October 3, 2017 Reference No. 11121241

Ms. Olivia Yu
Environmental Specialist, District 1
Oil Conservation Division, EMNRD
1625 N French Dr.
Hobbs, New Mexico 88240

Re: Soil Delineation Work Plan
VGSAU #148
Remediation Permit No 1RP-3688
Lea County, New Mexico

Dear Ms. Yu:

On behalf of Chevron Environmental Management Company (CEMC), GHD Services (GHD) is pleased to present this Soil Delineation Work Plan to the New Mexico Oil Conservation Division (NMOCD) outlining our proposed approach to delineation activities for the Vacuum Grayburg San Andres Unit No. 148 (VGSAU #148) produced water release location (hereafter referred to as the "Site").

1. Project Information and Background

The Site is located in Unit S, Section 1, Township 18 South, Range 34 East, approximately one-half mile south of the Chevron Buckeye Field Management Team office in Lea County, New Mexico. The Site is located within the Vacuum (Grayburg-San Andres) oil field.

The release site is situated proximate to multiple produced water and oil gathering lines that converge at a surface manifold location. According to the NMOCD Release Notification and Corrective Action Form C-141 submitted to the agency by Chevron, the release occurred on June 22, 2015 and was immediately reported to Ms. Kellie Jones, Hobbs District 1 NMOCD office. The volume of the spill was reported as 153.55 barrels of produced water, of which 30 barrels were recovered. A failure of a fiberglass water line was listed as the cause of the release.

Previous Soil Assessment Activities

In June 2016, GHD advanced five soil borings (SB-1 through SB-5) utilizing an air-rotary drilling rig. Four additional soil borings (SB-6 through SB-9) were advanced during a second mobilization in August 2016. All borings were drilled to depths of approximately 50 feet below ground surface (ft. bgs).

All samples collected during the June mobilization (SB-1 through SB-5) were below the NMOCD Site-specific RRAL for TPH (5,000 mg/kg) and total BTEX (50 mg/kg). Chloride concentrations in samples collected from SB-2, SB-3, and SB-5 exceeded the NMOCD Site-specific RRAL of 500 mg/kg for chlorides. The chloride concentrations ranged from 813 mg/kg to 4,210 mg/kg at depths ranging from 5 to 10 feet bgs.

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Samples collected for chlorides analysis during the August mobilization (SB-6 through SB-9) were below the NMOCD RRAL in all but two samples. Chloride exceeded the RRAL in SB-7 at 20 ft. bgs (954 mg/kg) and in SB-9 at 5 ft. bgs (6,540 mg/kg).

Geophysical Survey Activity Methods and Results – EM31 and ER

In June and August 2017, GHD completed a two-phase geophysical investigation at the Site. The purpose of the investigation was to delineate areas of elevated conductivity in order to map the extent of suspected chloride impacts to soil at the Site. The first phase of the investigation consisted of an electromagnetic (EM) survey to delineate the footprint of the suspected impacts. Based on the EM survey results, an electrical resistivity (ER) survey was completed to determine the vertical distribution of the suspected impacts. Survey coverage data are presented on attached Figures 1 and 2.

The EM survey was completed with an EM31 terrain conductivity meter. Prior to conducting the EM31 survey, a grid consisting of parallel lines was established over the proposed area of investigation indicated on Figure 1. Measurements of EM31 data were collected along 30-foot spaced grid lines over the area of investigation, with station spacings of approximately 4 feet on all grid lines. The ER survey line location was chosen based on the EM31 survey results, and transected the EM31 conductivity anomaly. The configuration of the electrodes (also called array) and the electrode spacings were optimized to achieve an approximate depth of investigation of approximately 70 ft. bgs, and the electrode spacing on all grid lines was on the order of 6.6 feet (i.e. 2 meters).

- **EM31 Survey Methodology**

The EM31 survey was completed to determine the horizontal extent or limits of chloride impacts in the shallow subsurface soils at the Site. The EM31 consists of transmitter and receiver coils located at opposite ends of a rigid boom. The coil separation for the EM31 is approximately 13 feet, which yields an approximate depth of penetration of 18 ft. bgs in vertical dipole mode. Measurements of terrain conductivity from the EM31 were used to assess the extent of chloride impacts at the Site. The data for the EM31 survey were then processed as a colored contour plot. The plot was superimposed on an aerial image of the Site plan, and is used to locate elevated conductivity responses indicative of chloride-impacted areas relative to the Site features. Figure 1 depicts the EM31 survey results.

- **EM31 Survey Results**

The colored contour conductivity plot presented on Figure 1 reveals that the highest intensity conductivity responses are colored red to purple, while areas of low response are colored blue. All remaining intermediate responses correspond to the color scale presented on the figure. Results from non-impacted areas within the survey coverage indicate that background conductivity responses were approximately 20 milliSiemens/m (mS/m). Anomalous responses relative to background were generally 3 to 10 times higher, and ranged from approximately 60 to 200 mS/m. The EM31 survey results delineated one main area of suspected brine-impacted soils (northeast perimeter of the Site). A second smaller conductive zone was detected along the southwest perimeter of the Site. Several additional small conductive zones were detected along the pipelines that intercept the Site, some of the higher responses are believed associated with conductive metallic piping.

- **ER Survey Methodology**

The ER survey profile was completed in August 2017 to determine the vertical extent of chloride-impact in soil on one selected survey line located along the northeast section of the Site. This area exhibited the highest responses during the EM31 survey (see Figure 1). The ER survey was conducted with a dual-function resistivity meter, which operates simultaneously as a transmitter and receiver. The survey utilized two multi-electrode cables yielding a total spread of 72 electrodes. The receiver was programmed to automatically "switch" between measured quadripoles, yielding a pseudosection of apparent resistivity. The apparent resistivity data were then imported into an inversion software program, and processed to yield a modeled profile section of resistivity.

- **ER Survey Results**

The electrical resistivity results for the survey line are presented on Figure 2. These results are based on the measured apparent resistivity values for various depths along the survey line. Calculations of measured apparent resistivity values include the type of ER array (Wenner), the electrode spacing, and raw field data (i.e., applied current and measured voltage for each data point).

The measured apparent resistivity data were processed with the inversion program RES2DINV, to yield the modeled resistivity section presented on Figure 2. The modeled section represents the resistance of earth materials in the shallow subsurface, and thus provides an interpretation of the overburden sequences and areas of suspected brine impacts along the survey line. The highest resistivity values are colored dark blue, while areas of low resistivity (or conversely, high conductivity) are colored yellow to red. All remaining intermediate responses correspond to the color scale presented on the bottom of each section.

The colored plot reveals that the contour intervals ranged from 2,25 to 1000 Ohm.meters (Ohm.m). The intermediate contour intervals were determined by applying a normalized distribution curve to the data such that the entire range of responses could be identified by discrete colors. The interpreted colored contoured plot suggests that suspected brine-impacted soils can be likely characterized by modeled responses of approximately 2.25 to 30 Ohm.m.

Soil Assessment and Geophysical Survey Correlation/Conclusions

- The geophysical investigation successfully delineated the horizontal and vertical extents of suspected brine-impacted areas in the shallow subsurface.
- The EM31 survey delineated two main areas of suspected brine-impacted soils at the Site.
- In general, the ER survey results indicate the zone of suspected brine impact is a surficial zone, affecting soils at surface down to approximately 25 ft. bgs.
- The suspected brine impacts appear confined to near surface areas that correlate well with soil sample analytical results for chlorides from the previous assessment activities.

2. Recommended Remediation Action Levels

Information available on the Petroleum Recovery Research Center (PRRC) Mapping Portal, current (GHD) managed groundwater site(s) data, and the United States Geological Survey (USGS) Current Water Database for the Nation indicate:

- The depth to groundwater at the Site is greater than 100 feet bgs.
- The nearest private domestic water source is greater than 200 feet from the release site.
- The nearest public/municipal water source is greater than 1,000 feet from the release site.
- The release site lies more than 1,000 horizontal feet from the nearest surface water body.

As summarized below, the NMOCD ranking criteria total score for the Site is 0. The anticipated site-specific Recommended Remediation Action Levels (RRALs) to be applied to this location by the NMOCD are 10 milligrams per kilogram (mg/kg) for benzene; 50 mg/kg for total benzene, toluene, ethylbenzene and xylenes (BTEX); 5,000 mg/kg for total petroleum hydrocarbons (TPH); and an NMOCD-accepted 500 mg/kg for chlorides.

New Mexico Oil Conservation Division Site Assessment	
Depth to Ground Water (> 100 feet)	0
Wellhead Protection Area (> 1000 feet from water source, > 200 feet from domestic source)	0
Distance to Surface Body Water (> 1000 horizontal feet)	0
Ranking Criteria Total Score	**0***
*Because the ranking criteria total score is 0, NMOCD established RRALs are 50 mg/kg for BTEX, 5,000 mg/kg TPH (GRO + DRO), and 500 mg/kg for chlorides[1].	

[1] NMOCD Guidance for Remediation of Leaks, Spills and Releases, August 13, 1993

3. Soil Delineation Path Forward

GHD proposes to advance six (6) additional soil borings to delineate the chloride exceedances in SB-3, SB-5, SB-7 and SB-9 (see Figure 1). Field screening of soil cuttings for chlorides will be performed to guide drilling activities, and the terminal depth of each boring will be based on these field screening results. The following outlines basic project details that will be completed by GHD and GHD subcontractors:

Field Program

The field program will consist of the following:

Soil Boring Installation:

- Prior to mobilizing the drilling equipment to the Site, a site visit will be performed by GHD to mark the proposed boring locations for New Mexico 811 notification. A One Call ticket will be initiated by the driller to identify subsurface hazards within the proposed drilling areas. Chevron will spot locate any underground utilities and/or pipelines within the assessment area;
- A ground penetrating radar (GPR) survey was previously conducted across the Site for additional utility clearance assurance and the findings of the survey were documented. Findings will be confirmed following the One Call notification and marking;
- GHD will coordinate all field work with management personnel of the Chevron Buckeye FMT. A MCBU Dig Plan and Buckeye FMT drilling permit will be acquired before performing the proposed tasks;
- Hydro-excavation methods or similar borehole clearance equipment will be utilized to clear each boring location to a depth of approximately 5 ft. bgs (or refusal) and approximately 8-inches in diameter. An air-rotary drilling rig, operated by a licensed State of New Mexico water well driller, will be utilized to advance the proposed borings;
- A geologist will record the subsurface lithology and sample data on soil boring logs. At a minimum, soil samples will be collected at ten-foot intervals. A chloride field sampling kit will be used to field test intervals during boring activities. The total depth and nature of any sampling of soils will be based on results of the chloride field screening and the professional judgment of the GHD geologist with the intent to establish the depth at which soil concentrations are below the Site RRAL's.
- Selected soil samples will be submitted to Xenco Laboratories, Midland, Texas for analysis of chlorides by EPA Method 300.0; and
- The soil borings will be properly plugged with bentonite.

Health and Safety Considerations

Personal protective equipment, including fire-retardant clothing, steel-toed work boots, gloves, safety glasses, and hard hats will be required during all field tasks. The project health and safety plan will be maintained on Site and will be reviewed and signed by on-Site personnel, subcontractors, and authorized visitors.

Quality Assurance/ Quality ControlConfirmation soil sampling will be completed in accordance with our standard Quality Assurance/ Quality Control procedures designed to minimize cross-contamination between samples and to provide reliable laboratory results.

Reporting

A letter report summarizing assessment activities will be submitted to the NMOCD. The letter report will include a Site description, project history, description of field events, a discussion of results, and recommendations for a path forward.

The report will include:

- A scaled Site plan showing the locations of the soil borings and other Site features;
- Soil boring logs;
- Tabulation of field screening and laboratory analytical results;
- Copies of landfill manifests;
- Geotagged photographic documentation of field activities; and
- Assessment results and recommended path forward.

4. Work Plan Approval Request

GHD is prepared to initiate the proposed work plan activities immediately upon NMOCD concurrence. If you have any questions or comments with regards to this work plan, please do not hesitate to contact our Houston office at (713) 734-3090. Your timely response to this correspondence is appreciated.

Sincerely,

GHD

Megan Stratton
Project Scientist

Scott Foord
Project Manager

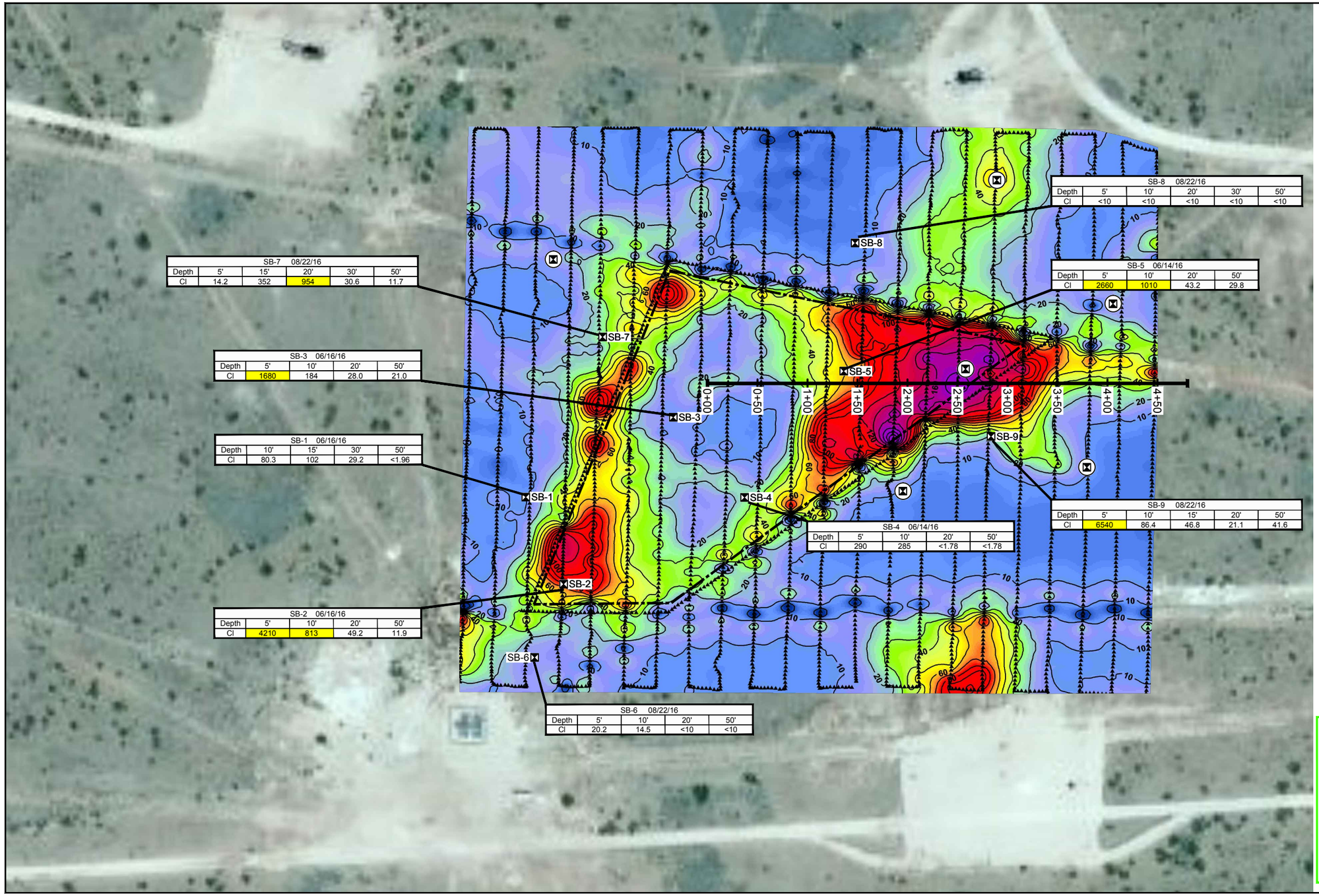
SF/ag/2

Encl.

Figure 1 – EM31 Geophysical Investigation and Historic Soil Analytical Data

Figure 2 – Electrical Resistivity Survey Results and Historical Soil Analytical Data

Figures



Source: Microsoft and Affiliated Data Providers

0 50 100ft

Coordinate System:
NAD 1983 (2011) State Plane
New Mexico East (US Feet)

DRAFT

CHEVRON ENVIRONMENTAL MANAGEMENT COMPANY
BUCKEYE FMT, LEA COUNTY, NEW MEXICO
VGSAU 148 PRODUCED WAYER RELEASE ASSESSMENT

EM31 GEOPHYSICAL INVESTIGATION & HISTORIC SOIL ANALYTICAL DATA

11121241-2017
Oct 2, 2017

FIGURE 1

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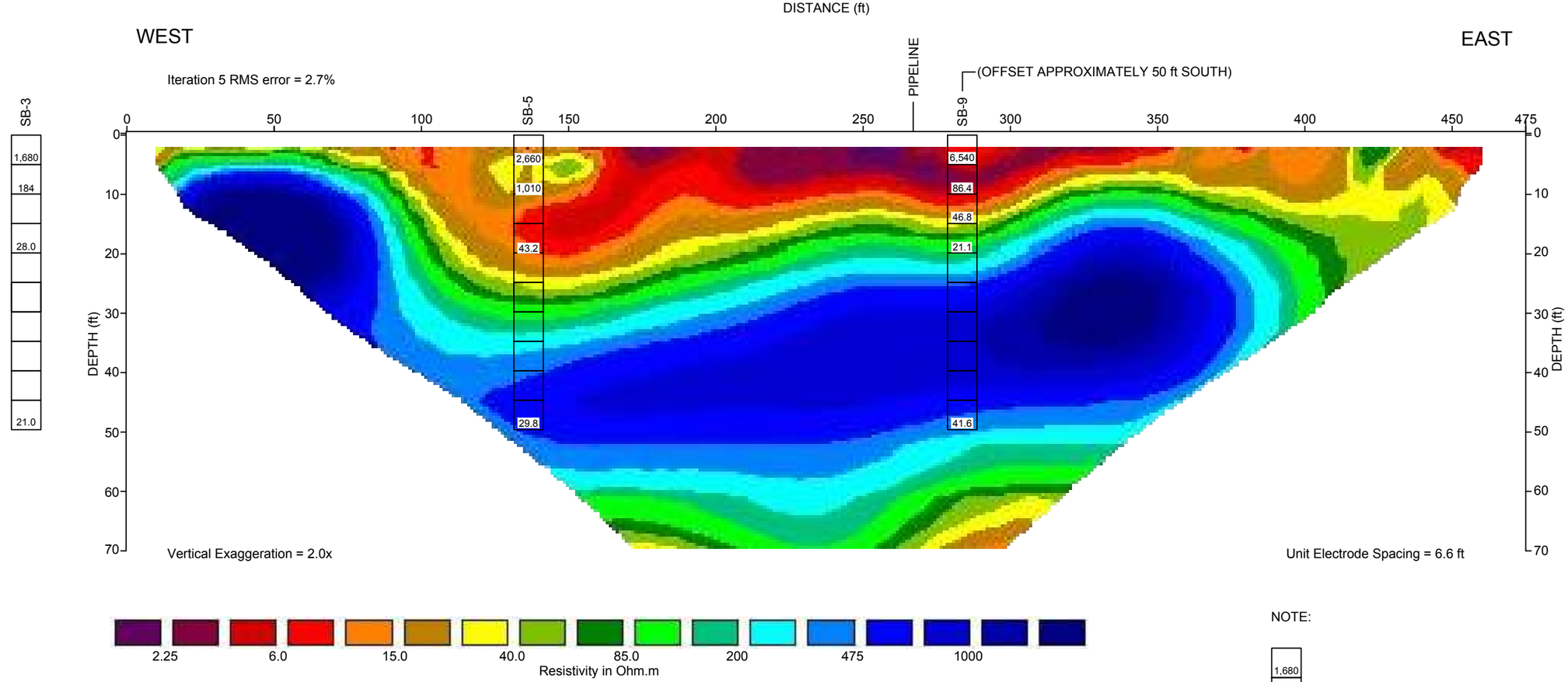
VGSAU 148 - LINE 1
INVERSE MODEL RESISTIVITY SECTION



NOTE:

1,680
184 – CHLORIDE CONCENTRATION (mg/Kg)
28.0

DRAFT

CHEVRON ENVIRONMENTAL MANAGEMENT COMPANY
BUCKEYE FMT, LEA COUNTY, NEW MEXICO
VGSAU 148 PRODUCED WATER RELEASE ASSESSMENT

ELECTRICAL RESISTIVITY SURVEY RESULTS AND HISTORICAL SOIL ANALYTICAL DATA

11121241-2017
Oct 2, 2017

FIGURE 2

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