

3.5 FILLING AND COMPACTION

Prepare ground surface on which backfill is to be placed and provide compaction requirements for backfill materials in conformance with the applicable portions of paragraphs for SUBGRADE PREPARATION. Do not place material on surfaces that are muddy, frozen, or contain frost. Finish compaction by sheepsfoot rollers, pneumatic-tired rollers, steel-wheeled rollers, or other approved equipment well suited to the soil being compacted. Moisten material as necessary to provide the moisture content that will readily facilitate obtaining the specified compaction with the equipment used. Fill and backfill to contours, elevations, and dimensions indicated. Compact and test each lift before placing overlaying lift.

3.5.1 Trench Backfill

Backfill trenches to the grade shown. Backfill the trench to 2 feet above the top of pipe prior to performing the required pressure tests. Leave the joints and couplings uncovered during the pressure test. Do not backfill the trench until all specified tests are performed.

3.5.1.1 Replacement of Unyielding Material

Replace unyielding material removed from the bottom of the trench with satisfactory material or initial backfill material.

3.5.1.2 Replacement of Unstable Material

Replace unstable material removed from the bottom of the trench or excavation with satisfactory material placed in layers not exceeding 6 inches loose thickness.

3.5.1.3 Bedding and Initial Backfill

Provide bedding of the type and thickness shown. Place initial backfill material and compact it with approved tampers to a height of at least one foot above the utility pipe or conduit. Bring up the backfill evenly on both sides of the pipe for the full length of the pipe. Take care to ensure thorough compaction of the fill under the haunches of the pipe. Except where shown or when specified otherwise in the individual piping section, provide bedding for buried piping in accordance with PART 2 paragraph UTILITY BEDDING MATERIAL. Compact backfill to top of pipe to 85 percent of ASTM D1557. Provide plastic piping with bedding to spring line of pipe.

3.5.1.4 Final Backfill

Do not begin backfill until construction below finish grade has been approved, underground utilities systems have been inspected, tested and approved, forms removed, and the excavation cleaned of trash and debris. Bring backfill to indicated finish grade. Heavy equipment for spreading and compacting backfill are not to be operated closer to foundation or retaining walls than a distance equal to the height of backfill above the top of footing; compact remaining area in layers not more than 4 inches in compacted thickness with power-driven hand tampers suitable for the material being compacted. Place backfill carefully around pipes or tanks to avoid damage to coatings, wrappings, or tanks. Do not place backfill against foundation walls prior to 7 days after completion of the walls. As far as practicable, bring backfill up evenly on each side of the wall and sloped to drain away from the wall.

Fill the remainder of the trench, except for special materials for buildings and pavements with satisfactory material. Place backfill material and compact as follows:

3.5.1.4.1 Turfed or Seeded Areas and Miscellaneous Areas

Deposit backfill in layers of a maximum of 12 inches loose thickness, and compact it to 85 percent maximum density for cohesive soils and 90 percent maximum density for cohesionless soils. Allow water flooding or jetting methods of compaction for granular non-cohesive backfill material. Do not allow water jetting to penetrate the initial backfill. Apply this requirement to all other areas not specifically designated above.

3.5.1.5 Electrical Distribution System

Provide a minimum cover of 24 inches from the finished grade to direct burial cable and conduit or duct line, unless otherwise indicated.

3.5.1.6 Buried Tape And Detection Wire

3.5.1.6.1 Buried Warning and Identification Tape

Provide buried utility lines with utility identification tape. Bury tape

12 inches below finished grade; under pavements and slabs, bury tape 6 inches below top of subgrade.

3.5.1.6.2 Buried Detection Wire

Bury detection wire directly above non-metallic piping at a distance not to exceed 12 inches above the top of pipe. Extend the wire continuously and unbroken, from manhole to manhole. Terminate the ends of the wire inside the manholes at each end of the pipe, with a minimum of 3 feet of wire, coiled, remaining accessible in each manhole. Furnish insulated wire over its entire length. Install wires at manholes between the top of the corbel and the frame, and extend up through the chimney seal between the frame and the chimney seal.

3.5.2 Backfill for Appurtenances

After the manhole, catch basin, inlet, or similar structure has been constructed and the concrete has been allowed to cure for 7 days, place backfill in such a manner that the structure is not be damaged by the shock of falling earth. Deposit the backfill material, compact it as specified for final backfill, and bring up the backfill evenly on all sides of the structure to prevent eccentric loading and excessive stress.

3.5.3 Flowable Fill

Place fill in a manner to completely fill voids in the location indicated. Do not place when atmospheric temperatures are expected to be below 33 degrees F at any time during the 3 day period following placement.

3.5.4 Compaction

3.5.4.1 General Site

Compact underneath areas designated for vegetation and areas outside the 5 foot line of the paved area or structure to 85 percent of [ASTM D698] [ASTM D1557].

3.6 EMBANKMENTS

3.9 FINISHING/FINISH OPERATIONS

During construction, keep embankments and excavations shaped and drained. Maintain ditches and drains along subgrade to drain effectively at all times. Do not disturb the finished subgrade by traffic or other operation. Protect and maintain the finished subgrade in a satisfactory condition until ballast, subbase, base, or pavement is placed. Do not permit the storage or stockpiling of materials on finished subgrade. Do not lay subbase, base course, ballast, or pavement until the subgrade has been checked and approved, and in no case place subbase, base, surfacing, pavement, or ballast on a muddy, spongy, frozen or otherwise unstable subgrade.

Finish the surface of excavations, embankments, and subgrades to a smooth and compact surface in accordance with the lines, grades, and cross sections or elevations shown. Provide the degree of finish for graded areas within 0.1 foot of the grades and elevations indicated except as indicated for subgrades specified in paragraph SUBGRADE PREPARATION. Finish gutters and ditches in a manner that will result in effective drainage. Finish the surface of areas to be turfed to a smoothness suitable for the application of turfing materials. Repair graded, topsoiled, or backfilled areas prior to acceptance of the work, and re-established grades to the required elevations and slopes.

3.9.1 Grading

Finish grades as indicated within one-tenth of one foot. Grade areas to drain water away from structures. Maintain areas free of trash and debris. For existing grades that will remain but which were disturbed by Subcontractor's operations, grade as directed.

3.9.2 Topsoil and Seed

On areas to receive topsoil, prepare the compacted subgrade soil to a 2 inches depth for bonding of topsoil with subsoil. Spread topsoil evenly to a thickness of 2 inches and grade to the elevations and slopes shown. Do not spread topsoil when frozen or excessively wet or dry. Keep topsoil separate from other excavated materials, brush, litter, objectionable weeds, roots, stones larger than 2 inches in diameter, and other materials that would interfere with planting and maintenance operations. Remove from the site any surplus of topsoil from excavations and gradings. Obtain material required for topsoil in excess of that produced by excavation within the grading limits from Operable Unit 2 Landfills.

3.10 DISPOSITION OF SURPLUS MATERIAL

Remove from Government property all surplus or other soil material not required or not suitable for filling or backfilling, along with brush, refuse, stumps, roots, and timber. Properly disposed of in accordance with all applicable laws and regulations. Prepare plan for Disposition of Surplus Materials to include permissions document to dispose of nonsalable products.

3.11 TESTING

Perform testing as indicated in Table 1. Submit Material Test Reports within 7 days of tests being completed.

Material Type [list materials to be tested as identified in paragraph DEFINITIONS]	Location of Material	Test Method	Test Frequency
		Density - [ASTM D1556/D1556M] [ASTM D2167] [ASTM D6938] [ASTM D8167/D8167M]. [When ASTM D6938 or ASTM D8167/D8167M is used, check the calibration curves and adjust using only the sand cone method as described in ASTM D1556/D1556M.]	One test per [2000] [___] square feet, or fraction thereof, of each lift of fill or backfill areas compacted by other than hand-operated machines. Double testing frequency for areas compacted by hand-operated machines. [If ASTM D6938 or ASTM D8167/D8167M is used, check in-place densities by ASTM D1556/D1556Mn as follows: One check test per lift for every [6] [10] tests.] [Where ASTM D8167/D8167M is used, provide water Content verification in
		Relative Density - ASTM D4253 and ASTM D4254	One test per [2000] [___] square feet, or fraction thereof, of each lift of fill or backfill areas compacted by other than hand-operated machines. Double testing frequency for areas compacted by hand-operated machines.

-- End of Section --

SECTION 31 05 19.13: GEOTEXTILES FOR EARTHWORK
02/21

PART 1 GENERAL

1.1.1 Measurement

Installed geotextiles will be measured for payment in place to the nearest 10 square feet of protected area as delineated in the drawings.

1.1.2 Unit of Measure

Unit of measure: square feet.

1.2 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ASTM INTERNATIONAL (ASTM)

ASTM D123	(2015b; R 2017) Standard Terminology Relating to Textiles
ASTM D4354	(2012; R 2020) Sampling of Geosynthetics for Testing
ASTM D4355/D4355M	(2014) Deterioration of Geotextiles from Exposure to Light, Moisture and Heat in a Xenon-Arc Type Apparatus
ASTM D4491/D4491M	(2017) Standard Test Methods for Water Permeability of Geotextiles by Permittivity
ASTM D4533/D4533M	(2015) Standard Test Method for Trapezoid Tearing Strength of Geotextiles
ASTM D4632/D4632M	(2015a) Grab Breaking Load and Elongation of Geotextiles
ASTM D4751	(2020) Standard Test Method for Determining Apparent Opening Size of a Geotextile
ASTM D4873/D4873M	(2017) Standard Guide for Identification, Storage, and Handling of Geosynthetic Rolls and Samples
ASTM D4884/D4884M	(2014a) Strength of Sewn or Thermally Bonded Seams of Geotextiles
ASTM D6241	(2014) Standard Test Method for the Static Puncture Strength of Geotextiles and Geotextile-Related Products Using a 50-mm Probe

U.S. ARMY CORPS OF ENGINEERS (USACE)

EM 1110-2-1601 (1991; 1994 Change 1) Engineering and Design -- Hydraulic Design of Flood Control Channels

1.3 SUBMITTALS

Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-07 Certificates

Geotextiles

1.4 DELIVERY, STORAGE, AND HANDLING

Deliver only approved geotextile [rolls] to the project site. Label, ship, store, and handle all geotextile in accordance with ASTM D4873/D4873M. Do not use hooks, tongs, or other sharp instruments for handling geotextile.

PART 2 PRODUCTS

2.1 MATERIALS

2.1.1 General

Provide geotextile that is a [woven][non-woven] pervious sheet of plastic yarn as defined by ASTM D123 matching or exceeding the minimum average roll values listed in TABLE 1. Strength values indicated in the table are for the weaker principal direction.

TABLE 1
MINIMUM PHYSICAL REQUIREMENTS FOR DRAINAGE GEOTEXTILE

PROPERTY	UNITS	ACCEPTABLE VALUES	TEST METHOD
GRAB STRENGTH	lb	120	ASTM D4632/D4632M
SEAM STRENGTH	lb	50	ASTM D4632/D4632M
PUNCTURE	lb	50	ASTM D6241
TRAPEZOID TEAR	lb	223	ASTM D4533/D4533M
PERMEABILITY	cm/sec	1.7	ASTM D4491/D4491M
APPARENT OPENING SIZE	U.S. SIEVE	70	ASTM D4751
PERMITTIVITY	sec -1	1.7	ASTM D4491/D4491M
ULTRAVIOLET DEGRADATION	Percent strength	70 at 500 Hrs	ASTM D4355/D4355M

2.1.2 Geotextile Fiber

Use fibers consisting of a long-chain synthetic polymer composed of at least 85 percent by weight of polyolefins, polyesters, or polyamides. Add stabilizers and/or inhibitors to the base polymer, if necessary to make the filaments resistant to deterioration caused by ultraviolet light and heat exposure. Do not add reclaimed or recycled fibers or polymer to the formulation. Form geotextile into a network such that the filaments or yarns retain dimensional stability relative to each other, including the edges. Finish the edges of the geotextile to prevent the outer fiber from pulling away from the geotextile.

2.1.3 Seams

Sew the seams of the geotextile with thread of a material meeting the chemical requirements given above for geotextile yarn or bond the seams by cementing or by heat. Attach the sheets of geotextile at the factory or another approved location, if necessary, to form sections not less than 8 feet wide. Test seams in accordance with method ASTM D4884/D4884M. Seam strength less than 90 percent of the required grab tensile strength of the unaged geotextile in any principal direction is not permitted.

2.1.4 Securing Pins

Secure the geotextile to the embankment or foundation soil by pins to prevent movement prior to placement of revetment materials. Other appropriate means to prevent movement such as staples, sand bags, and stone could also be used. Insert securing pins through both strips of overlapped geotextile along the line passing through midpoints of the overlap. Remove securing pins as placement of revetment materials are placed to prevent tearing of geotextile or enlarging holes. Maximum spacing between securing pins depends on the steepness of the embankment slope. Provide maximum pins spacing equal to or less than the values listed in TABLE 2. When windy conditions prevail at the construction site, increase the number of pins upon the demand of the Contractor/Buyer. Anchor terminal ends of the geotextile with key trench or apron at crest, toe of the slope and upstream and downstream limits of installation.

TABLE 2
MAXIMUM SPACING FOR SECURING PINS

EMBANKMENT	SPACING, feet
STEEPER THAN 1V ON 3H	2
1V ON 3H TO 1V ON 4H	3
FLATTER THAN 1V ON 4H	5

2.2 INSPECTIONS, VERIFICATIONS, AND TESTING

2.2.1 Manufacturing and Sampling

Provide geotextiles and factory seams meeting the requirements specified in TABLE 1.

2.2.1.1 Conformance Testing

Perform conformance testing in accordance with the manufacturers approved quality control manual. Submit manufacturer's quality control conformance test results.

2.2.1.2 Factory Sampling

Randomly sample geotextiles in accordance with ASTM D4354 (Procedure Method A). Sample factory seams at the frequency specified in ASTM D4884/D4884M. Provide all samples from the same production lot as will be supplied for the contract, of the full manufactured width of the geotextile by at least 10 feet long, except that samples for seam strength may be a full width sample folded over and the edges stitched for a length of at least 5 feet. Identify samples submitted for testing by manufacturers lot designation.

2.2.1.3 Needle Punched Geotextile

For needle punched geotextile, provide manufacturer certification that the geotextile has been inspected using permanent on-line metal detectors and does not contain any needles.

2.2.1.4 Manufacturer Certification

All brands of geotextile and all seams to be used will be accepted on the basis of mill certificates or affidavits. Submit duplicate copies of the mill certificate or affidavit signed by a legally authorized official from the company manufacturing the geotextile. Attest that the geotextile meets the chemical, physical and manufacturing requirements stated in this specification.

2.2.2 Site Verification and Testing

Collect samples at approved locations upon delivery to the site in accordance with ASTM D4354

PART 3 EXECUTION

3.1 SURFACE PREPARATION

Prepare surface, on which the geotextile will be placed, to a relatively smooth surface condition in accordance with the applicable portion of this specification and must be free from obstruction, debris, depressions, erosion feature, or vegetation. Remove any irregularities so as to ensure continuous, intimate contact of the geotextile with all the surface. Remove loose material, soft or low density pockets of material; grade erosion features such as rills and gullies out of the surface before geotextile placement.

3.2 INSTALLATION OF THE GEOTEXTILE

3.2.1 General

Place the geotextile in the manner and at the locations shown. At the time of installation, reject the geotextile if it has defects, rips, holes, flaws, deterioration or damage incurred during manufacture, transportation or storage.

3.2.2 Placement

Place the geotextile with the long dimension parallel to the centerline of the trench and laid smooth and free of tension, stress, folds, wrinkles, or creases. Place the strips to provide a minimum width of 12 inches of overlap for each joint. Adjust the actual length of the geotextile used based on initial installation experience. Temporary pinning of the geotextile to help hold it in place until the [bedding layer] is placed will be allowed. Remove the temporary pins as the bedding is placed to relieve high tensile stress which may occur during placement of material on the geotextile. Perform trimming in such a manner that the geotextile is not damaged in any way.

3.3 PROTECTION

Protect the geotextile at all times during construction from contamination by surface runoff; remove any geotextile so contaminated and replaced with uncontaminated geotextile. Replace any geotextile damaged during its installation or during placement of [bedding materials] at no cost to the Contractor/Buyer. Schedule the work so that the covering of the geotextile with a layer of the specified material is accomplished within 7 calendar days after placement of the geotextile. Failure to comply will require replacement of geotextile.

Protect the geotextile from damage prior to and during the placement of materials. This may be accomplished by limiting the height of drop to less than 1 foot, by placing a cushioning layer of sand or gravel on top of the geotextile before placing the material, or other methods deemed necessary. Care should be taken to ensure that the utilized cushioning materials will not impede the flow of water. Before placement of materials, demonstrate that the placement technique will not cause damage to the geotextile. Do not allow equipment on the unprotected geotextile.

3.4 PLACEMENT OF CUSHIONING MATERIAL

Perform placing of cushioning material in a manner to ensure intimate contact of the geotextile with the prepared surface and with the cushioning material. Do not damage the geotextile, including tear, puncture, or abrasion, during placement. On sloping surfaces place the cushioning material from the bottom of the slopes upward. Uncover any geotextile damaged beneath the cushioning material, as necessary, and replaced at no cost to the Contractor/Buyer.

3.5 OVERLAPPING AND SEAMING

3.5.1 Overlapping

The overlap of geotextile [rolls] must be 12 inches. Appropriate measures will be taken to ensure required overlap exists after cushion placement.

3.5.2 Sewn Seams

High strength thread should be used so that seam test conforms to ASTM D4884/D4884M. Provide thread meeting the chemical, ultraviolet, and physical requirements of the geotextile, and provide color different from that of the geotextile. Provide seam strength equal to the strength required for the geotextile in the direction across the seam. Overlapping J-type seams are preferable over prayer-type seams as the overlapping geotextile reduces the chance of openings to occur at the seam. Use double sewing, especially for field seams, to provide a safety factor against undetected missed stitches.

-- End of Section --

SECTION 31 11 00: CLEARING AND GRUBBING

11/18

PART 1 GENERAL

1.1 SUBMITTALS

Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

1.2 DELIVERY, STORAGE, AND HANDLING

Deliver materials to the site, and handle in a manner which will maintain the materials in their original manufactured or fabricated condition until ready for use.

PART 2 PRODUCTS

2.1 MATERIALS

2.1.1 Tree Wound Paint

Use bituminous based paint from standard manufacture specially formulated for tree wounds.

PART 3 EXECUTION

3.1 PREPARATION

3.1.1 Protection

3.1.1.1 Roads and Walks

Keep roads and walks free of dirt and debris at all times.

3.1.1.2 Trees, Shrubs, and Existing Facilities

[Protect trees and vegetation to be left standing from damage incident to clearing, grubbing, and construction operations by the erection of barriers or by such other means as the circumstances require.]

3.1.1.3 Utility Lines

3.2 Protect existing utility lines that are indicated to remain from damage. Notify the Contractor/Buyer immediately of damage to or an encounter with an unknown existing utility line. The Subcontractor is responsible for the repair of damage to existing utility lines that are indicated or made known to the Subcontractor prior to start of clearing and grubbing operations. When utility lines which are to be removed are encountered within the area of operations, notify the Contractor/Buyer in ample time to minimize interruption of the service. CLEARING

Clearing consists of the felling, trimming, and cutting of trees into sections and the satisfactory disposal of the trees and other vegetation designated for removal, including downed timber, snags, brush, and rubbish occurring within the areas to be cleared. [Clearing also includes the removal and disposal of structures that obtrude, encroach upon, or otherwise obstruct the work.] Cut off flush with or below the original ground surface trees, stumps, roots, brush, and other vegetation in areas to be cleared, except such trees and vegetation as may be indicated or directed to be left standing. Trim dead branches 1½ inches or more in diameter on trees designated to be left standing within the cleared areas and trim all branches to the heights indicated or directed. Neatly cut close to the bole of the tree or main branches, limbs and branches to be trimmed. Paint, with an approved tree-wound paint, cuts more than 1½ inches in diameter. Apply herbicide [in accordance with the manufacturer's label] to the top surface of stumps designated not to be removed.

3.2.1 Tree Removal

Where indicated or directed, remove trees and stumps that are designated as trees from areas outside those areas designated for clearing and grubbing. This work includes the felling of such trees and the removal of their stumps and roots as specified in paragraph GRUBBING. Dispose of trees as specified in paragraph DISPOSAL OF MATERIALS.

[3.2.2 Pruning

[Prune] [Trim] trees designated to be left standing within the cleared areas of dead branches 1½ inches or more in diameter; and trim branches to heights and in a manner as indicated. Neatly cut limbs and branches to be trimmed close to the bole of the tree or main branches. Paint cuts more than 1¼ inches in diameter with an approved tree wound paint.

]3.2.3 Grubbing

Grubbing consists of the removal and disposal of stumps, roots larger than 3 inches in diameter, and matted roots from the designated grubbing areas. Remove material to be grubbed, together with logs and other organic or metallic debris not suitable for foundation purposes, to a depth of not less than 18 inches below the original surface level of the ground in areas indicated to be grubbed and in areas indicated as construction areas under this contract, such as areas for buildings, and areas to be paved. Fill depressions made by grubbing with suitable material and compact to make the surface conform with the original adjacent surface of the ground.

3.3 DISPOSAL OF MATERIALS

Dispose of excess materials in accordance with the approved solid waste management permit and include those materials in the solid waste management report.

All wood or wood like materials, except for salable timber, remaining from clearing, pruning or grubbing such as limbs, treetops, roots, stumps, logs, rotten wood, and other similar materials is the property of the Subcontractor and dispose of as specified. All non-saleable timber and wood or wood like materials remaining from timber harvesting such as limbs, treetops, roots, stumps, logs, rotten wood, and other similar materials is the property of the Subcontractor and dispose of as specified.

-- End of Section --

SECTION 33 51 39: MONITORING WELLS

08/17

PART 1 GENERAL

1.1 UNIT PRICES

Payment for each specified item is made at the contract unit price for that item. Payment includes full compensation for equipment, materials and labor for drilling; removal and disposal of temporary casing, cuttings, and drill fluid; preparation of borehole logs; and sample handling, containers, storage, and testing. Measure depth, logging, installation, casing, riser pipe, and well screen by linear distance. Payment is not allowed for test holes or wells abandoned due to construction practices not in accordance with this specification, or for the convenience of the Subcontractor. Submit catalog data for the well screen (to include the screen slot size), well casing, riser pipe, filter pack material, Bentonite, cement, centralizers, surface protective covers, well vaults, locking caps, airline oil filters for pneumatic drilling, dedicated sampling equipment, and chemical specifications on drill lubricants and tracers, if used. Include any information, written or otherwise, supplied by the manufacturers or suppliers of the above listed items.

1.1.1 Test Holes

If the total depth of the test hole is greater than that specified in the contract for "Test Holes and Samples" due to justifiable site specific conditions and other justifiable reasons, the additional depth is paid for at the contract unit price for "Additional Test Hole Depth." If the test hole is developed into the permanent monitoring well, no separate payment is made for the test hole.

1.1.2 Well Drilling and Sampling

If the total depth of the well is greater than that specified in the contract for "Monitoring Wells and Samples," the additional depth is paid for at the contract unit price for "Additional Test Hole Depth."

1.1.3 Geophysical Logging

The "Geophysical Logging" unit price includes interpretation of the logs and their delivery to the Government.

1.1.4 Well Casing and Riser Pipe Selection and Installation

Payment is made for length of blank casing actually installed in the well. Payment includes compensation for decontamination and installation of the casing, riser pipe, cap, tail piece (if any), end cap and centralizers; and for the furnishing and installing of the well identification tag with information recorded thereon, or well marking in accordance with contract.

1.1.5 Monitoring Well Screen

Payment is made for monitoring well screen actually installed in the well.

1.1.6 Filter Pack Construction

Filter pack construction is measured by the cubic foot. Payment includes compensation for furnishing, delivering, storage, decontamination, analytical testing, and installing the filter pack.

1.1.7 Bentonite Seal

The bentonite seal is measured by the cubic foot. Payment includes full compensation for hydrating, and tremieing necessary for the work.

1.1.8 Grout Placement

The cement and/or bentonite grout used in the annulus above the bentonite seal is paid by the cubic foot used. Payment includes compensation for cement, mixing of the grout, and pumping of grout, bentonite, mixing of bentonite grout, and pumping of bentonite grout, necessary for the work.

1.1.9 Monitoring Well Development

Payment for monitoring well development is made by the hour. Payment includes compensation for pumping, surging, sample photograph, discharge water containers, analysis, and disposal.

1.1.10 Monitoring Well Completion Aboveground

Payment includes compensation for protective covers, keyed-alike padlocks, locking caps, project photographs, concrete well pads, gravel, electrical components, lighting components, fencing, sign(s) and protective steel posts.

1.1.11 Monitoring Well or Test Hole Decommissioning/Abandonment

Permanent decommissioning/abandonment of monitoring wells or test holes is paid for only if it becomes necessary to abandon a well or test hole as specified, and only for work completed and accepted as specified. Payment includes compensation for drilling, casing removal, well sampling, materials, cement, mixing of cement, bentonite, and water, pumping of grout, equipment, removal of foreign objects, and transportation necessary to abandon the well or test hole and for the required well or test hole abandonment records.

1.1.12 Site Cleanup

Separate payment is not made for cleanup of the site. Cleanup means restoring the site to its pre-construction condition. Cleanup is considered part of and incidental to the drilling, construction, and/or decommissioning of the monitoring well.

1.2 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS (AASHTO)

AASHTO M 306	(2010; R 2015) Standard Specification for Drainage, Sewer, Utility, and Related Castings

AMERICAN WATER WORKS ASSOCIATION (AWWA)

AWWA 10084	(2017) Standard Methods for the Examination of Water and Wastewater

ASTM INTERNATIONAL (ASTM)

ASTM A53/A53M	(2022) Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
ASTM A312/A312M	(2022a) Standard Specification for Seamless, Welded, and Heavily Cold Worked Austenitic Stainless Steel Pipes
ASTM C117	(2017) Standard Test Method for Materials Finer than 75-um (No. 200) Sieve in Mineral Aggregates by Washing
ASTM C136/C136M	(2019) Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates
ASTM C150/C150M	(2022) Standard Specification for Portland Cement
ASTM C387/C387M	(2017) Standard Specification for Packaged, Dry, Combined Materials for Concrete and High Strength Mortar
ASTM D1452/D1452M	(2016) Standard Practice for Soil Exploration and Sampling by Auger Borings
ASTM D1586/D1586M	(2018) Standard Test Method for Standard Penetration Test (SPT) and Split-Barrel Sampling of Soils
ASTM D1587/D1587M	(2015) Thin-Walled Tube Sampling of Soils for Geotechnical Purposes
ASTM D1785	(2015; E 2018) Standard Specification for Poly(Vinyl Chloride) (PVC), Plastic Pipe, Schedules 40, 80, and 120
ASTM D2216	(2019) Standard Test Methods for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass
ASTM D2487	(2017; E 2020) Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System)
ASTM D2488	(2017; E 2018) Standard Practice for Description and Identification of Soils (Visual-Manual Procedure)
ASTM D4318	(2017; E 2018) Standard Test Methods for Liquid Limit, Plastic Limit, and

	Plasticity Index of Soils
ASTM D4397	(2016) Standard Specification for Polyethylene Sheeting for Construction, Industrial, and Agricultural Applications
ASTM D5088	(2020) Decontamination of Field Equipment Used at Nonradioactive Waste Sites
ASTM D5092	(2016) Standard Practice for Design and Installation of Ground Water Monitoring Wells in Aquifers
ASTM D5521/D5521M	(2013) Standard Guide for Development of Ground-Water Monitoring Wells in Granular Aquifers
ASTM D5608	(2016) Decontamination of Field Equipment Used at Low Level Radioactive Waste Sites
ASTM D6725/D6725M	(2016) Standard Practice for Direct Push Installation of Prepacked Screen Monitoring Wells in Unconsolidated Aquifers
ASTM F480	(2014; R 2022) Standard Specification for Thermoplastic Well Casing Pipe and Couplings Made in Standard Dimension Ratios (SDR), SCH 40 and SCH 80
ASTM F883	(2013; R 2022) Standard Performance Specification for Padlocks

FORESTRY SUPPLIERS INC. (FSUP)

FSUP 77341	(2009) Munsell (R) Soil Color Book

GEOLOGICAL SOCIETY OF AMERICA (GeoSA)

GSA RCC00100R	(2009) Geological Rock Color Chart (Munsell)

U.S. ARMY CORPS OF ENGINEERS (USACE)

EM 385-1-1	(2014) Safety – Safety and Health Requirements Manual

U.S. ENVIRONMENTAL PROTECTION AGENCY (EPA)

EPA 530/F-93/004	(1993; Rev O; Updates I, II, IIA, IIB, and III) Test Methods for Evaluating Solid Waste (Vol IA, IB, IC, and II) (SW-846)
EPA 600-4-89-034	(1990) Handbook of Suggested Practices for the Design and Installation of Groundwater Monitoring Wells
EPA 600/4-79/020	(1983) Methods for Chemical Analysis of Water and Wastes

EPA SW-846	(Third Edition; Update IV) Test Methods for Evaluating Solid Waste: Physical/Chemical Methods

U.S. NATIONAL ARCHIVES AND RECORDS ADMINISTRATION (NARA)

29 CFR 1910	Occupational Safety and Health Standards
49 CFR 172	Hazardous Materials Table, Special Provisions, Hazardous Materials Communications, Emergency Response Information, and Training Requirements

1.3 ADMINISTRATIVE REQUIREMENTS

Ensure each system, including equipment, materials, installation, and performance, is in accordance with local, State, and Federal regulations, ASTM D5092, EPA 600-4-89-034 and DoD policies and standards except as modified herein. Consider the advisory or recommended provisions to be mandatory.

1.3.1 Notification

Notify the Contractor 14 calendar days prior to drilling. The Contractor is responsible for contacting the State of California and USEPA in accordance with the applicable reporting requirements.

1.4 SUBMITTALS

Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-01 Preconstruction Submittals

QAPP (prepared by Contractor), to include Investigation-derived

Waste Management Plan; Installation Plan; Sampling and Analysis

Plan;

Well Construction Permit (obtained by Contractor);

Accident Prevention Plan (prepared by Contractor)

SD-02 Shop Drawings

Survey Maps and Notes;

Well Construction Drawings;

SD-03 Product Data

Riser Pipe;

Cement; Centralizers;

Surface Protective Covers; Well Vaults;

Oil Filters; Sampling Equipment;
Chemical Specifications on Drill Lubricants and Tracers;

Well Casing;

Well Screen;

Filter Pack;

Neat Cement Grout; Bentonite;

SD-06 Test Reports

Drilling Fluid Additive; Well Development Record; Filter Pack

Material Test Results; Sieve Analyses of Sampled Material; Water

Source Analytical Test Results

SD-07 Certificates Permits

Installation Survey Report;

Well Development Report;

Borehole Analysis Report;

Correspondence;

Photographs

SD-11 Closeout Submittals

Installation Diagram;

Well Decommissioning/Abandonment Record;

Geophysical Logs;

Borehole Logs

1.5 QUALITY CONTROL

1.5.1 Qualifications

Contractor to provide an onsite geologist with at least 3 years' experience in hazardous waste projects, soil and rock logging, and monitoring well installation. Ensure the geologist is registered in the State of CA, and responsible for all geophysical and borehole logging, drilling, well installation, developing and testing activities. Provide a driller licensed in the State of CA, according to State requirements. Perform and provide geophysical log interpretation by a qualified log analyst, demonstrating competence through background, training, and experience when so called upon. Ensure the drill crew is experienced and trained in drilling, and health and safety requirements for contaminated sites.

The Contractor shall furnish documentation proving:

a. A minimum of 3 years of monitor well installation experience

b. Appropriate health and safety personnel are on staff

c. That qualified personnel are available to perform the necessary chemical sampling as presented in the approved QAPP.

1.5.2 Required Drawings

The Contractor shall submit well construction drawings showing components and details of well casing, well screen, filter pack, annular seal, and associated items. Ensure drawings are prepared and sealed by a State certified professional geologist, hydrogeologist, or a State registered professional civil engineer, hereafter referred to as the Contractor's Professional Consultant (CPC).

1.5.3 Investigation-derived Waste Management Plan

The Contractor shall furnish a material handling plan 15 days prior to initiation of the work that describes the plan for handling the investigation-derived waste, including the following: a schedule to be employed in the well drilling and development stages, a sequence of operations, the method of drilling and development, material hauling, proposed equipment, handling of the investigation-derived waste, testing requirements for the investigation-derived waste.

1.5.4 Accident Prevention Plan (APP)

The Contractor shall provide an APP to describe safety precautions for each phase of the project as specifically related to handling of soil and water removed during well drilling and development operations. Identify appropriate requirements of 29 CFR 1910 and EM 385-1-1. Identify safety equipment and procedures available for use during the project. Furnish the name and qualifications based on education, training, and work experience of the proposed Health and Safety Officer (HASO) and the members of the drill crew. The CPC may perform the responsibilities of the HASO if properly qualified.

1.5.5 Quality Assurance Project Plan (QAPP)

The Contractor shall provide a QAPP to describe field sampling methods, quality control procedures, and identify a certified laboratory with laboratory methods to be used for contamination testing. Ensure sample reports show sample identification with location, date, time, sample method, contamination level, name of individual sampler, identification of laboratory, quality control procedures, and chain of custody information.

1.5.6 Installation Plan

The Contractor shall submit a plan, describing the drilling methods, sampling, and monitoring well construction and well development 30 calendar days prior to beginning drilling operations. Mobilization activities may start prior to submittal of the plan. Provide the plan approved and signed by a geologist as specified in the paragraph QUALIFICATIONS. Incorporate the following requirements into the Monitoring Well Installation Plan and follow in the field. Include in the plan, but do not limit to a discussion of the following:

a. Description of well drilling methods, and installation procedures, including any temporary casing used, placement of filter pack and seal materials, drill cuttings and fluids disposal, and soil/rock sample disposition.

b. Description of well construction materials, including well screen, riser pipe, centralizers, tailpiece (if used), filter pack and filter pack gradation, bentonite, drilling fluid additives (if used), drilling water, cement, and well protective measures.

c. Description of quality control procedures to be used for placement of filter pack and seals in the boring, including depth measurements.

d. Include sample of forms used for written boring logs, installation diagrams of wells, geophysical logs, well development records, well sampling data records, State well registration forms, and well abandonment records.

e. Description of contamination prevention. Describe decontamination procedures for well materials and equipment.

f. Description of well development methods to be used.

g. List of applicable publications, including State and local regulations and standards.

h. List of personnel assignments for this project, and personnel qualifications.

i. Description of in-situ permeability determination techniques if testing is required.

j. Description and discussion of geophysical techniques to be employed at the site.

1.5.7 Well Development Report

Provide a report, containing the following data: project name and location, well designation, date and time of well installation, date and time of well development, static water level from top of well casing before development and 24 hours after development, field measurements of pH, temperature, and specific conductivity, depth of well from top of casing to bottom of well, screen length, description of development methodology size/capacity of pump or bailer, pumping rate, and recharge rate.

1.5.8 Well Construction Permit

The Contractor shall submit a completed permit application and a proposed method of construction to the appropriate state agency prior to construction of the well. Well construction is not allowed to start until the Contractor/Buyer has an approved Well Construction Permit.

1.6 DELIVERY, STORAGE, AND HANDLING

Deliver materials in an undamaged condition. Unload and store with minimal handling. Store materials in on-site enclosures or under protective coverings. Store plastic piping and jointing materials, and rubber gaskets under cover, out of direct sunlight. Store materials off the ground. Keep insides of pipes and fittings free of dirt and debris. Replace defective or damaged materials with new materials.

1.7 PROJECTS/SITE CONDITIONS

Access to each monitoring well site, including any utility clearance, permits, licenses, or other requirements and the payment thereof necessary for execution of the work is the responsibility of the Contractor.

Before beginning work, the Contractor shall notify the local health department of the type and location of wells to be constructed, the method of construction and anticipated schedule for construction of the wells.

Obtaining rights-of-entry is the responsibility of the Government. Visit each proposed well location to observe any condition that may hamper transporting equipment or personnel to the site. If clearing or relocation is necessary, the Subcontractor, Contractor, and the Government will agree on a suitable clearing, or relocation plan and the location of any required access road.

PART 2 PRODUCTS

2.1 SYSTEM DESCRIPTION

The screened interval is that portion of a monitoring well which is directly open to the host aquifer by way of openings in the well screen and indirectly open to the aquifer by way of the filter pack (or other permeable material) extending continuously below and/or above the screen.

2.2 COMPONENTS

2.2.1 Well Casing

2.2.1.2 PVC Pipe

Use ASTM F480, Type 1, Grade 1, PVC 12454, NSF wc or NSF pw, Schedule 80 pipe, with flush threaded joint fittings. Wrap threaded joints with fluoropolymer tape, and provide with nitrile O-ring gaskets.

2.2.2 Well Screen

2.2.2.1 Stainless Steel Screens

Provide a well screen consisting of new commercially fabricated flush-joint threaded 10-inch nominal internal diameter Type 316 stainless steel continuous wrap, non-clogging design. Use screens conforming to ASTM A312/A312M, Type 316, Schedule 40S, with continuous slot construction, wire wound, with flush threaded joint ends. Provide schedule 40 end fittings on the continuous wrap screen. Provide a screen slot size 0.045-inch, and screen length of 40 feet. Seal the bottom section of the screen watertight by means of a flush threaded end cap of the same material as the well screen, within 6 inches of the open portion of the screen.

2.2.3 Primary Filter Pack

Provide a filter pack consisting of clean, washed, rounded to sub-rounded siliceous material free from calcareous grains or material. Organic matter, soft, friable, thin, or elongated particles are not permissible. Use a uniformity coefficient for the filter pack material not exceeding 2.5. Fill an airtight pint size [plastic] [glass] container with a sample of filter pack material and furnish to the Contractor/Buyer for each well to serve as a quality control.

2.2.3.1 Secondary Filter Pack

Ensure gradation is in accordance with ASTM D5092. Provide clean, durable, well-rounded, and washed quartz or granite. Pack cannot contain organic matter or friable materials.

2.2.4 Annular Sealants

2.2.4.1 Bentonite Seal

Provide powdered, granular, pelletized, or chipped [sodium] [calcium] montmorillonite in sealed containers from a commercial source, free of impurities. Ensure pellet size is less than one fifth the diameter of the borehole annular space to prevent bridging. Ensure bentonite base grout is in accordance with ASTM D5092.

If the bentonite seal is located above any borehole fluid levels, place a layer of fine sand at the top of the bentonite seal, to provide an additional barrier to any downward migration of grout.

2.2.4.2 Neat Cement Grout

Provide neat cement grout in accordance with ASTM D5092. Ensure cement is in accordance with ASTM C150/C150M. Quick setting admixtures are not allowed. Do not use drilling mud or cuttings as a sealing material.

2.2.4.3 Cement And Bentonite Grout

Provide cement grout with a mixture of a maximum of 7 gallons of approved water per 94 lb bag of Portland cement, conforming to ASTM C150/C150M, Type I or Type II. Add no more than 5 percent by weight of bentonite powder to reduce shrinkage and hold the cement in suspension prior to the grout set. Use sodium bentonite powder and/or granules for high-solids bentonite grout.

2.2.5 Bottom Plugs

Provide a flush threaded solid plug at the bottom of the well. Ensure plug material is the same as the well screen to which it is attached. Wrap joints with fluoropolymer tape and provide nitrile O-ring gaskets.

2.2.6 Polyethylene Sheeting

Ensure polyethylene sheeting conforms to ASTM D4397.

PART 3 EXECUTION

Notify the Contractor/Buyer at least 15 days prior to commencement of work. Well locations are as indicated. Drilling, installation, and development of the monitoring well[s] is supervised, directed, and monitored by the geologist in charge. Decontaminate equipment used for drilling, sampling, and well development before and after each use in accordance with ASTM D5088.

3.1 PREPARATION

3.1.1 Decontamination

Clean the drill rig, drill rods, drill bits, augers, temporary casing, well developing equipment, tremie pipes, grout pumping lines, and other associated equipment with high-pressure hot water/steam prior to drilling at each monitoring well location. Perform decontamination in accordance with [ASTM D5088][ASTM D5608], at a central decontamination station located in an area that is remote from, and cross- or down-gradient from the well being drilled.

Clean the screen and well casing with high-pressure hot water and detergent cleaning solution immediately prior to installation in the well. The use of factory sealed (plastic wrapped) screen and well casing does not waive this requirement for pre-installation cleaning. Decontaminate samplers in accordance with the QAPP.

3.1.2 Decontamination Station

a. Construct a temporary decontamination pad onsite, bermed and slightly inclined towards a sump located in one of the back corners of the pad. Line the pads and berms with plastic sheeting to contain decontamination water. Place exterior-grade plywood sheeting over the plastic sheeting to prevent damage to the plastic and allow the drill rig and heavy equipment to use the pad.

b. Make the minimum dimensions of the pad the length and width of the drill rig, plus 4 feet per side to allow access and steam cleaning. Use yellow ribbon to encircle the decontamination pad.

3.1.3 Containerization Of Development Water, And Drill Cuttings

Furnish D.O.T. approved [polyethylene] [steel] drums or vessels with lids, lid gaskets, bolts, chain of custody forms and drum labels. Mark each drum label in accordance with 49 CFR 172 in addition to the following information:

a. Drum number,

b. Site name,

c. Well name and number,

d. Contents and date,

e. Approximate depth of material contained in each drum, and

f. The name and phone number of the Contractor/Buyer.

3.2 INSTALLATION

Install the well in accordance with California Well Standards, and as indicated on the well construction drawings submitted by the CPC and approved by the Contractor/Buyer.

Prevent aquifer contamination by the drilling operation and equipment, intra- and inter-aquifer contamination, and vertical [or horizontal] seepage of surface water adjacent to the well into the subsurface, especially the monitoring well intake zone. Perform work in conformance with California Well Standards.

Ensure the borehole is stable and verified straight before beginning installation.

3.2.1 Drilling Method

a. Use a drilling method which prevents the collapse of formation material against the well screen and casing during installation of the well. Size the inside diameter of any temporary casing used sufficient to allow accurate placement of the screen, riser, centralizer, filter pack, seal and grout.

b. The use of drilling aids such as bentonite, other clay-based agents, or any other foreign matter capable of affecting the characteristics of the ground water is prohibited. Ensure any drilling fluid additive used is inorganic in nature. Grease or oil on drill rods, casing, or auger joints are not permitted; however, PTFE tape or vegetable oil (in solid phase form) are acceptable. Submit manufacturer's data, if available, including analytical test results of the additive, if not a part of the manufacturer's data.

c. Provide a drill rig free from leaks of fuel, hydraulic fluid, and oil which may contaminate the borehole, ground surface or drill tools. During construction of the wells, use precautions to prevent tampering with the well or entrance of foreign material. Prevent runoff from entering the well during construction. If there is an interruption in work, such as overnight shutdown or inclement weather, close the well opening with a watertight uncontaminated cover. Secure the cover in place or weighted down so that it cannot be removed except with the aid of the drilling equipment or through the use of drill tools.

Advance borehole using conventional sonic and mud rotary drilling methods. If it is the opinion of the geologist in charge that an alternate drilling method is required, submit justification for a boring method change to the Contractor/Buyer, and receive approval for the change granted prior to drilling.

3.2.2 Test Hole Requirements

Drill one test hole for every monitoring well or well cluster installed. A well cluster, as defined in this specification, is two or more wells completed (screened) to different depths in a single borehole or in a series of boreholes in close proximity (10 feet or less) to each other. The test hole may be converted to the permanent monitor well. Log test holes in accordance with paragraph BOREHOLE LOGS, and if temporary casing is used, use in accordance with paragraph DECONTAMINATION.

3.2.3 Borehole Diameter and Depth

Provide sufficient diameter in borings for monitoring well installation to allow at least 2 inches of annular space between the borehole wall and all sides of the centered riser pipe and screen. Determine depths of individual borings as specified in the approved Monitoring Well Installation Plan, with actual depth adequate to allow for the collection of representative ground water samples for chemical analysis at the time of initial sampling.

3.2.4 Screen, Well Casing And Riser Pipe Placement

Locate well screens as indicated. Ensure the length of the screen is as indicated. Distribute slotted openings uniformly around the circumference of the screen. Ensure the open areas approach the formation's natural porosity.

Ensure personnel wear clean cotton or surgical gloves while handling the assembly. Ensure well casings, screens, plugs, and caps are decontaminated prior to delivery by the manufacturer and certified clean. Deliver, store, and handle materials in such a manner as to ensure that grease, oil, or other contaminants do not contact any portion of the well screen and casing assembly prior to installation.

a. Provide the monitoring well screen in length as determined by the Contractor and approved by the Government, with specified bottom cap securely attached, set to the appropriate depth.

b. Place the bottom of the well screen no more than 3 feet above the bottom of the drilled borehole.

c. Clean the screen and well casing and riser pipe with high pressure hot water/steam just prior to installation; allowing no foreign material to remain on the screen and well casing before installation. The use of factory-sealed (plastic wrapped) screen, free from painted markings, does not waive requirements for pre-installation cleaning. Place the well screen as specified by the geologist in charge. Ensure the well casing and riser pipe extends upwards from the screen to an elevation appropriate for the surface completion described in paragraph PROTECTIVE COVER PLACEMENT. Do not allow the well screen and riser pipe to drop or fall uncontrolled into the borehole.

d. Join the screen and well casing and riser pipe sections by flush threaded watertight joints and fastenings. Solvent glue or set screws are not permitted.

e. Use centralizers to ensure that the well screen and casing assembly is installed concentrically in the borehole. Center and plumb the well by the use of stainless steel centralizers, spaced at intervals not exceeding 40 feet along the length of the casing. Do not place centralizers on the screened interval or within the bentonite seal. Verify the alignment of the well by passing a 5 foot long section of rigid pipe ¼ inch smaller in diameter than the inside diameter of the casing through the entire well. If the pipe does not pass freely, the well is not accepted. Thoroughly clean the pipe section with high pressure hot water prior to each test. Use temporary casing, hollow stem augers or other measures, as necessary, to prevent collapse of the boring against the well screen and well casing and riser pipe prior to placement of the filter pack and sealing materials. Install a cap on the top of the riser pipe, either vented, or a telescopic fit, constructed to preclude binding to the well casing caused by tightness of fit, unclean surfaces, or weather conditions. Make cap secure enough to preclude the introduction of foreign material into the well, yet allow pressure equalization between the well and the atmosphere.

When the assembly has been installed at the appropriate elevation, adequately secure the assembly to preclude movement during placement of the filter packs and annular seals. Cap the top of the well casing during filter pack placement.

3.2.5 Filter Pack Placement

Protect filter pack material from contamination prior to placement by either storing it in plastic lined bags, or in a location protected from the weather and contamination on plastic sheeting. Transport filter pack material to the well site in a manner which prevents contamination by other soils, oils, grease, and other chemicals.

Prior to commencement of work, receive approval from the Contractor/Buyer for equipment and methods required to place filters. Place primary and secondary filter packs as indicated on the approved well construction drawings to fill the entire annular space between the screen and casing assembly and the outside wall of the borehole. Place both the primary and secondary filters with a tremie pipe in accordance with EPA 600-4-89-034 and ASTM D5092. Placement of the primary and secondary filters by gravity or free fall methods is not allowed. Control speed of filter placement to prevent bridging and to allow for settlement. Take frequent measurements inside the annulus during tremie pipe retraction to ensure that the filter pack is properly placed.

Dumping filter pack material from the surface of the ground and agitating the well in an effort to settle the filter material is not allowed. Install the filter pack continuously and without interruption until the filter pack has been placed to a minimum of 5 feet above the top of the screen in the monitoring well. Directly measure the depth to the top of the filter pack and record. Obtain any additional water required to be added to the filter pack material in accordance with paragraph WATER SOURCE.

3.2.6 Bentonite Seal

3.2.6.1 Bentonite Pellets

Pouring of pellets is acceptable in shallow boreholes less than 40 feet. To provide accurate measurement of bentonite pellet thickness in the well boring, tamp the pellet seal during measurement. If not placed in lifts, allow the seal a minimum hydration time of three hours, unless the manufacturer recommends a longer hydration time.

3.2.6.2 Bentonite Chips

Adequate annular space is required in the use of bentonite chips to reduce the risk of bridging. Chips are preferable to use over pellets when installing a seal in a deep water column. To provide accurate measurement of bentonite chip seal thickness in the well boring, tamp the seal during measurement. If not placed in lifts, allow the seal a minimum hydration time double the hydration time for pellets.

3.2.6.3 Bentonite Slurry

A bentonite slurry seal can be used when the seal location is too deep for the use of pellets or chips, or within a narrow borehole annulus. The slurry is made from granular or powder sodium bentonite. The specific gravity of cement grout placed atop a slurry seal will be greater than the bentonite slurry. Exercise care to preclude the grout from migrating downward into the slurry.

Mix water from an approved source with granular or powder bentonite to form a thick bentonite slurry, consisting of a mixture of bentonite and the manufacturer's recommended volume of water to achieve an optimal seal. A typical slurry mix contains at least 20 percent solids by weight and has a density of 9.4 lb per gallon of water or greater.

3.2.6.4 Bentonite Seal Thickness And Replacement

Place a minimum 5 foot thick hydrated bentonite seal on top of the filter pack. Control speed of bentonite placement to prevent bridging of pellets or chips, or segregation of slurry. Place bentonite chips and pellets in lifts of 6 inches to 1 foot with each lift allowed to hydrate for a minimum of 30 minutes prior to placing the next lift. If not placed in lifts, the minimum hydration time for pellets is 3 hours, unless manufacturer recommendations for hydration are longer. The hydration time for chips can require twice the time required for pellets. Directly measure the depth to the top of the bentonite seal and record immediately after placement, without allowance for swelling. Add water to the annular space as directed by the geologist in charge to ensure complete hydration of the bentonite. If the bentonite seal is located above any borehole fluid levels, place a 1 foot layer of fine sand at the top of the bentonite seal.

3.2.7 Grout Placement

Mechanically mix a cement bentonite grout, and place in one continuous operation into the annulus above the bentonite seal to within 5 feet of the ground surface. Make grout injection in accordance with ASTM D5092.

Place cement grout in the annular space above the bentonite seal as indicated on the well construction drawings. Place the cement grout as a slurry through a tremie pipe, and inject from the bottom up. For deep wells, inject grout in lifts to ensure that the casing is not damaged. Cure grout a minimum of 48 hours before beginning well development operations.

Add additional grout from the surface to maintain the level of the grout at the land surface as settlement occurs. Work is not permitted in the well within 48 hours after cement grouting.

Thoroughly clean the tremie pipe with high pressure hot water/steam before use in each well.

3.3 FIELD QUALITY CONTROL

3.3.1 Temporary Containment of Soil Removed from the Borehole

Stockpile soil in roll-off bins suitable for transporting contaminated soils as specified herein.

3.3.2 Well Alignment

For wells deeper than 200 feet, verify that the well is plumb.

3.3.3 Sampling

Obtain soil samples in accordance the QAPP.

Record boring information in accordance with ASTM D2487 and ASTM D2488. Indicate groundwater elevation in the log.

3.3.4 Sampling for Chemical Analysis

Include sampling requirements for obtaining and preserving samples for chemical analysis in the QAPP.

3.3.6 In-Situ Permeability Determination

Determine the in-situ permeability for each well following development but no sooner than 48 hours after development. After the well is developed and allowed to equilibrate for at least 24 hours, and before in-situ permeability testing, measure and record the static water level in the well. Determine, for each well installed, the in-situ permeability of the screened formation using an appropriate method after the well has been developed. State proposed details of the methods expected to be used and references for those methods in the Well Installation Plan. Except for formation water from the well, do not introduce any other water or liquid into the well.

3.3.7 Well Development

Within 7 days of completion of each well, but no sooner than 48 hours after cement grouting is completed, develop the well. Perform development using only mechanical surging or over pumping or a combination thereof in accordance with ASTM D5521/D5521M. Include details of the proposed development method in the Well Installation Plan. Maintain a well development record in accordance with paragraph WELL DEVELOPMENT RECORDS. Development is complete when:

a. Well water is clear to the unaided eye,

b. Sediment thickness in the well is less than 1 percent of the screen length,

c. A minimum of ten times the standing water volume in the well plus three times the volume of all added water and drilling fluid lost during drilling and installation of the well is removed, and

d. Stabilization has occurred for the following parameters: temperature, specific conductivity, pH, and turbidity readings, measured before, at least ten times during, and after development operations. Stabilization means variation of less than 0.2 pH units, variation of plus or minus 1 degree Celsius, plus or minus 10 percent change in specific conductance, and turbidity less than 5 Nephelometric Turbidity Unit (NTU), measured between three consecutive readings with one casing volume of water removed between each reading]. Conduct temperature, specific conductance, turbidity, and pH readings in accordance with EPA 600/4-79/020. At completion of well development, collect approximately 1 pint of well water in a clear glass jar. Label the jar with project name, well number and date; and digitally photograph. Suitably backlight the subject in the photograph close-up to show the clarity of the water and any suspended sediment. The photograph is a part of the well development record. Contain water removed during development and testing operations in D.O.T. approved drums, containers or vessels and dispose of by treatment at the

Operable Unit 2 Groundwater Treatment Plant or the Sites 2 and 12 Groundwater Treatment Plant, in accordance with paragraph CONTAINERIZATION OF DEVELOPMENT WATER, AND DRILL CUTTINGS, and DRILLING WASTE DISPOSAL.

3.3.7.1 Well Development Records

Prepare and submit a monitoring well development record for each monitoring well installed under the supervision of the geologist present during well installation operations, within 45 working days of the completion of development. Include the following information on the well development record, but do not limit to the following:

a. Date, time, and elevation of water level in the well before development.

b. Depth to bottom of well, name of project and site, well identification number, and date of development.

c. Method used for development, to include size, type and make of equipment, bailer, and/or pump used during development.

d. Time spent developing the well by each method, to include typical pumping rate, if pump is used in development.

e. Volume and physical character of water removed, to include changes during development in clarity, color, particulates, and odor.

f. Volume of water added to the well, if any.

g. Source of any water added to the well.

h. Volume and physical character of sediment removed, to include changes during development in color, and odor.

i. Clarity of water before, during, and after development. NTU measurements.

j. Total depth of well from top of the casing and the static water level, immediately after pumping/development, and 24 consecutive hours after development.

k. Readings of pH, specific conductance, and temperature taken before, during, and after development.

l. Name and job title of individual developing well.

m. Name and/or description of the disposal facility, for the waters removed during development.

3.3.8 Surveys

Establish coordinates and elevations for each monitoring well/test hole. Determine horizontal coordinates to the closest 1.0 foot and referenced to the State Plane Coordinate System, or Universal Transverse Mercator (UTM). If the State Plane Coordinate System/UTM is not readily available, use an existing local grid system. Obtain a ground elevation to the closest 0.1 foot at each well. The highest point on the top of the riser pipe serves as a measurement point; reference this elevation and survey to the nearest 0.01 foot using the National Geodetic Vertical Datum of 1929. If the datum is not readily available, use the existing local vertical datum. Plot the location, identification, coordinates, and elevations of the well and monuments on maps by a registered land surveyor licensed in the State of CA, with a scale large enough to show their location with reference to other structures. Submit this data with a well location map as the Installation Survey Report.

3.3.8.1 Survey Maps and Notes

Prepare and submit a tabulated list of all monitoring wells and monuments, copies of all field books, maps showing the locations, and elevations of all monitoring wells, and all computation sheets, consisting of the designated number of the well or monument, the X and Y coordinates, and all the required elevations within 45 working days after completion of the survey.

3.3.9 Project Photographs

Submit digital photographs taken before, during, and after completion of the work, of each well installation site. Also take photographs of any rock that is cored at the site; take a minimum of one view of each well installation. Document the following information:

Project No. Contract No. Contractor/Photographer:

Photograph No. Date/Time:

Description:

Direction of View:

3.4 ADJUSTING AND CLEANING

3.4.1 Site Cleanup

After completion of the work, remove tools, appliances, surplus materials, temporary drainage, rubbish, and debris incidental to work. Backfill excavation and vehicular ruts and dress to conform with the existing landscape or terrain. Repair or replace utilities, structures, roads, fences, or any other pre-existing item damaged due to negligence. Accomplish repair or replacement prior to completion of this contract.

3.4.2 Water From Well Development Operations

Water generated during well installation will be containerized and treated at the Operable Unit 2 Groundwater Treatment Plant or the Site 2 and 12 Groundwater Treatment Plant.

]3.4.3 Drilling Waste Disposal

Dispose of slurry, drill cuttings, rock core; other solid or liquid material bailed, pumped, or otherwise removed from the borehole during drilling, installation, completion, and well development procedures; and fluids from material/equipment decontamination activities per the QAPP.

3.4.4 Transportation Of Contaminated Soil And Water

Comply with Federal, State, and local requirements for transporting contaminated materials through the applicable jurisdictions and bear responsibility and cost for any noncompliance. In addition to those requirements, do the following:

a. Inspect and document vehicles and containers for proper operation and covering.

b. Inspect vehicles and containers for proper markings, and other requirements for waste shipment.

c. Perform and document decontamination procedures prior to leaving the worksite and again before leaving the disposal site.

3.4.5 Disposal of Contaminated Soil And Water

Dispose contaminated materials removed from the site in accordance with the QAPP.

3.5 CLOSEOUT ACTIVITIES

3.5.1 Well Acceptance

Properly construct, install, develop, and test all wells according to the requirements of this specification so that they are suitable for the intended purpose. If installed wells are not functional or not in accordance with these specifications, the Contractor/Buyer will disapprove the well and direct repair or replacement, and instruct abandonment of the disapproved well.

3.5.2 Documentation Reports

Submit reports for well construction and development. Establish and maintain documentation reports for well construction and development to record the desired information and to assure compliance with contract requirements, including, but not limited to: borehole logs, well construction diagrams, well development record, and analytical results for well and investigation-derived waste samples.

3.5.2.1 Borehole Logs

Submit original borehole logs, within 45 working days after completion of the boring and well installation procedures. Prepare and complete a borehole log for each boring drilled, prepared by the geologist present onsite during all well drilling and installation activities. Keep copies current and complete all well logs in the field at each well site and make available at all times for inspection by the Government. Include, as a minimum, the following:

a. Name of the project and site.

b. Boring/well identification number.

c. Location of boring (coordinates, if available).

d. Make and manufacturer's model designation of drilling equipment and name of drilling firm.

e. Date boring was drilled.

f. Reference data for all depth measurements.

g. Name of driller and name and signature of geologist preparing log.

h. Nominal hole diameter and depth at which hole diameter changes.

i. Total depth of boring.

j. Method of drilling, including information such as rod size, bit type, pump type, etc. Also include a description of any temporary casing used, drill fluids and fluid additives used, if any, including brand name and amount used, along with the reason for and start (by depth) of its use, and, if measured, mud viscosities and weight.

k. Depth of each change of stratum. If location of strata change is approximate, so state in the report.

l. Description of the material of which each stratum is composed, in accordance with ASTM D2488 and/or standard rock nomenclature, as necessary. Include in soil parameters for logging, but do not limit to: classification, depositional environment and formation, if known, Unified Soil Classification Symbol, secondary components and estimated percentages, color (using FSUP 77341 or GSA RCC00100R), plasticity, consistency (cohesive soil), density (non-cohesive soil), moisture content, structure and orientation, and grain angularity.

m. Note and record the results of visual observation of the material encountered, and any unusual odor detected.

n. Depth of any observed fractures, with strike and dip, weathered zones, or any abnormalities encountered.

o. Depth and estimated percent of drill fluid loss or lost circulation. Measures taken to regain drill water circulation. Significant color changes in the drilling fluid return.

3.5.2.2 Installation Diagrams

Submit as-built installation diagram for each monitoring well installed within 45 working days of the completion of the installation, prepared by the geologist present during well installation operations. The well will not be accepted by the Government before the geologic logs and installation diagrams are received. Clearly illustrate in the diagram the as-built condition of the well and include, but do not limit to the following items:

a. Name of the project and site.

b. Well identification number.

c. Name of driller and name and signature of the geologist preparing diagram.

d. Date of well installation.

e. Description of material from which the well is constructed, including well casing and riser pipe and screen material, centralizer composition, if used, diameter and schedule of casing and screen, gradation of filter pack, lithologic description, brand name (if any), source, and processing method, and method of placement of the filter pack, bentonite seal type (pellets, granules, chips, or slurry), grout type (cement or high-solids bentonite) and type of protective cover (protective casing or flush-to-ground).

f. Total depth of well.

g. Nominal hole diameter.

h. Depth to top and bottom of screen, and filter pack.

i. Depth to top and bottom of any seals installed in the well boring (grout or bentonite).

j. Type of cement and/or bentonite used, mix ratios of grout, method of placement and quantities used.

k. Elevations/depths/heights of key features of the well, such as top of well casing and riser pipe, top and bottom of protective casing, ground surface, the depth of maximum frost penetration (frost line), bottom of well screen, top and bottom of filter pack, and top and bottom of seal.

l. Other pertinent construction details, such as slot size and percent open area of screen, type of screen, and manufacturer of screen.

m. Well location by coordinates. Include a plan sheet showing the coordinate system used and the location of each well. A plan sheet is not required for each well installation diagram; multiple wells may be shown on the same sheet.

n. Static water level upon completion of the well.

o. Special problems and their resolutions; e.g., grout in wells, lost casing, or screens, bridging, etc.

p. Description of surface completion.

-- End of Section --

SECTION 40 60 00: PROCESS CONTROL
05/20

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI C12.1	(2014; Errata 2016) Electric Meters - Code for Electricity Metering
ANSI INCITS 154	(1988; R 2004) Office Machines and Supplies - Alphanumeric Machines - Keyboard Arrangement

AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)

ASME B31.8	(2022; Supplement 2022) Gas Transmission and Distribution Piping Systems
ASME BPVC SEC VIII	(2010) Boiler and Pressure Vessel Codes: Section VIII Rules for Construction of Pressure Vessel

AMERICAN WATER WORKS ASSOCIATION (AWWA)

AWWA C606	(2022) Grooved and Shouldered Joints ASTM

INTERNATIONAL (ASTM)

ASTM B88	(2022) Standard Specification for Seamless Copper Water Tube
ASTM D635	(2018) Standard Test Method for Rate of Burning and/or Extent and Time of Burning of Plastics in a Horizontal Position
ASTM D638	(2014) Standard Test Method for Tensile Properties of Plastics
ASTM D792	(2013) Density and Specific Gravity (Relative Density) of Plastics by Displacement
ASTM D1238	(2013) Melt Flow Rates of Thermoplastics by Extrusion Plastometer
ASTM D1693	(2015) Standard Test Method for Environmental Stress-Cracking of Ethylene Plastics
ASTM D2000	(2018) Standard Classification System for Rubber Products in Automotive Applications INSTITUTE OF ELECTRICAL AND ELECTRONICS

ENGINEERS (IEEE)

IEEE 142	(2007; Errata 2014) Recommended Practice for Grounding of Industrial and Commercial Power Systems - IEEE Green Book
IEEE C37.90.1	(2013) Standard for Surge Withstand Capability (SWC) Tests for Relays and Relay Systems Associated with Electric Power Apparatus
IEEE C62.41.1	(2002; R 2008) Guide on the Surges Environment in Low-Voltage (1000 V and Less) AC Power Circuits
IEEE C62.41.2	(2002) Recommended Practice on Characterization of Surges in Low-Voltage (1000 V and Less) AC Power Circuits

INTERNATIONAL ELECTROTECHNICAL COMMISSION (IEC)

IEC 60584-1	(2013) Thermocouples - Part 1: EMF Specifications and Tolerances
IEC 61131-3	(2013) Programmable Controllers - Part 3: Programming Languages

INTERNATIONAL SOCIETY OF AUTOMATION (ISA)

ISA 7.0.01	(1996) Quality Standard for Instrument Air
ISA 92.00.01	(2010; R 2015) Performance Requirements for Toxic Gas Detectors
ISA 101.01	(2015) Human Machine Interfaces for Process Automation Systems

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA 250	(2020) Enclosures for Electrical Equipment (1000 Volts Maximum)
NEMA ICS 1	(2022) Standard for Industrial Control and Systems: General Requirements
NEMA ICS 2	(2000; R 2020) Industrial Control and Systems Controllers, Contactors, and Overload Relays Rated 600 V
NEMA ICS 3	(2005; R 2010) Medium-Voltage Controllers Rated 2001 to 7200 V AC
NEMA ICS 4	(2015) Application Guideline for Terminal Blocks
NEMA ICS 5	(2017) Industrial Control and Systems: Control Circuit and Pilot Devices

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2023) National Electrical Code
NFPA 79	(2015) Electrical Standard for Industrial Machinery

NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY (NIST)

NIST SP 250	(1991) Calibration Services Users Guide

U.S. NATIONAL ARCHIVES AND RECORDS ADMINISTRATION (NARA)

40 CFR 60	Standards of Performance for New Stationary Sources
47 CFR 15	Radio Frequency Devices UNDERWRITERS

LABORATORIES (UL)

UL 94	(2023; Reprint May 2023) UL Standard for Safety Tests for Flammability of Plastic Materials for Parts in Devices and Appliances
UL 508A	(2018; Reprint Jul 2022) UL Standard for Safety Industrial Control Panels
UL 1059	(2019; Reprint Jul 2022) UL Standard for Safety Terminal Blocks

1.2 SUBMITTALS

Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Contractor Design Drawings; Draft As-Built Drawings;

SD-03 Product Data Control Drawings Sensors and Meters

Performance Verification Test (PVT) Factory Test Procedure

SD-06 Test Reports Factory Test Report

Testing, Adjusting and Commissioning Performance Verification

Test(PVT) Endurance Test

SD-07 Certificates

Control and Sensor Wiring Ground Rods

Wiring Installation

SD-10 Operation and Maintenance Data Training Manual; Control System;

SD-11 Closeout Submittals Final As-Built Drawings;

1.3 SITE ENVIRONMENTAL CONDITIONS

The expected site environmental conditions are a minimum of [54] degrees F and a maximum of [67] degrees F.

1.4 SEQUENCING

TABLE I: PROJECT SEQUENCING specifies the sequencing of submittals as specified in paragraph SUBMITTALS (denoted by an 'S' in the 'TYPE' column) and activities as specified in PART 3 EXECUTION (denoted by an 'E' in the 'TYPE' column).

1.5.1 Sequencing for Submittals

The sequencing specified for submittals is the deadline by which the submittal must be initially submitted to the Contractor/Buyer. Following submission there will be a Contractor/Buyer review period as specified in Section 01 33 00 SUBMITTAL PROCEDURES. If the submittal is not accepted by the Contractor/Buyer, revise the submittal and resubmit it to the Government within 14 calendar days of notification that the submittal has been rejected. Upon re-submittal there will be an additional Contractor/Buyer review period. If the submittal is not accepted the process repeats until the submittal is accepted by the Contractor/Buyer.

1.5.2 Sequencing for Activities

The sequencing specified for activities indicates the earliest the activity may begin.

1.5.3 Abbreviations

In TABLE I the abbreviation AAO is used for 'after approval of' and 'ACO' is used for 'after completion of'.

PART 2 PRODUCTS

2.1 SYSTEM DESCRIPTION

The process control system must be used to monitor and control the operation of process equipment as specified and in accordance with the sequence of operation and control schematics shown on the drawings. The process control system must provide for operator interaction, overall process control system supervision, and process equipment control and monitoring. Provide hardware configured and sized to support expansion as specified and shown on the drawings.

The process control system must be complete including sensors, field preamplifiers, signal conditioners, offset and span adjustments, amplifiers, transducers, transmitters, control devices, engineering units conversions and algorithms for the applications; and must maintain the specified end-to-end process control loop accuracy from the sensor to display and final control element. Connecting conductors must be suitable for installed controls. Enclosers must be rated for NEMA 4.

2.1.1 Operation

The process control system provided under this specification must operate using a combination of sequential function charts, function block diagrams, structured text, instruction, and ladder logic type as defined in IEC 61131-3 and supervisory control to provide the required sequences of operation. Input data to the controller must be obtained by using instruments and controls interfaced to mechanical, electrical, utility systems and other systems as shown and specified. All required setpoints, settings, alarm limits, and sequences of operation must be as identified [in the database/ settings tables] [and] [or] [sequences of operation indicated].

2.1.2 Points

Provide inputs to and outputs from the process control system in accordance with the Input/Output (I/O) Summary Table indicated. Each connected analog output (AO), analog input (AI), binary output (BO), binary input (BI), pulse accumulator (PA) input and other input or output device connected to the control system must represent a "point" where referred to in this specification.

2.1.3 System Reliability

The system must be designed for maximum reliability, safety and integrity while maintaining an availability of [99.99%] or better.

2.2 MATERIALS AND EQUIPMENT

2.2.1 Product Certifications

Computing devices, as defined in FCC Part 15, supplied as part of the process control system must be certified to comply with the requirements of Class B computing devices.

2.2.2 Standard Products

Materials and equipment must be standard unmodified products of a manufacturer regularly engaged in the manufacturing of such products. Units of the same type of equipment must be products of a single manufacturer. Items of the same type and purpose must be identical and supplied by the same manufacturer, unless replaced by a new version approved by the Contractor/Buyer.

2.2.3 Nameplates

Each major component of equipment must have the manufacturer's name and address, and the model and serial number in a conspicuous place. Laminated plastic nameplates must be provided for equipment devices and panels furnished. Each nameplate must identify the device, such as pump "P-1" or valve "VLV-402". Labels must be coordinated with the schedules and the process and instrumentation drawings. Laminated plastic must be 1/8 inch thick, white with black center core. Nameplates must be a minimum of 1 by 3 inches with minimum ¼ inch high engraved block lettering. Nameplates for devices smaller than 1 by 3 inches must be attached by a nonferrous metal chain. All other nameplates must be attached to the device.

2.3 GENERAL REQUIREMENTS

Equipment located outdoors, not provided with climate controlled enclosure, must be capable of operating in the ambient temperature range. Equipment and wiring must be in accordance with NFPA 70, with proper consideration given to environmental conditions such as moisture, dirt, corrosive agents, and hazardous area classification.

2.4 SENSORS

2.4.1 Transmitter

Unless indicated otherwise, each sensor must be provided with a transmitter, selected to match the sensor. Except where specifically indicated otherwise on the drawings, the transmitter must be provided with a four digit or analog visual display of the measured parameter and with a [4 to 20 mAdc] [binary] [0-10 vdc] [________________] output signal proportional to the level of the measured parameter. Accuracy must be plus or minus [0.5] [1] [2] [5] [_____] percent of full scale reading with output error not exceeding plus or minus [0.25] [0.5] [_____] percent of [the calibrated measurement] [full scale]. Transmitter must be located where indicated, mounted integrally with the sensor, pipe mounted, wall mounted or installed in the control panel. The distance between the sensor and transmitter must not exceed the manufacturer's recommendation. Field preamplifiers and signal conditioners must be included when necessary to maintain the accuracy from sensor to the programmable logic controller or recorder.

2.4.2 Flow Rate Sensors and Meters

Liquid flow indication must be provided in [gpm]. Pressure taps must incorporate appropriate snubbers. Unless indicated otherwise, the flow transmitter must produce a signal that is proportional to the volumetric flow rate, compensated for fluid temperature, and must have an accuracy of plus or minus [1] [3] [_________________] percent of [full flow] [the actual flow]. Flow transmitter must be located within [15 feet] of the flow element. The flow transmitter must include a [digital] [______] readout of the volumetric flow rate to [3] [_____] significant figures. [The controller must be provided with a minimum of three alarm lights. The first alarm light must indicate when the lower (warning) detection level has been exceeded. The second alarm light must indicate when the upper (alarm) detection level has been exceeded. The third alarm light must indicate a controller malfunction, including loss of power or loss of sensor input.] [The controller must be provided with a minimum of three sets of dry contacts rated in accordance with NEMA ICS 1. The first set of contacts must close when the lower (warning) detection level has been exceeded. The second set of contacts must close when the upper (alarm) detection level has been exceeded. The third set of contacts must close when a controller malfunction has occurred, including loss of power or loss of sensor input.] The alarm levels must be individually adjustable. The controller must be provided with an audible warning horn that sounds when the upper detection level has been exceeded, and a warning horn silence button. The controller must provide a [4-20 mAdc] [________] output signal to the programmable logic controller, proportional to the measured parameter. The controller must be provided with an internal battery to maintain operation for a minimum of 12 hours if power is lost. Flow rate must be controlled to within plus or minus [5] [_________] percent of the design
flow.

2.4.2.1 Magnetic Flowmeter

Magnetic flowmeter must be [non-intrusive,] DC pulse type and must measure fluid flow through the use of a self-generated magnetic field. The meter must have automatic zeroing circuitry. The magnetic flow element must be encapsulated in [type 300 stainless steel] [or] [anodized aluminum]. Flowmeter must be capable of measuring up to a maximum flow velocity of [10] [____] fps. The metering tube must be constructed of [316 stainless steel] [anodized aluminum] [_____]. The meter must be rated for a process temperature range of [32 to 212 F] and [0 to 149F] ambient. The maximum pressure drop across the meter and appurtenances must be 5 psi at the maximum flow rate.

2.4.2.2 Leak Detection

Double walled containment system leak detectors must use electrodes mounted in the interstices of double walled containment systems with a minimum time delay of [0.5] [_____] seconds.

2.4.3 Pressure Instrumentation

Pressure taps must incorporate appropriate snubbers.

2.4.3.1 Pressure Switch

Sensors must be [diaphragm] [Bourdon tube] [solid state] and must be constructed of [brass] [316 stainless steel] [_____]. Pressure switch must have a repetitive accuracy of plus or minus [5.0] [____________] percent of the operating range and must withstand up to [150] [__] percent of rated pressure.

Switch actuation set point must be adjustable over the operating pressure range with a differential adjustment span of [20] [_____] to [40] [_____] percent of the range of the switch. The switch must have Form C snap-action contacts rated in accordance with NEMA ICS 1.

2.5 PROGRAMMABLE LOGIC CONTROLLER (PLC)

2.5.1 PLC General Requirements

PLCs must be micro-processor based, capable of receiving binary and analog inputs and, through programming, must be able to control binary and analog output functions, perform data handling operations and communicate with external devices. PLCs must meet the requirements of Class A computing devices, and must be labeled as set forth in 47 CFR 15 and must be able to withstand conducted susceptibility test as outlined in NEMA ICS 1, NEMA ICS 2, NEMA ICS 3, [and] [or] IEEE C37.90.1. PLCs must function properly at temperatures between 32 and 122 degrees F at 5 to 95 percent relative humidity non-condensing and must tolerate storage temperatures between minus 40 and plus 140 degrees F at 5 to 95 percent relative humidity non-condensing.

2.5.2 Modular PLC

PLCs must be based on a modular, field expandable design allowing the system to be tailored to the process control application. The system must be expandable through the use of additional hardware and/or user software. As a minimum, the PLC must include a mounting backplane, power supply module, central processing unit (CPU) module, communications module, and input/output (I/O) module. The modules must be grouped together in a mounting rack or cabinet. The mounting rack backplane must provide the communications mechanism to fully integrate the individual modules located within the rack. Modules other than I/O modules must plug directly into the backplane. The use of wire connectors between modules will not be allowed except for expansion of the system to include multiple backplanes. The rack size must be as needed to hold the equipment necessary while performing the required control functions. [The system configuration must allow for the removal and/or installation of modules under power.]

2.5.2.1 Central Processing Unit (CPU) Module

The CPU module must be a self-contained, microprocessor based unit that provides time of day, scanning, application program execution, storage of application programs, storage of numerical values related to the application process and logic, I/O bus traffic control, peripheral and external device communications and self-diagnostics. The scan time must be [250 milliseconds] or better including spare I/O channels.

2.5.2.2 Communications Module

The communications module must allow peer-to-peer communication with other PLCs and must allow the PLC to communicate with the central station, or workstation. The communication module must utilize the manufacturer's standard communication architecture and protocol, ethernet architecture and protocol or a combination of these. The communication module must allow programming of the PLC to be done locally through the use of a laptop computer[or from the central station or remote workstation].

2.5.2.3 Power Supply Module

One or more power supply modules must be provided as necessary to power other modules installed in the same cabinet. Power supply modules must plug directly into the backplane. Auxiliary power supplies may be used to supply power to remote cabinets or modules.

a. Power supply modules must use [AC] [DC] power with a nominal voltage of [120 VAC] [220 VAC] [24 VDC] [48 VDC] [125VDC] plus or minus 5 percent. The power supply module must monitor the incoming line voltage level and must provide over current and over voltage protection. If the voltage level is detected as being out of range the power supply module must continue to provide power for an adequate amount of time to allow for a safe and orderly shutdown. Power supply modules must be capable of withstanding a power loss for a minimum of 20 milliseconds while still remaining in operation and providing adequate power to all connected modules.

b. Each power supply module must be provided with an on-off switch integral to the module. If the manufacturer's standard power supply module is not provided with an on-off switch, a miniature toggle type switch must be installed near the PLC and must be clearly labeled as to its function..

c. Provide power supply modules with an indicating light which must be lit when the module is operating properly.

2.5.2.4 Input/Output (I/O) Modules

Modules must be self-contained, microprocessor based units that provide an interface to field devices.[The modules must be located in the same cabinet as the other PLC components.] Each module must contain visual indication to display the on-off status of individual inputs or outputs. Each I/O must be protected against reversal of polarity of the signal. Analog inputs and analog outputs must have 'open, short and out of range circuit' detection. It must be configurable per channel.

2.5.3 Loop PLC

PLCs must be single or multiple loop controllers depending on the process control system requirements. Controllers must be self-contained and must include a central processing unit (CPU), program memory, power supply, input/output capability, [network communications capability] and display/keyboard. The controller must have a scalable process variable for each loop. Controller must have proportional, integral and derivative (PID) control logic. Analog outputs must be configured as direct acting or reverse acting. The controller must have keyboard, display, auto/manual selection for control of each loop output, remote setpoint, adjustment/local setpoint adjustment selection with adjustable high-end and low-end limits, ratio and bias adjustment on remote setpoint input, [operator-initiated self-tune/manual-tune selection] [and anti-reset wind-up feature]. Controller must power analog output loops to 20 mAdc when connected to a load of 600 ohms.

2.5.3.1 Central Processing Unit (CPU)

The central processing unit must be microprocessor based and must provide time of day, scanning, application program (ladder rung logic) execution, storage of application programs, storage of numerical values related to the applications process and logic, I/O bus traffic control, peripheral and external device communications and self-diagnostics.

2.5.3.2 Power Requirements

Each controller must be powered by [AC] [DC] power with a nominal voltage of [120 VAC] [220 VAC] [24 VDC] [48 VDC] [125VDC]. Power consumption must not exceed 25 watts. Controller must provide electrical noise isolation between the AC power line and the process variable inputs, remote setpoint inputs and output signals of not less than 100 dB at 60 Hertz common mode rejection ration and not less than 60 dB at 60 hertz normal-mode rejection ration.

2.5.3.3 On-Off Switch

Each controller must be provided with an integral on-off switch. If the controller is not provided with a manufacturers standard on-off switch, a miniature toggle type switch must be installed near the controller and must be clearly labeled as to its function.

2.5.3.4 Parameter Input and Display

Enter and display control parameters directly, in the correct engineering units, through a series of keystrokes on a front panel display with decimal point and polarity indication. Provide display [in metric English units] [in metric or English units as selected by the operator].

[2.6.3.5 Self Tuning

Provide controllers with self-tuning operation which applies to proportional, integral and derivative modes of control and modify the mode constants as required. Self-tuning must only be in operation when selected from the front panel.

]2.6.3.6 Manual Tuning

Controllers must be provided with manual tuning operation which must apply to proportional, integral and derivative modes of control, by means of individually adjustable mode constants. These adjustments must be set for the appropriate value if a particular control mode action is required or to zero if that particular mode is not desired. The proportional mode constant must be adjustable from 0 to 200 percent of the input signal range. The integral mode constant must be adjustable from 0 to 20 repeats per minute. The derivative mode constant must be adjustable from 0 to [5] [____] minutes.

2.5.4 Program Storage/Memory Requirements

The CPU must utilize the manufacturer's standard non-volatile memory for the operating system. The controller must have electronically [readable and writeable nonvolatile memory (EPROM, EEPROM, or Flash PROM)] [battery backup volatile memory. Must be possible to change battery with power on] for storage of user programs. The user programs must be loaded through the controller keypad, central station or through the use of a laptop computer. The CPU memory capacity must be based on the system's control requirements. The memory capacity must be sized such that, when the system is completely programmed and functional, no more than 50 percent of the memory allocated for these purposes is used.

2.5.5 Input/Output Characteristics

Each controller must allow for analog input, analog output, binary input and binary output. The number and type of inputs and outputs for the system must be as shown on the drawings and must comply with the sequence of control. The system capacity must include a minimum of 20 percent spare input and output points (no less than two points) for each point type provided. During normal operation, a malfunction in any input/output channel must affect the operation of that channel only and must not affect the operation of the CPU or any other channel. All input circuits must have a minimum optical isolation of 1500 VRMS and must be filtered to guard against high voltage transients from the externally connected devices. All output circuits must have a minimum optical isolation of 1500 VRMS and must be filtered to guard against high voltage transients from the externally connected devices.

2.5.5.1 Analog Inputs

Analog input circuits must be available in [+/-10V] [+/-5V] [0-10V] [0-5V] [4-20 mA].

2.5.5.2 Binary Inputs

Binary input circuits must be available in [5 volt TTL] [10-30 VDC] [18-26 VDC] [79-132VDC] [79-132 VAC].

2.5.5.3 Analog Outputs

Analog output circuits must be available in [+/-10V] [4-20 mA].

2.5.5.4 Binary Outputs

Binary output circuits must be available in [5 volt TTL] [10-30 VDC] [18-26 VDC] [79-132 VAC].

2.5.5.5 Pulse Inputs

Pulse inputs must be able to detect a pulse of [x milliseconds] or less.

2.5.6 Wiring Connections

Wiring connections must be heavy duty, self-lifting, pressure type screw terminals to provide easy wire insertion and secure connections. The terminals must accept two #14 AWG wires. A hinged protective cover must be provided over the wiring connections. The cover must have write-on areas for identification of the external circuits.

2.5.7 On-Off Switch

Each controller must be provided with an integral on-off power switch. If the controller is not provided with a manufacturer's standard on-off switch, a miniature toggle type switch must be installed in the control panel near the controller and must be clearly labeled as to its function.

2.5.8 Diagnostics

Each PLC must have diagnostic routines implemented in firmware. The CPU must continuously perform self-diagnostic routines that will provide information on the configuration and status of the CPU, memory, communications and input/output. The diagnostic routines must be regularly performed during normal system operation. A portion of the scan time of the controller must be dedicated to performing these housekeeping functions. In addition, a more extensive diagnostic routine must be performed at power up and during normal system shutdown. The CPU must log input/output and system faults in fault tables which must be accessible for display. When a fault affects input/output or communications modules the CPU must shut down only the hardware affected and continue operation by utilizing the healthy system components. All faults must be annunciated at [the PLC] [and] [the central station]. Diagnostic software must be useable in conjunction with the portable tester. The following diagnostics must be performed:

a. Analog Inputs: Sensor out of range, open or shorted loop, analog-to-digital converter check

b. Analog Outputs: Open or shorted loop

c. Configuration: Check compatibility and availability of selected I/O hardware and software

d. Memory: Checksum, parity check End-to End CPU memory

2.5.9 Accuracy

Provide controllers with an accuracy of plus or minus [0.25] percent of input span.

[2.6.10 Primary/Secondary PLC

The Primary/Secondary PLCs must have redundancy built into the process control system by having two systems (power supply and CPU) either of which is capable of controlling the system. Data must be transferred from the primary processor to the secondary processor each logic cycle. [The I/O scan must be transferred from the PLC currently in charge to the other at the end of each logic execution and the logic must be executed.] [The data must be transferred via asynchronous transfer where the primary processor haws two separate microprocessors embedded in its circuitry and at the end of logic execution all data must be passed to the second microprocessor and the second microprocessor must handle all transfer tasks while the first executes the next program scan.] The Primary must perform the execution of the outputs unless a fault is detected, in which case execution of the outputs is performed by the Secondary. Switchover must be automatic and indication of the switchover must be displayed on the Central Operator Workstation.

2.7 PLC SOFTWARE

Furnish all PLC software described in this specification as part of the complete control system.

2.7.1 Operating System

Each PLC must be provided with the manufacturer's standard operating system software package. The PLC must maintain a point database in its memory that includes all parameters, constraints and the latest value or status of all points connected to the PLC. Execution of the PLC application programs must use the data in memory resident files. The operating system must support a full complement of process control functions. It must be possible to define these functions using a mix of ladder logic diagrams, function blocks, sequential function charts and text programming.
Programming methods and interactions must be based on IEC 61131-3. A combination of the programming methods must be possible within a single controller. The operating system must allow loading of control logic locally [or from the central station in which case it must require a password to do so] and data files from the portable tester. It must also support data entry and diagnostics using an operator interface panel attached directly to the PLC. Each PLC must be capable of operating in standalone mode.

2.7.1.1 Startup

The PLC must have startup software that causes automatic commencement of operation without human intervention, including startup of all connected I/O functions. A PLC restart program based on detection of power failure at the PLC must be included in the PLC software. The restart program must include start time delays between successive commands to prevent demand surges or overload trips.

2.7.1.2 Failure Mode

Upon failure for any reason, each PLC must perform an orderly shutdown. Systems which are not Primary/Secondary must force all PLC outputs to a predetermined (failure mode) state, consistent with the failure modes shown and the associated control device. Primary/Secondary systems must transfer I/O scan and control to the PLC not currently failed.

2.7.2 Functions

The controller operating system must be able to scan inputs, control outputs, and read and write to its internal memory in order to perform the required control as indicated in the sequence of control on the drawings. The controller must periodically perform self-diagnostics to verify that it is functioning properly. [If the system is set up as a Primary/Secondary system the system must attempt to switch to the other PLC upon sensing a fault in the currently controlling PLC.]

2.7.2.1 Analog Monitoring

Measure and transmit all analog values including calculated analog points.

2.7.2.2 Logic (Virtual)

Logic (virtual) points must be software points entered in the point database which are not directly associated with a physical I/O function. Logic (virtual) points must be analog or binary points created by calculation from any combination of binary and analog points, or other data having all the properties of real points, including alarms, without the associated hardware. Logic (virtual) points must be defined or calculated and entered into the database. The calculated analog point must have point identification in the same format as any other analog point.

2.7.2.3 State Variables

If an analog point represents more than two (up to 8) specific states, each state must be nameable. For example, a level sensor must be displayed at its measured engineering units plus a state variable with named states usable in programs or for display such as low alarm/low/normal/high/high alarm.

2.7.2.4 Analog Totalization

Any analog point must be operator assignable to the totalization program. Up to eight analog values must be totalized within a selectable time period.

2.7.3 Alarm Processing

Each PLC must have alarm processing software for AI, DI, and PA alarms for all real and virtual points connected to that PLC.

2.7.3.1 Binary Alarms

Binary alarms are those abnormal conditions indicated by BIs as specified and shown. The system must automatically suppress analog alarm reporting associated with a binary point when that point is turned off.

2.7.3.2 Analog Alarms

Analog alarms are those conditions higher or lower than a defined value, as measured by an AI. Analog readings must be compared to predefined high and low limits, and alarmed each time a value enters or returns from a limit condition. Unique high and low limits must be assigned to each analog point in the system. In control point adjustment (CPA) applications, key the limit to a finite deviation traveling with the setpoint. The system must automatically suppress analog alarm reporting associated with an analog point when that analog point is turned off.

2.7.3.3 Pulse Accumulator (PA) Alarms

Pulse accumulator alarms are those conditions calculated from totalized values of accumulator inputs or PA input rates that are outside defined limits as specified and shown. PA totalized values must be compared to predefined limits and alarmed each time a value enters a limit condition. Unique limits must be assigned to each PA point in the system.

2.7.4 Constraints

2.7.4.1 Equipment Constraints Definitions

Each control point in the database must have PLC resident constraints defined and entered by the Subcontractor, including as applicable: maximum starts (cycles) per hour; minimum off time; minimum on time; high limit (value in engineering units); and low limit (value in engineering units).

2.7.4.2 Constraints Checks

All control devices connected to the system must have the PLC constraints checked and passed before each command is issued. Each command point must have unique constraints assigned. High and low "reasonableness" values or one differential "rate-of-change" value must be assigned to each AI. Each individual point must be capable of being selectively disabled by the operator from the central station.

2.7.5 Control Sequences and Control Loops

Specific functions to be implemented are defined in individual system control sequences and database tables shown on the drawings, and must include, as applicable, the following functions: PI control must provide proportional control and proportional plus integral control; two position control must provide control for a two state device by comparing a set point against a process variable and an established dead band; floating point control must exercise control when an error signal exceeds a selected dead band, and must maintain control until the error is within the dead band limits; signal selection must allow the selection of the highest or lowest analog value from a group of analog values as the basis of control and must include the ability to cascade analog values so that large numbers of inputs can be reduced to one or two outputs; signal averaging must allow the mathematical calculation of the average analog value from a group of analog values as the basis of control and must include the ability to "weight" the individual analog values so that the function output can be biased as necessary to achieve proper control; reset function must develop an AO based on up to two AIs and one operator specified reset schedule.

2.7.6 Command Priorities

A scheme of priority levels must be provided to prevent interaction of a command of low priority with a command of higher priority. Override commands entered by the operator must have higher priority than those emanating from applications programs.

2.7.7 Resident Application Software

Provide resident applications programs developed in accordance with paragraph GRAPHICAL PROGRAMMING to achieve the sequences of operation, parameters, constraints, and interlocks necessary to provide control of the process systems connected to the process control system. All application programs must be resident in the PLC and must execute in the PLC, and must coordinate with each other, to ensure that no conflicts or contentions remain unresolved.

2.7.7.1 Program Inputs and Outputs

Use program inputs listed for each application program to calculate the required program outputs. Where specific program inputs are not available, a "default" value or virtual point appropriate for the equipment being controlled and the proposed sequence of operation must be provided to replace the missing input, thus allowing the application program to operate.

2.7.7.2 Failure Mode

In the event of a PLC failure, the controlled equipment must continue to function in the failure mode shown on the drawings. Systems that are Primary/Secondary must transfer control to the non-failed system.

2.8 CONTROL PANELS

2.8.1 Components

2.8.1.1 Enclosures

The enclosure for each control panel must conform to the requirements of NEMA 250 for the types specified. Finish color must be the manufacturer's standard, unless otherwise indicated. Enclosures for installation in mechanical equipment rooms must be Type [1] [4] [12]; those for installation in clean, dry indoor occupied space may be Type 1; other locations must be as otherwise specified or shown. Enclosures for equipment installed outdoors must be Type 4 or as shown. Enclosures for installation in a corrosive environment must be Type 4X and must be constructed of [stainless steel] [fiberglass] [polymer plastic]. Painted steel must not be allowed for use in a corrosive environment. Enclosure must be provided with a single, continuously hinged exterior door with print pocket, 3-point latching mechanism and key lock and a single, continuously hinged interior door.

2.8.1.2 Controllers

Provide controllers in accordance with paragraph Programmable Logic Controller (PLC).

2.8.1.3 Standard Indicator Light

Indicator lights showing on, off, stand-by, automatic, manual depending on the application must comply with NEMA ICS 1, NEMA ICS 2 and UL 508A. Lights must be heavy duty, round and must mount in a 0.875-inch mounting hole. Indicator lights must be LED type and must operate at 120 VAC or 24 VDC. Long life bulbs must be used. Indicator light must be provided with a legend plate labeled as shown on the drawings. Lens color must be as indicated on the drawings. Lights must be push to test (lamp) type.

2.8.1.4 Selector Switches

Selector switches must comply with NEMA ICS 1, NEMA ICS 2 and UL 508A. Selector switches must be heavy duty, round and must mount in a 0.875-inch mounting hole. The number of positions must be as indicated on the drawings. Switches must be [illuminated] [non-illuminated] [as indicted of the drawings]. Switches must be rated for 600 volts, 10 amperes continuous. Selector switches must be provided with a legend plate labeled as shown on the drawings. Where indicated or required, dual auxiliary contacts must be provided for the automatic position to provide position sensing at the central station or workstation. Auxiliary contacts must be rated for 120 VAC, 1A as a minimum. Where indicated on the drawings, switches must be key operated. All keys must be identical.

2.8.1.5 Push Buttons

Push buttons must comply with NEMA ICS 1, NEMA ICS 2 and UL 508A. Push buttons must be heavy duty, round and must mount in a 22.5-mm 0.875-inch mounting hole. The number and type of contacts must be as indicated on the drawings or required by the Sequence of Control. Push buttons must be rated for 600 volts, 10 amperes continuous. Push buttons must be provided with a legend plate labeled as shown on the drawings.

2.8.1.6 Relays

Relays must comply with NEMA ICS 5 and derated for altitude above 1,500 m. Relays must be [single-pole, single-throw (SPST)] [single-pole, double-throw (SPDT)] [double-pole, single throw (DPST)] [double-pole, double-throw (DPDT)] [as required by the Sequence of Control]. Relay coil must be [120 VAC] [24 VDC] and must be provided with matching mounting socket. Power consumption must not be greater than 3 watts. Coils must have a minimum current rating of [___] amps and minimum voltage rating of [___] volts. Contacts must have a minimum current rating of [ ] amps and minimum voltage rating of [___] volts.

2.8.1.7 Terminal Blocks

Terminal blocks must comply with NEMA ICS 4 and UL 1059. Terminal blocks for conductors exiting control panels must be two-way type with double terminals, one for internal wiring connections and the other for external wiring connections. Terminal blocks must be made of bakelite or other suitable insulating material with full deep barriers between each pair of terminals. A terminal identification strip must form part of the terminal block and each terminal must be identified by a number in accordance with the numbering scheme on the approved wiring diagrams.

2.8.1.8 Alarm Horns

Alarm horns must be provided where indicated on the drawings. Horns must be vibrating type and must comply with UL 508A. Horns must provide 100 dB at 10 feet. Exterior mounted horns must be weather proof by design or must be mounted in a weather proof enclosure that does not reduce the effectiveness of the horn.

2.8.2 Panel Assembly

Control panels must be factory assembled and shipped to the jobsite as a single unit. Panels must be fabricated as indicated and devices must be mounted as shown or required. Each panel must be fabricated as a bottom-entry connection point for process control system electrical power, [process control system main air source,] process control system wiring, [control air pneumatic tubing,] [communications system wiring to [other control panels] [operators workstation]].

2.8.3 Electrical Requirements

Each panel must be powered by a dedicated [120 volts ac] [] [125VDC] circuit, with a fuse, [10 amp] [_____________] [sized as recommended by the equipment manufacturer], and a disconnect switch located inside the panel. Wiring must terminate inside the panel on terminal blocks.

2.8.4 Power Line Conditioner

Each control panel must be provided with a power line conditioner to provide both voltage regulation and noise rejection. The power line conditioner must be of a ferro-resonant design, with no moving parts and no tap switching, while electrically isolating the secondary from the power line side. The power line conditioner must be sized for 125 percent of the actual connected kva load. Characteristics of the power line conditioner must be as follows:

2.8.4.1 85 Percent Load

At 85 percent load, the output voltage must not deviate by more than plus or minus 1 percent of nominal voltage when the input voltage fluctuates between minus 20 percent to plus 10 percent of nominal voltage.

2.8.4.2 Load Changes

During load changes of zero to full load, the output voltage must not deviate by more than plus or minus 3 percent of nominal voltage. Full correction of load switching disturbances must be accomplished within 5 cycles, and 95 percent correction must be accomplished within 2 cycles of the onset of the disturbance.

2.8.5 Grounding

Control panel enclosures must be equipped with a solid copper ground bus or equivalent. The ground bus must be securely anchored to the enclosure so as to effectively ground the entire structure. Clamp-type terminals sized large enough to carry the maximum expected current must be provided on the ground bus for grounding cables. Where a definite circuit ground is required, a single wire not less than #10 AWG must run independently to the panel ground bus and must be fastened to the ground bus with a bolted terminal lug. Cases of instruments, relays and other devices must be effectively grounded through the enclosures steel structure unless otherwise indicated. Insulated wiring having a continuous rated current of not less than the circuit fuse rating must be used for grounding.

Grounding terminals of power receptacles must be solidly grounded to the panel enclosure.

2.8.6 Convenience Outlet

A 120 volt ac, 20 amp, ground fault interruption (GFI) type duplex convenience outlet must be provided inside the panel. The outlet circuit must be separate from the panel power circuit.

2.8.7 Panel Interior Light

[Where indicated,] control panel[s] must be provided with a [60 watt incandescent] [40 watt fluorescent] [15 watt LED] light. The light must be operated by a manual on-off switch mounted on the interior door of the enclosure. The light must be powered by the same circuit as the convenience outlet.

2.8.8 Ventilation System

Where indicated, control panel[s] must be provided with two single phase, 120 volt ac ventilation fans. Each fan must supply a minimum of 100 cfm of ventilation air through the enclosure. Each fan must be provided with a line voltage thermostat. Thermostat setpoints must be adjustable in a range of 70 to 140 degrees F as a minimum. Each supply and exhaust grille must contain a filter that is easily removed for cleaning or replacement.

PART 3 EXECUTION

3.1.1 Installation

Install system components and appurtenances in accordance with the manufacturer's instructions and provide necessary interconnections, services, and adjustments required for a complete and operable system. Adjust or replace devices not conforming to the required accuracies. Replace factory sealed devices, rather than adjusting. Installation, adjustment, and operation of the equipment specified must be supervised by a manufacturer's representative experienced in the installing, adjusting, and testing of the equipment.

a. Install instrumentation and communication equipment and cable grounding as necessary to preclude ground loops, noise, and surges from adversely affecting system operation.

b. Install wiring in exposed areas, including low voltage wiring, in [metallic raceways] [EMT conduit] [rigid conduit] as specified.

c. Submit detail drawings containing complete piping, wiring, schematic, flow diagrams and any other details required to demonstrate that the system has been coordinated and will properly function as a unit. Piping and Instrumentation (P&ID) drawings (prepared using industry recognized device symbols, clearly defined and describing piping designations to define the service and materials of individual pipe segments and instrument tags employing Instrument Society of America suggested identifiers). Include in the Drawings, as appropriate: product specific catalog cuts; a drawing index; a list of symbols; a series of drawings for each process control system using abbreviations, symbols, nomenclature and identifiers as shown; valve schedules; compressed instrument air station schematics and ASME air storage tank certificates for each type and make of compressed instrument air station.

3.1.1.1 Isolation, Penetrations and Clearance from Equipment

Dielectric isolation must be provided where dissimilar metals are used for connection and support. Holes in concrete, brick, steel and wood walls must be drilled or core drilled with proper equipment; conduits installed

through openings must be sealed with materials which are compatible with existing materials. Installation must provide clearance for control-system maintenance.
Process control system installation must not interfere with the clearance requirements for mechanical and electrical system maintenance.

3.1.1.2 Device Mounting

Devices must be installed in accordance with manufacturers' recommendations and as shown. Control devices to be installed in piping must be provided with required gaskets, flanges, thermal compounds, insulation, piping, fittings, and manual valves for shutoff, equalization, purging, and calibration. Any deviations must be documented and submitted to the Contractor/Buyer for approval prior to mounting. Damaged insulation must be replaced or repaired after devices are installed to match existing work. Damaged galvanized surfaces must be repaired by touching up with zinc paint.

3.1.2 Sequences of Operation

Study the operation and sequence of local equipment controls, as a part of the conditions report, and note any deviations from the described sequences of operation on the contract drawings. Perform necessary adjustments to make the equipment operate in an optimum manner and must fully document changes made.

3.2 INSTALLATION OF EQUIPMENT

Install equipment as specified, as shown and as required in the manufacturer's instructions for a complete and fully operational control system.

3.2.1 Control Panels

Control panels must be located as indicated on the drawings. Devices located in the control panels must be as shown on the drawings or as needed to provide the indicated control sequences.

3.2.2 Flow Measuring Device

Fluid flow instruments must be installed in accordance with manufacturer's recommendations, unless otherwise indicated in the specification. The minimum straight unobstructed piping for the flowmeter installation must be
10.0 pipe diameters upstream and 5.0 pipe diameters downstream. Meters for gases and vapors must be installed in vertical piping, and meters for liquids must be installed in horizontal piping, unless otherwise recommended by the manufacturer or indicated in the specifications.

3.2.2.1 Magnetic Flowmeter

Meter must be installed in vertical piping so that the flow tube remains full of the process fluid under all operating conditions. A minimum of ten pipe diameters straight run upstream of the flowmeter and five pipe diameters straight run downstream of the flowmeter must be provided. The flowmeter and piping system must be grounded to earth ground.

3.2.3 Pressure Instruments

Pressure sensors and pressure transducers must be verified by calibration. All pressure taps must incorporate appropriate snubbers. Pressure sensors and pressure switches must have valves for isolation, venting, and taps for calibration. Pressure switches and pressure transducers installed on liquid or steam lines must have drains. Pressure transducers, differential pressure sensors and differential pressure switches must have nulling valves. Pressure switches must be adjusted to the proper setpoint and must be verified by calibration. Switch contact ratings and duty must be selected for the application.

3.2.4 Electric Power Devices

3.2.4.1 Transducers

Transducers must be wired in accordance with the manufacturer's instructions, and installed in enclosures.

3.2.4.2 Current Sensing Relays and Current Transducers for Motors

When used to sense meter/fan/pump status, current sensing relays must be used for applications under 5 hp. Applications over 5 hp must use a current transducer.

3.2.5 Output Devices

Output devices (transducers, relays, contactors, or other devices) which are not an integral part of the control panel, must be mounted in an enclosure mounted adjacent to the control panel, unless otherwise shown. Where H-O-A and/or override switches on the drawings or required by the control sequence, the switches must be installed so that the process control system controls the function through the automatic position and other controls work through the hand position.

3.2.6 Enclosures

All enclosure penetrations must be from the bottom of the enclosure, and must be sealed to preclude entry of water using a silicone rubber sealant.

3.2.7 Transformers

Transformers for control voltages below 120 VAC must be fed from the nearest power panel or motor control center, using circuits provided for the purpose. Provide a disconnect switch on the primary side and a fuse on the secondary side. Transformers must be enclosed in a steel cabinet with conduit connections.

3.3 WIRE, CABLE AND CONNECTING HARDWARE

3.3.1.1 Sensor and Control Wiring Surge Protection

Digital and analog inputs must be protected against surges induced on control and sensor wiring. Protect binary and analog outputs against surges induced on control and sensor wiring installed outdoors and as shown. Fuses must not be used for surge protection. Test the inputs and outputs in both the normal and common mode using the following two waveforms: The first waveform must be 10 microseconds by 1000 microseconds with a peak voltage of 1500 volts and a peak current of 60 amperes. The second waveform must be 8 microseconds by 20 microseconds with a peak voltage of 1000 volts and a peak current of 500 amperes. Submit certified test results for surge protection.

3.4 CONTROL DRAWINGS

3.4.1 Control

Control drawings, [framed, non-fading half-size in laminated plastic] [reproducible, with corresponding CADD files] [____], must be provided for equipment furnished and for interfaces to equipment at each respective equipment location. Condensed operating instructions explaining preventive maintenance procedures, methods of checking the system for normal safe operation and procedures for safely starting and stopping the system manually must be prepared in typed form, [framed as specified for the instrumentation and control diagrams] [reproducible, with corresponding word processor files] [____________________________] and posted beside the diagrams. Diagrams and instructions must be submitted prior to posting. The framed instructions must be posted before acceptance testing of the system.

3.4.2 Subcontractor Design Drawings

Subcontractor Design Drawings as a single complete package: three hard copies and three copies in electronic form. As a minimum they must include wiring, logic, and layout. Submit hardcopy drawings on [ISO A1 841 by 594 mm 34 by 22 inches][or][A3 420 by 297 mm 17 by 11 inches] sheets, and electronic drawings in PDF and in [AutoCAD][Microstation][Bentley BIM V8][Autodesk Revit 2013] format. In addition, submit electronic drawings in editable Excel format for all drawings that are tabular, including but not limited to the Point Schedule and Equipment Schedule. Subcontractor Design Drawings must be approved prior to any fabrication.

3.4.2.1 Draft As-Built

Draft As-Built Drawings as a single complete package: two hard copies and two copies in electronic form. Submit hardcopy drawings on [ISO A1 841 by 594 mm 34 by 22 inches][or][A3 420 by 297 mm 17 by 11 inches] sheets, and electronic drawings in PDF and in [AutoCAD][Microstation][Bentley BIM V8][Autodesk Revit 2013] format. In addition, submit electronic drawings in editable Excel format for all drawings that are tabular, including but not limited to the Point Schedule and Equipment Schedule.

3.4.2.2 Final As-Built

Final As-Built Drawings as a single complete package: three hard copies and three copies in electronic form. Submit hardcopy drawings on [ISO A1 841 by 594 mm 34 by 22 inches][or][A3 420 by 297 mm 17 by 11 inches] sheets, and electronic drawings in PDF and in [AutoCAD][Microstation][Bentley BIM V8][Autodesk Revit 2013] format. In addition, submit electronic drawings in editable Excel format for all drawings that are tabular, including but not limited to the Point Schedule and Equipment Schedule.

3.4.3 Points Schedule

Provide a Points Schedule in tabular form for each system, with the indicated columns and with each row representing a hardware point, network point or configuration point in the system.

a. When a Points Schedule was included in the Contract Drawing package, use the same fields as the Contract Drawing with updated information in addition to the indicated fields.

b. When Point Schedules are included in the contract package, items requiring Subcontractor verification or input have been shown in angle brackets ("<" and ">"), such as <___> for a required entry or <value> for a value requiring confirmation. Complete all items in brackets as well as any blank cells. Do not modify values which are not in brackets without approval. Points Schedule Columns must include:

3.4.3.1 Point Name

The abbreviated name for the point using the indicated naming convention.

3.4.3.2 Description

A brief functional description of the point such as "Supply Air Temperature".

3.4.3.3 DDC Hardware Identifier

The Unique DDC Hardware Identifier shown on the DDC Hardware Schedule and used across all drawings for the DDC Hardware containing the point.

3.4.3.4 Settings

The value and units of any setpoints, configured setpoints, configuration parameters, and settings related to each point.

3.4.3.5 Range

The range of values, including units, associated with the point, including but not limited to setpoint adjustment range, a sensor measurement range, or the status of a safety.

3.4.3.6 Input or Output (I/O) Type

The type of input or output signal associated with the point. Use the following abbreviations for entries in this column:

a. AI: The value comes from a hardware (physical) Analog Input

b. AO: The value is output as a hardware (physical) Analog Output

c. BI: The value comes from a hardware (physical) Binary Input

d. BO: The value is output as a hardware (physical) Binary Output

e. PULSE: The value comes from a hardware (physical) Pulse Accumulator Input

f. NET-IN: The value is provided from the network (generally from another
device). Use this entry only when the value is received from another device as part of scheduling or as part of a sequence of operation,

not when the value is received on the network for supervisory functions such as trending, alarming, override or display at a user interface.

g. NET-OUT: The value is provided to another controller over the network.
Use this entry only when the value is transmitted to another device as part of scheduling or as part of a sequence of operation, not when the value is transmitted on the network for supervisory functions such as trending, alarming, override or display at a user interface.

3.4.3.7 Network Data Exchange Information

(Gets Data From, Sends Data To) Provide the DDC Hardware Identifier of other DDC Hardware the point is shared with.

3.4.3.8 Override Information

For each point requiring an Override, indicate if the Object for the point is Commandable.

3.4.3.9 Trend Object Information

For each point requiring a trend, indicate if the trend is Local or Remote. For remote trends provide the DDC Hardware Identifier for the device performing the trend.

3.4.3.10 Alarm Information Indicate the Alarm Generation Type.

3.5 FIELD TESTING AND ADJUSTING EQUIPMENT

Provide personnel, equipment, instrumentation, and supplies necessary to perform site testing. The Contractor/Buyer will witness the PVT, and written permission must be obtained from the Contractor/Buyer before proceeding with the testing. Original copies of data produced, including results of each test procedure, during PVT must be turned over to the Contractor/Buyer at the conclusion of each phase of testing prior to Contractor/Buyer approval of the test. The test procedures must cover actual equipment and functions specified for the project.

3.5.1 Testing, Adjusting and Commissioning

After successful completion of the factory test as specified, the Subcontractor will be authorized to proceed with the installation of the system equipment, hardware, and software. Once the installation has been completed, tested, adjusted, and commissioned each control loop and system in accordance with NIST SP 250 and must verify proper operation of each item in the sequences of operation, including hardware and software. Calibrate field equipment, including control devices, adjust control parameters and logic (virtual) points including control loop setpoints, gain constants, constraints, and verify data communications before the system is placed online. Test installed ground rods as specified in IEEE 142 and submit certification stating that the test was performed in accordance with IEEE 142. Calibrate each instrumentation device connected to the process control system control network by making a comparison between the reading at the device and the display at the workstation, using a standard at least twice as accurate as the device to be calibrated.

Check each control point within the process control system control network by making a comparison between the control command at the central station and field-controlled device. Deliver trend logs/graphs of all points showing to the Contractor/Buyer that stable control has been achieved. Points on common systems must be trended simultaneously. One log must be provided showing concurrent samples taken once a minute for a total of [4] [____] hours. One log must be provided showing concurrent samples taken once every 30 minutes, for a total of [24] [____________________________] hours. Verify operation of systems in the specified failure modes upon Process control system network failure or loss of power, and verify that systems return to process control system control automatically upon a resumption of process control system network operation or return of power. Deliver a report describing results of functional tests, diagnostics, calibrations and commissioning procedures including written certification to the Contractor/Buyer that the installed complete system has been calibrated, tested, adjusted and commissioned and is ready to begin the PVT. The report must also include a copy of the approved PVT procedure.

3.5.2 Performance Verification Test (PVT)

Submit test procedures for the PVT. The test procedure must describe all tests to be performed and other pertinent information such as specialized test equipment required and the length of the PVT. The test procedures must explain, in detail, step-by-step actions and the expected results, to demonstrate compliance with all the requirements of the drawings and this specification. The test procedure must be site specific and based on the inputs and outputs, required calculated points and the sequence of control. Refer to the actions and expected results to demonstrate that the process control system performs in accordance with the sequence of control. Include a list of the equipment to be used during the testing plus manufacturer's name, model number, equipment function, the date of the latest calibration and the results of the latest calibration.

Demonstrate that the completed Process control system complies with the contract requirements. All physical and functional requirements of the project including communication requirements must be demonstrated and shown. Demonstrate that each system operates as required in the sequence of operation. The PVT as specified must not be started until after receipt of written permission by the Contractor/Buyer, based on the written report including certification of successful completion of testing, adjusting and commissioning as specified, and upon successful completion of training as specified. Upon successful completion of the PVT, furnish test reports and other documentation.

3.5.3 Endurance Test

Use the endurance test to demonstrate the overall system reliability of the completed system. The endurance test must be conducted in phases. The endurance test must not be started until the Contractor/Buyer notifies the Subcontractor in writing that the PVT is satisfactorily completed, training as specified has been completed, outstanding deficiencies have been satisfactorily corrected, and that the Subcontractor has permission to start the endurance test. The Contractor/Buyer may terminate testing at any time when the system fails to perform as specified. Upon termination of testing by the Contractor/Buyer or by the Subcontractor, commence an assessment period as described for Phase II. Upon successful completion of the endurance test, deliver test reports and other documentation, as specified, to the Contractor/Buyer prior to acceptance of the system.

3.5.3.1 Phase I (Testing)

The test must be conducted 24 hours per day, 7 days per week, for [_____] consecutive calendar days, including holidays, and the system must operate as specified. Make no repairs during this phase of testing unless authorized by the Contractor/Buyer in writing.

3.5.3.2 Phase II (Assessment)

After the conclusion of Phase I, identify failures, determine causes of failures, repair failures, and deliver a written report to the Contractor/Buyer. The report must explain in detail the nature of each failure, corrective action taken, results of tests performed, and must recommend the point at which testing should be resumed. After delivering the written report, convene a test review meeting at the job site to present the results and recommendations to the Contractor/Buyer. The meeting must not be scheduled earlier than 5 business days after receipt of the report by the Contractor/Buyer. As a part of this test review meeting, demonstrate that failures have been corrected by performing appropriate portions of the performance verification test. The Contractor/Buyer reserves the right to cancel the test review meeting if no failures or deficiencies occur during the Phase I testing. If the Contractor/Buyer chooses to do so, the Subcontractor will be notified in writing. Based on the Subcontractor's report and the test review meeting, the Contractor/Buyer will determine if retesting is necessary and the restart point. The Contractor/Buyer reserves the right to require that the Phase I test be totally or partially rerun. Do not commence any required retesting until after receipt of written notification by the Contractor/Buyer. After the conclusion of any retesting which the Contractor/Buyer may require, the Phase II assessment must be repeated as if Phase I had just been completed.

3.5.3.3 Exclusions

The Subcontractor will not be held responsible for failures resulting from the following: Outage of the main power supply in excess of the capability of any backup power source, provided that the automatic initiation of all backup sources was accomplished and that automatic shutdown and restart of the process control system performed as specified. Failure of a Government furnished communications link, provided that the PLC automatically and correctly operates in the stand-alone mode as specified, and that the failure was not due to Subcontractor furnished equipment, installation, or software. Failure of existing Government owned equipment, provided that the failure was not due to Subcontractor furnished equipment, installation, or software.

3.6 OPERATION AND MAINTENANCE DATA REQUIREMENTS

Outline the step-by-step procedures required for system startup, operation and shutdown. Include in the instructions layout, wiring and control diagrams of the system as installed, the manufacturer's name, model number, service manual, parts list and a brief description of all equipment and their basic operating features. List routine maintenance procedures, possible breakdowns and repairs and troubleshooting guides.

-- End of Section --

ATTACHMENT F

Responses to U.S. Environmental Protection Agency Comments on the Draft Report

Responses to Comments submitted by the United States Environmental Protection Agency, Region IX[1]

GENERAL COMMENTS

GENERAL COMMENT 1: The text states that new extraction well EW-OU2-13-180 will be installed at an optimum location to improve plume capture and contaminant mass removal, but it appears that there are several other locations where potential extraction wells might improve plume capture if operated in unison with the proposed location. One possibility might be an additional extraction well located near monitoring well MP-BW-46-170 where contaminant concentrations are highest. Installing multiple additional wells should result in more timely mass removal. Please revise the text to clarify why the selected location is superior to other potential locations for plume capture and contaminant mass removal.

RESPONSE TO GENERAL COMMENT 1: *As indicated throughout Section 1.0 of the text, new extraction well EW-OU2-13-180 will be installed to improve plume capture and contaminant mass removal, with the primary purpose of preventing migration of carbon tetrachloride (CT) from the Upper 180-Foot Aquifer to the Lower 180-Foot Aquifer and downgradient drinking water supply wells. An extraction well in any other location, while potentially removing additional contaminant mass in the near term, would not meet this objective. The proposed location for EW-OU2-13-180 at the upgradient edge of the discontinuity in the Intermediate 180-Foot Aquitard accomplishes this. Additionally, currently declining CT concentration trends in the Upper 180-Foot Aquifer indicate upgradient CT mass is becoming depleted, potentially mitigating the need for additional groundwater extraction in the area of MP-BW-46-170. The text in Section 1.3 of the Addendum was revised to include this information. Regardless, analysis of whether additional extraction wells or other actions are necessary is not appropriate at this time because, as stated in Section 3.2 of the Operable Unit Carbon Tetrachloride Plume [OUCTP] Fourth Quarter 2021 through Third Quarter 2022 Groundwater Monitoring Report (Administrative Record No. OUCTP-0105B), progress toward achieving long-term remedy goals should be assessed after implementation of additional groundwater extraction to improve hydraulic control and containment of the OUCTP in the Upper 180-Foot Aquifer.*

GENERAL COMMENT 2: It is unclear why an extraction well is not proposed near the well with the highest carbon tetrachloride (CT) concentrations. The rationale for the location of proposed new extraction well EW-OU2-13-180 is to install the new extraction well at the downgradient edge of the CT plume as it migrates southeastward toward an area where the Upper 180-Foot Aquifer is communicating with the Intermediate 180-Foot Aquifer. The purpose is to control migration and mitigate the potential for downward migration into the intermediate aquifer. However, adding extraction well(s) in the northwestern source area portions of the plume (where concentrations are highest) would have the effect of removing a larger amount of mass centrally, while at the same time lowering the upgradient volume of CT that is advancing at the plume’s toe (i.e., at the downgradient plume edge). Also, adding a single extraction well at the downgradient edge of the plume will not provide backup redundancy if the capture zone or well performance are compromised. Please revise the

[1] In a letter dated June 22, 2023 (Administrative Record No. OUCTP-0109.5). The comments are reproduced here as provided to the Army and there have been no changes to spelling, grammar, or punctuation.

text to discuss how the single proposed additional extraction well will produce greater mass removal as well as provide for complete plume capture.

RESPONSE TO GENERAL COMMENT 2: *To clarify, proposed new extraction well EW-OU2-13-180 is intended to prevent migration of CT from the Upper 180-Foot Aquifer through the discontinuity in the Intermediate 180-Foot Aquitard to the Lower 180-Foot Aquifer and downgradient drinking water supply wells. Otherwise, please see the response to General Comment No. 1.*

SPECIFIC COMMENTS

SPECIFIC COMMENT 1: Section 1.3, Implementation Step 3, Hydrogeologic Testing, Page 9: The specific type of hydrogeologic testing to be conducted is not specified. In characterizing the aquifer parameters during this step, it is unclear if there are planning provisions for a multi-cycle step-drawdown test (and produced water storage and characterization) to provide more valuable input data for updating the aquifer model. Please add clarifying text detailing the specific testing procedures to be used in Step 3.

RESPONSE TO SPECIFIC COMMENT 1: *Please note this list presented in Section 1.3 is only the proposed sequence of implementation for the remedial action; therefore, adding clarifying text regarding hydrogeologic testing or any other step in the sequence is not appropriate for Section 1.3. General information regarding hydrogeologic testing is already provided in Section 4.1.2 and a detailed description of testing procedures will be included in a forthcoming Remedial Action Work Plan (RAWP) and Quality Assurance Project Plan (QAPP). The text in Section 1.3 was not revised per the comment.*

SPECIFIC COMMENT 2: Section 1.3, Plume Capture Strategy, Pages 9 and 10: The text states that the steps required to complete this program are dependent on each previous step, but it should be noted throughout this section that site professionals will address deviations from the plan, unrecognized site or ground conditions and other unknowns. The text also states," If installation of the one additional extraction well provides a sufficient quantity of water and yields the desired effects upon the aquifer no further testing work will be required," but the basis for this assumption is unclear. It is unclear what contingency actions were included in the planning effort to demonstrate that unforeseen conditions or situations will be readily addressed as they arise. Specifically, it is unclear how the system will be redesigned if the single additional well does not satisfy all the program objectives (e.g., is not able to sustain a flow rate of 30 to 60 gallons per minute or does not capture enough of the plume). Please revise the text to discuss how the system will be improved if this single extraction well does not satisfy all program objectives.

RESPONSE TO SPECIFIC COMMENT 2: *The text in Section 1.3 was revised to state the sequential activities listed will include sufficient flexibility for site professionals to respond to field conditions and to state further well-performance testing work may be conducted to collect additional data to support system redesign if initial testing results indicate the one additional extraction well cannot achieve remediation goals. Otherwise, discussion about how the system will be improved if a single extraction well does not satisfy program objectives is not within the scope of the remedial design as a redesign would require additional data inputs. As noted in the response to Specific Comment 1, there will be a RAWP/QAPP prepared for this project in the Uniform Federal Policy (UFP) format that will identify project personnel, specific issues that trigger deviations from the plan, and project/data quality objectives, including an analytic approach for decision-making and performance or acceptance criteria.*

SPECIFIC COMMENT 3: Section 3.1.1.6, Well Development and Sampling, Pages 17 and 18: The specific conditions that will be utilized to determine that well development can be successfully concluded are unclear. For example, if water quality parameters have stabilized it is unclear if 10 well volumes plus 1000 gallons will also be removed. It is also not clear what measures will be taken if water quality parameters do not stabilize, which is a critical issue for extraction wells. Please revise the text to clarify the measures that will be taken if well development processes deviate from the proposed plan.

RESPONSE TO SPECIFIC COMMENT 3: *Section 3.1.1.6 was revised to clarify well development procedures and the criteria for successful well development.*

SPECIFIC COMMENT 4 Section 3.2.1, Groundwater Extraction Equipment, Page 18: It is not clear if a temporary submersible pump will be installed for the specific capacity testing to determine the correct production pump size. There are also no details on the specific capacity testing procedures to be used for sizing the production pump. Please revise the text to clarify if a temporary pump will be used and provide the specific capacity testing procedures to be used.

RESPONSE TO SPECIFIC COMMENT 4: *The text in Section 3.2.1 was revised to clarify that specific capacity testing will occur during well development, as described in Section 3.1.1.6. Detailed specific capacity procedures will be provided in the forthcoming RAWP/QAPP.*

SPECIFIC COMMENT 5: Figure 3, Carbon Tetrachloride Plume, Lower 180-Foot/400-Foot Aquifers – Third Quarter 2022: The symbol for well BW-50-339 should be blue because CT was detected at 1.1 micrograms per liter (µg/L), rather than a black symbol that indicates there are no CT detections. Please revise this figure accordingly.

RESPONSE TO SPECIFIC COMMENT 5: *Figure 3 was revised per the comment.*

SPECIFIC COMMENT 6: Attachment A, Groundwater Capture Model, Figures: The legend symbol for extraction wells is a different color than the symbol used on these figures. Please resolve these discrepancies.

RESPONSE TO SPECIFIC COMMENT 6: *The figures in Attachment A were revised per the comment.*

ATTACHMENT F

Responses to California Central Coast Regional Water Quality Control Board Comments on the Draft Report

Responses to Comments submitted by the Central Coast Regional Water Quality Control Board[1]

COMMENT: Based on our review, the Central Coast Water Board concurs with the proposed plan for construction and operation of the new Upper 180-Foot Aquifer extraction well EW-OU2-13-180 and have general comments on the plume capture strategy and remediation of carbon tetrachloride (CT) in the Upper 180-Foot Aquifer at OUCTP.

It is understood that proposed extraction well EW-OU2-13-180 will be used to extract groundwater from the downgradient edge of the Upper 180-Foot Aquifer to improve plume capture, increase contaminant mass removal, and minimize further migration into the Lower 180-Foot Aquifer. Based on a review of the plume capture modeling in the Addendum and the *May 2023 Draft Final OU2 Remedy Monitoring and Operations and Maintenance Report for Fourth Quarter 2021 through Third Quarter 2022* (2023 Draft Final OU2 Annual Report), it appears additional remediation may also be warranted at the northern CT plume in the vicinity of well MP-BW-46-170. Section 1.3, Plume Capture Strategy, indicates that the simulated capture zone for extraction well EW-OU2-09-180 appears wide enough to encapsulate most of the CT plume located upgradient of this well, and this analysis is based on the *March 2022 OU2 Remedy Monitoring and Operations and Maintenance Report for Fourth Quarter 2020 through Third Quarter 2021*. However, the plume capture model provided in the 2023 Draft Final OU2 Annual Report shows that the northern CT plume is not captured with the operation of current extraction well EW-OU2-09-180. Additionally, the plume capture model provided in the Addendum shows that the CT plume in the vicinity of monitoring well MP-BW-46-170 is also outside of the capture area of the proposed extraction well except for a small portion of the southern end of the plume under certain average conditions at a pump rate of 30 and 60 gallons per minute. Therefore, please revise the plume capture discussion in Section 1.3 based on the modeling presented in the 2023 Draft Final OU2 Annual Report that shows the northern CT plume is not captured by the operating extraction well under the current conditions and how this will be addressed either as part of the Addendum or future remediation.

RESPONSE TO COMMENT: *The plume capture discussion in Section 1.3 of the report was revised to state that the northern CT plume is only partially captured by extraction well EW-OU2-09-180 and this capture may only be seasonal due changes in groundwater flow induced by agricultural pumping downgradient (i.e., during the dry period each year). To clarify, the 2023 OU2 Annual Report Figure 47 shows the CT plumes in the Upper 180-Foot Aquifer are not captured by operation of current extraction well EW-OU3-09-180; however, Figure 47 only depicts capture during the Third Quarter (dry period) of 2022. As described in Appendix G and shown on Appendix G Figure 32, operation of current extraction well EW-OU2-09-180 does partially capture the northern CT plume in the Upper 180-Foot Aquifer during the First Quarter (average period) of 2022 (Administrative Record No. OU2-738B). However, analysis of whether an additional extraction well or other actions are necessary to address the northern CT plume is not appropriate at this time because, as stated in Section 3.2 of the OUCTP Annual Report (Administrative Record No. OUCTP-0105B), progress toward achieving long-term remedy goals should be assessed after implementation of additional groundwater extraction to improve hydraulic control and containment of*

[1] In a letter dated June 22, 2023 (Administrative Record No. OUCTP-0109.3). The comments are reproduced here as provided to the Army and there have been no changes to spelling, grammar, or punctuation.

the OUCTP in the Upper 180-Foot Aquifer. Additionally, as noted in the revised text in Section 3.3 of the OUCTP Annual Report, currently declining CT concentration trends in the Upper 180-Foot Aquifer indicate upgradient CT mass is becoming depleted, potentially mitigating the need for additional groundwater extraction in the area of the northern CT plume. The text in Section 1.3 of the Addendum was revised to include this information.

ATTACHMENT G

Responses to Fort Ord Community Advisory Group Comments on the Draft Report

Responses to Comments submitted by Fort Ord Community Advisory Group (FOCAG)[1]

COMMENT 1: Page 6 under 1.3 Plume Capture Strategy; Please identify FO-29 as belonging to the Marina Coast Water District (MCWD). This was one of the three production wells they utilized for years, respectively FO-29, FO-30 and FO-31. These provided drinking water for the residents of Marina. I don't think CT was being tested for at the time. When did CT testing begin?

RESPONSE TO COMMENT 1: *The text was revised per the comment. According to the California State Water Resources Control Board GeoTracker database (https://geotracker.waterboards.ca.gov/), testing for carbon tetrachloride (CT) began in 1985. The following links show CT results for the three wells in GeoTracker:*

FO-29: https://shorturl.ac/7b5x5

FO-30: https://shorturl.ac/7b5x8

FO-31: https://shorturl.ac/7b5x9

COMMENT 2: Wasn't FO-29 taken offline for several years due to not meeting drinking water standards?

RESPONSE TO COMMENT 2: *The U.S. Department of the Army (Army) and MCWD test water supply wells FO-29, FO-30, and FO-31 at least every three months and there has been no indication these wells are not meeting drinking water standards. The Army reports the results of this testing in quarterly groundwater monitoring reports (e.g., see Administrative Record Nos. OUCTP-0108 and OUCTP-0111). MCWD reports the results in an annual consumer confidence report (CCR) found at www.mcwd.org. Water quality data and operational information are available at MCWD. Drinking water supplied by MCWD meets all federal, state, and local regulatory standards. For further information about MCWD water quality, please contact an MCWD representative. Contact information for MCWD is available at https://mcwd.org/contact.php.*

COMMENT 3: Figures 2,3, and 4 need better background definition. It is difficult to visibly establish locations of the various plumes and wells without labeling roadways and nearby housing areas.

RESPONSE TO COMMENT 3: *Road names were added to Figures 2, 3, and 4 per the comment.*

[1] In a letter dated June 6, 2023 (see Administrative Record No. OUCTP-0109.2). The comments are reproduced here as provided to the Army and there have been no changes to spelling, grammar, or punctuation.

ATTACHMENT G

Responses to California Central Coast Regional Water Quality Control Board Comments on the Draft Report

Responses to Comments submitted by the Central Coast Regional Water Quality Control Board[1]

COMMENT: Based on our review, the Central Coast Water Board concurs with the proposed plan for construction and operation of the new Upper 180-Foot Aquifer extraction well EW-OU2-13-180 and have general comments on the plume capture strategy and remediation of carbon tetrachloride (CT) in the Upper 180-Foot Aquifer at OUCTP.

It is understood that proposed extraction well EW-OU2-13-180 will be used to extract groundwater from the downgradient edge of the Upper 180-Foot Aquifer to improve plume capture, increase contaminant mass removal, and minimize further migration into the Lower 180-Foot Aquifer. Based on a review of the plume capture modeling in the Addendum and the *May 2023 Draft Final OU2 Remedy Monitoring and Operations and Maintenance Report for Fourth Quarter 2021 through Third Quarter 2022* (2023 Draft Final OU2 Annual Report), it appears additional remediation may also be warranted at the northern CT plume in the vicinity of well MP-BW-46-170. Section 1.3, Plume Capture Strategy, indicates that the simulated capture zone for extraction well EW-OU2-09-180 appears wide enough to encapsulate most of the CT plume located upgradient of this well, and this analysis is based on the *March 2022 OU2 Remedy Monitoring and Operations and Maintenance Report for Fourth Quarter 2020 through Third Quarter 2021*. However, the plume capture model provided in the 2023 Draft Final OU2 Annual Report shows that the northern CT plume is not captured with the operation of current extraction well EW-OU2-09-180. Additionally, the plume capture model provided in the Addendum shows that the CT plume in the vicinity of monitoring well MP-BW-46-170 is also outside of the capture area of the proposed extraction well except for a small portion of the southern end of the plume under certain average conditions at a pump rate of 30 and 60 gallons per minute. Therefore, please revise the plume capture discussion in Section 1.3 based on the modeling presented in the 2023 Draft Final OU2 Annual Report that shows the northern CT plume is not captured by the operating extraction well under the current conditions and how this will be addressed either as part of the Addendum or future remediation.

RESPONSE TO COMMENT: *The plume capture discussion in Section 1.3 of the report was revised to state that the northern CT plume is only partially captured by extraction well EW-OU2-09-180 and this capture may only be seasonal due changes in groundwater flow induced by agricultural pumping downgradient (i.e., during the dry period each year). To clarify, the 2023 OU2 Annual Report Figure 47 shows the CT plumes in the Upper 180-Foot Aquifer are not captured by operation of current extraction well EW-OU3-09-180; however, Figure 47 only depicts capture during the Third Quarter (dry period) of 2022. As described in Appendix G and shown on Appendix G Figure 32, operation of current extraction well EW-OU2-09-180 does partially capture the northern CT plume in the Upper 180-Foot Aquifer during the First Quarter (average period) of 2022 (Administrative Record No. OU2-738B). However, analysis of whether an additional extraction well or other actions are necessary to address the northern CT plume is not appropriate at this time because, as stated in Section 3.2 of the OUCTP Annual Report (Administrative Record No. OUCTP-0105B), progress toward achieving long-term remedy goals should be assessed after implementation of additional groundwater extraction to improve hydraulic control and containment of*

[1] In a letter dated June 22, 2023 (Administrative Record No. OUCTP-0109.3). The comments are reproduced here as provided to the Army and there have been no changes to spelling, grammar, or punctuation.

the OUCTP in the Upper 180-Foot Aquifer. Additionally, as noted in the revised text in Section 3.3 of the OUCTP Annual Report, currently declining CT concentration trends in the Upper 180-Foot Aquifer indicate upgradient CT mass is becoming depleted, potentially mitigating the need for additional groundwater extraction in the area of the northern CT plume. The text in Section 1.3 of the Addendum was revised to include this information.

ATTACHMENT H

Responses to Fort Ord Community Advisory Group Comments on the Draft Report

Responses to Comments submitted by Fort Ord Community Advisory Group (FOCAG)[1]

COMMENT 1: Page 6 under 1.3 Plume Capture Strategy; Please identify FO-29 as belonging to the Marina Coast Water District (MCWD). This was one of the three production wells they utilized for years, respectively FO-29, FO-30 and FO-31. These provided drinking water for the residents of Marina. I don't think CT was being tested for at the time. When did CT testing begin?

RESPONSE TO COMMENT 1: *The text was revised per the comment. According to the California State Water Resources Control Board GeoTracker database (https://geotracker.waterboards.ca.gov/), testing for carbon tetrachloride (CT) began in 1985. The following links show CT results for the three wells in GeoTracker:*

FO-29: https://shorturl.ac/7b5x5

FO-30: https://shorturl.ac/7b5x8

FO-31: https://shorturl.ac/7b5x9

COMMENT 2: Wasn't FO-29 taken offline for several years due to not meeting drinking water standards?

RESPONSE TO COMMENT 2: *The U.S. Department of the Army (Army) and MCWD test water supply wells FO-29, FO-30, and FO-31 at least every three months and there has been no indication these wells are not meeting drinking water standards. The Army reports the results of this testing in quarterly groundwater monitoring reports (e.g., see Administrative Record Nos. OUCTP-0108 and OUCTP-0111). MCWD reports the results in an annual consumer confidence report (CCR) found at www.mcwd.org. Water quality data and operational information are available at MCWD. Drinking water supplied by MCWD meets all federal, state, and local regulatory standards. For further information about MCWD water quality, please contact an MCWD representative. Contact information for MCWD is available at https://mcwd.org/contact.php.*

COMMENT 3: Figures 2,3, and 4 need better background definition. It is difficult to visibly establish locations of the various plumes and wells without labeling roadways and nearby housing areas.

RESPONSE TO COMMENT 3: *Road names were added to Figures 2, 3, and 4 per the comment.*

[1] In a letter dated June 6, 2023 (see Administrative Record No. OUCTP-0109.2). The comments are reproduced here as provided to the Army and there have been no changes to spelling, grammar, or punctuation.

ATTACHMENT I

Responses to U.S. Environmental Protection Agency Comments on the Draft Final Report

Responses to Comments submitted by the United States Environmental Protection Agency, Region IX[1]

GENERAL COMMENTS

GENERAL COMMENT 1: Evaluation of the Response to General Comment 1: The response addresses the comment. However, the information provided in the response regarding an assessment of the adequacy of the system to achieve long-term remedy goals following implementation of the proposed activities is not stated in the text. For clarity, please revise the Draft Final Design Addendum to include this information.

RESPONSE TO GENERAL COMMENT 1: *Section 1.0 of the text was revised per the comment.*

SPECIFIC COMMENTS

SPECIFIC COMMENT 1: Evaluation of the Response to Specific Comment 1: The response partially addresses the comment. While it is understood that a detailed description of testing procedures will be included in the forthcoming Remedial Action Work Plan (RAWP) and Quality Assurance Project Plan (QAPP), this information is not stated in the text. For clarity, please revise this section to include this information.

RESPONSE TO SPECIFIC COMMENT 1: *The text in Section 1.3 was revised per the comment.*

[1] In a letter dated October 17, 2023 (Administrative Record No. OUCTP-0109A.5). The comments are reproduced here as provided to the Army and there have been no changes to spelling, grammar, or punctuation.

ATTACHMENT J

Responses to California Department of Toxic Substances Control Comments on the Draft Final Report

Responses to Comments submitted by the California Department of Toxic Substances Control (DTSC) Engineering and Special Projects Office (ESPO)[1]

COMMENT 1: Section 1.3 Plume Capture Strategy

COMMENT 1a: It is stated that the groundwater model was run using the first quarter of 2022 (average period) calibration parameters and the third quarter of 2022 (dry period) calibration parameters. This appears to indicate the groundwater flow was simulated as two different steady-state conditions (i.e., one with the average flow condition and the other with the dry condition). Such an approach oversimplifies the groundwater flow condition and cannot effectively represent the transient nature of the groundwater system with seasonal variance in hydraulic stresses. Please discuss the limitations and uncertainties of this approach. ESPO recommends that transient flow simulations incorporating seasonal changes in hydraulic conditions be conducted to evaluate the plume capture.

RESPONSE TO COMMENT 1a: *It is agreed that two steady-state condition models are a simplified approach to evaluating groundwater flow conditions at different time periods; however, it is inaccurate to state this approach oversimplifies the groundwater flow condition. The two simulations were created to get a better understanding of the different (dry and average) groundwater flow conditions with only steady-state models. Both stand-alone simulations provide a valuable resource to evaluate groundwater flow at the site to help make decisions.*

Steady-state models do have limitations and uncertainties in comparison to a transient simulation. Steady-state models are less complex and utilize less historical data inputs for creation and calibration. A transient model for the site is currently in development and will be used to evaluate plume capture results in the future.

COMMENT 1b: Two different pumping rates for the new extraction well, i.e., 30 and 60 gallons per minute (gpm), were simulated with the average and dry flow conditions in four scenarios. It was concluded that the operational flowrate for the new extraction well should be 60 gpm or greater. However, the simulated scenarios are very limited, and the evaluation criteria appear to be mostly qualitative. The capture analysis is not sufficiently detailed to demonstrate that 60 gpm is the optimum pumping rate for the new well. It is not clear why only two pumping rates were selected for the evaluation and whether any other pumping rates or well locations could result in an equivalent or better plume capture. ESPO recommends that detailed qualitative and quantitative evaluation criteria for plume capture analysis be developed first, and a range of different extraction rates and well locations be simulated to determine the optimum pumping rate and location for the new extraction well.

RESPONSE TO COMMENT 1b: *The simulated pumping rate scenarios of 30 gpm and 60 gpm are based on observed Operable Unit 2 (OU2) groundwater treatment system (GWTS) and Upper 180-Foot Aquifer performance in the area of concern. As described in Section 1.3, 60 gpm is consistent with the performance of nearby extraction wells EW-OU2-08-180 and EW-OU2-09-180, and 30 gpm is intended to be a conservative evaluation of a potentially underperforming extraction well due to limitations in OU2 GWTS capacities (e.g., pipeline back pressure due to operation of EW-OU2-09-180), the aquifer, or other factors. Accordingly, the capture analysis is not intended to demonstrate an optimum pumping rate for*

[1] In a letter dated October 16, 2023 (Administrative Record No. OUCTP-0109A.2). The comments are reproduced here as provided to the Army and there have been no changes to spelling, grammar, or punctuation.

the new well. Additional pumping rates could be simulated and an optimum pumping rate identified; however, it may not be achievable. Simulating other well locations would have little value because the location of the proposed extraction well was selected based on the location of the discontinuity in the Intermediate 180-Foot Aquitard, as shown in Figures 4 and 5, and the objective of limiting migration of the carbon tetrachloride plume from the Upper 180-Foot Aquifer through the Intermediate 180-Foot Aquitard and into the Lower 180-Foot Aquifer. These constraints and objectives preclude the need for development of detailed qualitative and quantitative evaluation criteria for plume capture analysis or simulation of multiple extraction rates and well locations.

COMMENT 1c: The particle tracking results shown in Figures 1 through 4 in Attachment A only provide very limited qualitative information for the plume capture analysis of different scenarios. ESPO recommends that more details of the model settings for particle tracking be provided, such as the number and locations of particles released in each model layer and the total simulation time. ESPO also recommends that the travel time of each particle be shown on the particle tracking pathlines using different colors or arrows in select time intervals (e.g., 5-year increments).

RESPONSE TO COMMENT 1c: *Section 1.3 was revised to note that particle tracking was conducted using backward particle tracks over a duration of 15 years and 18 particles were evenly distributed at each cell containing an extraction well to evaluate plume capture. The recommendation to use different colors for selected time intervals on the particle tracks is noted. Although no changes will be made to the figures in the Remedial Design (RD) Addendum, this comment will be considered in future reporting.*

COMMENT 1d: It is not clear when the groundwater model was first developed. The model is stated to have been updated several times from 2016 to 2022 but there is very limited documentation of the model. Only one reference to the 2016 model update (USACE-HEC, 2016) was mentioned in the RD Addendum but it is not listed in the references in Section 7. Because the model is expected to be used for fate and transport analysis, remedial design, and performance evaluation of existing remedies as well as new remedies for emergent contaminants such as per- and polyfluoroalkyl substances (PFAS) in the future, ESPO recommends that a comprehensive modeling report be prepared to document all the key model assumptions, settings, updates, and simulations, and submitted together with the most current model files for regulatory review.

RESPONSE TO COMMENT 1d: *Attachment A to the RD Addendum was revised to include the 2022 Fort Ord Groundwater Model Report, which provides a summary of previous model updates and details the 2022 model update. The 2016 model update (USACE-HEC, 2016) was also added to the list of references in Section 7.0. The Fort Ord Groundwater Model is based on the finite-difference MODFLOW-2005 software (Harbaugh, 2005) originally completed for the Fort Ord basewide hydrogeological characterization and used in the Basewide Remedial Investigation/Feasibility Study (HLA, 1995). Particle tracking was originally generated using the PATH3D model code (Zheng, 1989) and is currently generated using MODPATH (Pollock, 1994) in conjunction with MODFLOW-2005. The current groundwater model was based off the groundwater model developed by the USACE Hydraulic Engineering Center (HEC) in January 2016 and updated annually thereafter. Detailed documentation for the USACE-HEC model was created for internal use but not reported. Results and discussion of the USACE-HEC model are included in the annual groundwater reports for Site OU2 and Sites 2 and 12 each year. Groundwater model construction, calibration, and capture zone analysis are performed using the*

Aquaveo Groundwater Modeling System (GMS), Version 9.4., which works in conjunction with MODFLOW-2005 and MODPATH.

COMMENT 2: Section 3.1.1.1 Construction Details. The description of well casing/screen materials for the new extraction well and the piezometer is not consistent with the information presented in Table 2. For example, the well casing and screen material for the piezometer is stated to be Schedule 80 polyvinyl chloride (PVC) but it is shown to be Schedule 40 PVC in Table 2. The extraction well screen is stated to be 40-foot long, Type 316 stainless steel but it is shown to be 4 x 10-foot sections of Type 304 stainless steel. Please revise the text in Section 3.1.1.1 and Table 2 to ensure the well construction details are presented correctly and consistently.

RESPONSE TO COMMENT 2: *The text in Section 3.1.1 (previously Section 3.1.1.1) and Table 2 were revised for consistency per the comment.*

ATTACHMENT K

Responses to Fort Ord Community Advisory Group Comments on the Draft Final Report

Responses to Comments submitted by Fort Ord Community Advisory Group (FOCAG)[1]

COMMENT 1: The FOCAG takes exception to the response BRAC labels as COMMENT 2 in this OUCTP-0109A document:

"FOCAG COMMENT 2: Wasn't FO-29 taken offline for several years due to not meeting drinking water standards?"

RESPONSE TO COMMENT 2: The U.S. Department of the Army (Army) and MCWD test water supply wells FO-29, FO-30, and FO-31 at least every three months and there has been no indication these wells are not meeting drinking water standards."

The FOCAG rebuttal to this BRAC response as published in the Draft Final is;

Army BRAC's own data reflects a maximum contaminant level of .5 for Carbon Tetrachloride. Quarterly test results show that it tested at .5 (the maximum) many times. On 12/16/2010 it tested at .78.

That may be the time that the California State Dept. of Health Services had FO-29 pulled offline.

This issue of Carbon Tetrachloride in the MCWD drinking water came up at a BRAC Community Involvement Workshop. CDHS representatives were there. The public was told that MCWD water well FO-29 was pulled offline. It was sometime later the public learned that the three wells 29, 30, and 31 were having their waters blended by MCWD to achieve legally potable water. There was still contamination but the blended amounts were below State mcl standards.

Attached: a portion of California State's Geotracker for MCWD's FO-29 for 12/16/2010.

https://shorturl.ac/7b5x5

MARINA COAST WATER DISTRICT (MARINA) **WELL 29 (A)** 11 RESERVATION ROAD MARINA, CA 93933933		**State Well #:** CA2710017_026_026 **Well Source:** Groundwater **Well Status:** Active Raw

12/16/2010	CARBON TETRACHLORIDE	0.78	UG/L	0.5

RESPONSE TO COMMENT 1: *The concentration of carbon tetrachloride has not exceeded the 0.5 microgram per liter (µg/L) State of California Maximum Contaminant Level (MCL) in Marina Coast Water District (MCWD) water supply wells FO-29, FO-30, or FO-31. The link provided in the comment leads to the State Water Resources Control Board (SWRCB) website and shows a graph of carbon tetrachloride over time (1985 through 2023) at FO-29 (aka Well 29(A)); however, the representation of these data on the graph is misleading because it shows the laboratory analytical method reporting limits as detectable*

[1] In a letter dated October 16, 2023 (see Administrative Record No. OUCTP-0109A.3). The comments are reproduced here as provided to the Army and there have been no changes to spelling, grammar, or punctuation.

concentrations. As can be seen from the data listed below the graph, all values (with the exception of one, which is discussed below) have a less than (<) symbol preceding the value. This symbol indicates that there was no quantifiable concentration of carbon tetrachloride in the samples at or above these values. The values for the reporting limit vary, which can lead to confusion as some are "<0", while others are "<0.5" indicating that the reporting limit was 0.5 µg/L for those samples.

The detection of carbon tetrachloride at 0.78 µg/L at supply well FO-29 on December 16, 2010 shown in GeoTracker is an error that likely occurred when the laboratory data were uploaded to GeoTracker. It was confirmed by examining the associated data reports that carbon tetrachloride was not detected in the sample collected at supply well FO-29 on December 16, 2010:

- *Report of Quarterly Monitoring, October through December 2010, Groundwater Monitoring Program, Sites 2 and 12, OU1, OU2, and OUCTP, Former Fort Ord, California (Administrative Record No. BW-2593). See page 26 of 116 in Table 4-1 and the Quality Control Summary Report in Appendix A.*
- *Final Annual Report of Quarterly Monitoring, October 2010 through September 2011, Groundwater Monitoring Program, Sites 2 and 12, OU2, OUCTP, and OU1, Off-Site, Former Fort Ord, California (Administrative Record No. BW-2626A). See page 109 of Appendix A, Organic Analytical Results.*

The Army appreciates the FOCAG identifying this error in GeoTracker and will work with the SWRCB to correct it.

Water source blending is a common and lawful practice, though with some additional requirements, in many communities for various reasons.[2] *Though the MCWD water supply system operates as a blended system, there is no evidence this is because any particular well has exceeded state or federal drinking water standards. To the contrary, as previously noted, the Army and MCWD test water supply wells FO-29, FO-30, and FO-31 at least every three months and there has been no indication these wells are not meeting drinking water standards.*

COMMENT 2: Further, as the FOCAG recalls, the MCWD then set about drilling additional water wells as close to the Salinas Valley as possible. These additional MCWD production wells are about 800 feet deep. These newer wells are in the Salinas Valley Groundwater Basin. The water located in the SVGWB at these depths is ancient water, the amounts of which are unknown at this time.

RESPONSE TO COMMENT 2: *For further information about MCWD water supply wells and water quality, please visit www.mcwd.org or contact an MCWD representative.*

COMMENT 3: The FOCAG asks why the entirety of the comment letter(s) are not published in the Draft Final?.

RESPONSE TO COMMENT 3: *Comment letters are available in their entirety (as submitted to the Army) in the Fort Ord Administrative Record. For example, the FOCAG comments on the Draft version of the Remedial Design Addendum are available as Administrative Record No. OUCTP-0109.2, which is also referenced in footnote 1 of Appendix G to the Draft Remedial Design Addendum). The comment letters are transcribed in document appendices to facilitate responding to each specific comment and so the*

[2] Additional water sampling requirements for multiple source systems are described in 40 C.F.R § 141.703.

reader will be able to review the comment and the associated response together. As such, it is unnecessary and would be redundant to include comment letters in their entirety in documents.