# Hydrogeologic Study Using Electrotelluric Transects Cosumnes Subbasin Sacramento, San Joaquin, and Amador Counties, California

# HYDROGEOLOGC STUDY USING
# ELECTROTELURIC TRANSECTS
# COSUMNES GROUNDWATER SUBBASIN
# SACRAMENTO, SAN JOAQUIN, AND
# AMADOR COUNTIES, CALIFORNIA


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Project G1876-01
December 11, 2020

Mr. John L. Fio
Principal Hydrogeologist
EKI Environmental & Water, Inc.
2827 Spafford Street
Davis, CA 95618

**RE: HYDROGEOLOGIC STUDY USING ELECTROTELLURIC TRANSECTS COSUMNES GROUNDWATER SUBBASIN SACRAMENTO, SAN JOAQUIN, AND AMADOR COUNTIES, CALIFORNIA**

**(Project No. EKI B80081.01)**

Attention: Kristyn Lindhart, Hydrogeologist

Dear Mr. Fio:

In accordance with Work Authorization B80081.01 No. 1, we have completed a hydrogeologic study by means of electrotelluric transects in five pre-selected areas, two of which begin southeast of the Cosumnes River, and three that were made in the southern and eastern portions of the Subbasin and cross Dry Creek at selected locations. Tasks included assembling relevant information including data from our similar study northwest of the Cosumnes River in 2016, field geological reconnaissance, collection of available well logs for calibration to soundings in electrotelluric transects, field work to complete the transects, and the hydrogeologic interpretation of the results. The following report contains the basic data generated by our study as well as our conclusions and recommendations.

It has been a pleasure working with you on this project. If you should have any questions or comments, please contact us at your convenience.

PROFESSIONAL GEOLOGIST KEIL A. ALBERT No.7273 STATE OF CALIFORNIA

PROFESSIONAL GEOLOGIST JEREMY C. WIRE CERTIFIED HYDROGEOLOGIST No.93 6/30/21 STATE OF CALIFORNIA

Sincerely,

Keil A. Albert
Senior Geologist, PG-7273

Jeremy C. Wire
Hydrogeologist, HG-93

Copies: Addressee (1 digital, 2 print)

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## HYDROGEOLOGIC STUDY USING ELECTROTELLURIC TRANSECTS, COSUMNES GROUNDWATER SUBBASIN, SACRAMENTO, SAN JOAQUIN, AND AMADOR COUNTIES, CALIFORNIA

### INTRODUCTION

In accordance with our Work Authorization B80081.01, this report presents the results of our hydrogeologic study using electrotelluric soundings that were evaluated to a depth of 250 feet at pre-selected intervals in each of five study areas within the Cosumnes Groundwater Subbasin. These are designated Area A through Area E on Figure 1. The transects in Areas A and B (Figures 2A and 2B) are southeast of the Cosumnes River, and the work therein is a continuation of our similar previous study generally confined to northwest of the River (Geoconsultants, 2016). Areas C, D, and E are in the southern portion of the Subbasin. The transects in these Areas cross Dry Creek at three locations, starting on the west near the community of Thornton and ending near the City of Ione in Amador County on the east (Figures 2C through 2E) *.

The purpose of this reconnaissance-level project is to provide initial input in evaluating subsurface hydrogeologic conditions for the Groundwater Sustainability Plan for the Cosumnes Groundwater Subbasin. This will assist the Cosumnes Subbasin Working Group in complying with the Sustainable Groundwater Management Act (SGMA). Accordingly, the focus of our study was to provide an

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**Note: Figures 1, 2A, 2B, and 4 through 8 are reduced for a digital copy of report from original 11 x 17-inch format and are best viewed and/or printed in larger format for clarity.*

evaluation of subsurface hydrogeologic conditions to a depth of 250 feet in more detail than known from previous investigations in the selected Areas. This provides a "framework" for future investigations in critical locations for additional study of subsurface conditions as required. The description of the survey configuration, a discussion of the electrotelluric sounding method used along the transects, and the hydrogeologic interpretation of the results are presented in the following sections of this report.

## HYDROGEOLOGIC SETTING

### Regional

Formations that contain ground water in the region include younger and older alluvial deposits of Quaternary age, and the Laguna, Mehrten, and Valley Springs Formations of Late Tertiary age (California Department of Water Resources, 1974, Helley and Harwood, 1985, Wagner and others, 1981). The younger alluvium is mainly composed of unconsolidated clay, silt, and sand associated with geologically recent floodplain deposits of the Cosumnes River and similar materials deposited along the relatively narrow channel of Dry Creek. The older alluvium is a sequence of overlapping alluvial fan and terrace systems originating from the Sierra Nevada. These deposits accumulated during Pleistocene glacial outwash cycles of high surface water run-off, and are assigned to the Modesto, Riverbank, and Turlock Lake Formations, in order of increasing age (Marchand and Allwardt, 1981, Wagner and others, 1981). These fluvial deposits primarily consist of gravel, sand, and silt, and since all these formations are similar in lithology, they are grouped together in one hydrogeologic unit for purposes of this report. The Laguna Formation is similar in character to the older alluvial formations described above, but overall is finer-grained, being a mixed assemblage of clay, silt, and sand, with local lenses of gravel. Laguna Formation materials were associated with such depositional environments as sheet-flow or debris-flow deposits in pre-glacial alluvial fan complexes (Weissmann and others, 2005).

As exposed in the eastern portion of the Subbasin that includes Area E (Figure 2E), the Mehrten Formation consists primarily of tuff and flow rock of volcanic origin, interbedded with distinctive unconsolidated to semi-consolidated black sand and gravel units and sandstone. The underlying Valley Springs Formation, included in transect CR 3 in Area E as described later in this report, consists primarily of volcanic tuff and fine-grained sand interbedded with greenish-gray clay.

**Lithology and Ground-Water Flow**

The lithology of the above geologic units, excluding the Mehrten and Valley Springs Formations, mainly consists of both fine-grained and coarse-grained materials reflecting their deposition in a geologic environment such as a braided stream. Fine grained deposits, such as saturated clay, silt, and silty or clayey sand do not transmit ground water readily. However, saturated, coarse-grained materials such as sand and gravel, particularly when interconnected in a channel deposit of regional extent can transmit significant quantities of ground water. Such channels might extend from those identified northwest of the River in our previous study (Geoconsultants, Inc., 2016)

## ELECTROTELLURIC SOUNDINGS

### Description

Electrotelluric soundings (ETS) measure, on the Earth's surface, the electrical fields generated by telluric currents flowing in the subsurface formations of differing lithology (Keller and Frischknect, 1966). The ionosphere induces these currents as pulses, with the pulse duration depending on the depth of penetration. A highly portable surface receiver transforms the electrotelluric radiation into an audible signal. There is a very specific relationship between depth of origin of an electromagnetic wave front and frequency. Accordingly, the relative electrical conductivity resulting from the electrotelluric response over the depth interval investigated at each survey station is determined.

At the surface, a receiver is set to investigate a specific depth range of frequencies that represent a specific depth interval. As the vertical interval is evaluated, a change in conductivity will cause a change in amplitude of the audible signal. This change is graphed on a relative scale from very low to very high. The vertical scale is set to match the amount of detail necessary for a specific investigation, and correlate with the level of detail from available exploratory boring or well logs. Except at the most sensitive settings, the readings from the receiver are insensitive to nearby power lines and other cultural electrical noise.

Ground water will usually cause a distinct and recognizable distortion in the audible signal. Where fluids are present, a qualitative evaluation is made based on the recognition of characteristic distortion effects. The result is a relative conductivity graph of the formations investigated along with a relative delineation of formation/porosity contacts and a qualitative evaluation of the fluids contained within the porosity zones.

Appendix D contains copies of all the electrotelluric logs for this project. Geophysics International of Carrollton, Texas performed the data processing and geophysical interpretation of the depth, thickness of potentially saturated intervals, and relative salinity (if elevated) of water contained therein, as presented on each electrotelluric log. The interpretation of this information in terms of evaluating the subsurface hydrogeologic conditions of the study area, as presented in this report was completed by Geoconsultants, Inc.

The potential zones of saturation are determined by evaluating the lithologic and fluid signatures. As applied to this project, generally the lower the lithologic signature, the greater is the potential for ground-water flow. For this reason, the lithologic signature is generally weighted more heavily than the fluid signature. Porosity zones with higher actual water saturation are shown by hachured areas in the **W** column under the Content Signature heading on the individual logs. The **F** column indicates those fluid zones with any elevated salinity, but none were found in this investigation. The Signature Depth column shows the approximate vertical limits of the individual porosity intervals (Figure 3A).

## TRANSECTS

### Field Survey

The fieldwork for this project was completed on July 28 and 29, July 31, and August 4, 2020. As previously noted, two transects extending southeast from the Cosumnes River were completed in Areas A and B and are designated CR 2 and

CR 3 (Figures 2A and 2B). Two additional transects designated DC 1 and DC 2 were performed in the region of Dry Creek in Areas C and D (Figures 2C and 2D). A third transect, DC 3 was completed and crosses Dry Creek in Area E (Figure 2E). Altogether, the five transects incorporate a total of 33 ETS, six (6) of which are combined work and calibration stations at water wells at or near, an ETS location. The Transect Data Sheets (Appendix A, Figures A-1 through A-5) include GPS coordinates provided by a Garmin 12-channel unit for every ETS along each transect. These Data Sheets also contain other pertinent information as discussed below.

**Calibration**

It is important to calibrate the soundings to known well data to the extent possible to help interpret subsurface hydrogeologic conditions along a transect. Several water well logs were provided to us at the initiation of this project and several other logs that could be identified with specific ETS locations were found in the DWR well log database for Sacramento County. Additional well log data was obtained from the California Division of Oil, Gas, and Geothermal (now CalGEM) well database, since exploratory gas wells exist in and around Area C (Figure1). On the Transect Data Sheets, the well information is divided into two categories. Calibration wells that are relatively close to an ETS location are shown on the Site Plans, and their logs are contained in Appendix B, Figures B-1 through B-9. Reference wells that are more distant from a specific ETS location, but have logs thought to be helpful in evaluating subsurface conditions in the vicinity, are included in Appendix C, Figures C-1 through C-5, but are not shown on the Site Plans.

An example from transect CR 2 and sounding CR 2-1 showing calibration to a well log and the designation of broad categories (or "packages") of subsurface materials for correlation in the transects as discussed below, is shown on Figure 3B. The well logs have limitations as they exhibit some uncertainty. Driller's lithologic descriptions, as evidenced by comparing two very closely spaced well logs, may report major differences in lithologies for a given depth interval. The difficulty of correlating alluvial materials even between closely spaced wells also involves uncertainty, considering the variable depositional environments of such deposits as exhibited by rapid vertical and lateral changes in lithology.

**Correlation**

In the subsurface cross sections for each transect that follow this discussion (Figures 4 through 8), some details shown on individual electrotelluric logs contained in Appendix D have been omitted. The interpretation of the lithology presented on the logs, relative to the corresponding electrotelluric response shown on the Key to Electrotelluric Logs (Figure 3A) may also be slightly modified to accommodate the generalized description for correlation purposes as shown on Figure 3B and described below.

For subsurface correlation shown on Figure 3B, three categories or "packages" of materials are identified: "clay", "fine-grained deposits", and "coarse-grained deposits with fluid" (water). The "clay" designation may include clay, silty clay, and sandy clay, and may include a small component of coarse-grained materials. Similarly, "fine-grained deposits" may include silt, clayey sand, and fine-grained cemented sand, and may be associated with small quantities of fine-grained clayey gravel. The category of "coarse-grained materials with fluid" can include sand, and sand or gravel mixtures and may include small quantities of clayey gravel or clayey sand.

Although the "clay" and "fine-grained deposits" may be saturated below a depth of 50 feet or greater in the transects, their relative permeability and transmissivity is low, and their contained water is "bound" and not considered "movable". Therefore, these units generally do not exhibit a fluid signature. Deposits included in the category of "coarse-grained deposits with fluid", have favorable permeability so that their contained ground water is "movable", such as flow in a channel deposit. As described in the previous section Electrotelluric Soundings, if a lithologic unit contains" movable" ground water, this is indicated by a hachured sign next to its overall corresponding depth interval, often near its midpoint.

In summary, the correlations shown on the transect subsurface cross sections *do not imply stratigraphic correlation* but show relative intervals and possible continuity of the more permeable lithologic units compared to the less permeable or fine-grained deposits. The term "clay" designates essentially impermeable materials for purposes of hydrogeologic correlation and evaluation.

**Transect CR 2 (Figure 4)**

Transect CR 2 includes soundings CR 2-1 through CR 2-5 as shown on Figure 2A and extends from the Cosumnes River, trending southeast across Dillard Road to slightly beyond the intersection of Riley and Salas Roads. The transect continues a previous one that ended across the Cosumnes River to the northwest (Geoconsultants, Inc. 2016). Soundings ETS-1-1 and ETS-1-2 from this study are included on the transect section for purposes of interpretation. Calibration wells are located near CR 2-1 and CR 2-5 and the logs are presented on Figures B-1 ad B-2, respectively. There is also a reference well near the southeast end of the transect, and the log is presented on Figure C-1.

From the Cosumnes River to the southeast end, the transect cross section reveals alternating layers consisting of fine-grained deposits to depths of 50 to 60 feet below the ground surface, followed by coarse-grained deposits with fluid that are about 20 feet thick on the northwest (Figure 4). This unit thickens to about 40 feet at Riley Road on the southeast. The base of the unit is about 80 feet deep on the northwest end of the cross section to as much as 100 feet below ground at the southeast end.

These deposits are underlain by an apparently continuous clay interval extending to a depth generally about 120 feet deep across the transect. In turn, another interval of coarse-grained deposits with fluid extends to a depth of 160 to 180 feet. There is potential development of a channel in this unit around CR 2-4, where the deposit thickens. Below this interval, fine-grained deposits are noted to a depth of about 200 feet, followed by coarse-grained deposits with fluid to 250 feet, the total depth of the transect.

Correlation with the end of the previous transect northwest of the Cosumnes River at ETS-1-1 and ETS-1-2 is uncertain. The coarse-grained channel deposits in these soundings below a depth of about 140 feet appear to diminish laterally or "pinch out" underneath the Cosumnes River. Correlation to the southeast with transect CR 2 and the nearby calibration well (Figures 3B and B-1) is also uncertain. The designation of "pea gravel" in the well log in the depth interval roughly between

200 and 250 feet correlates with a similar depth interval of coarse-grained deposits with fluid in sounding CR 2-1. This suggests the existence of a channel deposit in this area. With several episodes of channel cutting and filling, a local topography with relief of up to 75 feet may have existed resulting in sand and gravel filled drainage channels with rather steep walls (Shlemon, 2000). This observation could help explain the apparent rapid change in subsurface conditions observed in attempting correlation between the two transects.

**Transect CR 3 (Figures 5A and 5B)**

Transect CR 3 extends along Wilton Road from southeast of the Cosumnes River starting at ETS 3-1 from the previous study and extends across Dillard Road, continuing southeast to Blake Road (Figure 2B). Soundings ETS-3-1 and ETS-3-2 from the previous study are included in the transect section for purposes of interpretation. This transect includes soundings CR 3-1 through CR 3-8. Calibration wells are located near CR 3-4 and CR 3-8 and the logs are shown on Figures B-3 and B-4. Since this is a long transect, the cross section is shown in two parts, Part A and Part B, Figures 5A and 5B, respectively.

Correlation with the previous sounding data northwest of the Cosumnes River is uncertain. However, fine-grained deposits dominate the relatively shallow depth interval in this area. No coarse-grained deposits with fluid are present in the upper portion of soundings ETS-3-1 and 3-2 (Figure 5A). However, this may be in part due to lack of data because the upper 50 feet of the soundings in the previous study was not processed. Starting at CR3-1, coarse-grained deposits with fluid extend across the transect, starting at a rough depth of 40 to 60 feet, with their base at 80 to 100 feet below the ground surface. Within this interval, possible channel deposits occur between CR 3-2 and CR 3-4. If this interval was extended northwest to the vicinity of ETS-3-1, these coarse-grained deposits with fluid might directly underlie a portion of the Cosumnes River floodplain. Below this interval, fine-grained deposits extend to a depth of about 140 feet across the transect, followed by coarse-grained deposits with fluid to a depth of about 180 feet. This interval is underlain in turn by fine-grained materials extending to 250 feet, the total depth evaluated.

**Transect DC 1 (Figure 6)**

Transect DC 1 includes soundings DC 1-1 through DC 1-7 and trends in a northwest-southeast direction starting at Grizzly Slough. The transect extends across a portion of the Cosumnes River Preserve and crosses New Hope Road, ending in the Kautz private property (Figure 2C). There are no calibration wells on this transect, but there are some reference exploratory gas wells associated with the Thornton Gas Field (Loken,1957). Information from several of the reference wells provides some insight into subsurface conditions, even though log data usually begins at a depth of 500 feet, below our depth of interest (Figures C-2 through C-4).

Fine-grained deposits are predominant to a depth of about 60 feet across the cross section, and may correspond to the "blue clay and blue clay with streaks of sand" noted on the log for the Amerada "Goodfellow-Capital No. 1" reference well to a depth of 200 feet (Figure C-3) The well is about 2000 feet east of DC 1-2. This lithology continues on the log as "blue shale with streaks of sand": to the depth of 1415 feet, as confirmed by the resistivity curve values on the electric log, Figure C-4.

The mud log of the TXO Production Company "Transamerica-Thornton" 26-1, located about 1700 feet east of DC 1-1 records similar intervals as "siltstone'.

As noted previously, although deeper than our interval of interest, the logs suggest that primarily fine-grained materials may prevail in the subsurface in an area relatively close to the transect. Below the 60-foot deep interval of fine-grained deposits noted previously, an interval of coarse-grained materials with fluid about 20 feet thick extends across the cross section to a depth of about 80 feet where an apparently continuous interval of clay is present to a depth of about 120 feet. This unit in turn is underlain by additional coarse-grained deposits with fluid to a depth of about 180 feet, where fine-grained materials extend to 250 feet, the total depth of evaluation. Based on a thickening of the interval, there is the suggestion that channel deposits could be developed in DC 1-1 through DC1-3, between the depths of 140 and 200 feet.

**Transect DC 2 (Figure 7)**

Transect DC 2 extends in a north-south orientation along Alta Mesa Road from its intersection with Simmerhorn Road, extending across Dry Creek into San Joaquin County (Figure 2D). Alta Mesa Road then becomes Dustin Road, and transect ends at Liberty Road. Soundings DC-2-1 through D-7 are included in this transect, and there is one calibration well near DC 2-5. The log for this well is presented on Figure B-5.

Fine-grained deposits occur to a depth of about 60 feet across the transect to a depth of about 60 feet, followed by coarse-grained deposits with fluid extending to about 120 feet in depth, becoming slightly thicker to the south. Then a 30-foot thick apparently continuous clay interval is present in the cross section to a depth of about 160 feet. An underlying unit coarse-grained deposits with fluid occurs in the general depth interval between 160 and 180 feet across the transect, thickening to the depth of about 200 feet in the vicinity of DC 2-3. This anomaly may represent a possible channel deposit, incised into the underlying fine-grained materials that extend to 250 feet, the total depth of evaluation.

**Transect DC 3 (Figure 8)**

Transect DC 3 extends southeast from the upland area of Cook Road, across the floodplain of Dry Creek, and continues into the upland area on the southeast side, ending at State Highway 88 (Figure 2E). The transect includes soundings DC 3-1 through DC 3-6, with calibration to the Bamert monitoring well at DC 3-5. This transect differs from the others in that it crosses an upland area underlain by the Valley Springs Formation, as mapped by Bartow and Marchand (1979), and as confirmed by a volcanic tuff outcrop at sounding DC 3-6 along Highway 88.

There is some alluvium in the Dry Creek channel, estimated to be about 20 feet thick as shown on the cross section. Subsurface deposits occurring in the Bamert well consist mostly of fine-grained sand and gravel, interbedded with sandy clay and clay according to the lithologic log and construction detail of the well, as presented on Figures B-6 through B-9. At a depth of 330 feet, “basement” rock consisting of greenstone and slate was encountered in the borehole, correlating with a predicted depth to such “basement” rock based on a gravity survey in the vicinity (Chapman and Bishop, 1975).

Aside from the alluvium in Dry Creek, fine-grained materials are noted to a depth of about 40 feet across the transect, followed by coarse grained deposits with fluid extending to a depth of 70 feet. These deposits correlate with the screened interval in the shallow portion of the Bamert well. An interval of apparently continuous clay follows to a depth of about 100 feet, where coarse-grained deposits with fluid again occur to an average depth of 150 feet in the cross section. This general interval also correlates with the screened section in the deeper portion of the well. At the average depth of 150 feet, another apparently continuous clay interval extends across the transect, being about 40 feet thick, followed by fine-grained deposits to a depth of 250 feet, the total depth of evaluation. No "basement" rock was noted in any of the soundings at this depth.

## CONCLUSIONS AND RECOMMENDATIONS

The five electrotelluric transects reveal reconnaissance-level information on subsurface conditions to a depth of 250 feet in the hydrogeologic environment of the Areas in the Cosumnes Subbasin that were evaluated. In the transect cross sections, the subsurface deposits are differentiated into three general categories or "packages" that include "clay", "fine-grained deposits", and "coarse-grained deposits with fluid". This classification reflects the relative permeability of the three categories of the materials with respect to their hydrogeologic properties and assumes that clay intervals and fine-grained deposits vary from being impermeable and less permeable, to permeable in the case of the coarse-grained deposits with fluid. It is worth repeating from previous discussion of the transects that the correlations shown on the subsurface cross sections do not imply stratigraphic correlation but show relative intervals and possible continuity of the more permeable lithologic units compared to the less permeable fine-grained deposits and clay intervals.

As a general conclusion, development of channel deposits in Areas A through D like those occurring around the Cosumnes River area in the northwest portion of CR 2 where it joins transect T-1 of our previous study appears to be relatively rare. However, as noted in the discussion of transect CR 2, subsurface relationships here are uncertain and need better resolution.

In addition to the area of transect CR 2 noted above, other areas of interest previously discussed in the Transect section of the report that warrant further study as hydrogeologic input to the Subbasin Groundwater Sustainability Plan are:

1. Transect CR 2, vicinity of CR 2-4, Riley Road, for further definition of a possible channel.

2. Transect CR 3, transition area between ETS 3-1 and CR 3-1 that could be a recharge site if the coarse-grained deposits with fluid extend into the floodplain of the Cosumnes River.

3. Transect CR 3, area around CR 3-2 and CR 3-3 for further definition of a possible channel.

4. Transect DC 1, area around DC 1-1 and DC 1-3 for further definition of a possible channel.

5. Transect DC 2, area around DC 2-3 and DC 2-4 for definition of a possible deep channel underlying Dry Creek.

## ACKNOWLEDGMENTS

We would like to acknowledge the help of Tom Mahon of Mahon Ranch in furnishing well log data, and Steve Fredrick, General Manager of the Jackson Valley Irrigation District for access and guiding us through the Bamert property to obtain the data for transect DC 3, and to Kristyn Lindhart, Hydrogeologist, EKI

Environment and Water, Inc. for facilitating access to all the private properties, and including State Lands, that were involved in the project.

## LIMITATIONS

Geoconsultants, Inc. has provided its findings, recommendations, specifications, and professional advice after preparing such information in a manner consistent with that level of care and skill ordinarily exercised by the members of the profession currently practicing under similar conditions in the field of hydrogeology. This acknowledgment is in lieu of all warranties either express or implied

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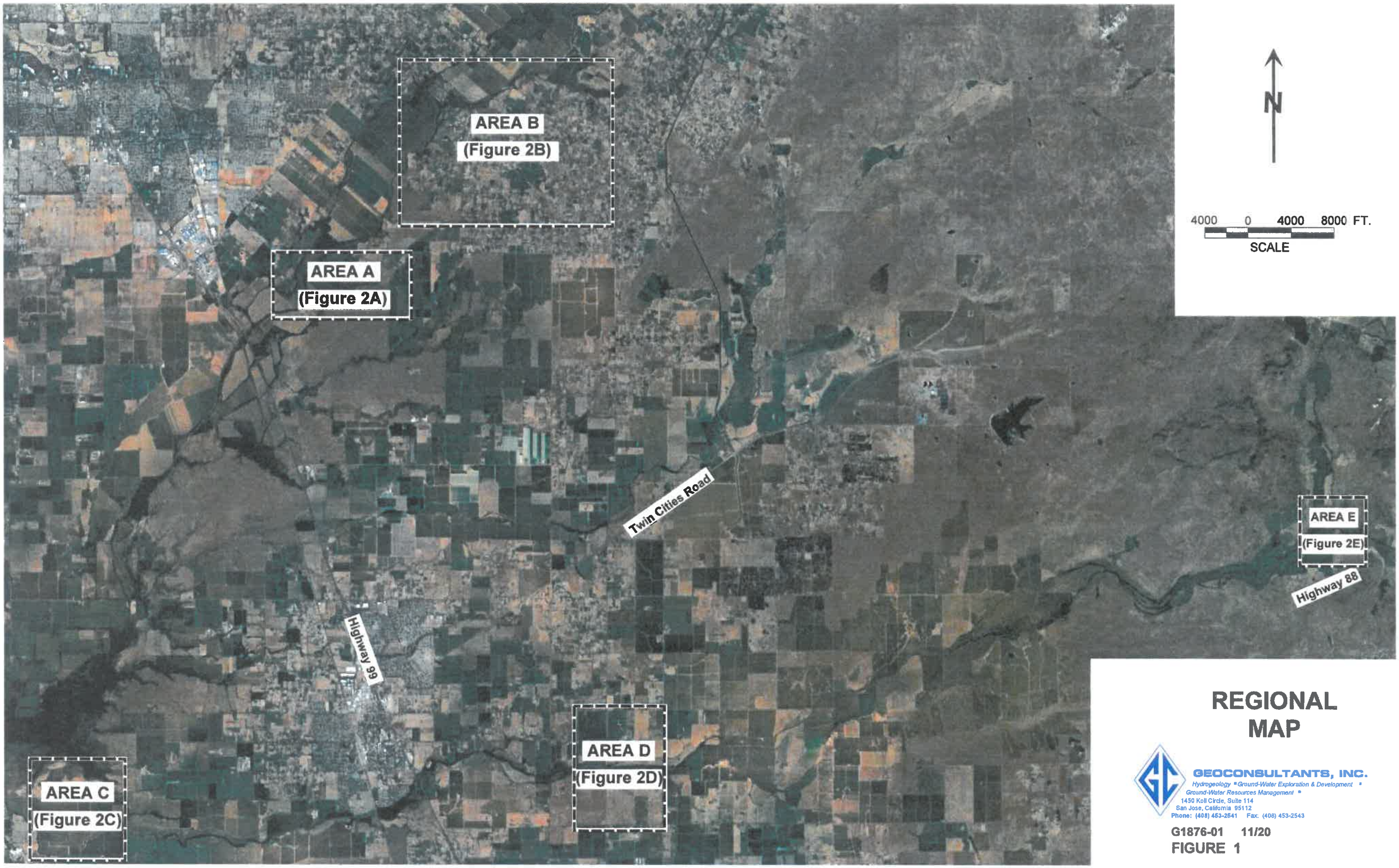
# FIGURES




# REGIONAL MAP

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FIGURE 1


**LEGEND**

- CR2 — Transect
- ETS-1-2 — Electrotelluric Sounding from Previous Study
- CR2-5 — Electrotelluric Sounding from Current Study
- Calibration Well

400 0 400 800 FT.
SCALE

## SITE PLAN
## AREA A

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FIGURE 2A


## SITE PLAN AREA B

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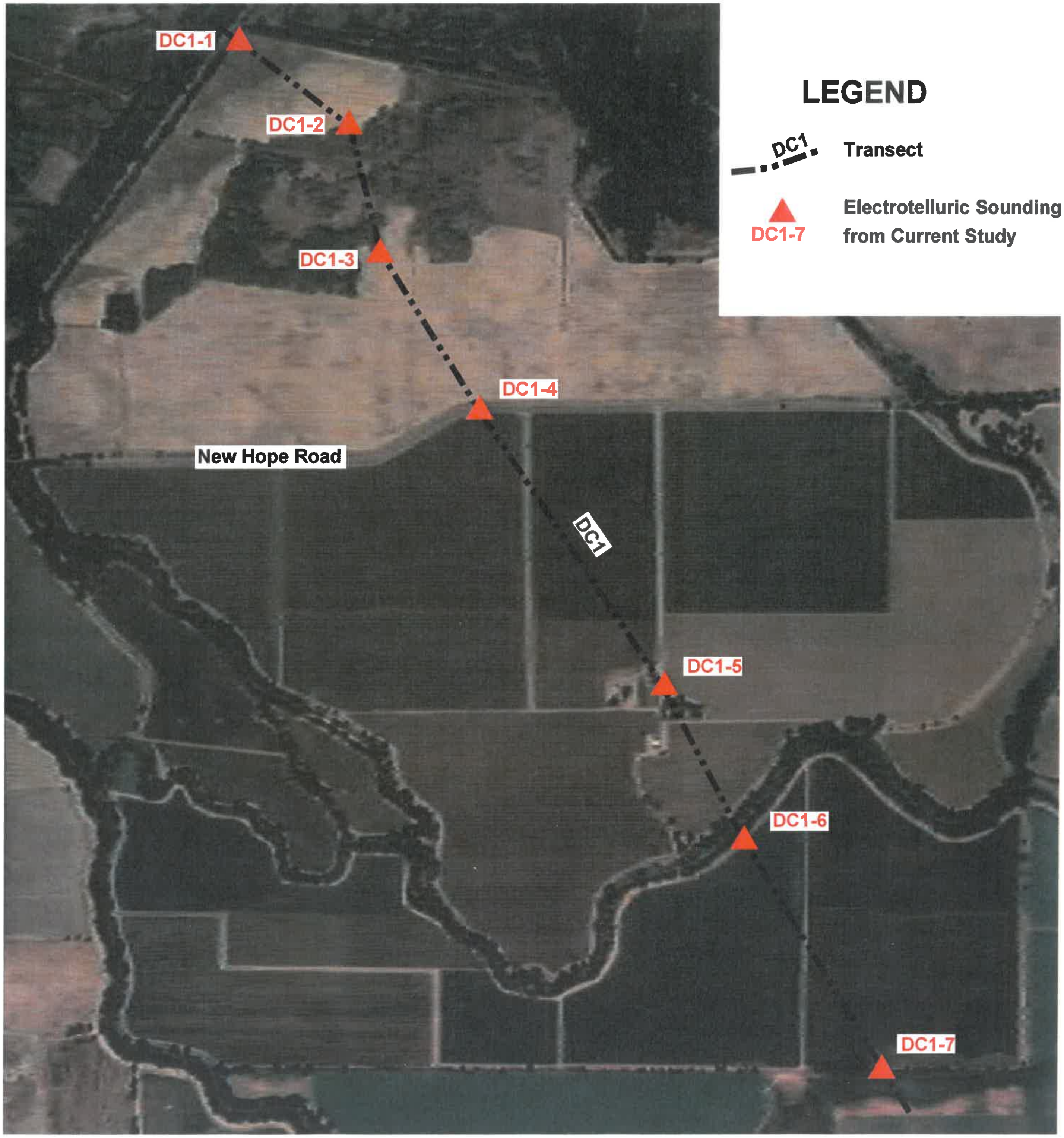
FIGURE 2B




N

600 0 600 1200 FT.

SCALE

# SITE PLAN
# AREA C

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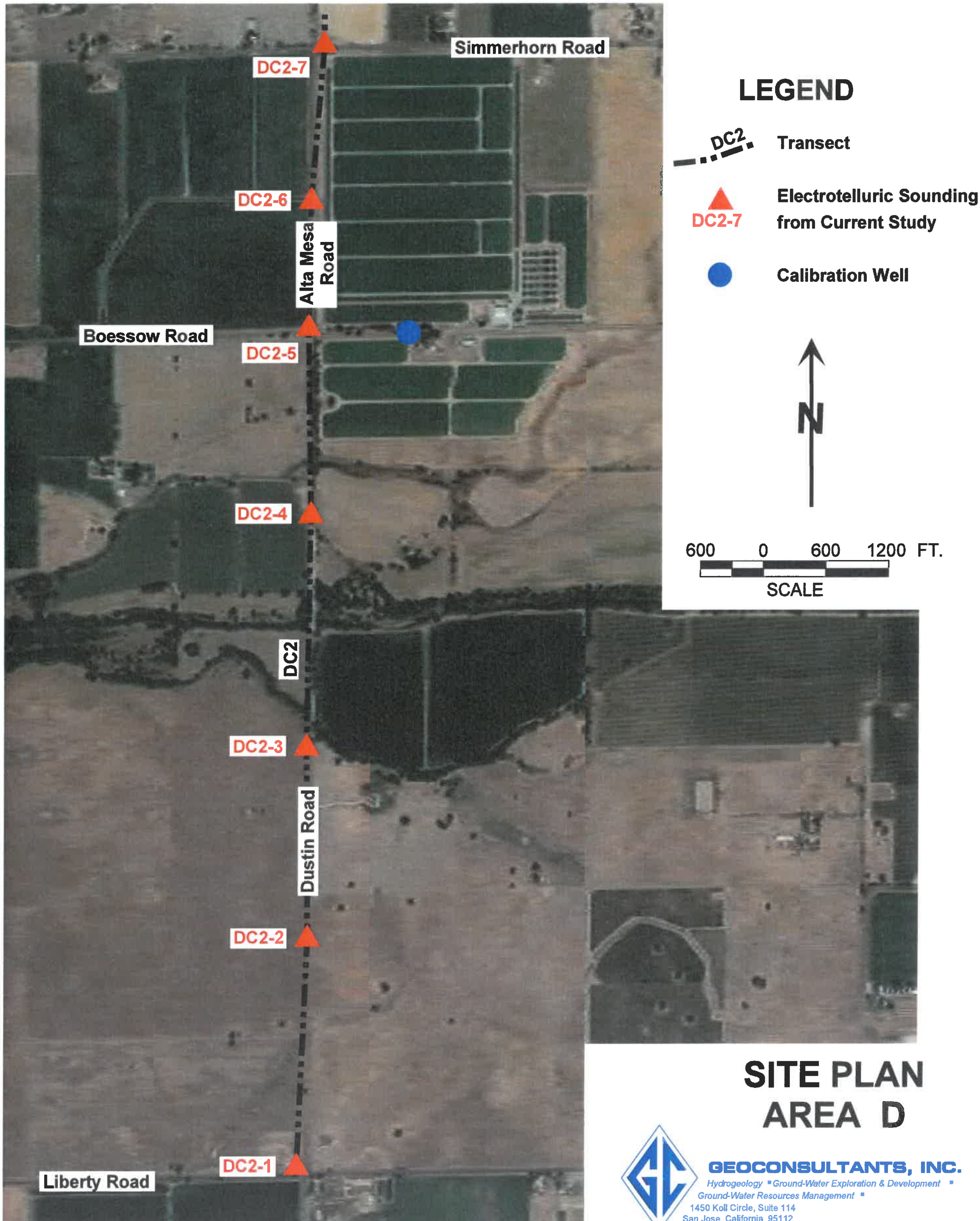
FIGURE 2C




# SITE PLAN
# AREA D

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FIGURE 2D


# SITE PLAN
# AREA E


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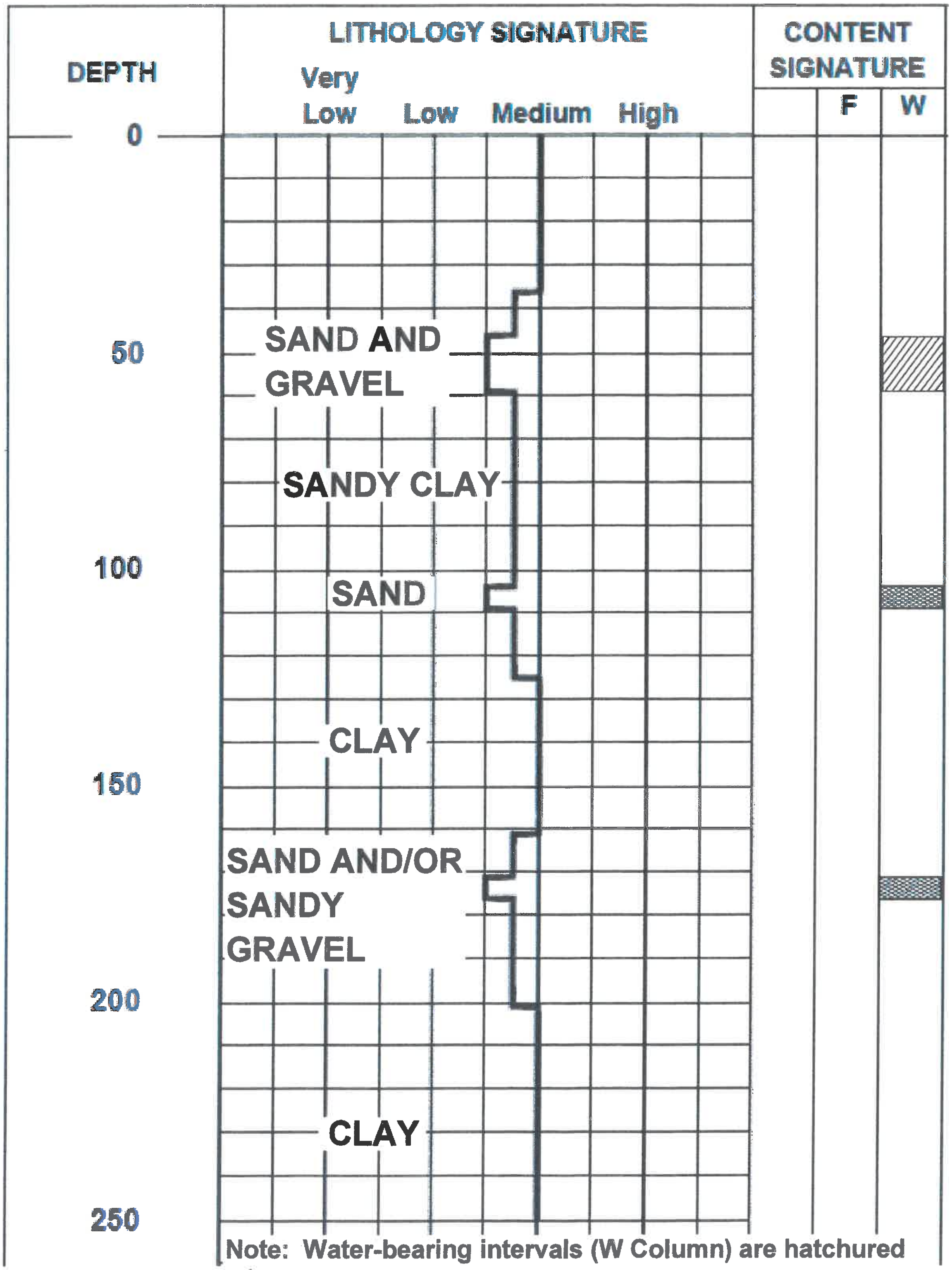
FIGURE 2E



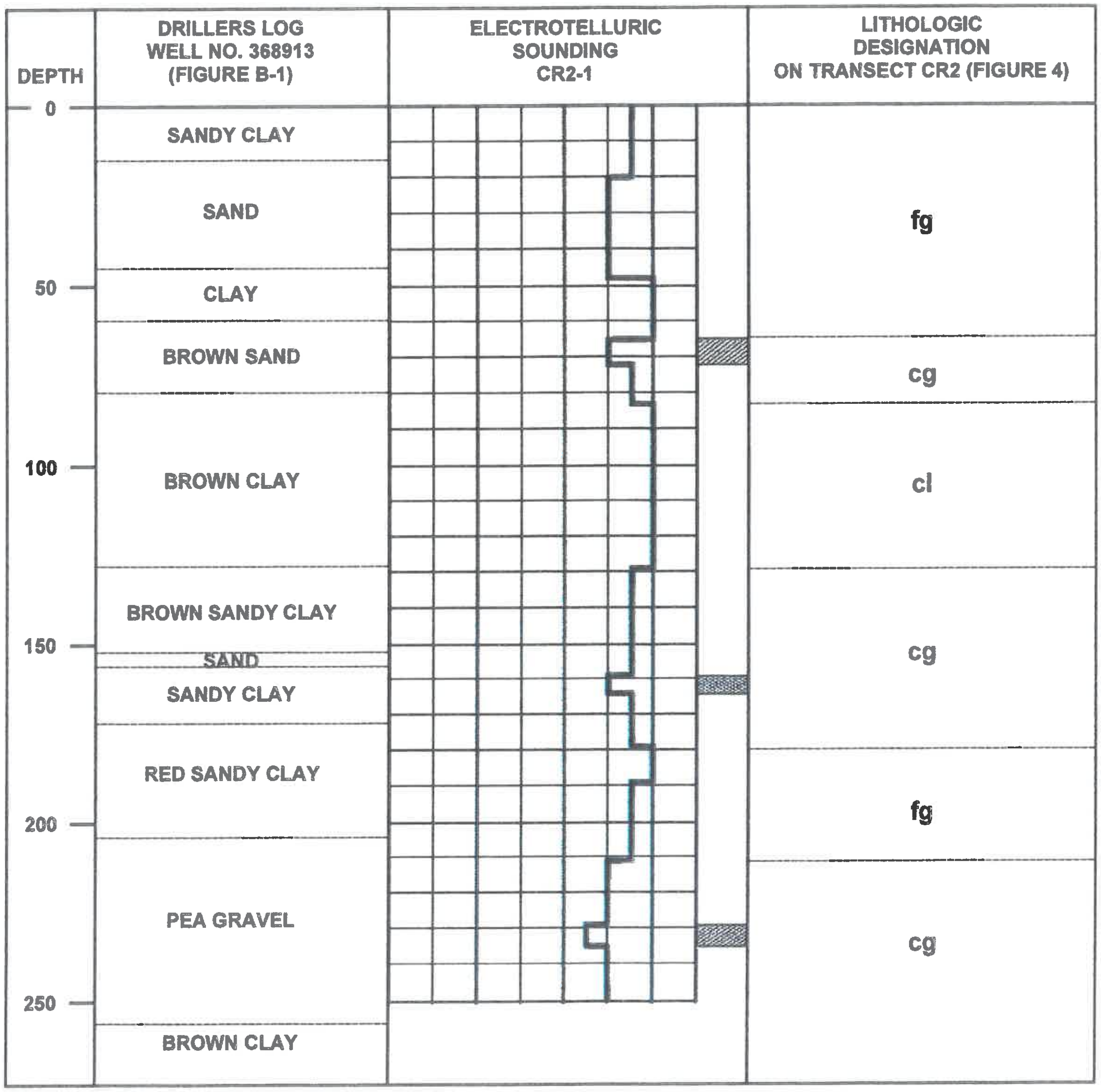

# KEY TO ELECTROTELLURIC LOGS

GEOCONSULTANTS, INC.
*Hydrogeology ▪ Ground-Water Exploration & Development ▪*
*Ground-Water Resources Management ▪*
1450 Koll Circle, Suite 114
San Jose, California 95112
Phone: (408) 453-2541 Fax: (408) 453-2543

G1876-01 11/20

FIGURE 3A

# CALIBRATION EXAMPLE




## EXPLANATION

| | |
|---|---|
| cg | Coarse-Grained Deposits With Fluid |
| fg | Fine-Grained Deposits |
| cl | Clay |

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San Jose, California 95112
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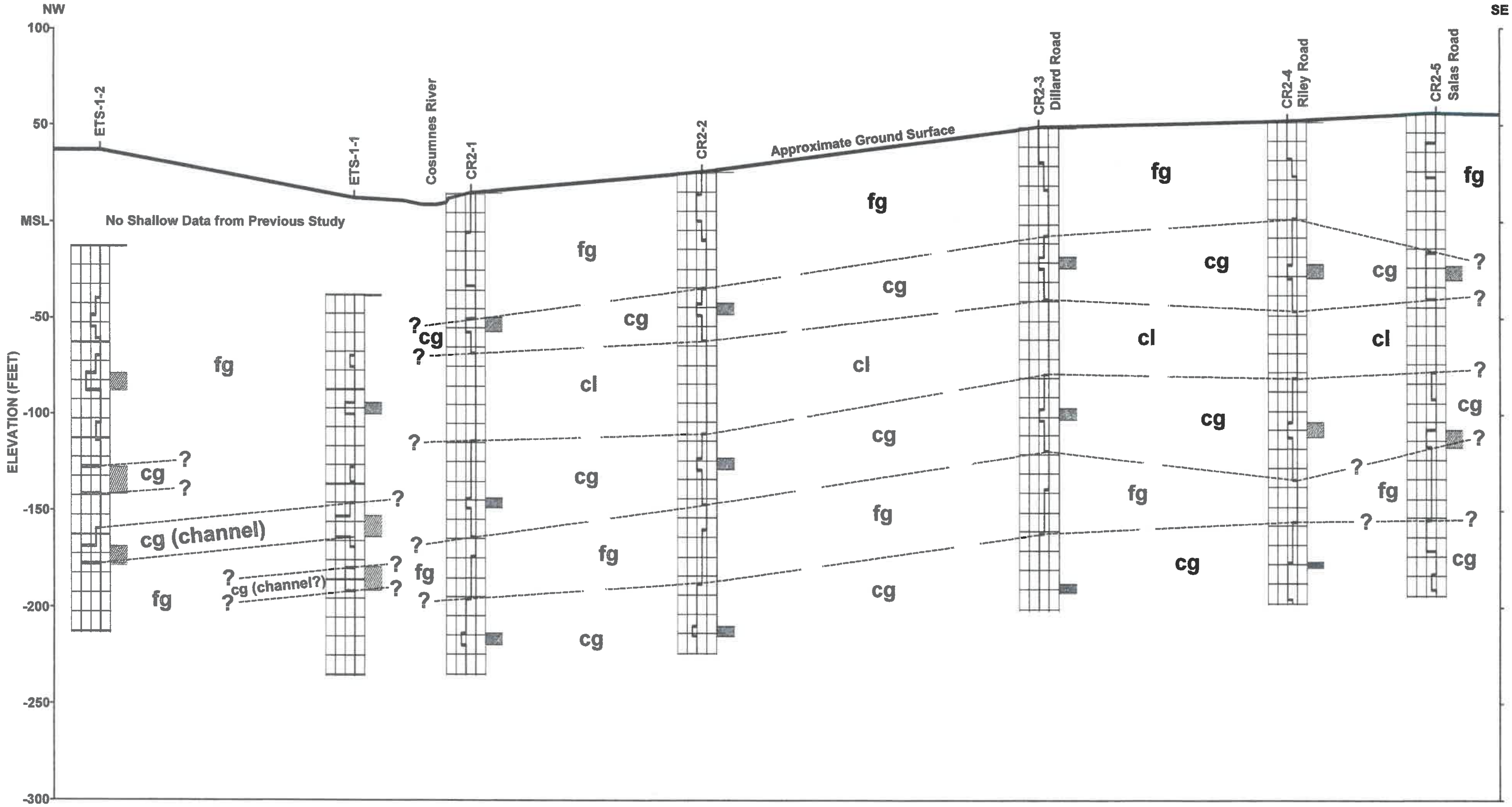
G1876-01 11/20

FIGURE 3B




EXPLANATION

| | |
|---|---|
| cg | Coarse-Grained Deposits With Fluid |
| fg | Fine-Grained Deposits |
| cl | Clay |

## TRANSECT CR2

500 0 500 1000 FT.
HORIZONTAL SCALE

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1450 Koll Circle, Suite 114
San Jose, California 95112
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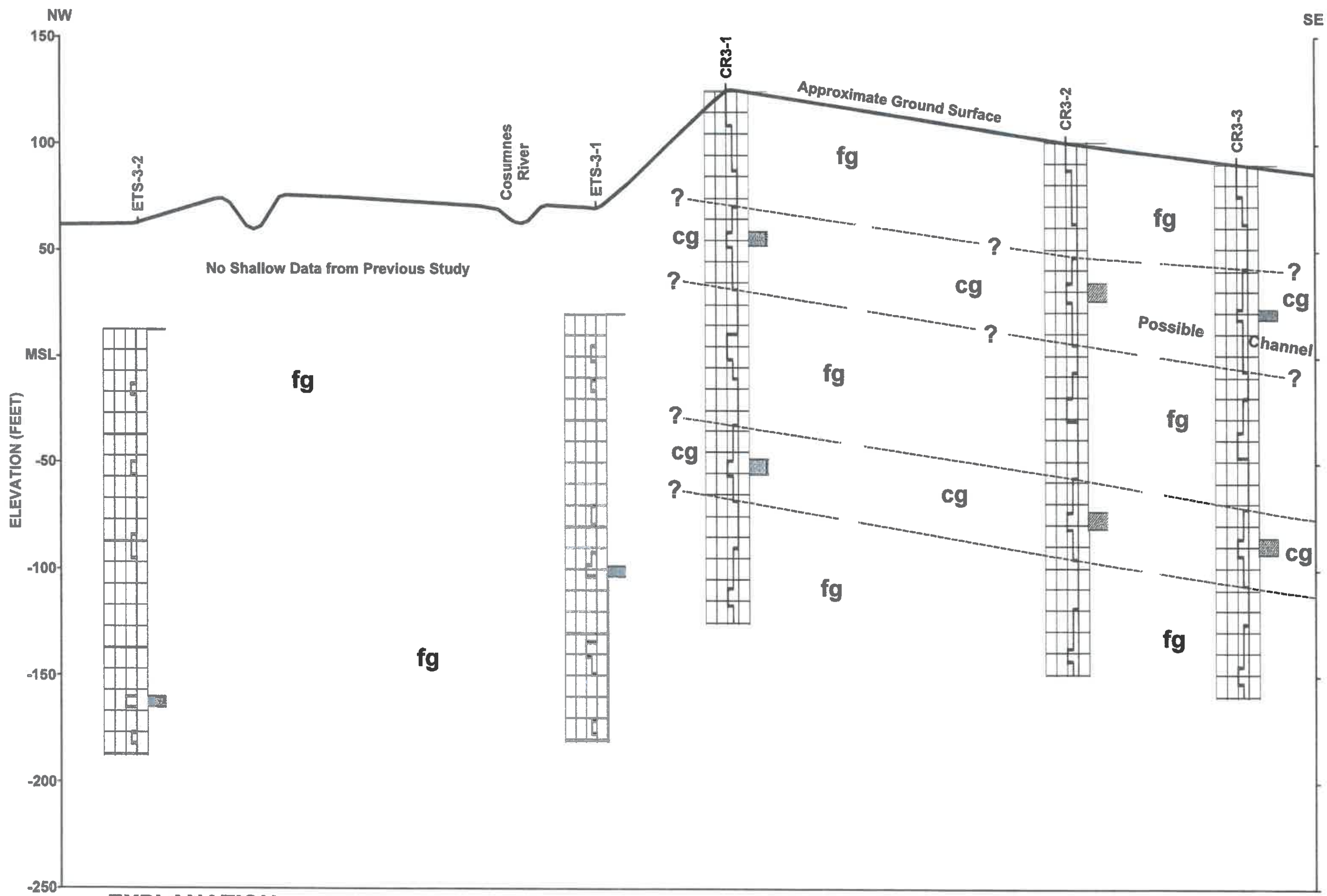
FIGURE 4




EXPLANATION

cg Coarse-Grained Deposits With Fluid

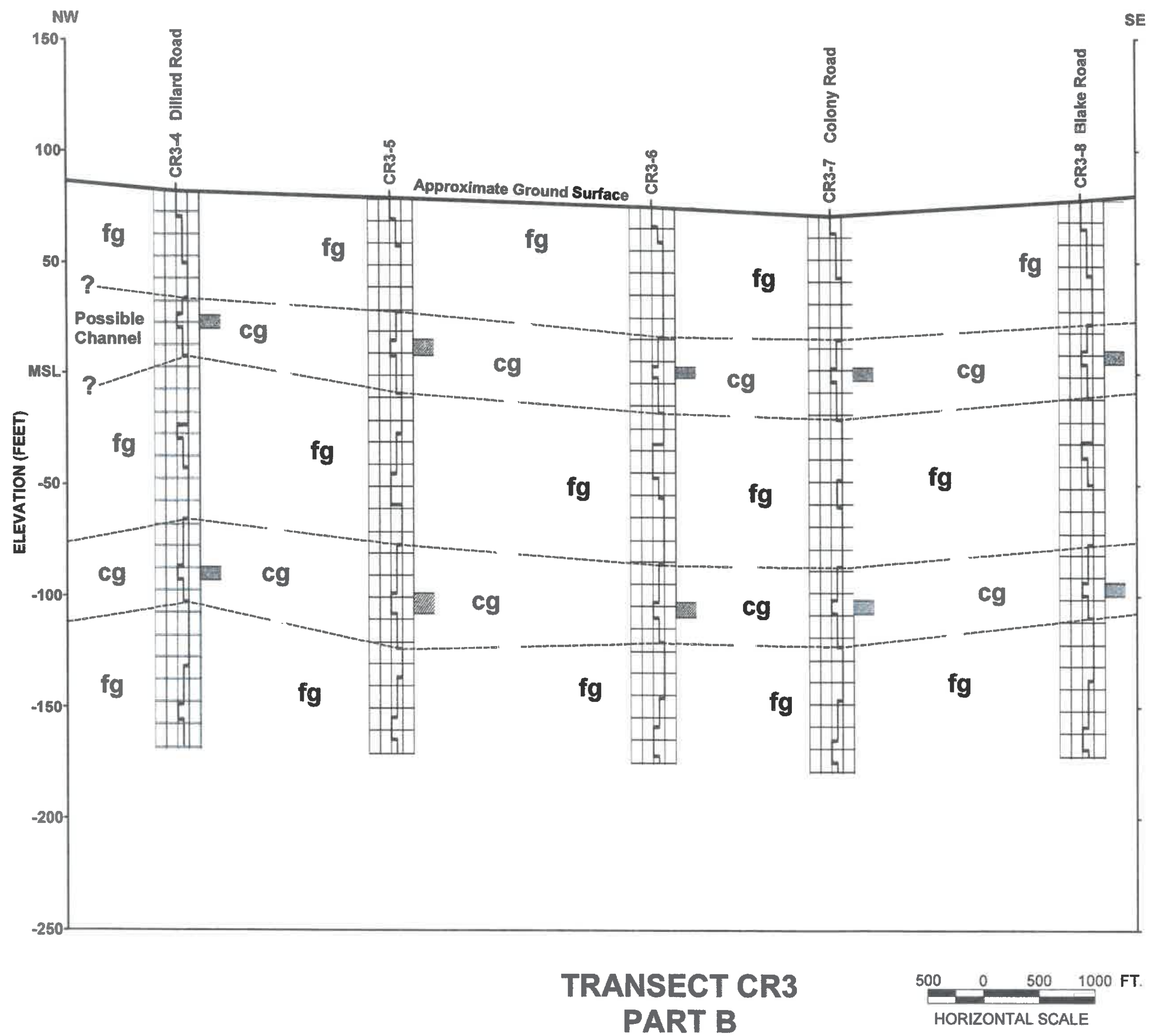
fg Fine-Grained Deposits

# TRANSECT CR3
# PART A

500 0 500 1000 FT.
HORIZONTAL SCALE

GEOCONSULTANTS, INC.
Hydrogeology • Ground-Water Exploration & Development • Ground-Water Resources Management •
1450 Koll Circle, Suite 114
San Jose, California 95112
Phone: (408) 453-2541 Fax: (408) 453-2543

G1876-01 11/20
FIGURE 5A




# TRANSECT CR3
# PART B

## EXPLANATION

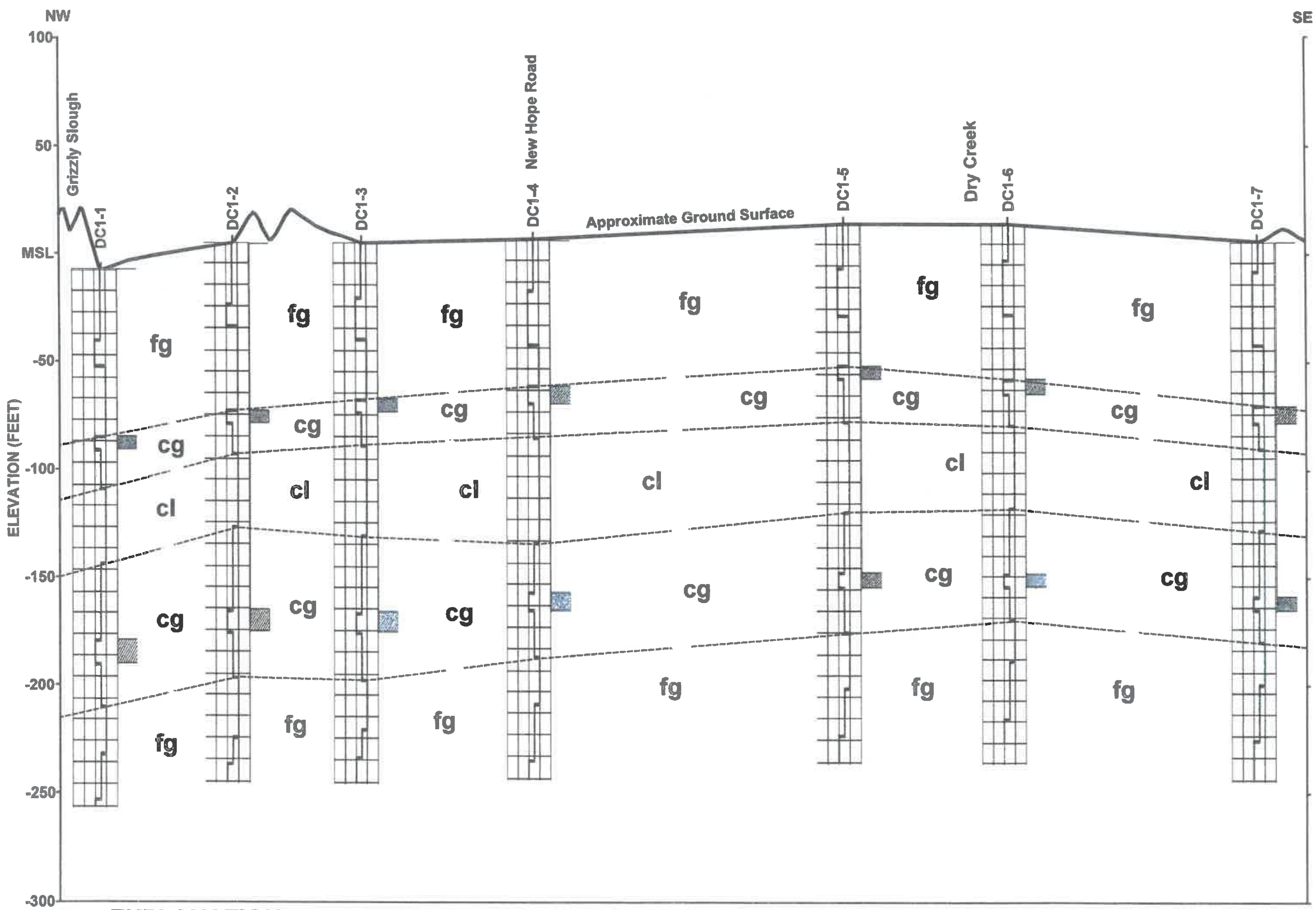
cg Coarse-Grained Deposits With Fluid

fg Fine-Grained Deposits

GEOCONSULTANTS, INC.

G1876-01 11/20

FIGURE 5B




## EXPLANATION

cg Coarse-Grained Deposits With Fluid

fg Fine-Grained Deposits

cl Clay

# TRANSECT DC1

GEOCONSULTANTS, INC.
Hydrogeology * Ground-Water Exploration & Development * Ground-Water Resources Management *
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San Jose, California 95112
Phone: (408) 453-2541 Fax (408) 453-2543

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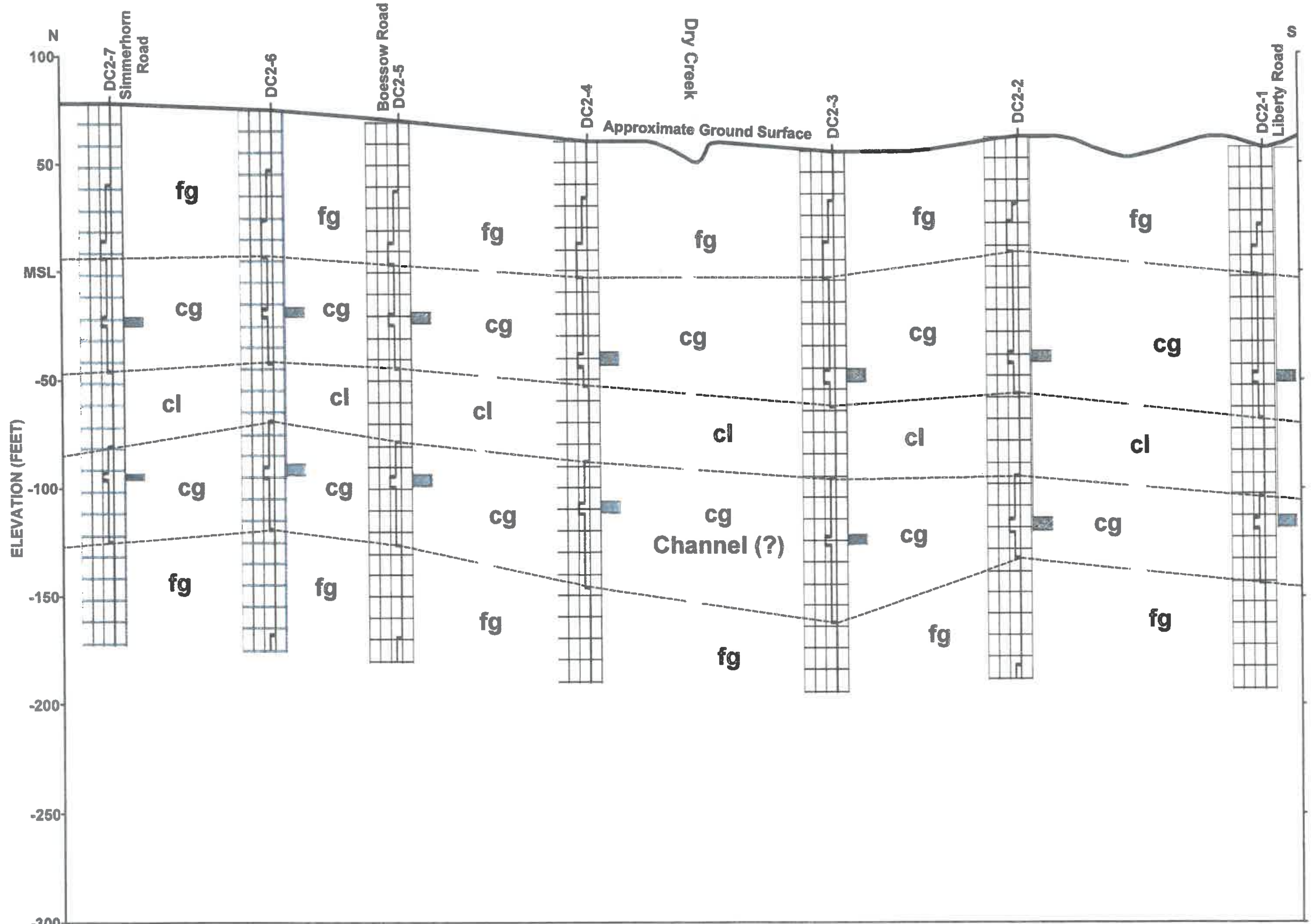
FIGURE 6




## EXPLANATION

**cg** Coarse-Grained Deposits With Fluid

**fg** Fine-Grained Deposits

**cl** Clay

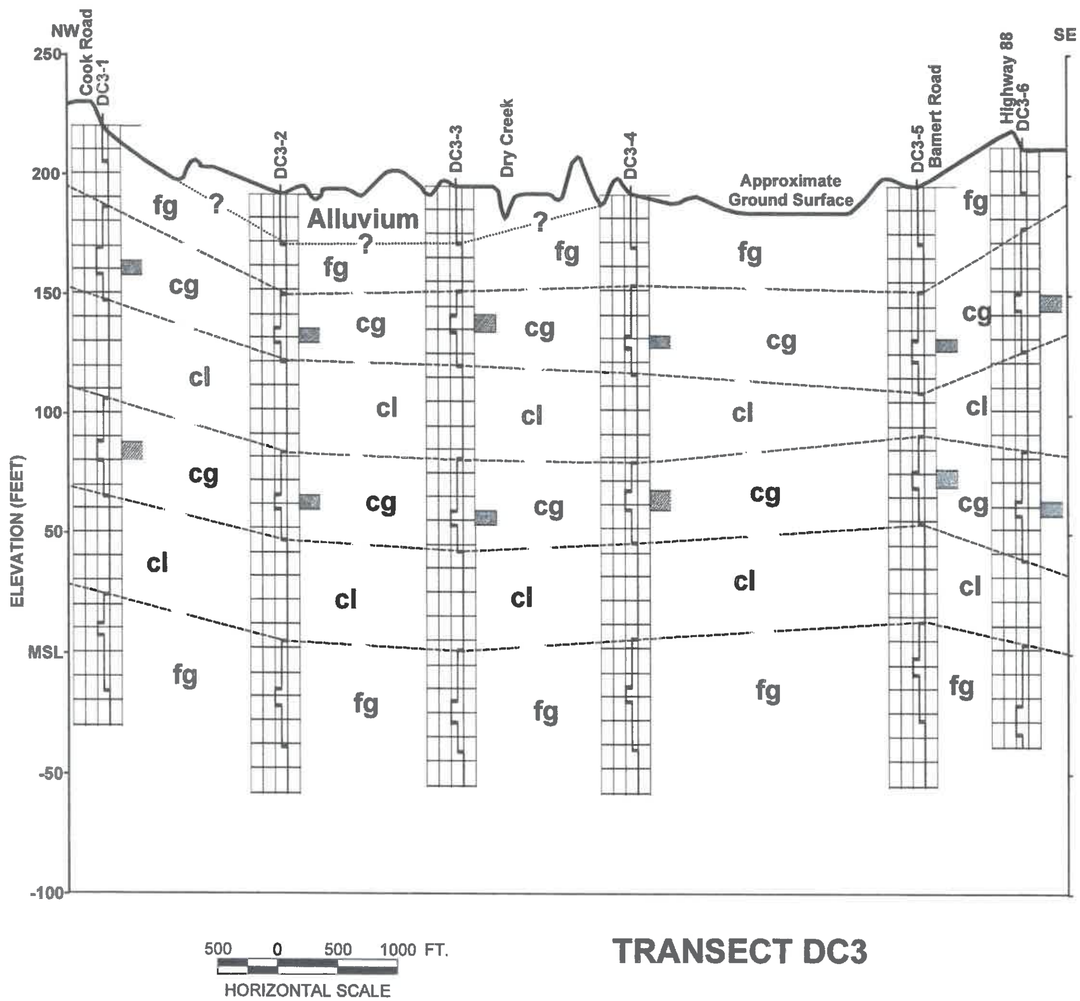
# TRANSECT DC2

GEOCONSULTANTS, INC.

Hydrogeology • Ground-Water Exploration & Development • Ground-Water Resources Management •
1450 Koll Circle, Suite 114
San Jose, California 95112
Phone: (408) 453-2541 Fax: (408) 453-2543

G1876-01 11/20

FIGURE 7




# TRANSECT DC3

## EXPLANATION

| | |
|---|---|
| cg | Coarse-Grained Deposits With Fluid |
| fg | Fine-Grained Deposits |
| cl | Clay |

GEOCONSULTANTS, INC.

Hydrogeology • Ground-Water Exploration & Development • Ground-Water Resources Management •
1450 Koll Circle, Suite 114
San Jose, California 95112
Phone: (408) 453-2541 Fax: (408) 453-2543

G1876-01 11/20

FIGURE 8

# APPENDIX A

## TRANSECT DATA SHEET

## CR2

**GPS Coordinates:**

CR2-1: N38° 22.345'; W121° 19.445'
CR2-2: N38° 22.099'; W121° 19.051'
CR2-3: N38° 22.017'; W121° 18.326'
CR2-4: N38° 21.836'; W121° 17.851'
CR2-5: N38° 21.796'; W121° 17.541'

**CALIBRATION WELLS (Located on Site Plan, Area A):**

Mahon, Dillard Road
DWR Water Well Drillers Report No. 368913
At CR2-1, Log on Figure B-1

Salas Road, 0.4 mile east of Riley Road
DWR Water Well Drillers Report No. 081317
At CR2-5, Log on Figure B-2

**REFERENCE WELL (Not shown on Site Plan, Area A)**

Southeast of intersection of Salas and Riley Roads
DWR Water Well Drillers Report No. e0176844
Log on Figure C-1

## TRANSECT DATA SHEET

## CR3

**GPS Coordinates:**

CR3-1: N38° 24.811'; W121° 16.460'
CR3-2: N38° 24.455'; W121° 15.962'
CR3-3: N38° 24.283'; W121° 15.710'
CR3-4: N38° 24.095'; W121° 15.436'
CR3-5: N38° 23.890'; W121° 15.131'
CR3-6: N38° 23.600'; W121° 14.798'
CR3-7: N38° 23.445'; W121° 14.526'
CR3-8: N38° 23.213'; W121° 14.158'

**CALIBRATION WELLS (Located on Site Plan, Area B):**

Dillard Store, Dillard and Wilton Roads
DWR Water Well Drillers Report No. 42882
At CR3-4, Log on Figure B-3

11860 Blake Road
DWR Water Well Drillers Report No. 730
At CR3-8, Log on Figure B-4

**REFERENCE WELLS**

None

# TRANSECT DATA SHEET

## DC1

**GPS Coordinates:**

DC1-1: N38° 14.997'; W121° 24.408'
DC1-2: N38° 14.876'; W121° 24.206'
DC1-3: N38° 14.283'; W121° 24.148'
DC1-4: N38° 14.465'; W121° 23.964'
DC1-5: N38° 14.890'; W121° 23.624'
DC1-6: N38° 13.852'; W121° 23.483'
DC1-7: N38° 13.445'; W121° 23.222'

**CALIBRATION WELLS:**

None

**REFERENCE WELLS (Not shown on Site Plan, Area C):**

TXO Production Co. "Transamerica-Thornton" 26-1
1700' east of DC 1-1, in projected Section 26, T.5N., R.5 E.
Mud log (see text), Log on Figure C-2

Amerada Petroleum Corp. "Goodfellow-Capital" No. 1
(now Sage Oil Co.)
2000' east of DC 1-2, in projected Section 26, T.5N., R.5 E.
Drillers log and electric log (see text), Logs on Figures C-3 and C-4

## TRANSECT DATA SHEET

## DC2

**GPS Coordinates:**

DC2-1: N38° 14.085'; W121° 13.629'
DC2-2: N38° 14.412'; W121° 13.607'
DC2-3: N38° 14.696';W121° 13.603'
DC2-4: N38° 15.068'; W121° 13.603'
DC2-5: N38° 15.354'; W121° 13.605'
DC2-6: N38° 15.548'; W121° 13.602'
DC2-7: N38° 15.791'; W121° 13.582'

**CALIBRATION WELL (Shown on Site Plan, Area D):**

12180 Boessow Road
DWR Water Well Drillers Report No. 079071
DC 2-5 is about 0.25 mile to the west, Log on Figure B-5

**REFERENCE WELL (Not shown on Site Plan, Area D):**

Located ".26 miles west and .23 miles south" of
Intersection of Alta Mesa and Boessow Roads
DWR Water Well Drillers Report No. 54942, Log on Figure C-5

## TRANSECT DATA SHEET

## DC3

**GPS Coordinates:**

DC3-1: N38º 19.115'; W121º 00.059'
DC3-2: N38º 18.936'; W120º 59.849'
DC3-3: N38º 18.755';W120º 59.644'
DC3-4: N38º 18.587'; W120º 59.429'
DC3-5: N38º 18.226'; W120º 59.236'
DC3-6: N38º 18.108'; W121º 59.126'

**CALIBRATION WELL (Shown on Site Plan, Area E):**

DWR ACGMA Bamert Road Monitor Well (DC 3-5)
Lithologic log and well construction diagram on Figures B-6 through B-9

**REFERENCE WELLS:**

None

# APPENDIX B

**TRIPLICATE**
**Owner's Copy**

STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES

# WATER WELL DRILLERS REPORT

*Do not fill in*

No. 368913

Notice of Intent No. ______
Local Permit No. or Date [illegible]

State Well No. ______
Other Well No. ______

**(1) OWNER:** Name [illegible]
Address [illegible]
City [illegible] ZIP [illegible]

**(2) LOCATION OF WELL (See instructions):**
County [illegible] Owner's Well Number ______
Well address if different from above [illegible]
Township 6 N Range 6 E Section 15
Distance from cities, roads, railroads, fences, etc.
1 mile N. of DILLARD RD.
100 yds. WEST of COSUMNES RIVER

WELL LOCATION SKETCH

**(3) TYPE OF WORK:**
New Well ☒ Deepening ☐
Reconstruction ☐
Reconditioning ☐
Horizontal Well ☐
Destruction ☐ (Describe destruction materials and procedures in Item 12)

**(4) PROPOSED USE:**
Domestic ☒
Irrigation ☒
Industrial ☐
Test Well ☐
Municipal ☐
Other ☒
(Describe)

**(5) EQUIPMENT:**
Rotary ☐ Reverse ☐
Cable ☒ Air ☐
Other ☐ Bucket ☐

**(6) GRAVEL PACK:**
Yes ☐ No ☒ Size ______
Diameter of bore ______
Packed from ______ to ______ ft.

**(7) CASING INSTALLED:**
Steel ☒ Plastic ☐ Concrete ☐

**(8) PERFORATIONS:**
Type of perforation or size of screen ______

| From ft. | To ft. | Dia. in. | Gage or Wall | From ft. | To ft. | Slot size |
|---|---|---|---|---|---|---|
| 0 | 268 | [illegible] | 8 | 168 | 268 | 1x2 |
| | | | | | | |
| | | | | | | |

**(9) WELL SEAL:**
Was surface sanitary seal provided? Yes ☒ No ☐ If yes, to depth 50 ft.
Were strata sealed against pollution? Yes ☐ No ☐ Interval ______ ft.
Method of sealing 9 sk. pea gravel, pumped

**(10) WATER LEVELS:**
Depth of first water, if known 15 ft.
Standing level after well completion 67 ft.

**(11) WELL TESTS:**
Was well test made? Yes ☒ No ☐ If yes, by whom? [illegible]
Type of test Pump ☒ Bailer ☐ Air lift ☐
Depth to water at start of test 67 ft. At end of test ______ ft.
Discharge ______ gal/min after ______ hours Water temperature ______
Chemical analysis made? Yes ☐ No ☒ If yes, by whom? ______
Was electric log made? Yes ☐ No ☒ If yes, attach copy to this report

**(12) WELL LOG:** Total depth 415 ft. Completed depth 410 ft.

| from ft. | to ft. | Formation (Describe by color, character, size or material) |
|---|---|---|
| 0 | 15 | sandy clay |
| 15 | 45 | sand |
| 45 | 50 | clay |
| 50 | 60 | " tan |
| 60 | 80 | br. sand |
| 80 | 128 | br. clay |
| 128 | 152 | sandy br. clay |
| 152 | 156 | mud sand |
| 156 | 172 | sandy clay |
| 172 | 176 | red clay |
| 176 | 204 | sandy red clay |
| 204 | 256 | pea gravel |
| 256 | 272 | br. clay |
| 272 | 282 | blue clay |
| 282 | 400 | sandy blue clay |
| 400 | 415 | blue sand |

Work started 5/21 1991 Completed 12/27/ 1991

**WELL DRILLER'S STATEMENT:**
*This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.*

Signed ______
(Well Driller)
NAME [illegible]
(Person, firm, or corporation) (Typed or printed)
Address [illegible]
City [illegible] ZIP 95758
License No. [illegible] Date of this report 1/15/92

CONFIDENTIAL WATER CODE SEC. 13752

DWR 188 (REV. 12-86)

IF ADDITIONAL SPACE IS NEEDED, USE NEXT CONSECUTIVELY NUMBERED FORM

86 96355

GEOCONSULTANTS, INC.
G1876-01 11/20
FIGURE B-1

**ORIGINAL**
**File with DWR** CT 94

STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES
# WATER WELL DRILLERS REPORT

*Do not fill in*
No. 081317

State Well No.
Other Well No. 06N05E23L

...e of Intent No.
Local Permit No. or Date 6157

(1)
Address
City

(2) LOCATION OF WELL (See instructions):
County — Owner's Well Number
Well address if different from above N/S SALAS RD - #134-250-3300.
Township Wilton Range Section .4 mile
Distance from cities, roads, railroads, fences, etc. E of Riley Rd

WELL LOCATION SKETCH

(3) TYPE OF WORK:
New Well ☑ Deepening ☐
Reconstruction ☐
Reconditioning ☐
Horizontal Well ☐
Destruction ☐ (Describe destruction materials and procedures in Item 12)

(4) PROPOSED USE:
Domestic ☑
Irrigation ☐
Industrial ☐
Test Well ☐
Stock ☐
Municipal ☐
Other ☐

(5) EQUIPMENT:
Rotary ☐ Reverse ☐
Cable ☑ Air ☐
Other ☐ Bucket ☐

(6) GRAVEL PACK:
Yes ☑ No ☐ Size
Diameter of bore 20" Pea Gravel
Packed from 130' to 130 ft.

(7) CASING INSTALLED:
Steel ☑ Plastic ☐ Concrete ☐

| From ft. | To ft. | Dia. in. | Gage or Wall |
|---|---|---|---|
| | 225 | 18" | #10 |

(8) PERFORATIONS:
Type of perforation or size of screen

| From ft. | To ft. | Slot size |
|---|---|---|
| | | |

(9) WELL SEAL:
Was surface sanitary seal provided? Yes ☑ No ☐ If yes, to depth 130' ft.
Were strata sealed against pollution? Yes ☐ No ☑ Interval ft.
Method of sealing Cement Grout.

(10) WATER LEVELS:
Depth of first water, if known ft.
Standing level after well completion ft.

(11) WELL TESTS:
Was well test made? Yes ☐ No ☑ If yes, by whom?
Type of test Pump ☐ Bailer ☐ Air lift ☐
Depth to water at start of test ft. At end of test ft
...arge gal/min after hours Water temperature
...ical analysis made? Yes ☐ No ☑ If yes, by whom?
Was electric log made? Yes ☐ No ☑ If yes, attach copy to this report

(12) WELL LOG: Total depth ft. Depth of completed well ft.

| from ft. | to ft. | Formation (Describe by color, character, size or material) |
|---|---|---|
| 0- | 14 | red C |
| 14- | 21 | Br SC |
| 21- | 29 | grey SC |
| 29- | 72 | red C |
| 72- | 88 | gravel S |
| 88- | 159 | Red C |
| 159- | 176 | Red Br S & muds |
| 176- | 205 | Br S C |
| 205- | 211 | grey Pack |
| 211 | 223 | pea Grav. |
| 223- | 227 | Red C. |
| 227- | 233 | Grey Pack S |
| 233 | 275 | Br C. |
| 275- | 283 | Brown fine C |
| 283 | 301 | Red C |
| 301- | 305 | Br Pack & Pinto Pea Grav |

Work started 19 Completed 19

WELL DRILLER'S STATEMENT:
*This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.*
SIGNED Glen Kunkel Jr (Well Driller)
NAME Lester A Baker Wells & Pumps (Person, firm, or corporation) (Typed or printed)
Address 8370 Elk Grove Blvd
City Elk Grove, Ca Zip 95624
License No. 219295 Date of this report 10/6/81

DWR 188 (REV. 7-76) IF ADDITIONAL SPACE IS NEEDED, USE NEXT CONSECUTIVELY NUMBERED FORM

LOCATION NOT CHECKED

ORIGINAL
File Original, Duplicate and Triplicate with the REGIONAL WATER POLLUTION CONTROL BOARD No. 5
(Insert appropriate number)

# WATER WELL DRILLERS REPORT

(Sections 7076, 7077, 7078, Water Code)

## STATE OF CALIFORNIA

9845

Do Not Fill In
№ 42882
State Well No.
Other Well No. [illegible]

## (1) OWNER

Name
Address

## (2) LOCATION OF WELL:

County Sacramento Owner's number, if any—
R. F. D. or Street No.
[illegible]
at the Dillard Store
just across the RR trackes from
the Dillard School on Dillard Rd.

## (3) TYPE OF WORK (check):

New well XX Deepening ☐ Reconditioning ☐ Abandon ☐
If abandonment, describe material and procedure in Item 11.

## (4) PROPOSED USE (check):

Domestic XX Industrial ☐ Municipal ☐
Irrigation ☐ Test Well ☐ Other ☐

## (5) EQUIPMENT:

Rotary ☐
Cable XX
Dug Well ☐

## (6) CASING INSTALLED:

SINGLE XX DOUBLE ☐

| From ft. | to ft. | Diam. | Gage or Wall | If gravel packed: Diameter of Bore | from ft. | to ft. |
|---|---|---|---|---|---|---|
| | | | | | | |

Type and size of shoe or well ring 1/2" X 4" plow steel
Describe joint ark but welded

## (7) PERFORATIONS:

Type of perforator used none
Size of perforations in., length, by in.

| From ft. | to ft. | Perf. per row | Rows per ft. |
|---|---|---|---|
| | | | |

## (8) CONSTRUCTION:

Was a surface sanitary seal provided? ☐ Yes XX No To what depth ft.
Were any strata sealed against pollution? ☐ Yes XX No If yes, note depth of strata
From ft. to ft.
Method of Sealing

## (9) WATER LEVELS:

Depth at which water was first found 50 ft.
Standing level before perforating ft.
Standing level after perforating ft.

## (10) WELL TESTS:

Was a pump test made? ☐ Yes ☐ No If yes, by whom?
Yield: gal./min. with ft. draw down after hrs.
Temperature of water Was a chemical analysis made? ☐ Yes ☐ No
Was electric log made of well? ☐ Yes ☐ No

## (11) WELL LOG:

Total depth 120 ft. Depth of completed well 112 ft.
Formation: Describe by color, character, size of material, and structure.

| ft. | to ft. | Formation |
|---|---|---|
| 0 | 3 | top soil |
| 3 | 7 | hard pan |
| 7 | 14 | red sandy clay |
| 14 | 20 | dry sand |
| 20 | 31 | stickey yellow clay |
| 31 | 37 | small gravel |
| 37 | 48 | red clay |
| 48 | 52 | silt & pea gravel |
| 52 | 73 | silty red clay |
| 73 | 76 | tight sand & pea gravel |
| 76 | 85 | soft crumbly red clay |
| 85 | 97 | tight red clay |
| 97 | 106 | silty red clay |
| 106 | 112 | small gravel |
| 112 | 120 | sandy redclay |

CONFIDENTIAL
Section 7076.1, Water Code

FOR OFFICIAL USE ONLY

Work started Aug. 14 57. Completed Aug 16 1957

WELL DRILLER'S STATEMENT:
This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

NAME LYLE W. CORNELIUS
(Person, firm, or corporation) (Typed or printed)
WELL DRILLING
Address Phone GI 8-6410 2809 Land Park Dr
SACRAMENTO, CALIF.

[SIGNED] Lyle W. Cornelius
Well Driller

License No. 142613 Dated , 19

95689 2-54 8OM QUIN SPO

DWR FORM NO. 246 (REV. 3-54)

GEOCONSULTANTS, INC.
G1876-01 11/20
FIGURE B-3

ORIGINAL
File with DWR

CONFIDENTIAL LOG
Water Code Sec. 13752

# WATER WELL DRILLERS REPORT

(Sections 7079, 7080, 7081, 7082, Water Code)

## THE RESOURCES AGENCY OF CALIFORNIA
## DEPARTMENT OF WATER RESOURCES

*Do Not Fill In*

№ 730

State Well No. ____
Other Well No. 6N/7E-7

**(2) LOCATION OF WELL:**
County Sac    Owner's number, if any
Township, Range, and Section
Distance from cities, roads, railroads, etc. 11860 Blake Rd
Galt Cal.

**(3) TYPE OF WORK (check):**
New Well ☑  Deepening ☐  Reconditioning ☐  Destroying ☐
*If destruction, describe material and procedure in Item 11.*

**(4) PROPOSED USE (check):**
Domestic ☑  Industrial ☐  Municipal ☐
Irrigation ☐  Test Well ☐  Other ☐

**(5) EQUIPMENT:**
Rotary ☐
Cable ☑
Other ☐

**(6) CASING INSTALLED:**
STEEL: ✓  OTHER:
SINGLE ☑  DOUBLE ☐

If gravel packed

| From ft. | To ft. | Diam. | Gage or Wall | Diameter of Bore | From ft. | To ft. |
|---|---|---|---|---|---|---|
| 0 | 140 | 6 7/8 | 12 | | | |

Size of shoe or well ring: 4 1/2 6 7/8 x 7/8    Size of gravel:
Describe joint Welded

**(7) PERFORATIONS OR SCREEN:**
Type of perforation or name of screen

| From ft. | To ft. | Perf. per row | Rows per ft. | Size in. x in. |
|---|---|---|---|---|
| | | | | |

**(8) CONSTRUCTION:**
Was a surface sanitary seal provided? Yes ☑ No ☐    To what depth 70 ft.
Were any strata sealed against pollution? Yes ☐ No ☐    If yes, note depth of strata
From 0 ft. to 70 ft.
From ft. to ft.
Method of sealing Cement Grout

**(9) WATER LEVELS:**
Depth at which water was first found, if known 98 ft.
Standing level before perforating, if known ft.
Standing level after perforating and developing 95 ft.

**(10) WELL TESTS:**
Was pump test made? Yes ☐ No ☐    If yes, by whom?
gal./min. with    ft. drawdown after    hrs.
Temperature of water    Was a chemical analysis made? Yes ☐ No ☐
Was electric log made of well? Yes ☐ No ☐    If yes, attach copy

**(11) WELL LOG:**
Total depth 210 ft.    Depth of completed well 180 ft.
Formation: *Describe by color, character, size of material, and structure*

| ft. to ft. | Formation |
|---|---|
| 0–4 | Brown Top Soil |
| 4–10 | Brown Hard Pan |
| 10–25 | " " Clay Hard |
| 25–40 | " " Clay Soft |
| 40–65 | " " Clay & Sand |
| 65–75 | " " Clay gravel |
| 75–90 | Yellow Clay & Gravel |
| 90–110 | " " " " |
| 110–130 | Brown Clay Hard Sand |
| 130–145 | " " " Sand & Gravel |
| 145–180 | " " " " " |
| 180–220 | " " " " " " |

CONFIDENTIAL LOG
Water Code Sec. 13752

Work started 5-8 1970, Completed 5-13 1970

**WELL DRILLER'S STATEMENT:**
*This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.*

NAME PRESTON WELL DRILLING, 2444 MORAINE CIRCLE, RANCHO CORDOVA, CALIF. 95670
(Person, firm, or corporation) (Typed or printed)

Address PRESTON WELL DRILLING, 2444 MORAINE CIRCLE, RANCHO CORDOVA, CALIF. 95670

[SIGNED] [signature]
(Well Driller)

License No. 253916    Dated 5-10, 1970

SKETCH LOCATION OF WELL ON REVERSE SIDE

XC R. Ford

DWR 188 (REV. 9-65)

86551-950 10-65 NOM TRIP ① △ OSP

GEOCONSULTANTS, INC.
G1876-01 11/20
FIGURE B-4

152-0240-016

**ORIGINAL**

**File with DWR** CT 94

STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES

# WATER WELL DRILLERS REPORT

*Do not fill in*

No. 079071

State Well No. 05N 07E 28

Other Well No. ____

Notice of Intent No. ____

Local Permit No. or Date 5911 80

**(12) WELL LOG:** Total depth 620 ft. Depth of completed well 620 ft.

| from ft. | to ft. | Formation (Describe by color, character, size or material) |
|---|---|---|
| 0 | 100 | clay |
| 100 | 110 | sand + Rock |
| 110 | 150 | clay |
| 150 | 160 | sand + Rock |
| 160 | 300 | clay |
| 300 | 310 | sand |
| 310 | 390 | clay |
| 390 | 405 | sand |
| 405 | 500 | clay |
| 500 | 510 | sand |
| 510 | 600 | clay |
| 600 | 620 | sand |

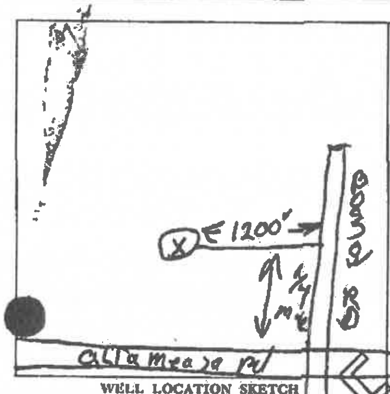
**(2) LOCATION OF WELL** (See instructions):

County ____ Owner's Well Number ____

Well address if different from above 12180 BOESSOW RD

Township ____ Range ____ Section ____

Distance from cities, roads, railroads, fences, etc. ____




WELL LOCATION SKETCH

**(3) TYPE OF WORK:**
New Well ☑ Deepening ☐
Reconstruction ☐
Reconditioning ☐
Horizontal Well ☐
Destruction ☐ (Describe destruction materials and procedures in Item 12)

**(4) PROPOSED USE:**
Domestic ☐
Irrigation ☑
Industrial ☐
Test Well ☐
Stock ☐
Municipal ☐
Other ☐

**(5) EQUIPMENT:**
Rotary ☐ Reverse ☐
Cable ☑ Air ☐
Other ☐ Bucket ☐

**(6) GRAVEL PACK:**
Yes ☐ No ☑ Size ____
Diameter of bore ____
Packed from ____ to ____

**(7) CASING INSTALLED:**
Steel ☑ Plastic ☐ Concrete ☐

| From ft. | To ft. | Dia. in. | Gage or Wall |
|---|---|---|---|
| 0 | 260 | 16 | 1/4 |

**(8) PERFORATIONS:**
Type of perforation or size of screen ____

| From ft. | To ft. | Slot size |
|---|---|---|
| | | |

**(9) WELL SEAL:**
Was surface sanitary seal provided? Yes ☑ No ☐ If yes, to depth ____ ft.
Were strata sealed against pollution? Yes ☐ No ☐ Interval ____ ft.
Method of sealing ____

**(10) WATER LEVELS:**
Depth of first water, if known 100 ft.
Standing level after well completion 100 ft.

**(11) WELL TESTS:**
Was well test made? Yes ☐ No ☑ If yes, by whom? ____
Type of test Pump ☐ Bailer ☐ Air lift ☐
Depth to water at start of test ____ ft. At end of test ____ ft
Discharge ____ gal/min after ____ hours Water temperature ____
Chemical analysis made? Yes ☐ No ☑ If yes, by whom? ____
Was electric log made? Yes ☐ No ☑ If yes, attach copy to this report

Work started ____ 19__ Completed ____ 19__

**WELL DRILLER'S STATEMENT:**
This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

SIGNED [signature] (Well Driller)

NAME JL GROSS + Sons BM/33
(Person, firm, or corporation) (Typed or printed)

Address 472 Sunset Rd

City Galt CA Zip ____

License No. 530019 Date of this report 12-21-90

DWR 188 (REV. 7-76) IF ADDITIONAL SPACE IS NEEDED, USE NEXT CONSECUTIVELY NUMBERED FORM



GEOCONSULTANTS, INC.
G1876-01 11/20
FIGURE B-5

**State of California, Natural Resources Agency, Department of Water Resources**

# Exploratory Boring Log

**Project:** SGMA TSS - Cosumnes Subbasin

**Well Number:** ACGMA Barnett Road MW

**Latitude:**

**Longitude:**

**Survey Method:**

**Datum:**

**Reference Point Elevation & Height Above Ground Surface:**

**Datum:**

**County:** Amador

**Logger (full name, title, organization):** Bryce Russell, Engineering Geologist, DWR

**Groundwater Sustainability Agency Name:** ACGMA Amador County Groundwater Management Authority

**Driller (full name, title, organization):**

**Date & Time Began:** 7/10/19 1430

**Drilling Rig Model & Method:** Speedstar 50K, Mud Rotary

**Date & Time Completed:**

**Drill Rod Type & Diameter:** 4"

**Total Depth Drilled (feet, bgs):** 330'

**Drill Bit Type and Diameter:** 8½" tri-cone

**Geophys-Log Description and Depth (feet, bgs):**

**Sampler Type Information:** Grab

**Conductor Casing Information:** Temp 10" conductor

**General Well Construction or Borehole Abandonment Information (full well construction details to be entered on separate form):**

**Groundwater Levels (during and after drilling):**

| Drill Time | Depth (feet) | Graphic/ Symbol | % by: Visual or Sieve (circle) 4 peb | 8 vf gvl | 30 c sd | 100 f sd | 200 vf sd/slt | cl | Field Classification and Description |
|---|---|---|---|---|---|---|---|---|---|
| 1430 | 0 | ML | | | | | | | Sand Silt (ML) Loam (TOP Soil) 0-3' |
| | ▽ | SM | | | T | 60 | 40 | | Silty Sand (SM). Strong Brown (7.5 YR 5/6) 60% fine sand, 40% silt, trace medium sand, loose, wet. Iron oxide staining. saturated @ 5' |
| | 10 | | | | | | | | Same as Above (SAA). - NO Fe Staining Silt content increasing w/ depth Color change to 10YR 4/3 Brown. Likely perched water zone - dry @ 20' |
| 1500 (7/11/19) | 20 | | | | | | | | Fat clay w/ Sand. Olive (5Y 5/3), high plasticity, hard consistency, dry. |
| 0805 | 30 | | | | | | | | Well Graded Sand (SW). Greenish black (GLEY1 2.5/5G), 40% coarse sand, 30% medium sand, 30% fine sand, trace small gravels, angular to sub-angular. |
| | 30' | | | | | | | | Silty Sand (SM), very dark greenish gray (GLEY1 4/10GY), 30% coarse sand, 10% med sand, 20% f[illegible] sand, 30% NP fines, grading finer w/ depth |
| | 40 | | | | | | | | Clayey Silt w/ sand (ML), Grayish green (GLEY1 4/5G) 80% low plasticity fines, [illegible]% fine to medium sand, [illegible] consistency, |
| 0915 | 50 | | | | | | | | |



GEOCONSULTANTS, INC.
G1876-01 11/20
FIGURE B-6

State of California, Natural Resources Agency, Department of Water Resources
Exploratory Boring Log

**Project:** SGMA TSS - Cosumnes Subbasin **Well Number:** ACGMA Barnett Rd MW

| Drill Time | Depth (feet) | Graphic/Symbol | % by: Visual or Sieve (circle) 4 peb | 8 vf gvl | 30 c sd | 100 f sd | 200 vf sd/slt | cl | Field Classification and Description |
|---|---|---|---|---|---|---|---|---|---|
| 0915 | | | | | | | | | Well Graded Sand w/Silt (SW-SC). Greenish gray (GLEY1 4/5G), 40% fine sand, 40% medium sand, 10% coarse sand, 10% low plasticity fines, sub-rounded. Rig Chatter @ 56'-62' |
| | 60 | | | | | | | | Well Graded Sand w/Gravel (SW). 30% coarse sand, 20% medium sand, 10% fine sand, 40% fine gravel, trace coarse gravel, angular to sub-rounded, light gray sandstone + dark green claystone |
| 0945 | 70 | | | | | | | 78' | Silt w/Sand (ML). Light greenish gray (GLEY1 7/10GY) 25% fine to medium sand, 75% NP fines, soft consistency, rapid dilatancy. |
| 0955 | 80 | | | | | | | | Fat Clay (CH). Dark greenish gray (GLEY1 4/5G), high plasticity, medium consistency, 10% fine sand. Increasing fine sand content w/depth |
| 1005 | 90 | | | | | | | 94' | SAA ~~Rig Chatter 90-100'~~ Well Graded Gravel w/Sand (GW). Greenish black (GLEY1 2.5/5G), 60% fine gravel, 20% coarse sand, 10% medium sand, 10% fine sand, angular. |
| 1020 | 100 | | | | | | | | Well Graded Sand (SW). Dark greenish gray (GLEY1 4/5G) 60% medium sand, 30% fine sand, 10% coarse sand, trace gravel |
| | 110 | | | | | | | 115 | SAA. Fat Clay (CH). Grayish green (GLEY1 4/5G), |
| 1045 | 120 | | | | | | | | high plasticity, medium consistency, 10% fine sand. |
| | 130 | | | | | | | | Well Graded Sand (SW). Dark greenish gray (GLEY1 4/5G), 50% medium sand, 40% fine sand, 10% coarse sand, trace gravel. Rig Chatter @ 135'-150' |
| 1110 | 140 | | | | | | | | SAA - Grain size increasing w/depth 65% medium, 25% fine, 10% coarse |
| 1125 | 150 | | | | | | | | |



GEOCONSULTANTS, INC.
G1876-01 11/20
FIGURE B-7

State of California, Natural Resources Agency, Department of Water Resources
**Exploratory Boring Log**

**Project:** SGMA TSS - Cosumnes Subbasin | **Well Number:** XGMA Barnett Rd MW

| Drill Time | Depth (feet) | Graphic/ Symbol | % by: Visual or Sieve (circle): 4 peb | 8 vf gvl | 30 c sd | 100 f sd | 200 vf sd/slt | cl | Field Classification and Description |
|---|---|---|---|---|---|---|---|---|---|
| 1125 | | | | | | | | | SAA (SW) - Interbedded w/ soft high plasticity Fat Clay (CH). |
| 1130 | 160 | | | | | | | | SAA<br>- - - - - - - - - - -<br>Fat Clay (CH). Greenish gray (GLEY1 5/10GY), |
| | 170 | | | | | | | | high plasticity, stiff to very stiff consistency<br>Heavy Rig Chatter @ 175'-178'<br>Greenish black angular clasts of greenstone? |
| 1200 | 180 | | | | | | | | Fat clay (CH) as above, with ~10% fine sand increasing w/ depth |
| 1210 | 190 | | | | | | | | SAA<br>Sandy Fat Clay (CH). Very dark grayish green (GLEY1 3/5G), 70% high plasticity clay, medium |
| 1220 | 200 | | | | | | | | consistency, 30% fine sand. |
| | 210 | | | | | | | 218 | Fat Clay (CH), Greenish gray (GLEY1 5/10GY), high plasticity, medium consistency, trace fine sand.<br>Heavy Rig chatter 218'-220' |
| 1245 | 220 | | | | | | | | Well Graded Sand (SW). Dark greenish gray (GLEY2 4/5BG), 40% coarse sand, 40% medium sand, 10% fine sand 10% fine gravel, sub-angular to angular |
| | 230 | | | | | | | | Fat clay (CH) as above |
| 1315 | 240 | | | | | | | | SAA |
| 1340 | 250 | | | | | | | | |



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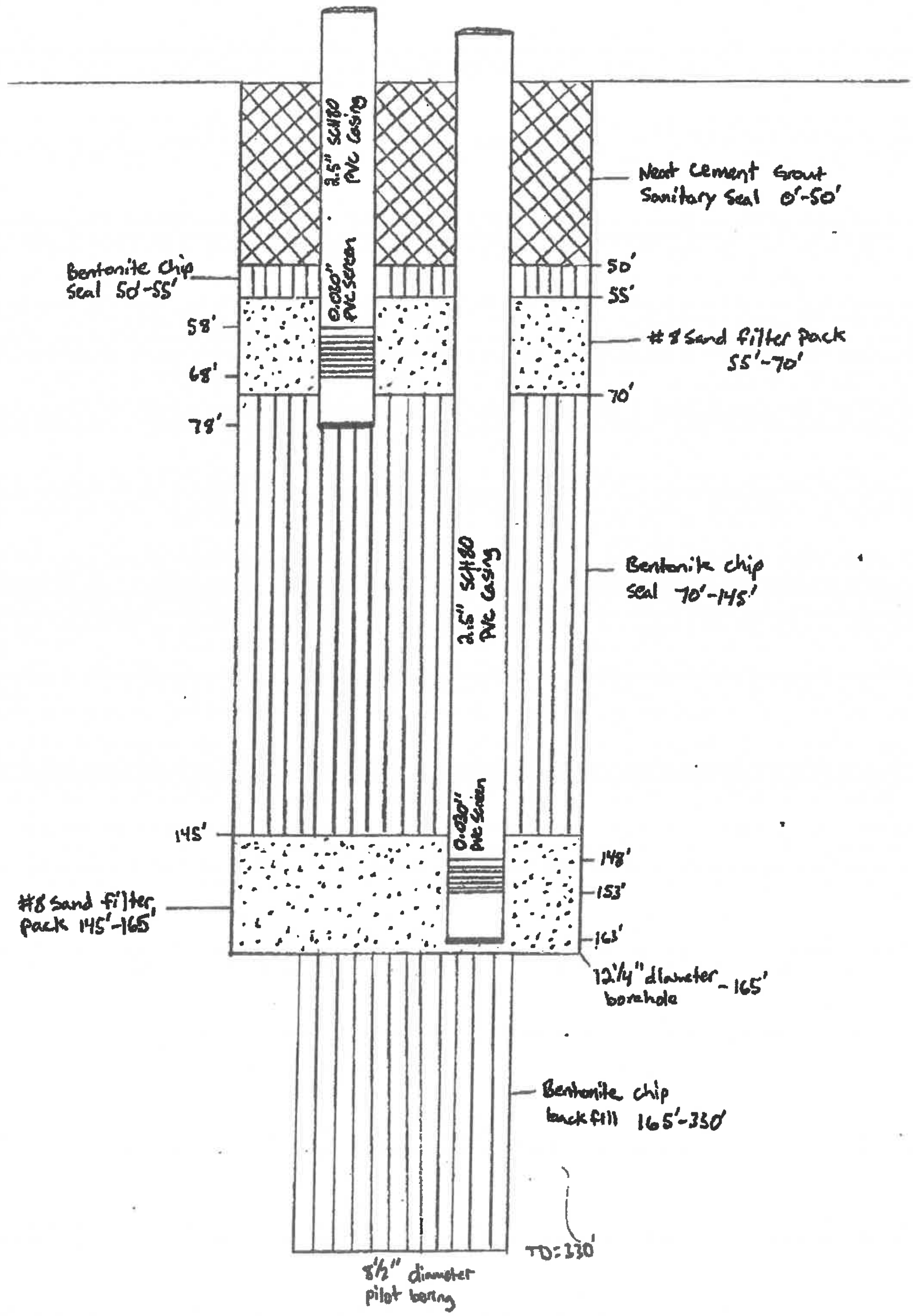
G1876-01 11/20
FIGURE B-8




GEOCONSULTANTS, INC.
G1876-01 11/20
FIGURE B-9

# APPENDIX C

*The free Adobe Reader may be used to view and complete this form. However, software must be purchased to complete, save, and reuse a saved form.

File Original with DWR

State of California

# Well Completion Report

*Refer to Instruction Pamphlet*

No. e0176844

Page ________ of ________

Owner's Well Number ____________________

Date Work Began ____________ Date Work Ended 3/15/2013

Local Permit Agency SACRAMENTO COUNTY

Permit Number 51821 Permit Date 9/6/12

**DWR Use Only – Do Not Fill In**

06N06E23

State Well Number/Site Number

382124 N | 1211738 W

Latitude | Longitude

APN/TRS/Other

## Geologic Log

Orientation ⦿ Vertical ○ Horizontal ○ Angle Specify ________

Drilling Method CABLE Drilling Fluid ________

| Depth from Surface Feet | to Feet | Description (Describe material, grain size, color, etc) |
|---|---|---|
| 0 | 15 | CLAY |
| 15 | 35 | SAND AND ROCK |
| 35 | 90 | CLAY |
| 90 | 92 | SAND |
| 92 | 128 | DIRT |
| 128 | 162 | BROWN CLAY |
| 162 | 230 | BROWN SAND AND ROCK |
| 230 | 280 | BROWN CLAY |
| 280 | 350 | BROWN DIRT |
| 350 | 360 | BLUE CLAY |
| 360 | 390 | BLUE HARD SAND |
| 390 | 460 | BLUE CLAY |
| 460 | 505 | BLUE SANDY CLAY |
| 505 | 510 | SAND AND ROCK |
| 510 | 530 | BLUE CLAY |
| 530 | 535 | SHALE AND BLUE CLAY |
| 535 | 615 | BLUE CLAY |
| 615 | 640 | HARD SAND |
| 640 | 695 | HARD SAND |
| 695 | 700 | BLUE CLAY |
| 700 | | SHALE |

Total Depth of Boring 700 Feet

Total Depth of Completed Well ____________ Feet

## Well Owner

## Well Location

Address 0 RILEY ROAD

City WILTON County Sacramento

Latitude ____ ____ ____ N Longitude ____ ____ ____ W (Deg. Min. Sec.)

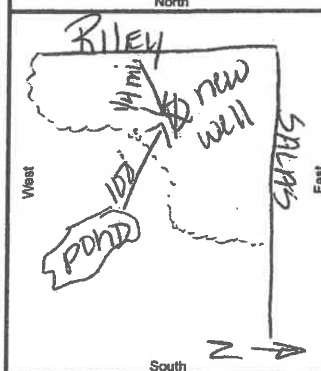
Datum ________ Decimal Lat. ________ Decimal Long. ________

APN Book ________ Page ________ Parcel 134-0280-065

Township ________ Range ________ Section ________

## Location Sketch

(Sketch must be drawn by hand after form is printed.)




Illustrate or describe distance of well from roads, buildings, fences, rivers, etc. and attach a map. Use additional paper if necessary. Please be accurate and complete.

## Activity

⦿ New Well
○ Modification/Repair
○ Deepen
○ Other ________
○ Destroy
Describe procedures and materials under "GEOLOGIC LOG"

## Planned Uses

⦿ Water Supply
☐ Domestic ☐ Public
☑ Irrigation ☐ Industrial
○ Cathodic Protection
○ Dewatering
○ Heat Exchange
○ Injection
○ Monitoring
○ Remediation
○ Sparging
○ Test Well
○ Vapor Extraction
○ Other ________

## Water Level and Yield of Completed Well

Depth to first water 88 (Feet below surface)

Depth to Static Water Level ________ (Feet) Date Measured ________

Estimated Yield * ________ (GPM) Test Type ________

Test Length ________ (Hours) Total Drawdown ________ (Feet)

*May not be representative of a well's long term yield.

## Casings

| Depth from Surface Feet | to Feet | Borehole Diameter (Inches) | Type | Material | Wall Thickness (Inches) | Outside Diameter (Inches) | Screen Type | Slot Size if Any (Inches) |
|---|---|---|---|---|---|---|---|---|
| 0 | 238 | 16 | Blank | Low Carbon Steel | 188 | 16 | | |
| 380 | 400 | 12 3/4 | Perforated | Low Carbon Steel | 188 | 12 3/4 | | |
| 400 | 540 | 12 3/4 | Blank | Low Carbon Steel | 188 | 12 3/4 | | |

## Annular Material

| Depth from Surface Feet | to Feet | Fill | Description |
|---|---|---|---|
| 0 | 50 | Cement | 6 SACK PEA |

## Attachments

☐ Geologic Log
☐ Well Construction Diagram
☐ Geophysical Log(s)
☐ Soil/Water Chemical Analyses
☐ Other ________

Attach additional information, if it exists.

## Certification Statement

I, the undersigned, certify that this report is complete and accurate to the best of my knowledge and belief

Name KEN GROSS PUMP SERVICE (Person, Firm or Corporation)

353 N. LINCOLN WAY (Address) GALT (City) CA (State) 95632 (Zip)

Signed ____________ (C-57 Licensed Water Well Contractor) 05/16/2013 (Date Signed) 530672 (C-57 License Number)

DWR 188 REV. 1/2006

IF ADDITIONAL SPACE IS NEEDED, USE NEXT CONSECUTIVELY NUMBERED FORM

067-20242

# ENERGYLOG

2MUD1

ENERGY WELL LOGGING SERVICE

COMPANY TXO PRODUCTION CORPORATION
WELL "Tenneco-Thornton" 26-1
FIELD Thornton Gas Field
LOCATION Sec. 26, T5N-R5E; MDB&M
Fr NE cor 2629'N 4752'S
COUNTY Sacramento STATE CA
ELEVATION 6.4'(GL) 21.4'(KB)
API WELL INDEX NO. 067-20242
SPUD DATE 3 Oct. 84 TIME 12:00 PM
LOG DATES 4 Oct. 84 TO 6 Oct. 84
LOG DEPTHS 540' TO 4450'
LOGGING GEOLOGISTS Dave Backs, John Hoolard

ENERGYLOG UNIT Frio
CO. GEOLOGIST Andrew Smith
CO. ENGINEER Jay Morton
CO. PUSHER Bob Holihan
DRILLING CO. Hunnicutt & Camp
RIG 1 PUSHER Ed Stanley
MUD COMPANY Al Barnold
MUD ENGINEER Bud Ball
MUD TYPE Thermo-Thin/Drispac

PUMPS: No. 1 Emsco D500 5 X 16
No. 2 Emsco D300 5 X 14

OCT 29 1984 WOODLAND, CALIFORNIA

| HOLE SIZE | | CASING SIZE | |
|---|---|---|---|
| 12 1/4" | TO 540' | 8 5/8" | TO 540' |
| 7 7/8" | TO 4450' | | TO |
| | TO | | TO |
| | TO | | TO |

**LITHOLOGY SYMBOLS**

CHERT, VOL. CONGL, ALTER. DIKE, LIME, DOLO., GYPSUM AND ANHYDRITE, SALT, COAL AND LIGNITE, CLAY, SHALE, SILTSTONE, SANDY SHALE, SAND, SAND-STONE, ...

**MUD DATA**

w WEIGHT pcf
v VISCOSITY
f FILTRATE
fc FILTER CAKE
sd SAND % VOL
s SALINITY ppm Cl⁻
sol SOLIDS % VOL
T TEMPERATURE °F
Rm RESISTIVITY OF MUD at 75°F
Rf RESISTIVITY OF FILTRATE at 75°F

**DRILLING DATA**

NB NEW BIT
RRB RERUN BIT
RTB RETIP BIT
CB CORE BIT
WOB WEIGHT ON BIT (lbs.)
RPM ROTARY REVS/MIN
Pp PUMP PRESSURE (psi)
SPM STROKES/MINUTE

**OTHER DATA**

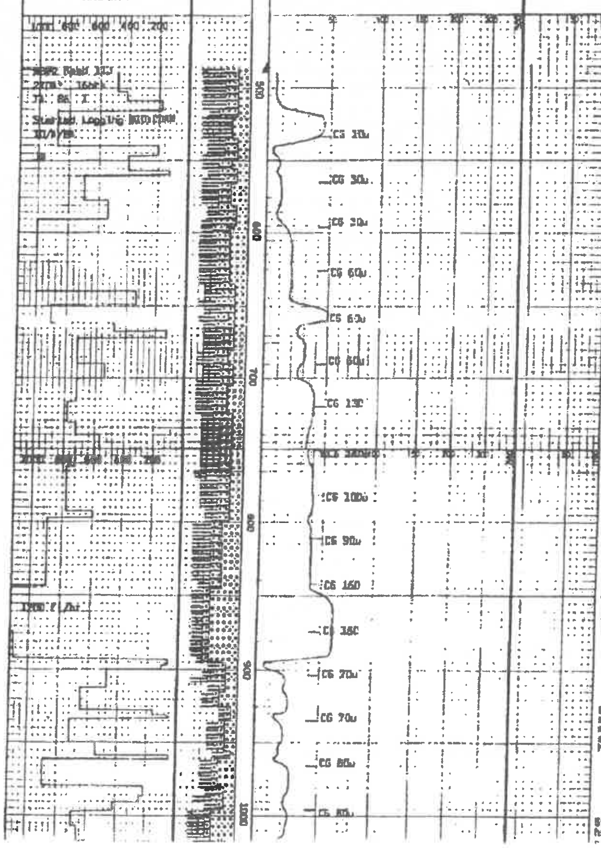
TG TRIP GAS
STG SHORT TRIP GAS
CG CONNECTION GAS
CR CIRCULATED RETURNS
NR NO RETURNS
LAT LOGGED AFTER TRIP
C CARBIDE
DST DRILL STEM TEST
DST INTERVAL
CORE INTERVAL
CASING POINT

DIRECT. CO.
DIRECT. ENGR.
DIRECT. K.O.P.

LIVE OIL IN MUD OR CUTTINGS
• SLIGHT TRACE •••• GOOD
•• TRACE ••••• EXCELLENT
••• FAIR

OIL based on live oil in unwashed cuttings, mud, and % staining of washed cuttings.
GAS detector calibration records 100 units with a mixture of 2% by volume methane in air.
CHROMATOGRAPH values at parts per million (PPM).
DEPTHS derived from drillers pipe measurements at kelly bushing.

| DRILL RATE (FT/HR) AND DATA | LITH | DEPTH | DITCH GAS: TOTAL GAS / PETROLEUM VAPORS / LIVE OIL IN MUD • •• ••• •••• ••••• | CUTTINGS GAS: TOTAL / PET VAP / LIVE OIL • •• ••• •••• ••••• | REMARKS |
|---|---|---|---|---|---|




Ran 13 jts 8 5/8" 24# K-55 ST&C csg to 540'

Rig water salinity=100

SLTST: lt gn-gn gy frm fri blky occ sdy, mnr gn frm-mod hd blky sl calc clyst, mnr lt gy vf-c lse con-mod hd v p srtd ang-sbang ss, pred clr qtz ed gr tr red brn lith gr tr mica

Cs30u 7 45v / 50cc
Lag=7.0min / 51spm

SLTST: lt gn-gy gn frm fri blky occ sl sdy mnr gn frm-mod hd blky sl calc clyst, mnr lt gy vf-c lse con-mod hd v p srtd ang-sbrd clr ss, pred clr frosted qtz gr, tr mica

SS: lt gy vf-f occ c-m lse-hd mod srtd sbang-sbrd pred wh-lt gy cly mtx occ calc cmt, pred clr qtz gr, mnr lt gn frm blky sl sdy sltst, mnr gn frm blky clyst

CLYST: lt gn-gn gy v sft-frm mod hyd mtr sol blky occ sdy, mnr lt gy-gn frm fri blky occ sdy sltst, mnr lt gy vf-f frm-hd mod srtd ss, tr mica

SS: gy-lt gy vf-f occ m-c mod hd-lse con mod srtd sbang-sbrd

GEOCONSULTANTS, INC.
G1876-01 11/20
FIGURE C-2

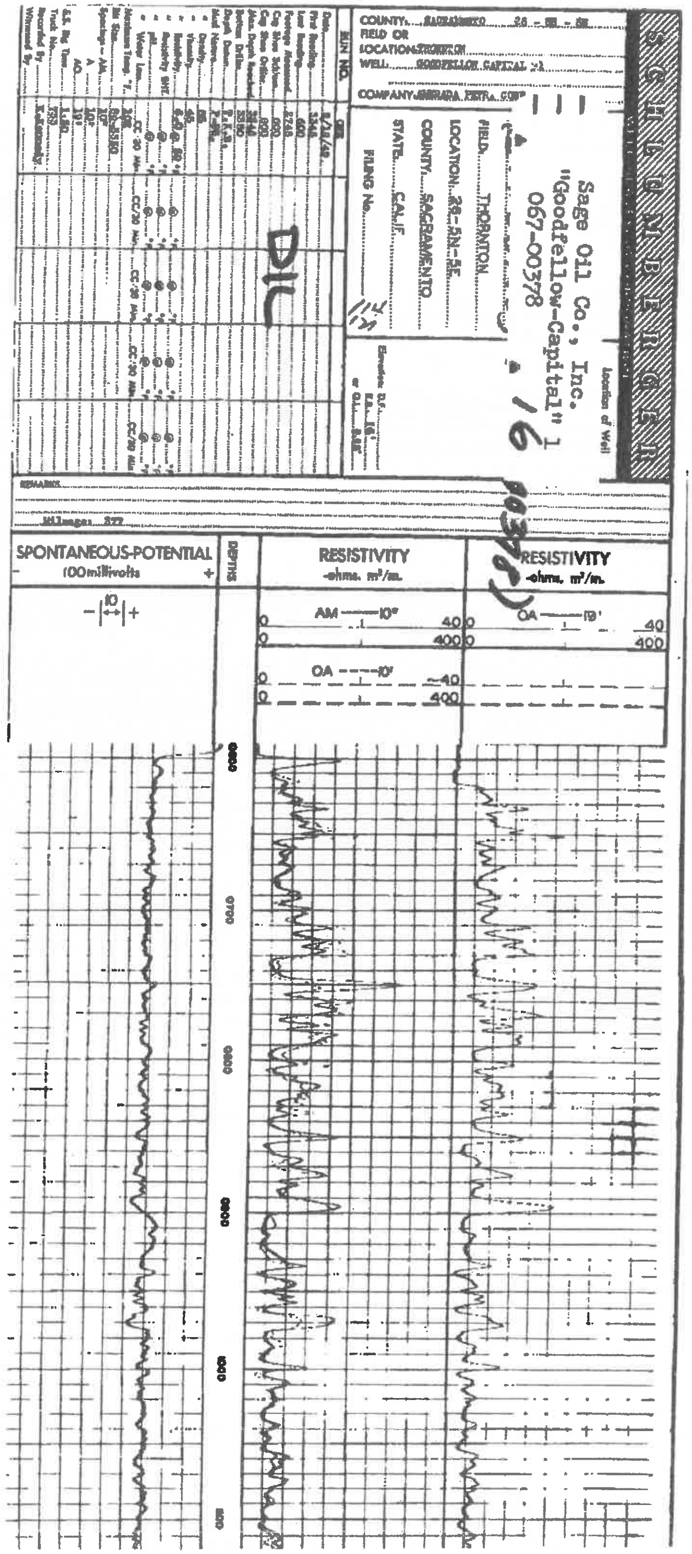
Amerada Petroleum Corporation
Goodfellow-Capital Co. 1

HISTORY

| | |
|---|---|
| 8-21-49 | Located top of cement at 3288'. Drilled out plugs, cement and baffle from 3288' to 3305' Circulated out perforated casing to bottom at 3350'. |
| 8-22-49 | 1½" Tubing Hung at 3338'<br>Ran in 5½" casing: 3328' of 1½" 2.7# J-55 Range 2 T&C seamless plain tubing with a venturi shoe bored with a 7/8" hole on bottom and a cross over swedge to 2-3/8", 8 rd. thread on top was landed in the tubing head 10' below the top of the K.B. Displaced mud with water. Forced water from well by injecting gas in casing under 600#.<br>Well began flowing gas at 12:45 A.M.<br>Blew well through 3/8" solid choke nipple to clean. |
| 8-24-49 | Back Pressure Test #1<br>Shut In Pressures: Tubing 1328#, Casing 1328#<br>Rate 4,750 Mcf/d Tubing 795#, Casing 1313# |

LOG AND CORE RECORD

| Top | Bottom | Thickness | Drilled or Cored | Recovery | Description |
|---|---|---|---|---|---|
| 0' | 16' | 16' | | | Ground to top of Kelly Bushings. |
| 16 | 40 | 24 | Drilled | | Blue clay |
| 40 | 204 | 164 | Drilled | | Blue clay with streaks of sand. |
| 204 | 1415 | 1211 | Drilled | | Blue shale with streaks of sand. |
| 1415 | 1718 | 303 | Drilled | | Shale with streaks of sand and shells |
| 1718 | 2204 | 486 | Drilled | | Blue shale with streaks of sand. |
| 2204 | 2294 | 90 | Drilled | | Shale with streaks of sand and shells. |
| 2294 | (-2278) | Top Markley Shale (Schlumberger) | | | |
| 2294 | 2471 | 177 | Drilled | | Blue shale with streaks of sand. |
| 2471 | 2508 | 37 | Drilled | | Blue sandy shale. |
| 2508 | 2580 | 72 | Drilled | | Shale and sand. |
| 2580 | (-2564) | Top Nortonville Shale (Schlumberger) | | | |
| 2580 | 2761 | 181 | Drilled | | Blue shale with streaks of hard sand. |
| 2761 | 3058 | 297 | Drilled | | Hard sand. |
| 3058 | (-3042) | Top Capay Shale (Schlumberger) | | | |
| 3058 | 3280 | 222 | Drilled | | Brown shale. |
| 3280 | 3310 | 30 | Drilled | | Blue shale. |




GEOCONSULTANTS, INC.
G1876-01 11/20
FIGURE C-4

LOCATION ~~NOT~~ CHECKED

ORIGINAL
File Original, Duplicate and Triplicate with the
REGIONAL WATER POLLUTION
CONTROL BOARD No. 5
(Insert appropriate number)

# WATER WELL DRILLERS REPORT

(Sections 7076, 7077, 7078, Water Code)

STATE OF CALIFORNIA 2384

Do Not Fill In
No. 54942
OSWN State Well No. 5N/7E-29K2
Other Well No. 5N/7E-29

(1) OWNER:
Name
Address

(2) LOCATION OF WELL:
County SACRAMENTO Owner's number, if any—
R. F. D. or Street No. FROM CORNER ALTA MESA & BRESSOW 0.26 MILES WEST & 0.23 MILES SOUTH
Same

(3) TYPE OF WORK (check):
New well ☒ Deepening ☐ Reconditioning ☐ Abandon ☐
If abandonment, describe material and procedure in Item 11.

(4) PROPOSED USE (check):
Domestic ☐ Industrial ☐ Municipal ☐
Irrigation ☒ Test Well ☐ Other ☐

(5) EQUIPMENT:
Rotary ☐
Cable ☒
Dug Well ☐

(6) CASING INSTALLED:
SINGLE ☐ DOUBLE ☐
From 1 ft. to 132 ft. 14 Diam. 12 Gage or Wall

If gravel packed: Diameter of Bore / from ft. / to ft. — No

Type and size of shoe or well ring 14 1/2 X 12 Size of gravel:
Describe joint Welded

(7) PERFORATIONS:
Type of perforator used
Size of perforations in., length, by in.
From ft. to ft. Perf. per row Rows per ft.

(8) CONSTRUCTION:
Was a surface sanitary seal provided? ☐ Yes ☒ No To what depth ft.
Were any strata sealed against pollution? ☐ Yes ☒ No If yes, note depth of strata
From ft. to ft.
Method of Sealing

(9) WATER LEVELS:
Depth at which water was first found 76 ft.
Standing level before perforating ft.
Standing level after perforating ft.

(10) WELL TESTS:
Was a pump test made? ☐ Yes ☒ No If yes, by whom?
Yield: gal./min. with ft. draw down after hrs.
Temperature of water Was a chemical analysis made? ☐ Yes ☐ No
Was electric log made of well? ☐ Yes ☒ No

(11) WELL LOG:
Total depth 530 ft. Depth of completed well 530 ft.
Formation: Describe by color, character, size of material, and structure.

| From (ft.) | To (ft.) | Formation |
|---|---|---|
| 1 | 72 | Br. Clay |
| 72 | 74 | Br. Sand |
| 74 | 94 | Br. clay |
| 94 | 96 | Br. sand |
| 96 | 120 | " Clay |
| 120 | 129 | Br. sand & P.G. |
| 129 | 150 | " clay |
| 150 | 156 | " Sand |
| 156 | 171 | " clay |
| 171 | 174 | " sand |
| 174 | 200 | " clay |
| 200 | 209 | " sand |
| 209 | 220 | " clay |
| 220 | 230 | Sand & P.G. |
| 230 | 250 | Br. clay |
| 250 | 256 | Br. sand |
| 256 | 274 | Br. clay |
| 274 | 276 | Br. sand |
| 276 | 330 | " clay |
| 330 | 336 | " sand |
| 336 | 388 | " clay |
| 388 | 394 | Br. sand |
| 394 | 420 | Br. clay |
| 420 | 426 | " sand |
| 426 | 496 | " clay |
| 496 | 498 | " sand |
| 498 | 518 | " clay |
| 518 | 528 | " sand |
| 528 | 530 | " clay |
| 530 | | clay |

CONFIDENTIAL Section 7076.1, Water Code

FOR OFFICIAL USE ONLY

Work started Jan 20 1960 Completed Jan 30 (?) 1960

WELL DRILLER'S STATEMENT:
*This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.*
NAME Otto Gross (?)
(Person, firm, or corporation) (Typed or printed)
Address Rt 1 Box 266
Galt (?) Calif.
[SIGNED] Otto Gross (?)
Well Driller
License No. 1 Dated July 20 (?), 1960

57025 6-57 20M QUIN SPO DWR 188 (REV. 3-54)

GEOCONSULTANTS, INC.
G1876-01 11/20
FIGURE C-5

# APPENDIX D

CR 2

**GEOCONSULTANTS, INC.**
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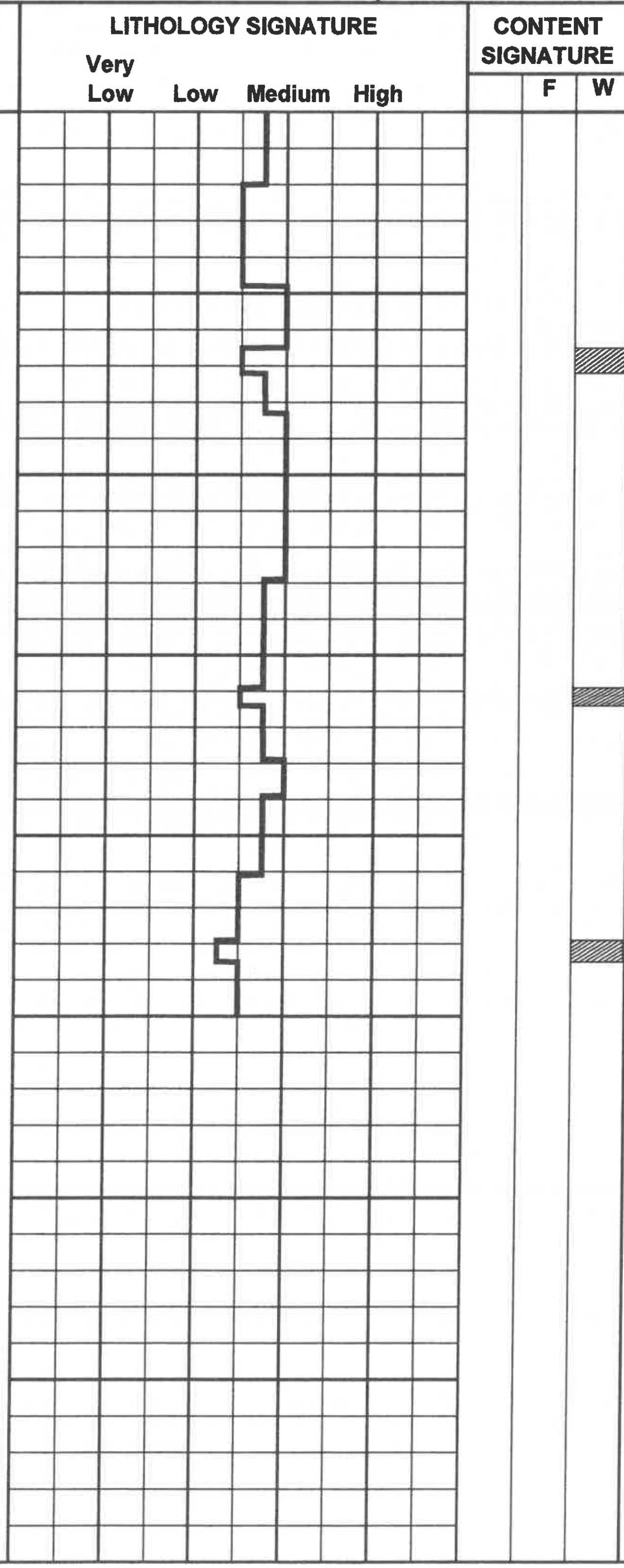
1450 Koll Circle, Suite 114
San Jose, California 95112
Phone: (408) 453-2541 Fax: (408) 453-2543

# ELECTROTELLURIC SOUNDING CR2-1

| | | | |
|---|---|---|---|
| **Project No.:** | G1876-01 | **Record Date:** | 07/29/2020 |
| **Elevation:** | 15 Feet | **Record Time:** | 11:53 |
| **Page:** | 01 of 01 | **Record No.:** | 1 |

| DEPTH | LITHOLOGY SIGNATURE (Very Low, Low, Medium, High) | CONTENT SIGNATURE (F, W) | SIGNATURE DEPTH | COMMENTS |
|---|---|---|---|---|
| 0 | | | | |
| | | | 20 | |
| 50 | | | 48 | |
| | | | 65 | |
| | | | 72 | |
| | | | 83 | |
| 100 | | | | |
| | | | 129 | |
| 150 | | | 159 | |
| | | | 164 | |
| | | | 179 | |
| | | | 189 | |
| 200 | | | 211 | |
| | | | 229 | |
| | | | 235 | |
| 250 | | | | |



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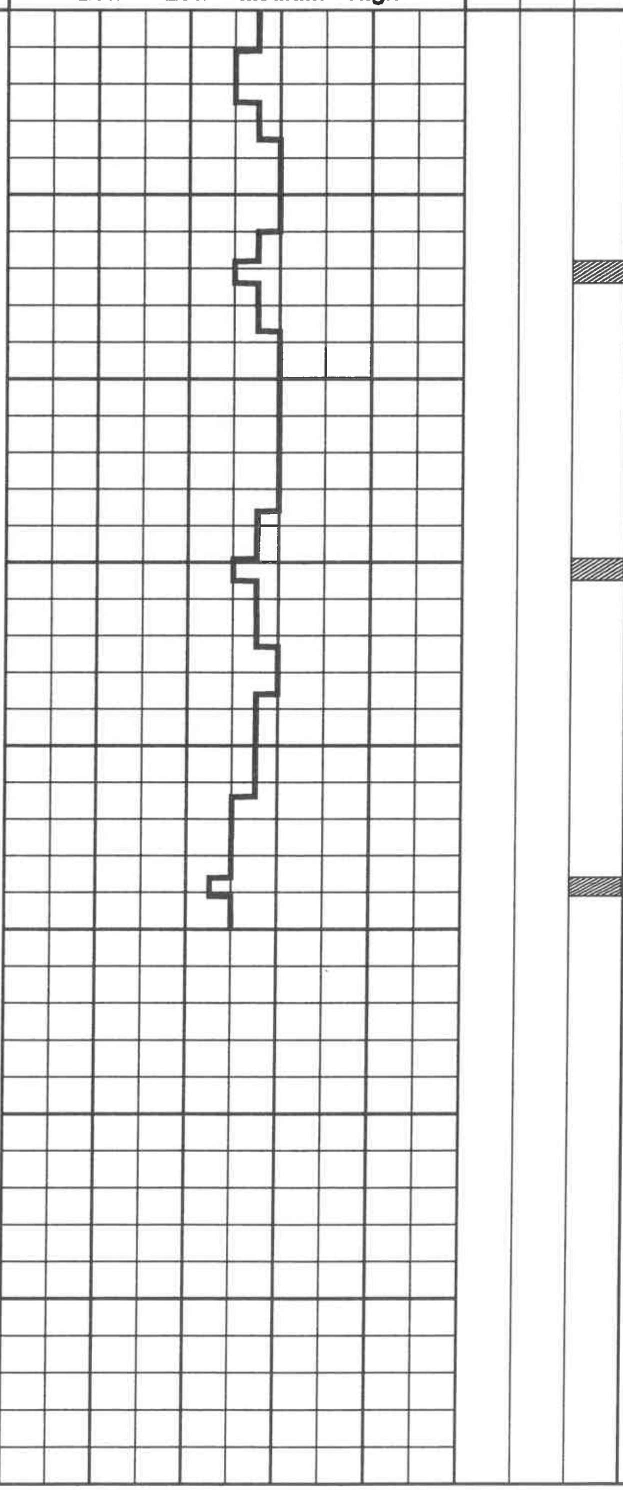
# ELECTROTELLURIC SOUNDING CR2-2

| | | | |
|---|---|---|---|
| Project No.: | G1876-01 | Record Date: | 07/29/2020 |
| Elevation: | 26 Feet | Record Time: | 12:13 |
| Page: | 01 of 01 | Record No.: | 2 |

| DEPTH | LITHOLOGY SIGNATURE (Very Low, Low, Medium, High) | CONTENT SIGNATURE (F, W) | SIGNATURE DEPTH | COMMENTS |
|---|---|---|---|---|
| 0 | | | | |
| | | | 11 | |
| | | | 25 | |
| | | | 35 | |
| 50 | | | | |
| | | | 60 | |
| | | | 68 | |
| | | | 74 | |
| | | | 87 | |
| 100 | | | | |
| | | | 136 | |
| | | | 149 | |
| 150 | | | | |
| | | | 155 | |
| | | | 173 | |
| | | | 186 | |
| 200 | | | | |
| | | | 214 | |
| | | | 236 | |
| | | | 241 | |
| 250 | | | | |



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*Ground-Water Resources Management ▪*
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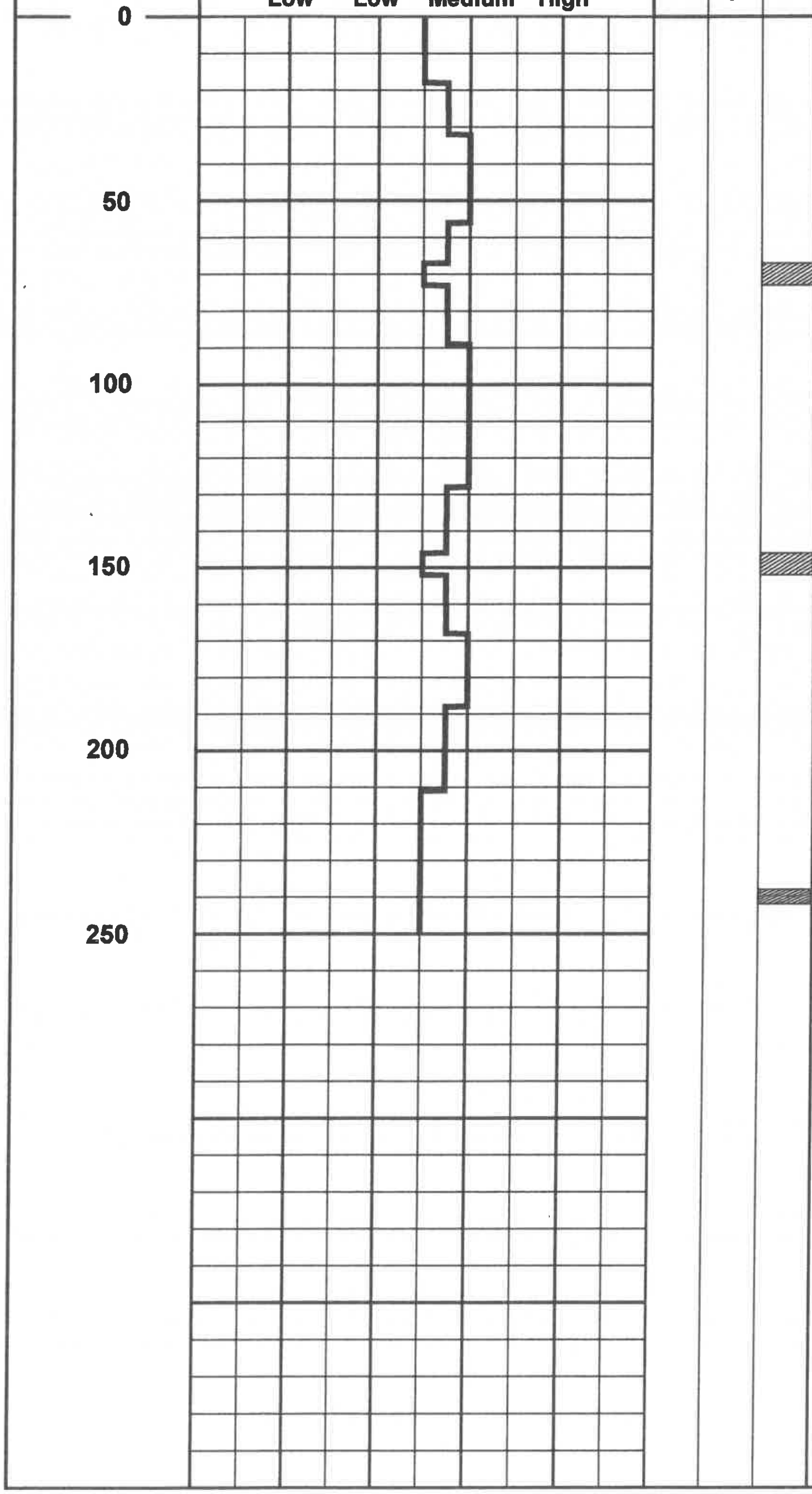
# ELECTROTELLURIC SOUNDING CR2-3

| | | | |
|---|---|---|---|
| **Project No.:** | G1876-01 | **Record Date:** | 07/29/2020 |
| **Elevation:** | 49 Feet | **Record Time:** | 12:37 |
| **Page:** | 01 of 01 | **Record No.:** | 3 |

**DEPTH** | **LITHOLOGY SIGNATURE** (Very Low, Low, Medium, High) | **CONTENT SIGNATURE** (F, W) | **SIGNATURE DEPTH** | **COMMENTS**




**SIGNATURE DEPTH**

18
32
56
67
73
89
128
146
152
168
188
211
238
242

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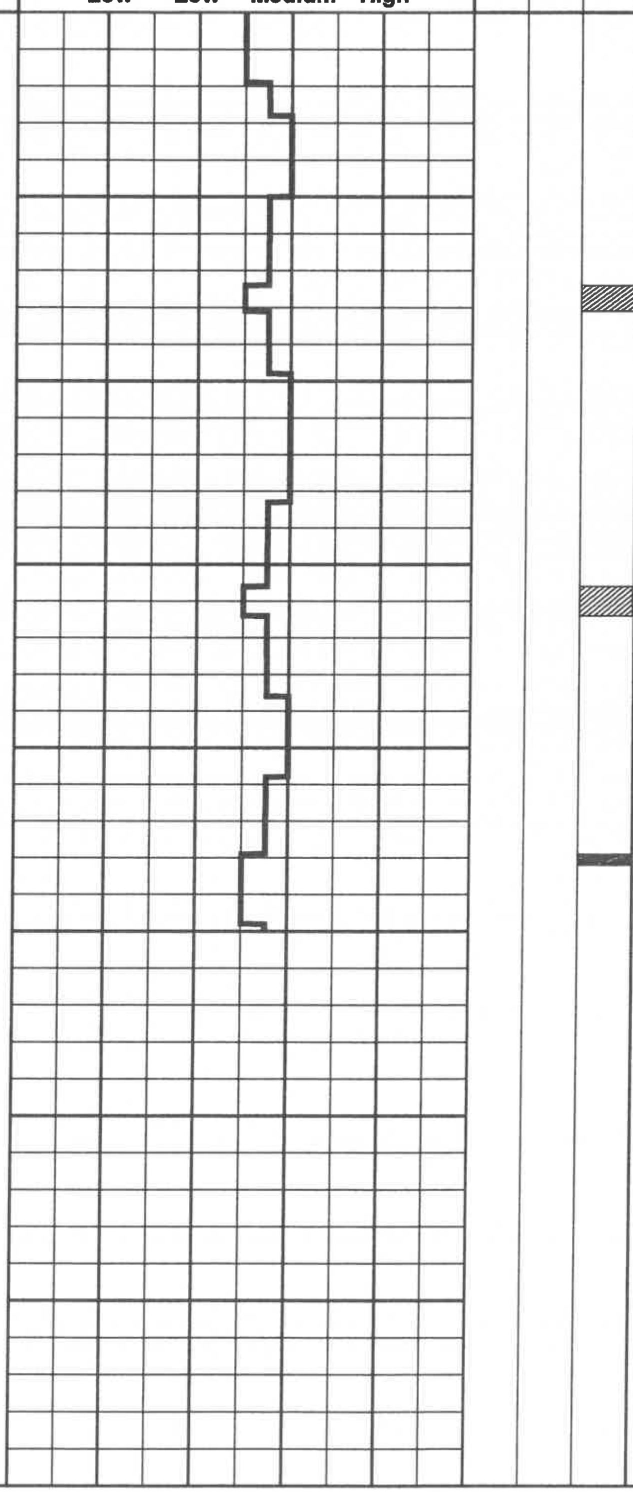
# ELECTROTELLURIC SOUNDING CR2-4

| | | | |
|---|---|---|---|
| Project No.: | G1876-01 | Record Date: | 07/29/2020 |
| Elevation: | 52 Feet | Record Time: | 12:59 |
| Page: | 01 of 01 | Record No.: | 4 |

| DEPTH | LITHOLOGY SIGNATURE (Very Low / Low / Medium / High) | CONTENT SIGNATURE (F / W) | SIGNATURE DEPTH | COMMENTS |
|---|---|---|---|---|
| 0 | | | | |
| | | | 19 | |
| | | | 28 | |
| 50 | | | 50 | |
| | | | 74 | |
| | | | 81 | |
| 100 | | | 98 | |
| | | | 133 | |
| 150 | | | 156 | |
| | | | 164 | |
| | | | 186 | |
| 200 | | | 208 | |
| | | | 229 | |
| | | | 232 | |
| 250 | | | 248 | |



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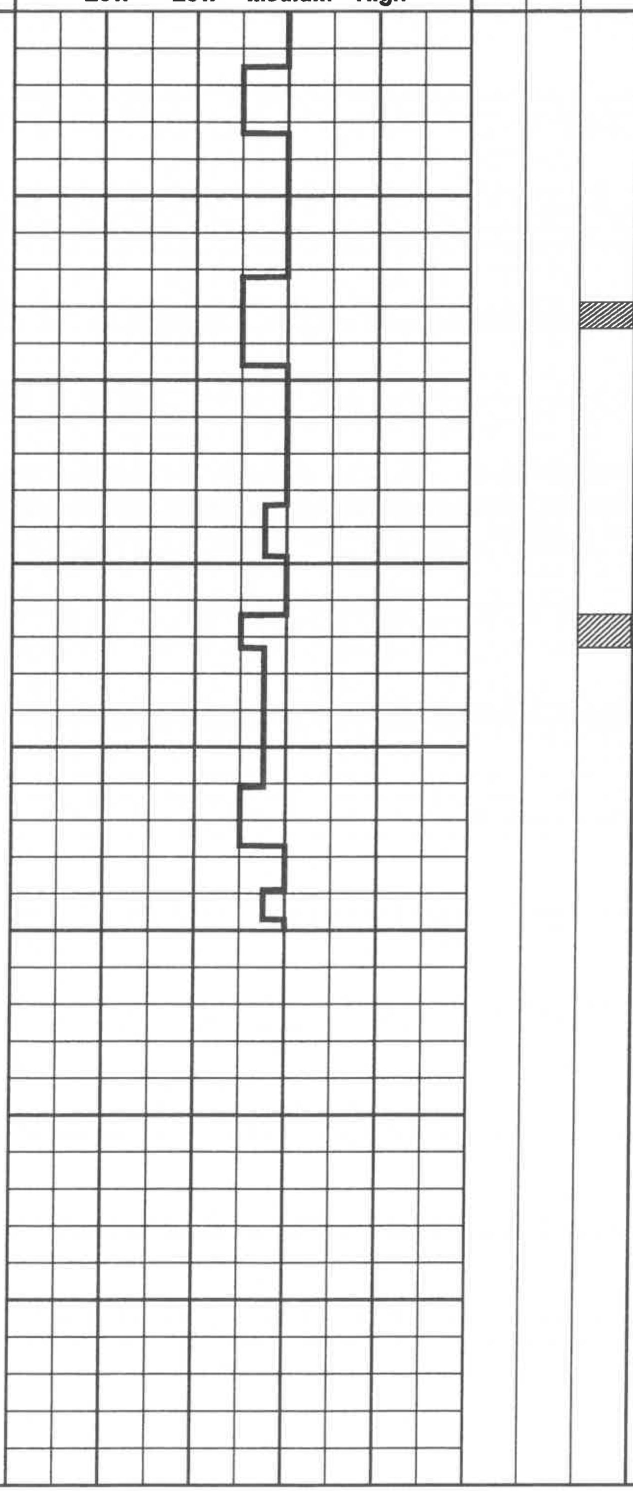
# ELECTROTELLURIC SOUNDING CR2-5

| | | | |
|---|---|---|---|
| Project No.: | G1876-01 | Record Date: | 07/29/2020 |
| Elevation: | 56 Feet | Record Time: | 13:15 |
| Page: | 01 of 01 | Record No.: | 5 |

DEPTH | LITHOLOGY SIGNATURE (Very Low, Low, Medium, High) | CONTENT SIGNATURE (F, W) | SIGNATURE DEPTH | COMMENTS



Depth: 0, 50, 100, 150, 200, 250

Signature Depth: 15, 38, 65, 72, 79, 86, 96, 134, 148, 164, 173, 211, 227, 239, 247

CR 3

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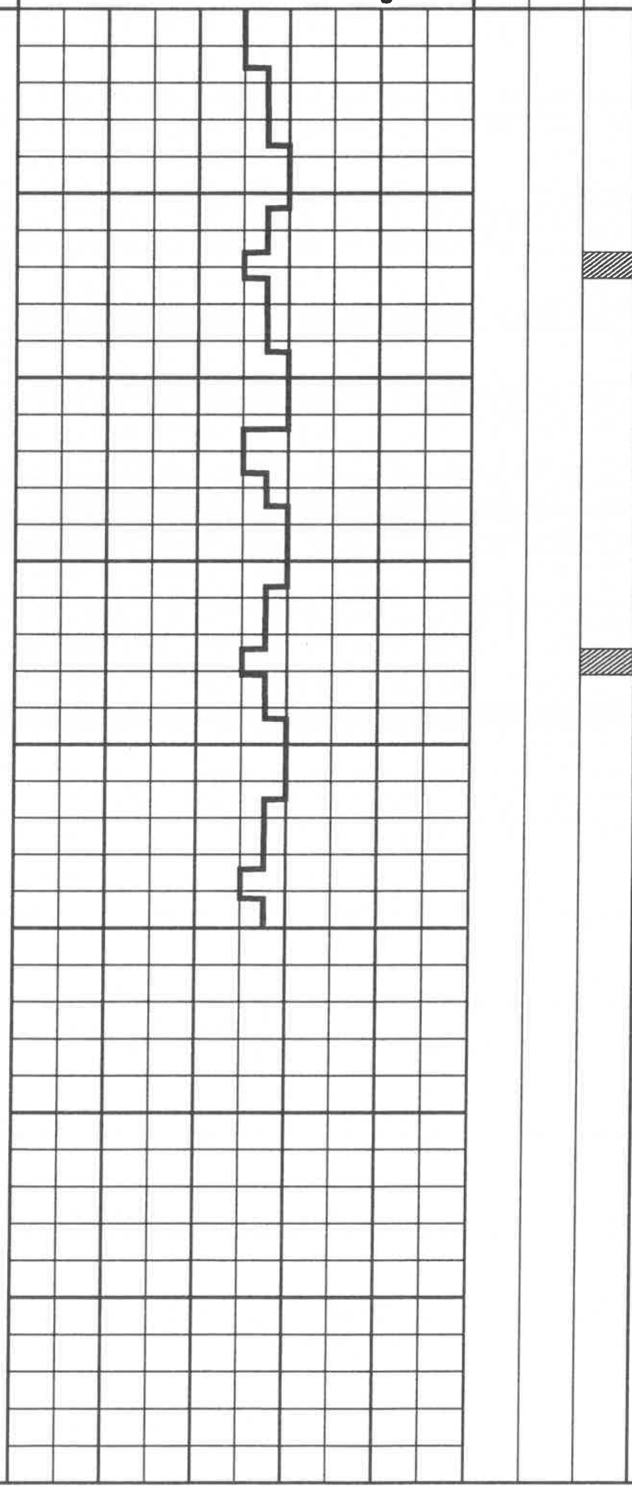
# ELECTROTELLURIC SOUNDING CR3-1

| | | | |
|---|---|---|---|
| Project No.: | G1876-01 | Record Date: | 07/28/2020 |
| Elevation: | 125 Feet | Record Time: | 12:13 |
| Page: | 01 of 01 | Record No.: | 1 |

| DEPTH | LITHOLOGY SIGNATURE (Very Low, Low, Medium, High) | CONTENT SIGNATURE (F, W) | SIGNATURE DEPTH | COMMENTS |
|---|---|---|---|---|

DEPTH: 0, 50, 100, 150, 200, 250



SIGNATURE DEPTH:

16
37
54
66
73
93
114
126
135
157
174
181
193
216
234
242

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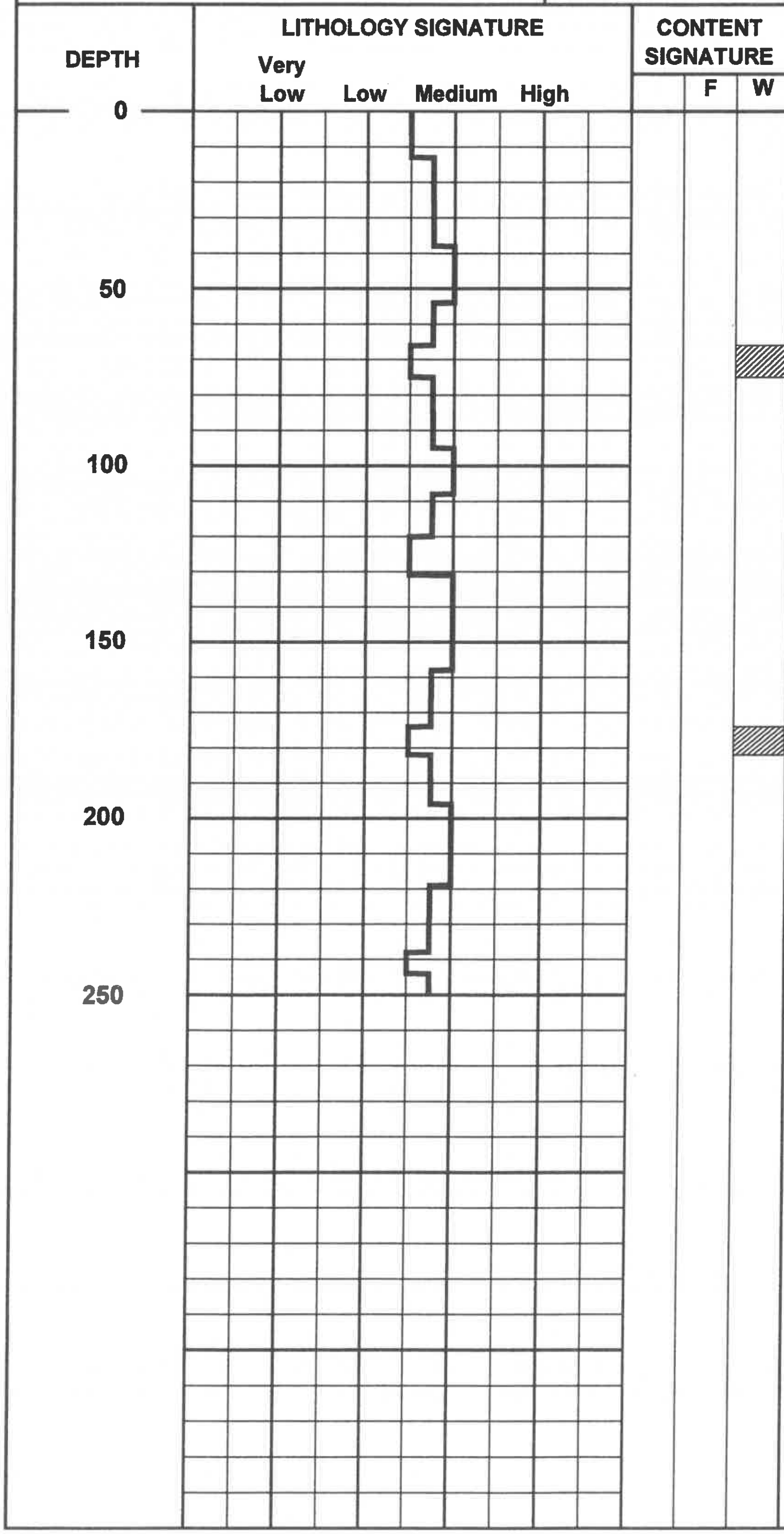
# ELECTROTELLURIC SOUNDING CR3-2

| | | | |
|---|---|---|---|
| **Project No.:** | G1876-01 | **Record Date:** | 07/28/2020 |
| **Elevation:** | 101 Feet | **Record Time:** | 12:44 |
| **Page:** | 01 of 01 | **Record No.:** | 2 |




| SIGNATURE DEPTH | COMMENTS |
|---|---|
| 13 | |
| 38 | |
| 54 | |
| 66 | |
| 75 | |
| 95 | |
| 108 | |
| 120 | |
| 131 | |
| 158 | |
| 174 | |
| 182 | |
| 196 | |
| 219 | |
| 238 | |
| 244 | |

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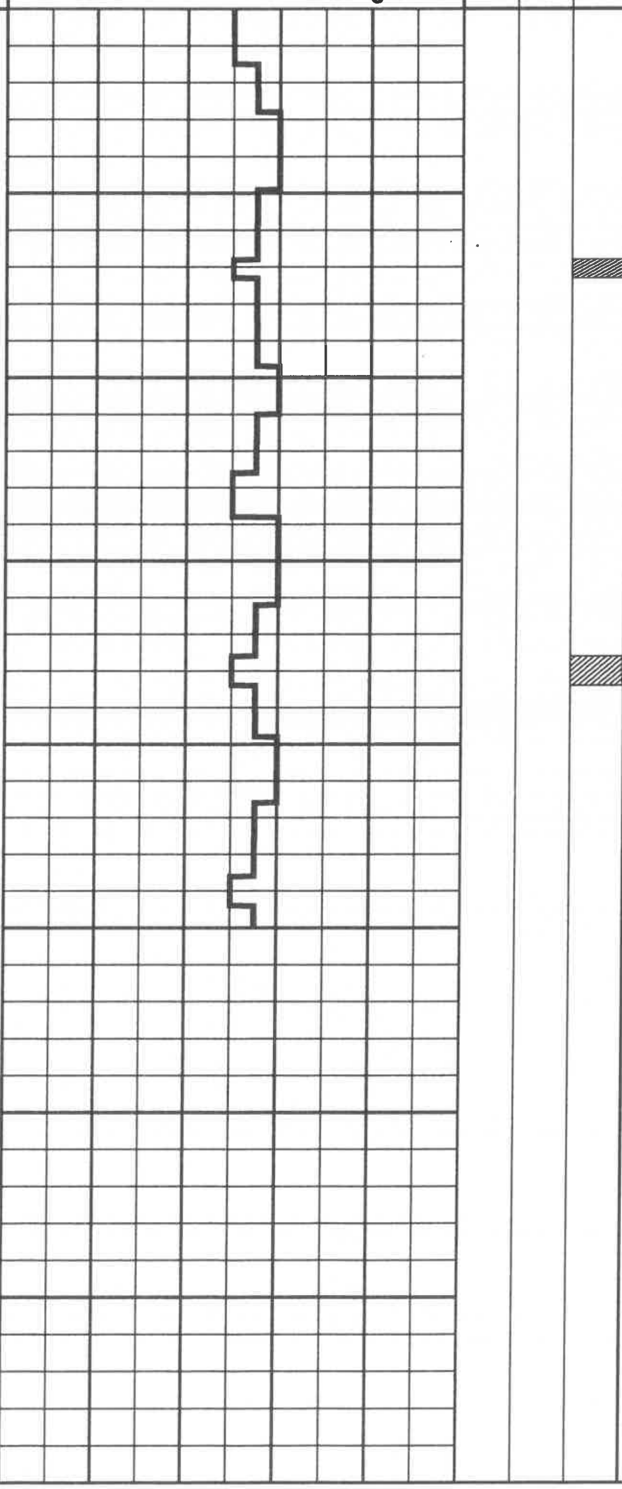
# ELECTROTELLURIC SOUNDING CR3-3

| | | | |
|---|---|---|---|
| Project No.: | G1876-01 | Record Date: | 07/28/2020 |
| Elevation: | 91 Feet | Record Time: | 13:08 |
| Page: | 01 of 01 | Record No.: | 3 |

| DEPTH | LITHOLOGY SIGNATURE (Very Low / Low / Medium / High) | CONTENT SIGNATURE (F / W) | SIGNATURE DEPTH | COMMENTS |
|---|---|---|---|---|
| 0 | | | 15 | |
| | | | 28 | |
| 50 | | | 49 | |
| | | | 68 | |
| | | | 73 | |
| 100 | | | 97 | |
| | | | 110 | |
| | | | 126 | |
| | | | 138 | |
| 150 | | | 162 | |
| | | | 176 | |
| | | | 184 | |
| 200 | | | 198 | |
| | | | 216 | |
| | | | 236 | |
| 250 | | | 244 | |



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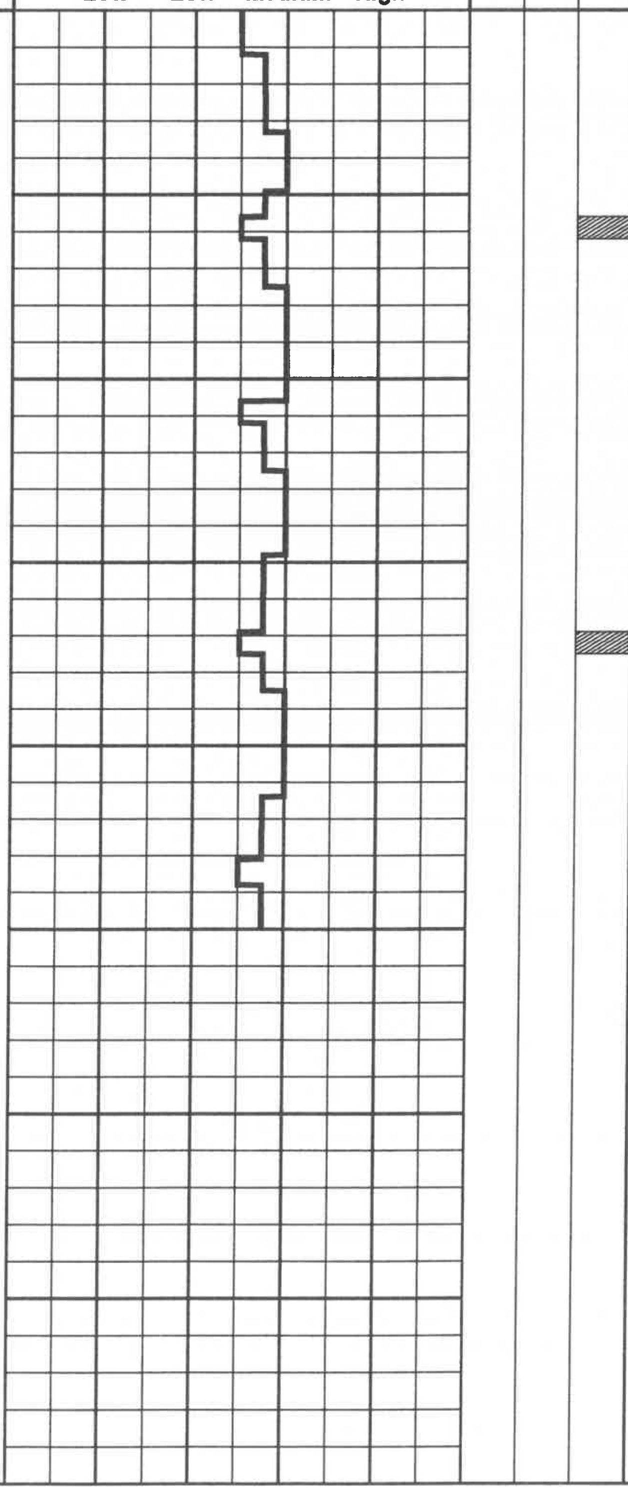
# ELECTROTELLURIC SOUNDING CR3-4

| | | | |
|---|---|---|---|
| **Project No.:** | G1876-01 | **Record Date:** | 07/28/2020 |
| **Elevation:** | 82 Feet | **Record Time:** | 13:30 |
| **Page:** | 01 of 01 | **Record No.:** | 4 |

| DEPTH | LITHOLOGY SIGNATURE (Very Low / Low / Medium / High) | CONTENT SIGNATURE (F / W) | SIGNATURE DEPTH | COMMENTS |
|---|---|---|---|---|
| 0 | | | | |
| | | | 12 | |
| | | | 33 | |
| 50 | | | 49 | |
| | | | 56 | |
| | | | 62 | |
| | | | 75 | |
| 100 | | | 106 | |
| | | | 112 | |
| | | | 125 | |
| 150 | | | 148 | |
| | | | 169 | |
| | | | 175 | |
| | | | 185 | |
| 200 | | | 214 | |
| | | | 231 | |
| | | | 238 | |
| 250 | | | | |



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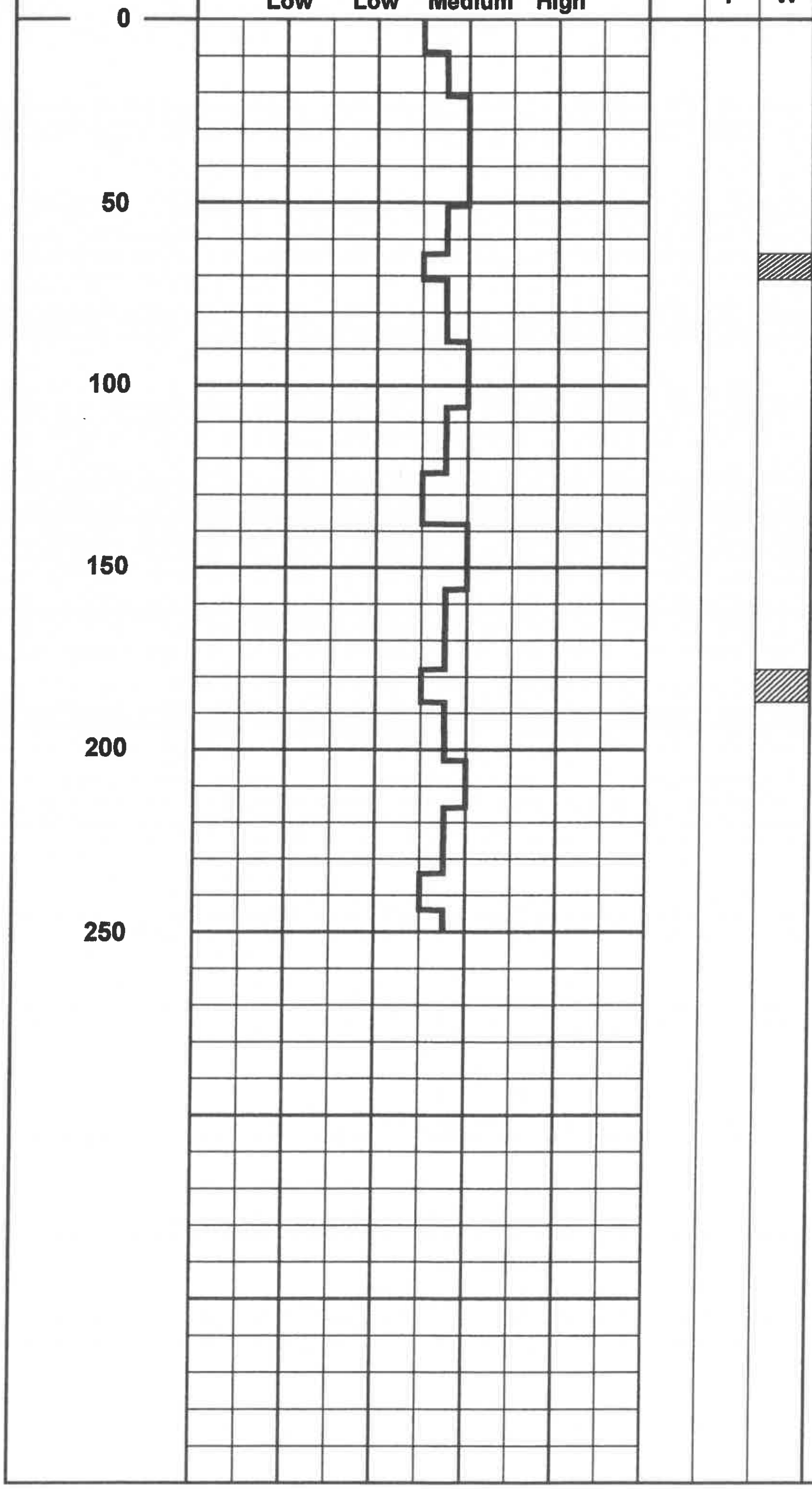
# ELECTROTELLURIC SOUNDING CR3-5

| | | | |
|---|---|---|---|
| Project No.: | G1876-01 | Record Date: | 07/28/2020 |
| Elevation: | 79 Feet | Record Time: | 14:04 |
| Page: | 01 of 01 | Record No.: | 5 |

| DEPTH | LITHOLOGY SIGNATURE (Very Low, Low, Medium, High) | CONTENT SIGNATURE (F, W) | SIGNATURE DEPTH | COMMENTS |
|---|---|---|---|---|




**Signature Depth:** 9, 21, 51, 64, 71, 88, 106, 124, 138, 156, 178, 187, 203, 216, 234, 244

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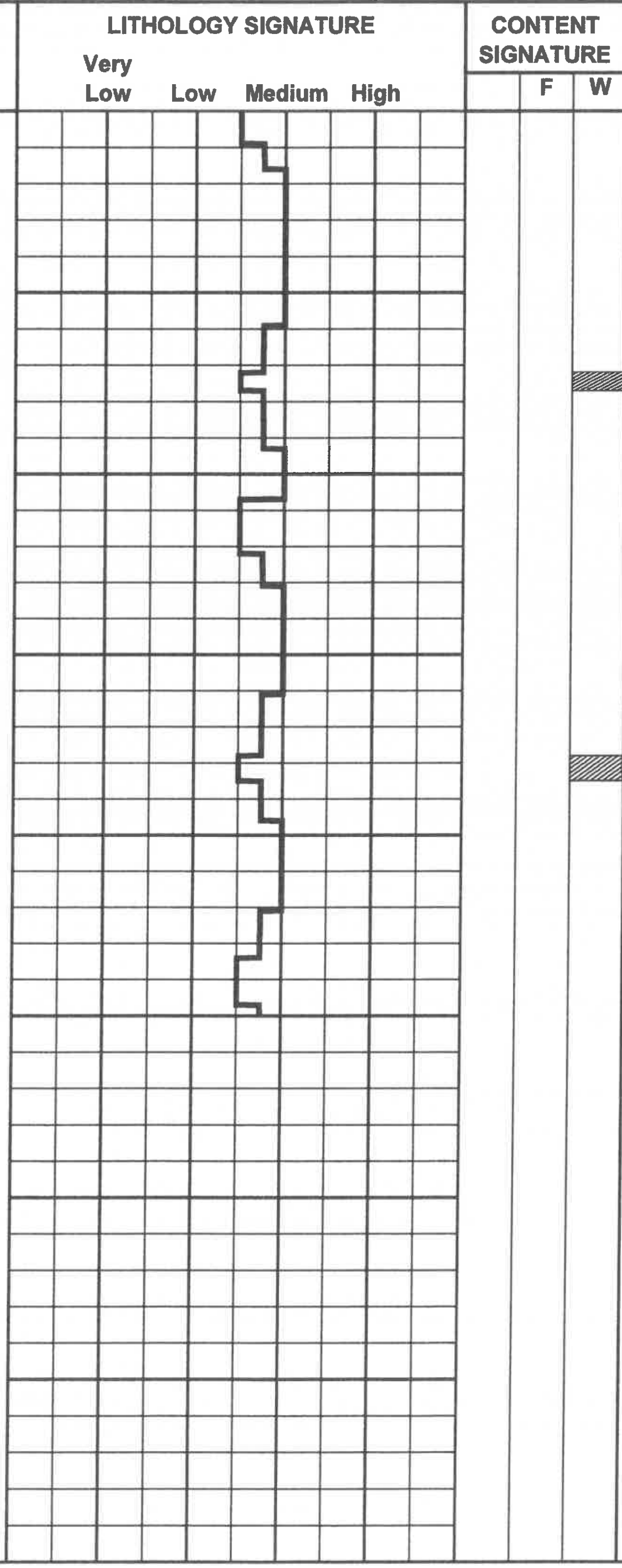
# ELECTROTELLURIC SOUNDING CR3-6

| | | | |
|---|---|---|---|
| Project No.: | G1876-01 | Record Date: | 07/28/2020 |
| Elevation: | 75 Feet | Record Time: | 14:51 |
| Page: | 01 of 01 | Record No.: | 6 |




DEPTH: 0, 50, 100, 150, 200, 250

SIGNATURE DEPTH: 9, 16, 59, 72, 77, 93, 107, 122, 131, 161, 178, 185, 196, 221, 234, 247

COMMENTS

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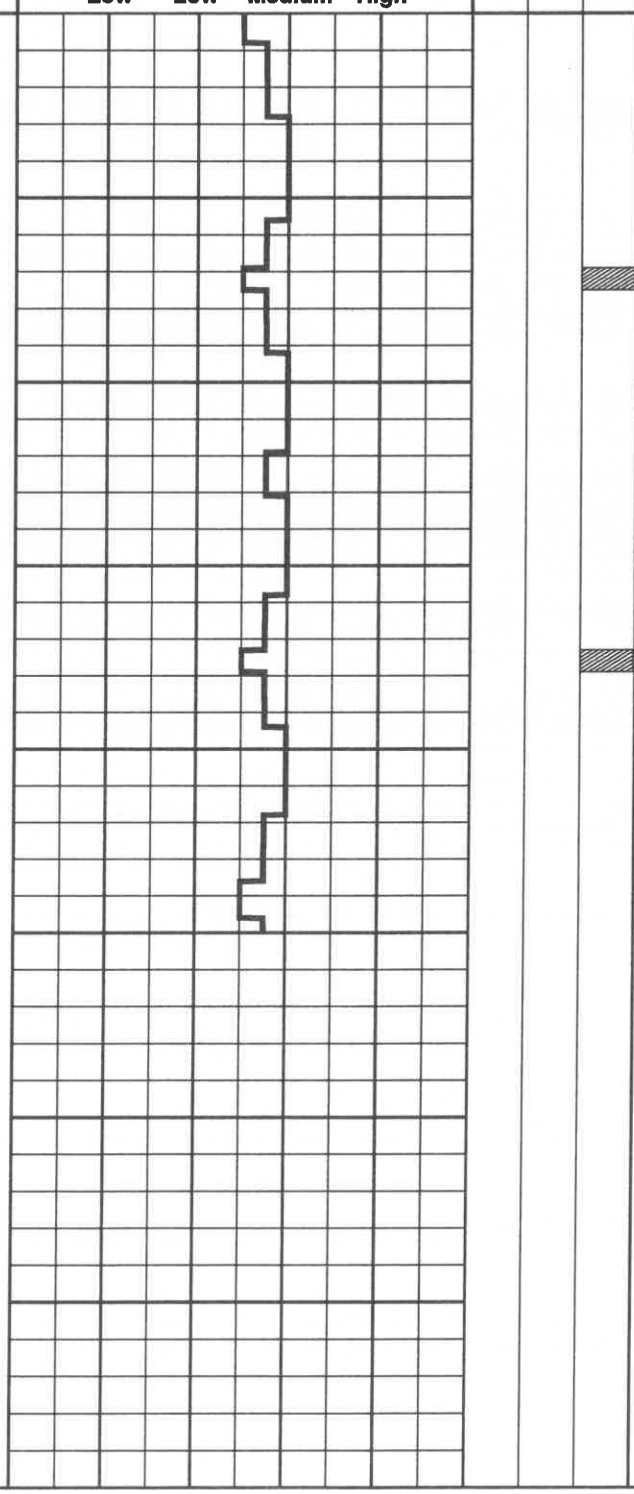
# ELECTROTELLURIC SOUNDING CR3-7

| | | | |
|---|---|---|---|
| **Project No.:** | G1876-01 | **Record Date:** | 07/28/2020 |
| **Elevation:** | 71 Feet | **Record Time:** | 15:16 |
| **Page:** | 01 of 01 | **Record No.:** | 7 |

| DEPTH | LITHOLOGY SIGNATURE (Very Low / Low / Medium / High) | CONTENT SIGNATURE (F / W) | SIGNATURE DEPTH | COMMENTS |
|---|---|---|---|---|
| 0 | | | 8 | |
| | | | 28 | |
| 50 | | | 56 | |
| | | | 69 | |
| | | | 75 | |
| | | | 92 | |
| 100 | | | 119 | |
| | | | 131 | |
| 150 | | | 158 | |
| | | | 173 | |
| | | | 179 | |
| | | | 194 | |
| 200 | | | 218 | |
| | | | 236 | |
| 250 | | | 246 | |



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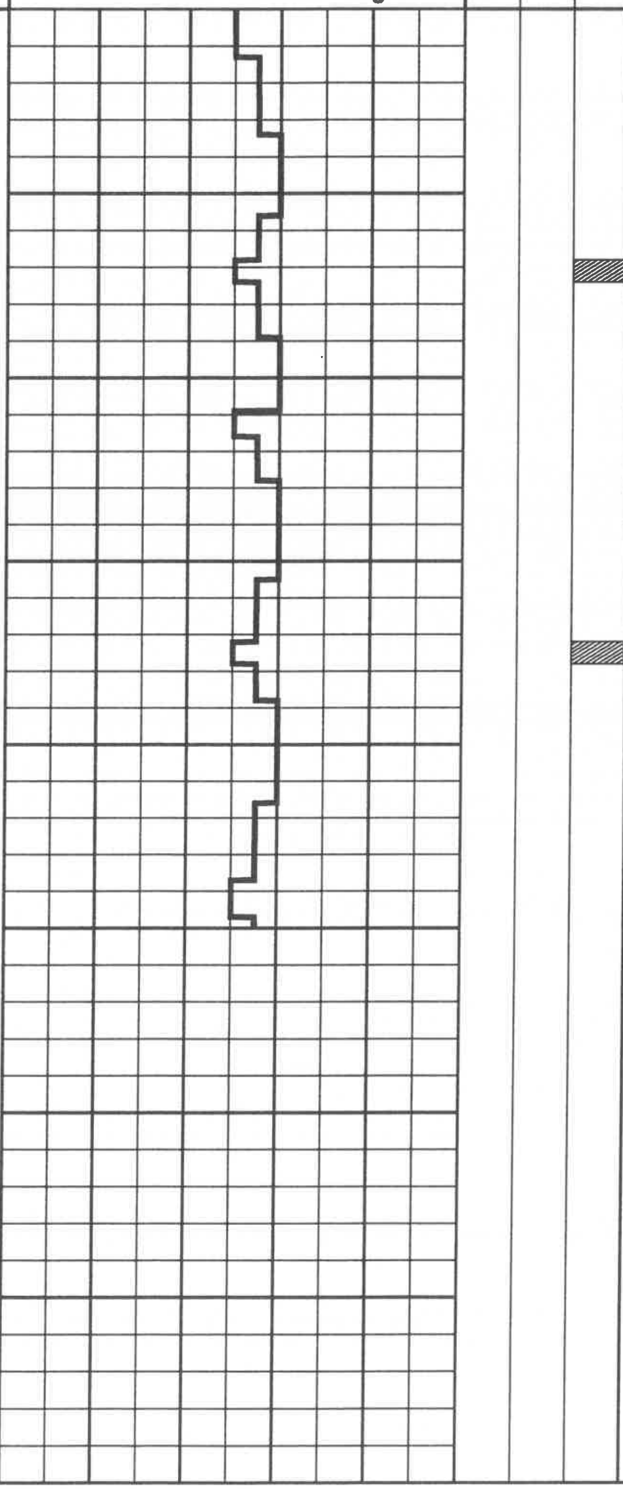
# ELECTROTELLURIC SOUNDING CR3-8

| | | | |
|---|---|---|---|
| Project No.: | G1876-01 | Record Date: | 07/28/2020 |
| Elevation: | 78 Feet | Record Time: | 15:49 |
| Page: | 01 of 01 | Record No.: | 8 |

| DEPTH | LITHOLOGY SIGNATURE (Very Low, Low, Medium, High) | CONTENT SIGNATURE (F, W) | SIGNATURE DEPTH | COMMENTS |
|---|---|---|---|---|



DEPTH: 0, 50, 100, 150, 200, 250

SIGNATURE DEPTH:
13
34
56
68
74
89
109
116
128
155
172
178
188
216
237
247

DC 1

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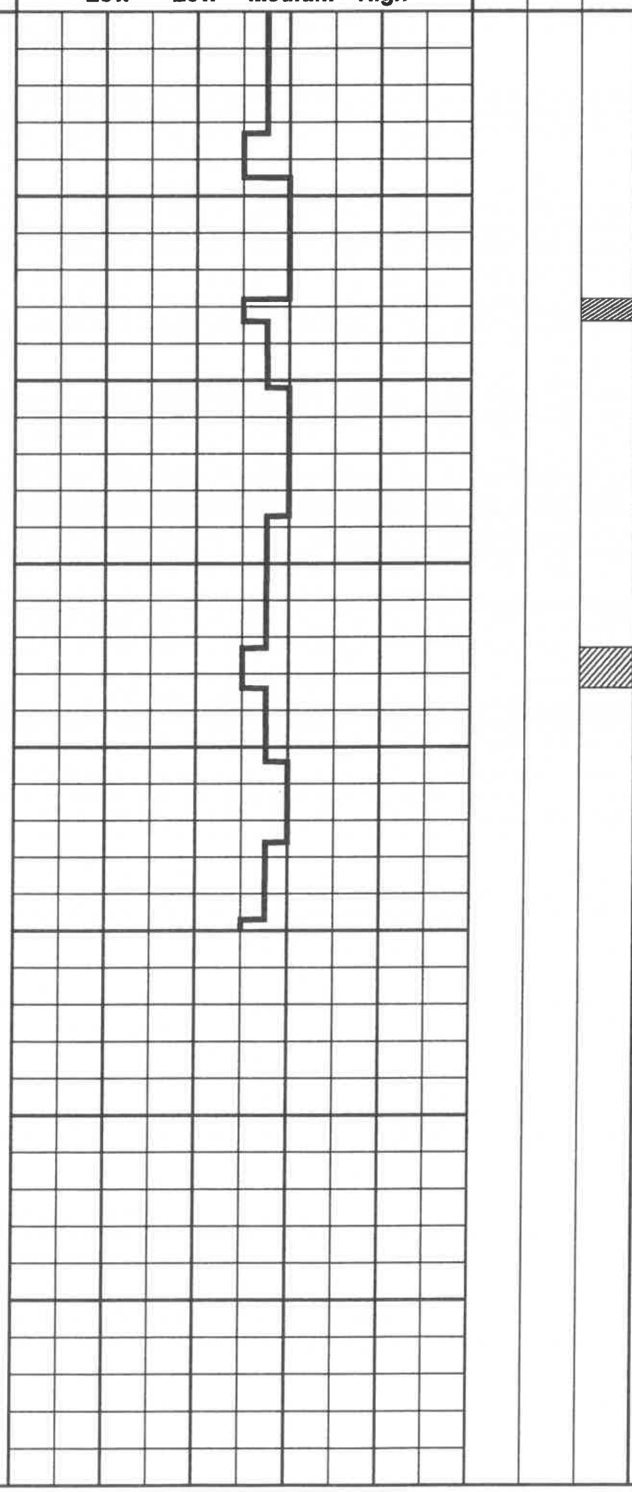
# ELECTROTELLURIC SOUNDING DC1-1

| | | | |
|---|---|---|---|
| **Project No.:** | G1876-01 | **Record Date:** | 07/31/2020 |
| **Elevation:** | -8 Feet | **Record Time:** | 15:10 |
| **Page:** | 01 of 01 | **Record No.:** | 7 |

| DEPTH | LITHOLOGY SIGNATURE (Very Low / Low / Medium / High) | CONTENT SIGNATURE (F / W) | SIGNATURE DEPTH | COMMENTS |
|---|---|---|---|---|
| 0 | | | | |
| | | | 33 | |
| | | | 45 | |
| 50 | | | | |
| | | | 78 | |
| | | | 84 | |
| 100 | | | 102 | |
| | | | 137 | |
| 150 | | | | |
| | | | 173 | |
| | | | 184 | |
| 200 | | | 204 | |
| | | | 226 | |
| | | | 247 | |
| 250 | | | | |



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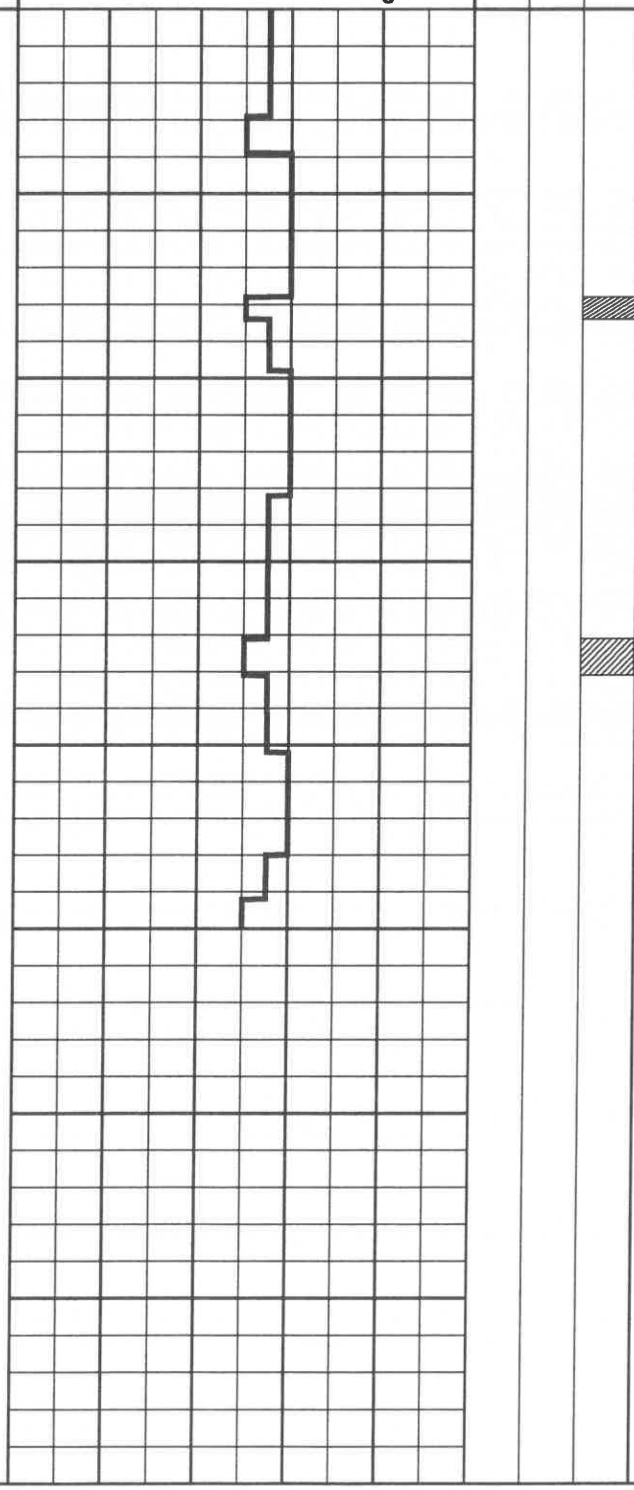
# ELECTROTELLURIC SOUNDING DC1-2

| | | | |
|---|---|---|---|
| Project No.: | G1876-01 | Record Date: | 07/31/2020 |
| Elevation: | 5 Feet | Record Time: | 14:32 |
| Page: | 01 of 01 | Record No.: | 6 |

| DEPTH | LITHOLOGY SIGNATURE (Very Low / Low / Medium / High) | CONTENT SIGNATURE (F / W) | SIGNATURE DEPTH | COMMENTS |
|---|---|---|---|---|
| 0 | | | | |
| | | | 29 | |
| | | | 39 | |
| 50 | | | | |
| | | | 78 | |
| | | | 84 | |
| 100 | | | 98 | |
| | | | 132 | |
| 150 | | | | |
| | | | 171 | |
| | | | 181 | |
| 200 | | | 202 | |
| | | | 230 | |
| | | | 242 | |
| 250 | | | | |



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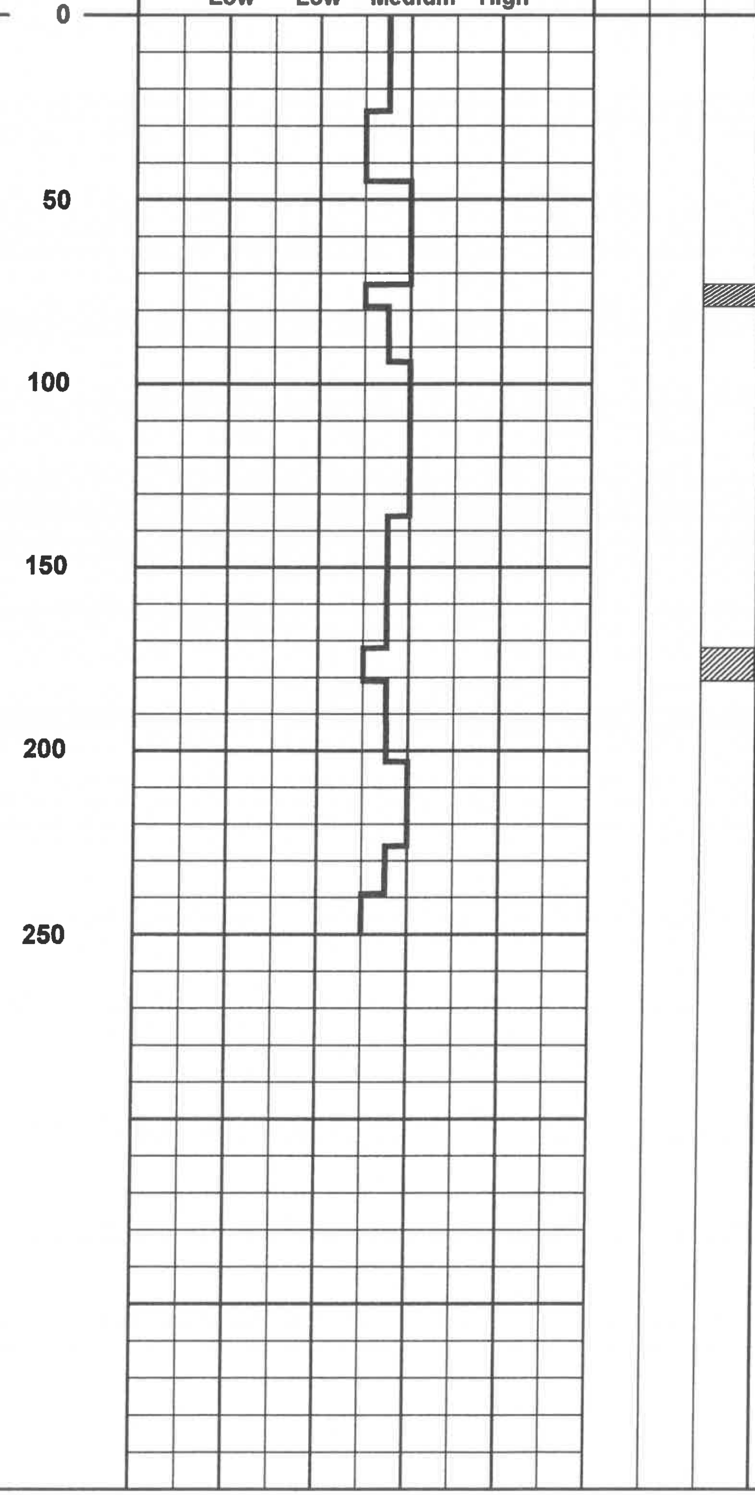
# ELECTROTELLURIC SOUNDING DC1-3

| | | | |
|---|---|---|---|
| Project No.: | G1876-01 | Record Date: | 07/31/2020 |
| Elevation: | 5 Feet | Record Time: | 13:57 |
| Page: | 01 of 01 | Record No.: | 5 |

| DEPTH | LITHOLOGY SIGNATURE (Very Low / Low / Medium / High) | CONTENT SIGNATURE (F / W) | SIGNATURE DEPTH | COMMENTS |
|---|---|---|---|---|




| SIGNATURE DEPTH |
|---|
| 26 |
| 45 |
| 73 |
| 79 |
| 94 |
| 136 |
| 172 |
| 181 |
| 203 |
| 226 |
| 239 |

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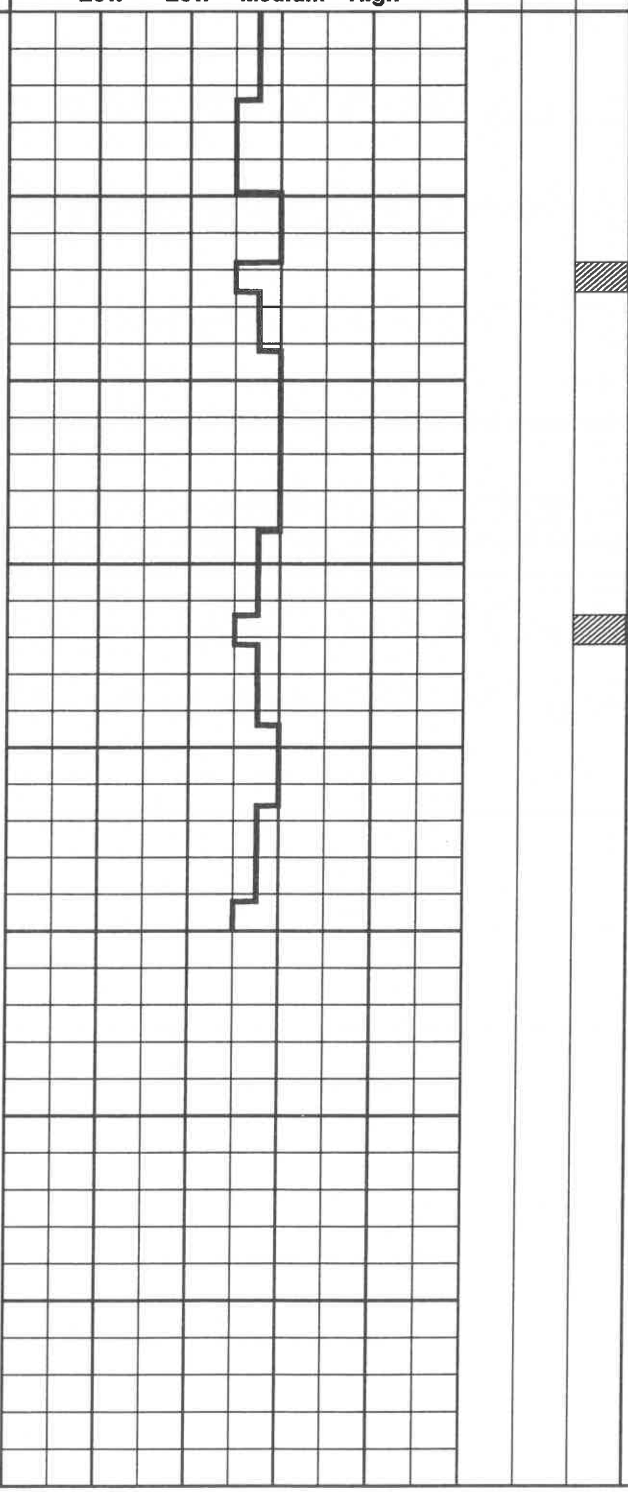
# ELECTROTELLURIC SOUNDING DC1-4

| | | | |
|---|---|---|---|
| Project No.: | G1876-01 | Record Date: | 07/31/2020 |
| Elevation: | 7 Feet | Record Time: | 12:38 |
| Page: | 01 of 01 | Record No.: | 4 |

| DEPTH | LITHOLOGY SIGNATURE (Very Low / Low / Medium / High) | CONTENT SIGNATURE (F / W) | SIGNATURE DEPTH | COMMENTS |
|---|---|---|---|---|



DEPTH: 0, 50, 100, 150, 200, 250

SIGNATURE DEPTH:
24
49
68
76
92
141
164
172
194
216
242

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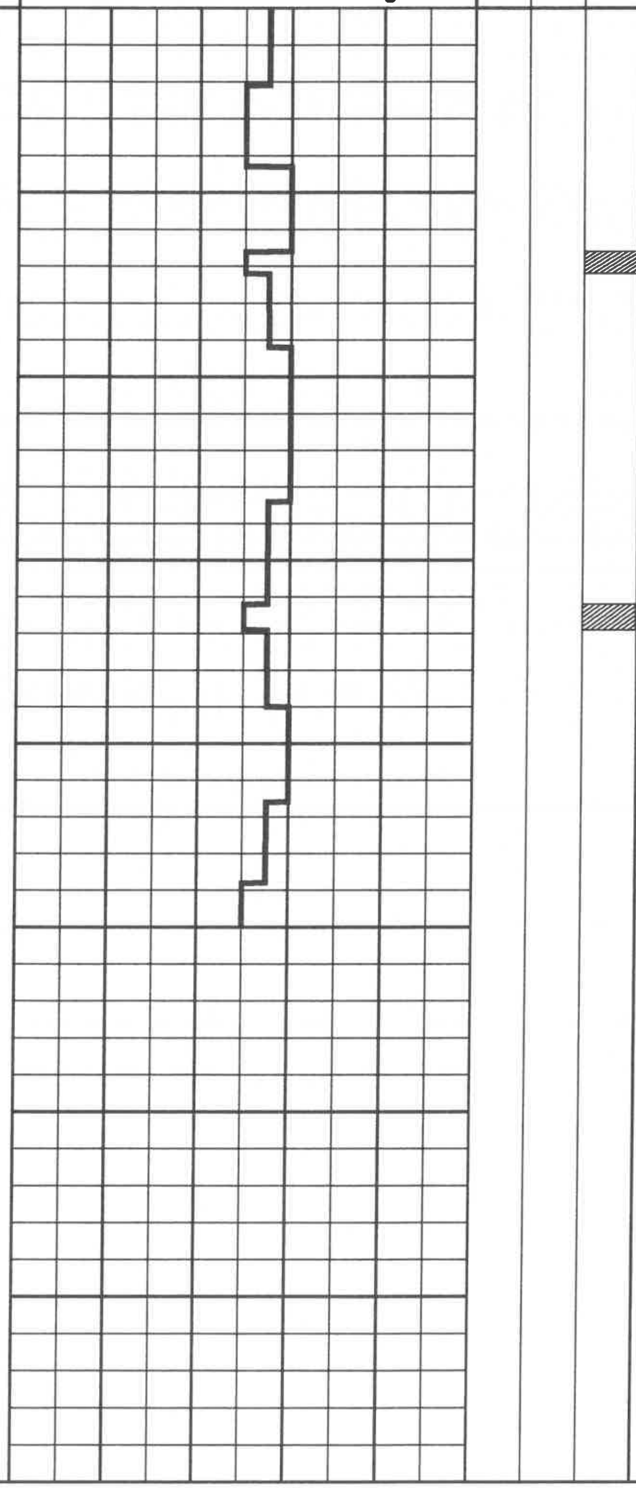
# ELECTROTELLURIC SOUNDING DC1-5

| | | | |
|---|---|---|---|
| **Project No.:** | G1876-01 | **Record Date:** | 07/31/2020 |
| **Elevation:** | 14 Feet | **Record Time:** | 12:23 |
| **Page:** | 01 of 01 | **Record No.:** | 3 |

| DEPTH | LITHOLOGY SIGNATURE (Very Low, Low, Medium, High) | CONTENT SIGNATURE (F, W) | SIGNATURE DEPTH | COMMENTS |
|---|---|---|---|---|
| | | | | |

DEPTH: 0, 50, 100, 150, 200, 250



SIGNATURE DEPTH:
21
43
66
72
92
134
162
169
190
216
238

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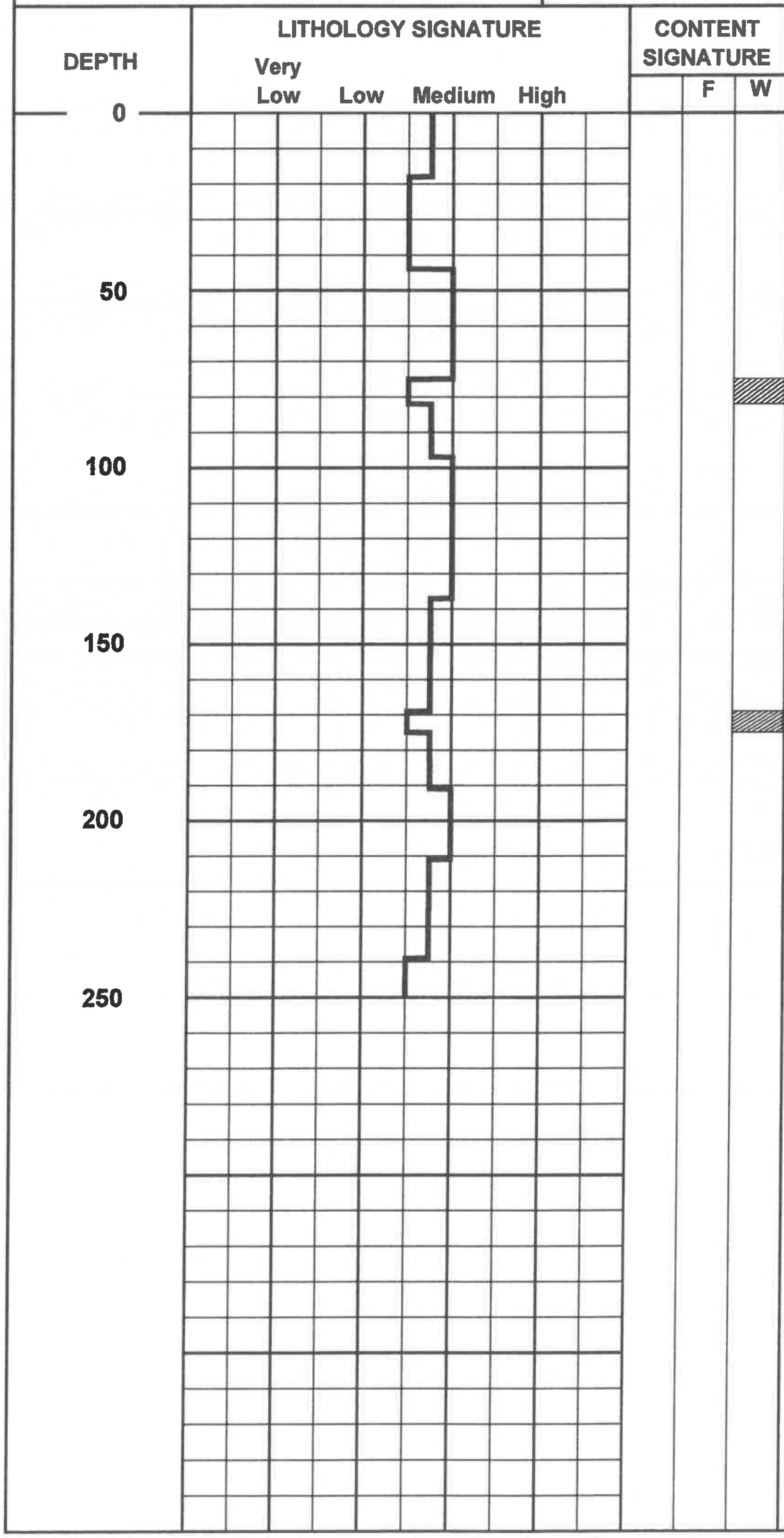
# ELECTROTELLURIC SOUNDING DC1-6

| | | | |
|---|---|---|---|
| Project No.: | G1876-01 | Record Date: | 07/31/2020 |
| Elevation: | 14 Feet | Record Time: | 12:10 |
| Page: | 01 of 01 | Record No.: | 2 |




| SIGNATURE DEPTH | COMMENTS |
|---|---|
| 18 | |
| 44 | |
| 75 | |
| 82 | |
| 97 | |
| 137 | |
| 169 | |
| 175 | |
| 191 | |
| 211 | |
| 239 | |

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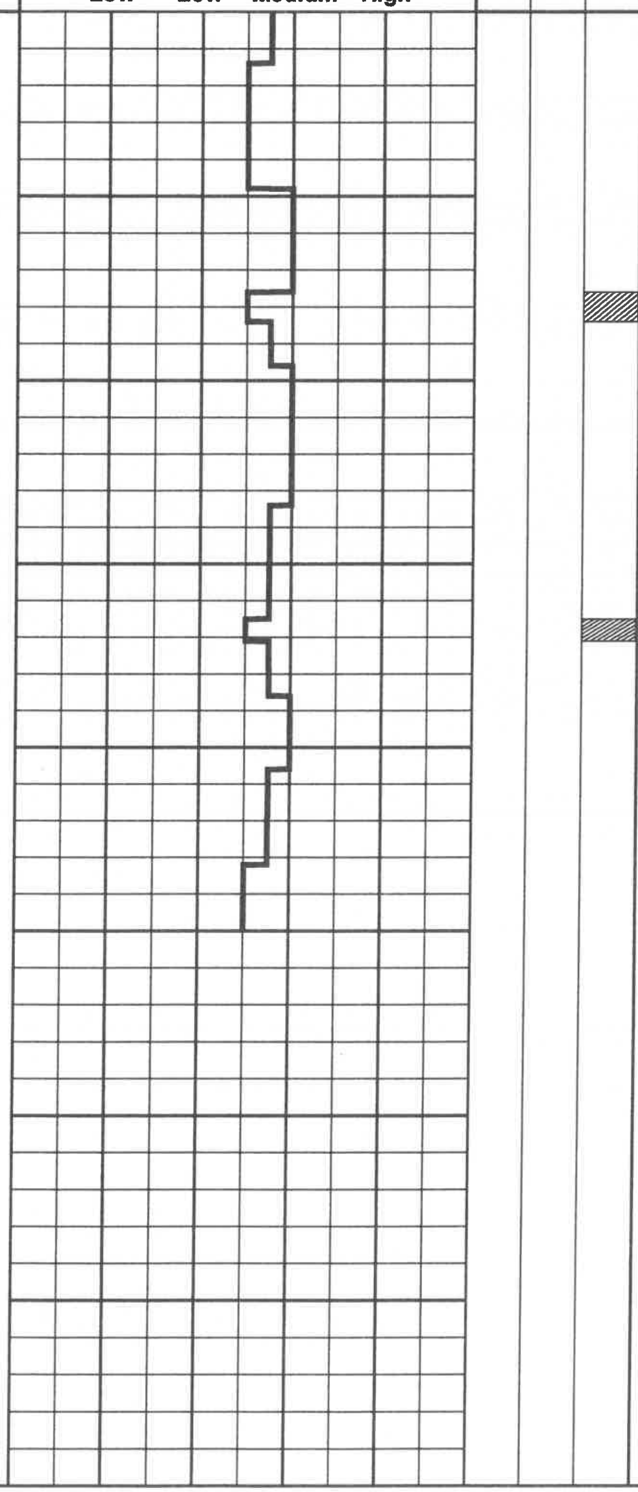
# ELECTROTELLURIC SOUNDING DC1-7

| | | | |
|---|---|---|---|
| **Project No.:** | G1876-01 | **Record Date:** | 07/31/2020 |
| **Elevation:** | 6 Feet | **Record Time:** | 11:48 |
| **Page:** | 01 of 01 | **Record No.:** | 1 |

| DEPTH | LITHOLOGY SIGNATURE (Very Low / Low / Medium / High) | CONTENT SIGNATURE (F / W) | SIGNATURE DEPTH | COMMENTS |
|---|---|---|---|---|
| 0 | | | | |
| | | | 14 | |
| 50 | | | 48 | |
| | | | 76 | |
| | | | 84 | |
| | | | 96 | |
| 100 | | | | |
| | | | 134 | |
| 150 | | | | |
| | | | 165 | |
| | | | 171 | |
| | | | 186 | |
| 200 | | | | |
| | | | 206 | |
| | | | 232 | |
| 250 | | | | |



DC 2

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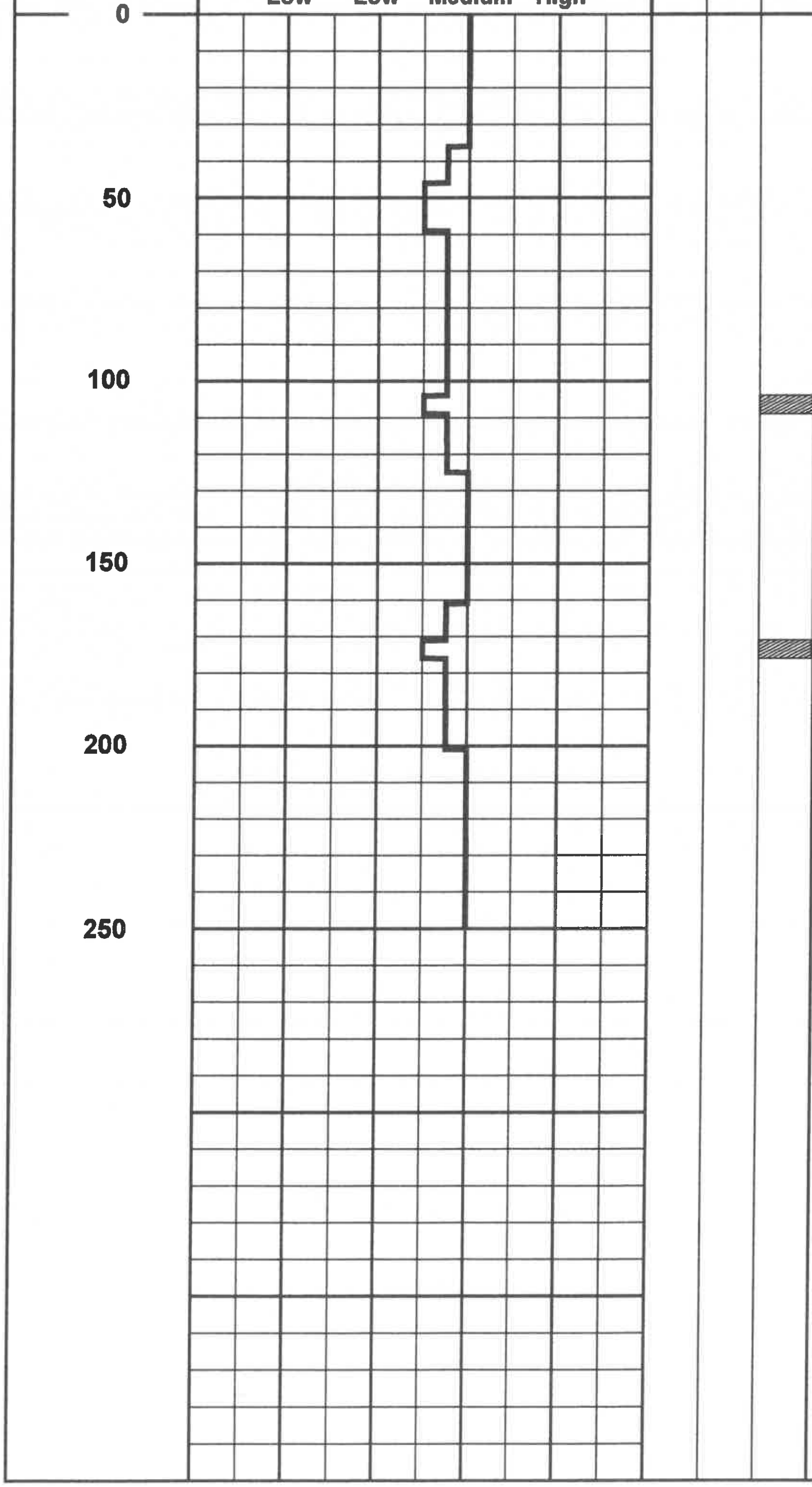
# ELECTROTELLURIC SOUNDING DC2-1

| | | | |
|---|---|---|---|
| Project No.: | G1876-01 | Record Date: | 07/29/2020 |
| Elevation: | 57 Feet | Record Time: | 16:11 |
| Page: | 01 of 01 | Record No.: | 7 |

| DEPTH | LITHOLOGY SIGNATURE (Very Low / Low / Medium / High) | CONTENT SIGNATURE (F / W) | SIGNATURE DEPTH | COMMENTS |
|---|---|---|---|---|




Signature depths: 36, 46, 59, 104, 109, 125, 161, 171, 176, 201

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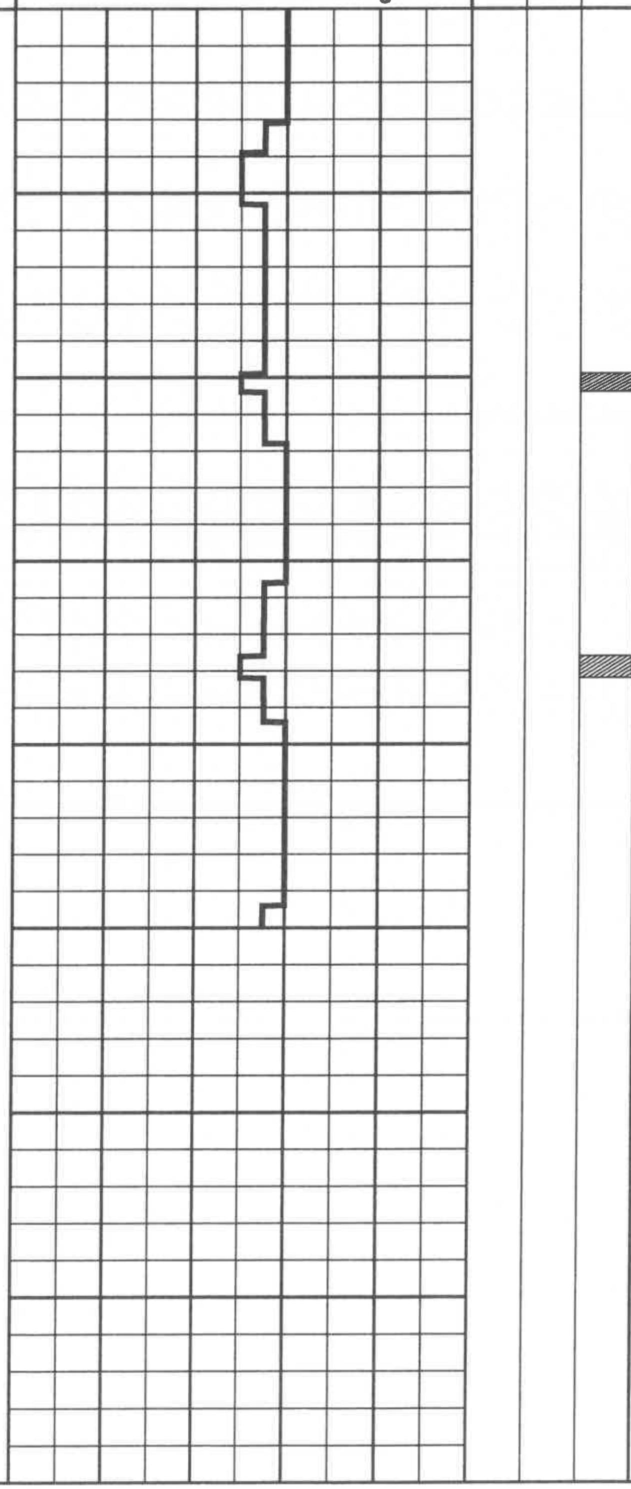
# ELECTROTELLURIC SOUNDING DC2-2

| | | | |
|---|---|---|---|
| **Project No.:** | G1876-01 | **Record Date:** | 07/29/2020 |
| **Elevation:** | 62 Feet | **Record Time:** | 15:59 |
| **Page:** | 01 of 01 | **Record No.:** | 6 |

| DEPTH | LITHOLOGY SIGNATURE (Very Low, Low, Medium, High) | CONTENT SIGNATURE (F, W) | SIGNATURE DEPTH | COMMENTS |
|---|---|---|---|---|
| 0 | | | | |
| | | | 31 | |
| | | | 39 | |
| 50 | | | 53 | |
| 100 | | | 99 | |
| | | | 104 | |
| | | | 118 | |
| 150 | | | 156 | |
| | | | 176 | |
| | | | 182 | |
| | | | 194 | |
| 200 | | | | |
| | | | 244 | |
| 250 | | | | |



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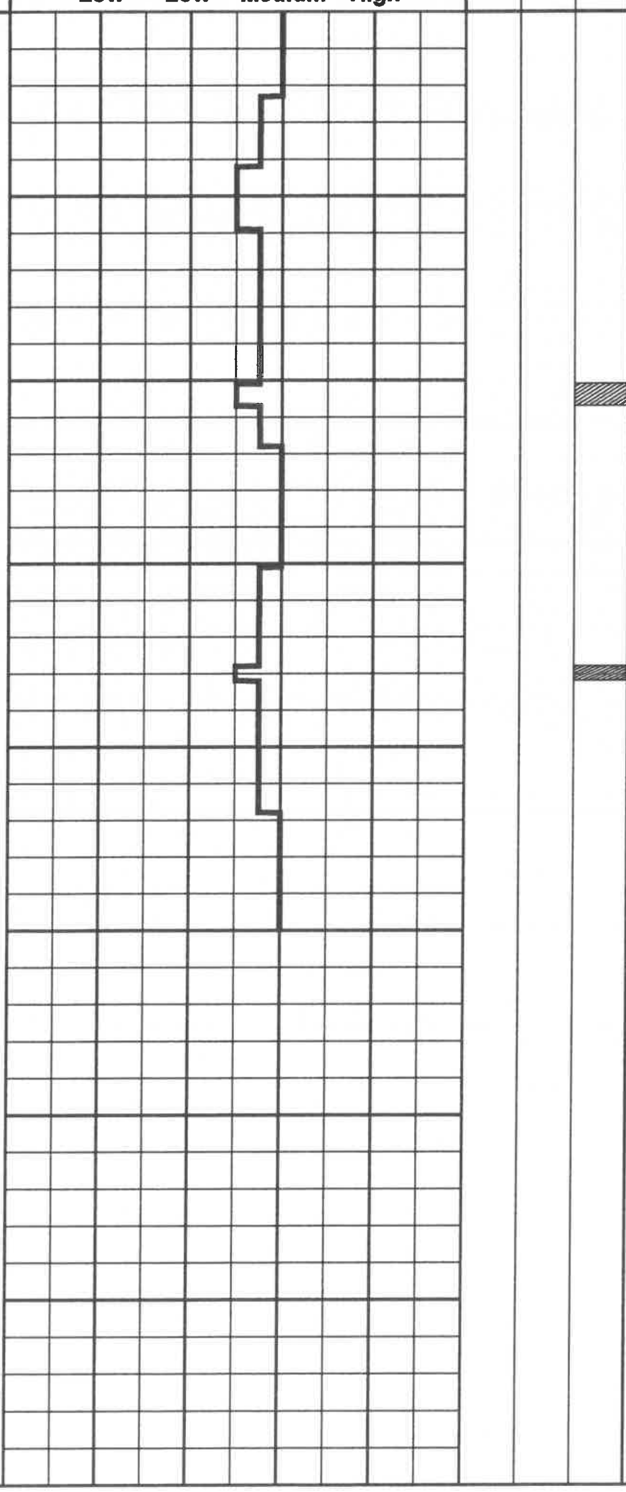
# ELECTROTELLURIC SOUNDING DC2-3

| | | | |
|---|---|---|---|
| Project No.: | G1876-01 | Record Date: | 07/29/2020 |
| Elevation: | 55 Feet | Record Time: | 15:42 |
| Page: | 01 of 01 | Record No.: | 5 |

| DEPTH | LITHOLOGY SIGNATURE (Very Low, Low, Medium, High) | CONTENT SIGNATURE (F, W) | SIGNATURE DEPTH | COMMENTS |
|---|---|---|---|---|



DEPTH: 0, 50, 100, 150, 200, 250

SIGNATURE DEPTH:
23
42
59
101
107
118
151
178
182
218

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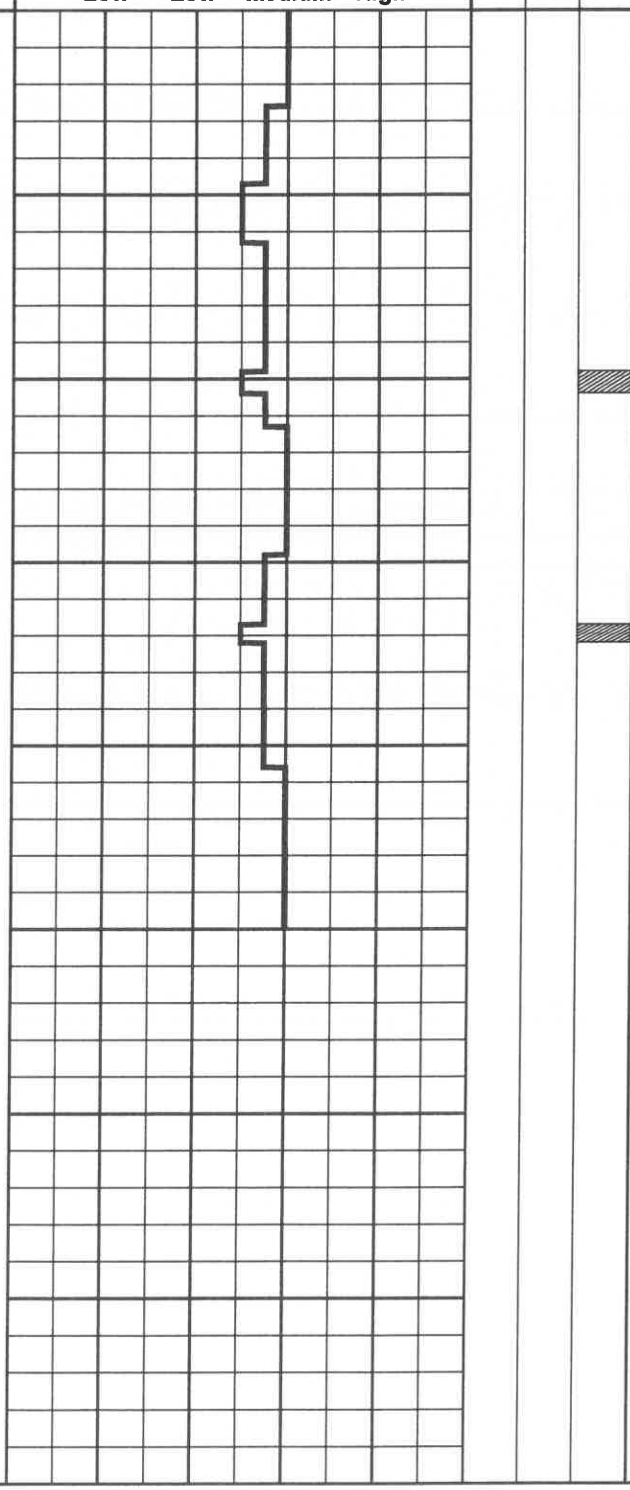
# ELECTROTELLURIC SOUNDING DC2-4

| | | | |
|---|---|---|---|
| **Project No.:** | G1876-01 | **Record Date:** | 07/29/2020 |
| **Elevation:** | 60 Feet | **Record Time:** | 15:29 |
| **Page:** | 01 of 01 | **Record No.:** | 4 |

| DEPTH | LITHOLOGY SIGNATURE (Very Low, Low, Medium, High) | CONTENT SIGNATURE (F, W) | SIGNATURE DEPTH | COMMENTS |
|---|---|---|---|---|
| 0 | | | | |
| | | | 26 | |
| 50 | | | 47 | |
| | | | 63 | |
| | | | 79 | |
| 100 | | | 98 | |
| | | | 104 | |
| | | | 113 | |
| 150 | | | 148 | |
| | | | 167 | |
| | | | 172 | |
| 200 | | | 206 | |
| 250 | | | | |



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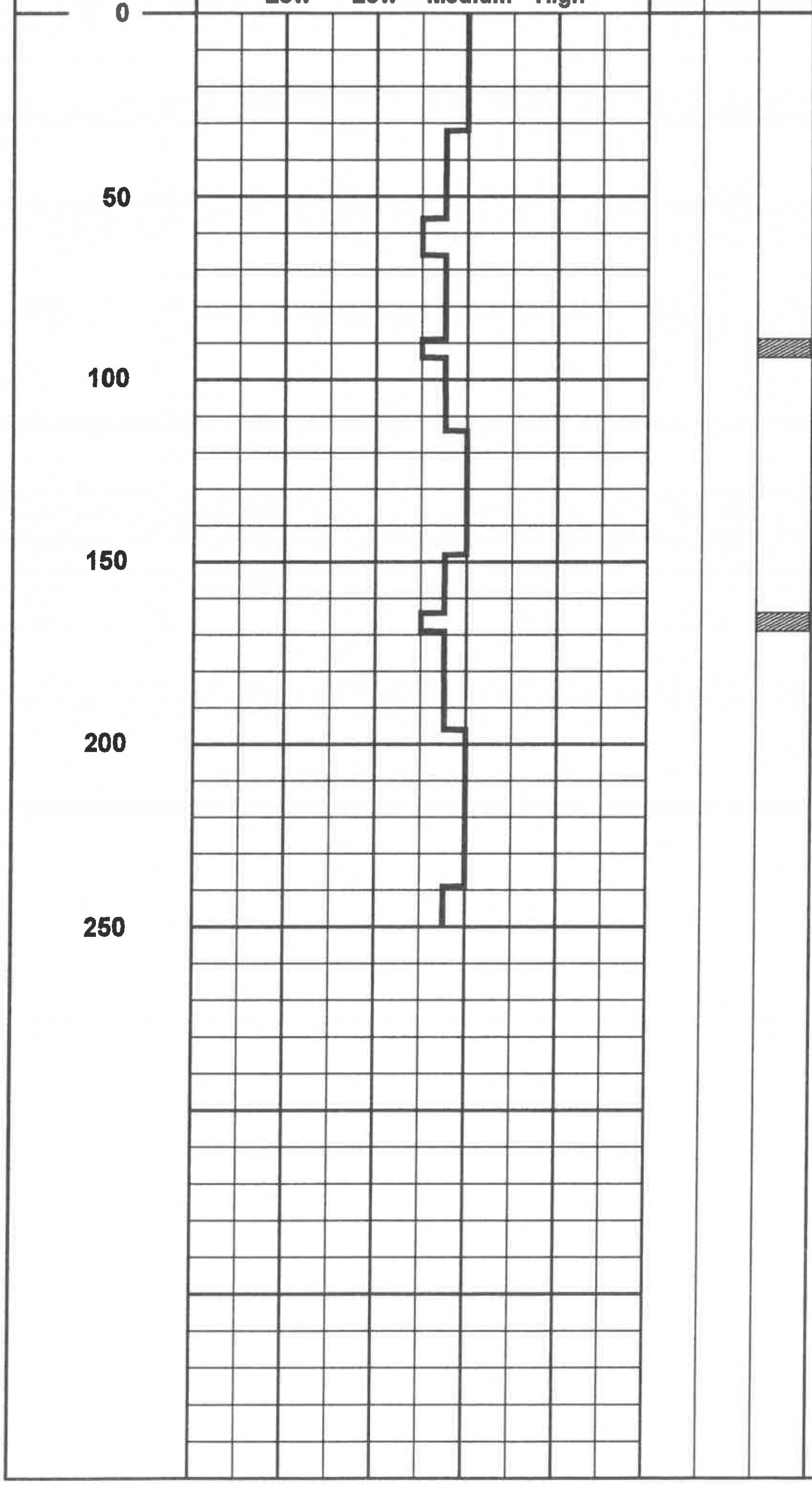
# ELECTROTELLURIC SOUNDING DC2-5

| | | | |
|---|---|---|---|
| **Project No.:** | G1876-01 | **Record Date:** | 07/29/2020 |
| **Elevation:** | 70 Feet | **Record Time:** | 15:14 |
| **Page:** | 01 of 01 | **Record No.:** | 3 |

| DEPTH | LITHOLOGY SIGNATURE (Very Low / Low / Medium / High) | CONTENT SIGNATURE (F / W) | SIGNATURE DEPTH | COMMENTS |
|---|---|---|---|---|



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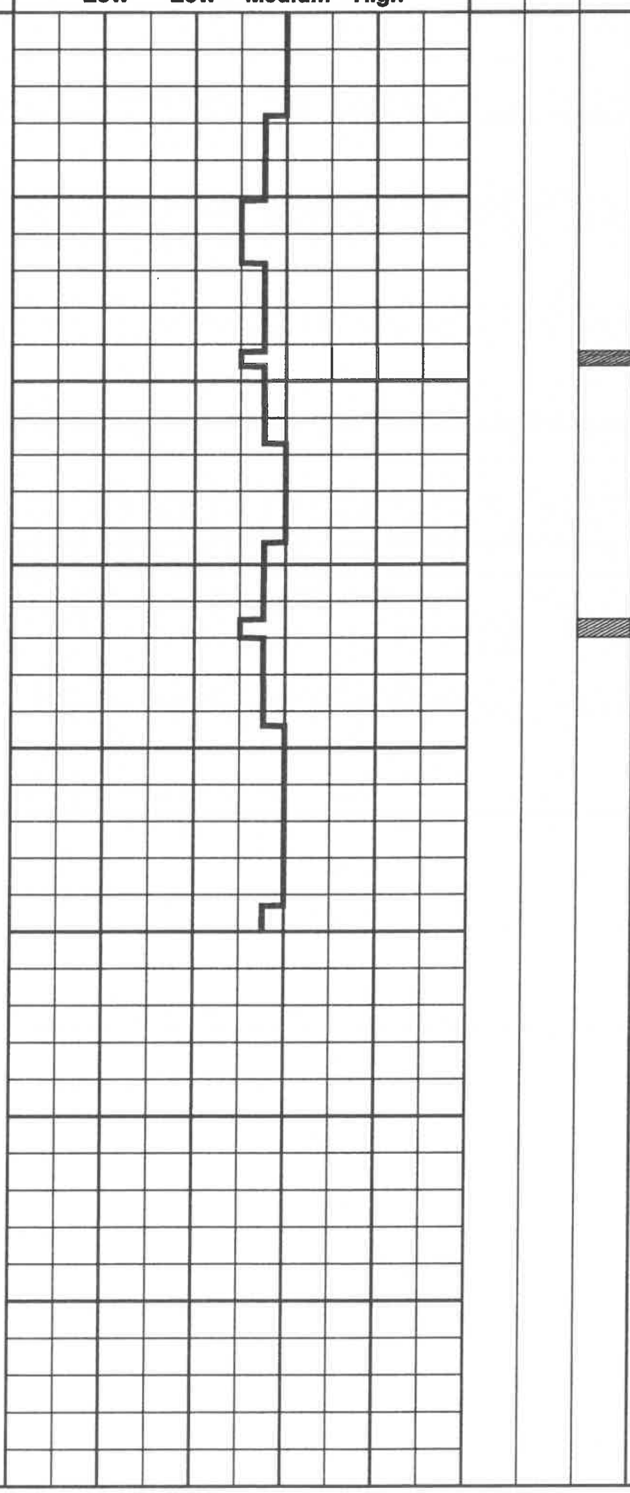
# ELECTROTELLURIC SOUNDING DC2-6

| | | | |
|---|---|---|---|
| Project No.: | G1876-01 | Record Date: | 07/29/2020 |
| Elevation: | 75 Feet | Record Time: | 15:00 |
| Page: | 01 of 01 | Record No.: | 2 |

| DEPTH | LITHOLOGY SIGNATURE (Very Low, Low, Medium, High) | CONTENT SIGNATURE (F, W) | SIGNATURE DEPTH | COMMENTS |
|---|---|---|---|---|

Depth: 0, 50, 100, 150, 200, 250



Signature Depth: 28, 51, 68, 92, 96, 117, 144, 165, 170, 194, 243

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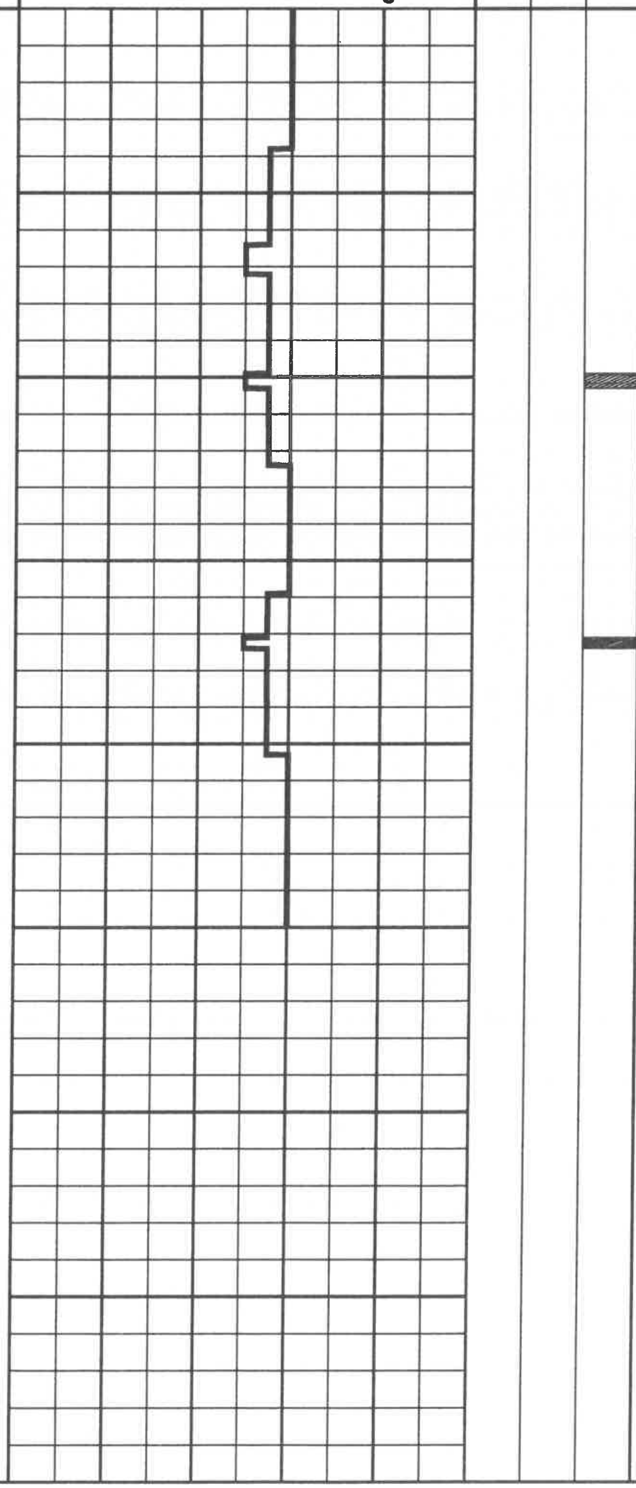
# ELECTROTELLURIC SOUNDING DC2-7

| | | | |
|---|---|---|---|
| **Project No.:** | G1876-01 | **Record Date:** | 07/29/2020 |
| **Elevation:** | 78 Feet | **Record Time:** | 14:45 |
| **Page:** | 01 of 01 | **Record No.:** | 1 |

| DEPTH | LITHOLOGY SIGNATURE (Very Low / Low / Medium / High) | CONTENT SIGNATURE (F / W) | SIGNATURE DEPTH | COMMENTS |
|---|---|---|---|---|
| 0 | | | | |
| | | | 38 | |
| 50 | | | | |
| | | | 64 | |
| | | | 72 | |
| | | | 99 | |
| 100 | | | 103 | |
| | | | 124 | |
| 150 | | | | |
| | | | 159 | |
| | | | 171 | |
| | | | 174 | |
| 200 | | | 203 | |
| 250 | | | | |



DC 3

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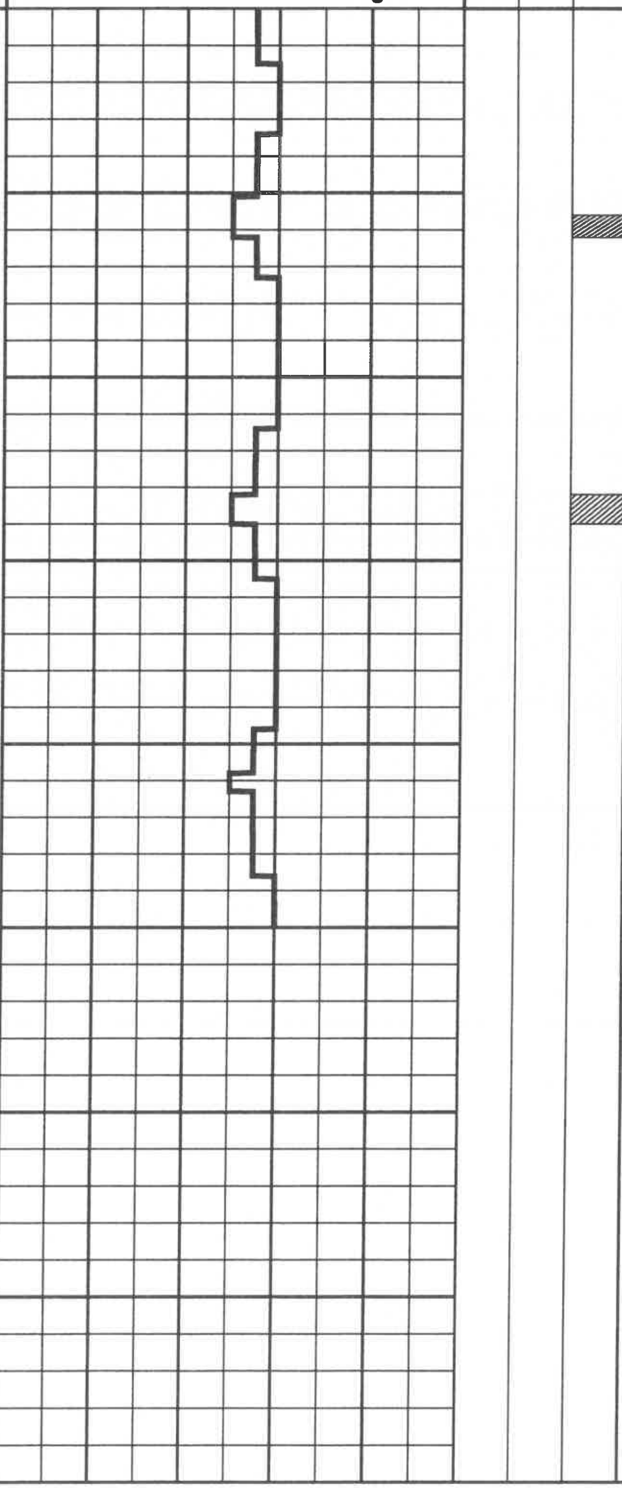
# ELECTROTELLURIC SOUNDING DC3-1

| | | | |
|---|---|---|---|
| **Project No.:** | G1876-01 | **Record Date:** | 08/04/2020 |
| **Elevation:** | 220 Feet | **Record Time:** | 11:54 |
| **Page:** | 01 of 01 | **Record No.:** | 1 |

| DEPTH | LITHOLOGY SIGNATURE (Very Low / Low / Medium / High) | CONTENT SIGNATURE (F / W) | SIGNATURE DEPTH | COMMENTS |
|---|---|---|---|---|
| 0 | | | | |
| | | | 15 | |
| | | | 34 | |
| 50 | | | 51 | |
| | | | 56 | |
| | | | 62 | |
| | | | 73 | |
| 100 | | | | |
| | | | 114 | |
| | | | 132 | |
| | | | 140 | |
| 150 | | | 155 | |
| | | | 196 | |
| 200 | | | 208 | |
| | | | 213 | |
| | | | 236 | |
| 250 | | | | |



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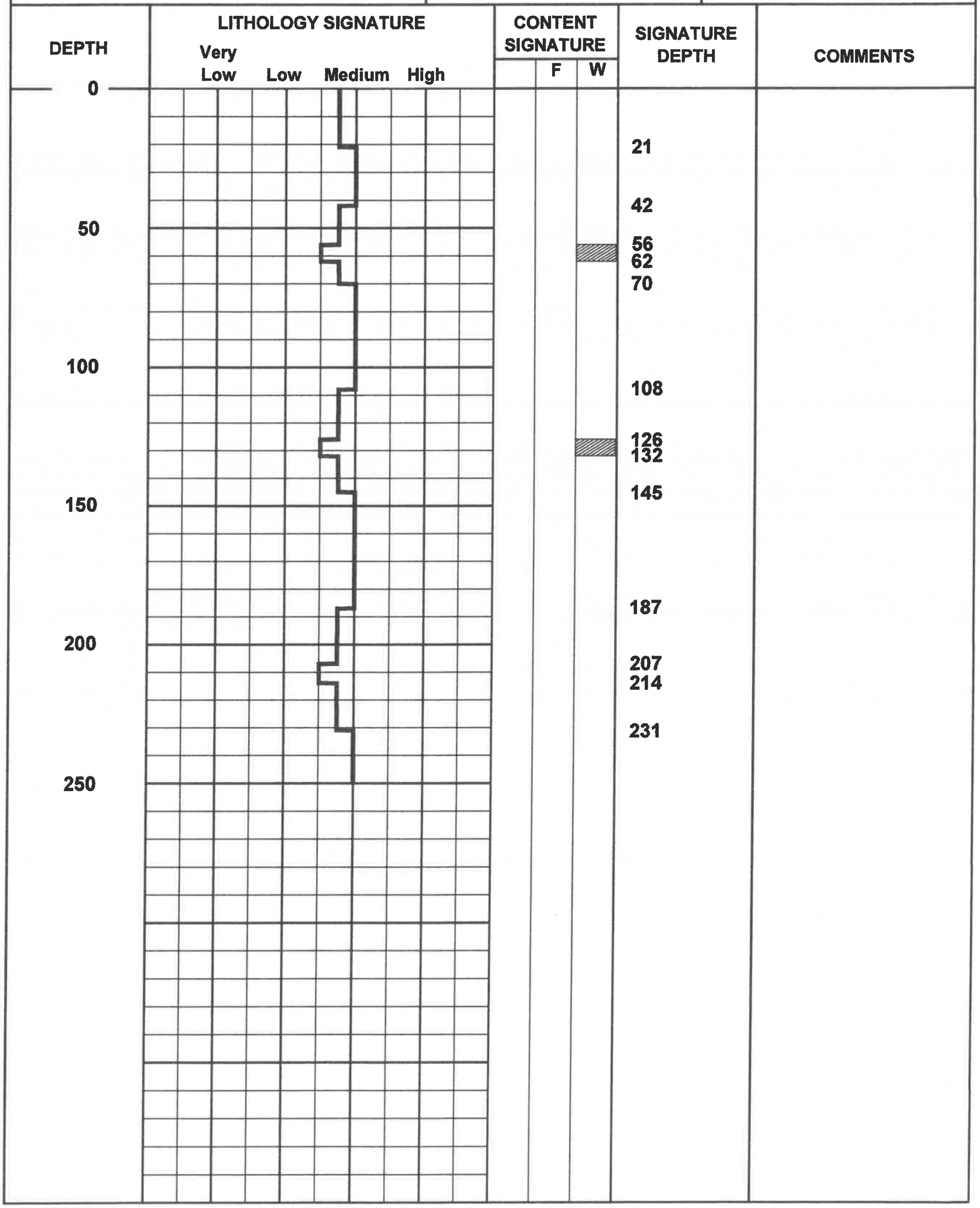
# ELECTROTELLURIC SOUNDING DC3-2

| | | | |
|---|---|---|---|
| **Project No.:** | G1876-01 | **Record Date:** | 08/04/2020 |
| **Elevation:** | 192 Feet | **Record Time:** | 12:03 |
| **Page:** | 01 of 01 | **Record No.:** | 2 |



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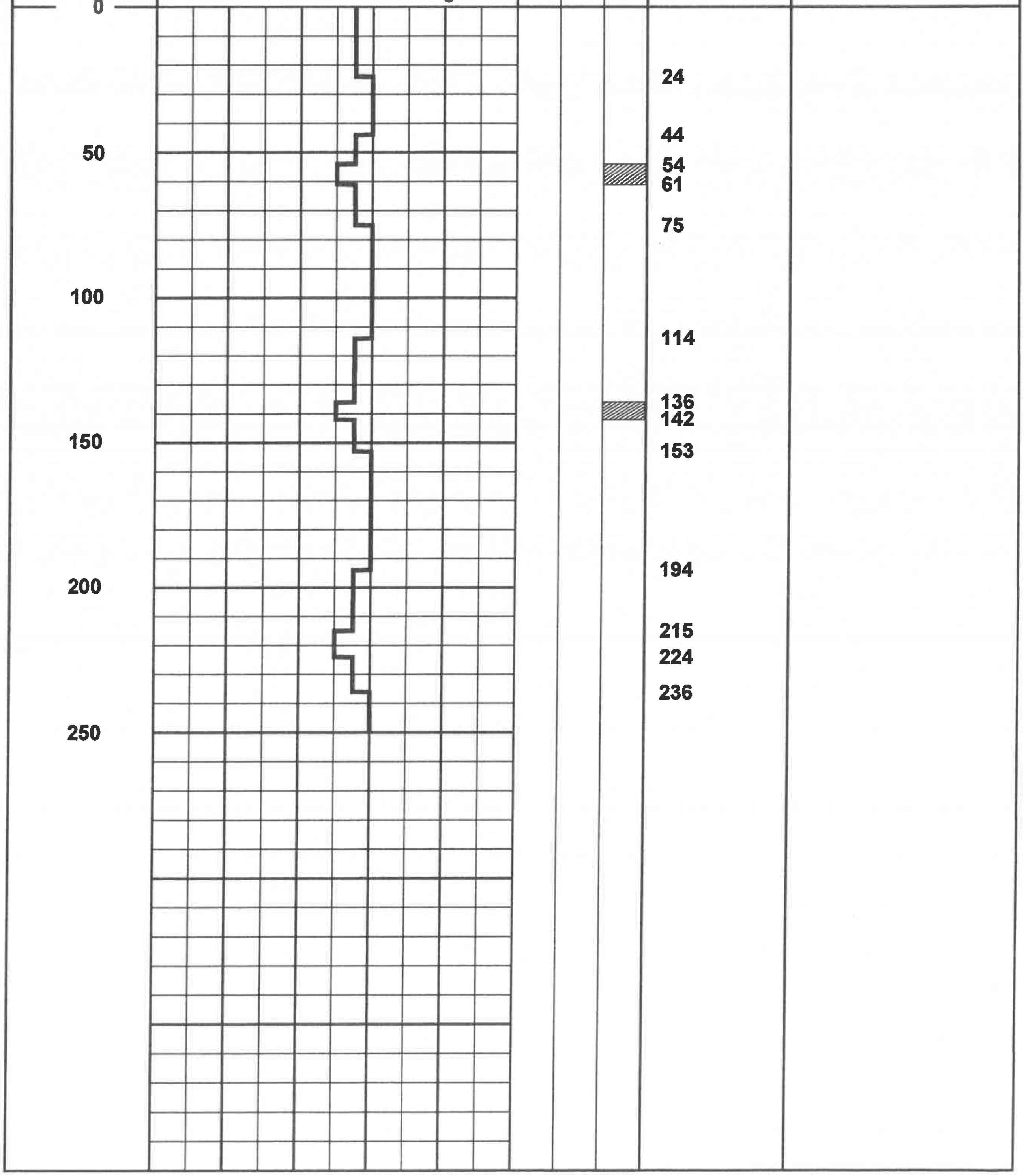
# ELECTROTELLURIC SOUNDING DC3-3

| | | | |
|---|---|---|---|
| **Project No.:** | G1876-01 | **Record Date:** | 08/04/2020 |
| **Elevation:** | 195 Feet | **Record Time:** | 12:15 |
| **Page:** | 01 of 01 | **Record No.:** | 3 |

| DEPTH | LITHOLOGY SIGNATURE (Very Low / Low / Medium / High) | CONTENT SIGNATURE (F / W) | SIGNATURE DEPTH | COMMENTS |
|---|---|---|---|---|



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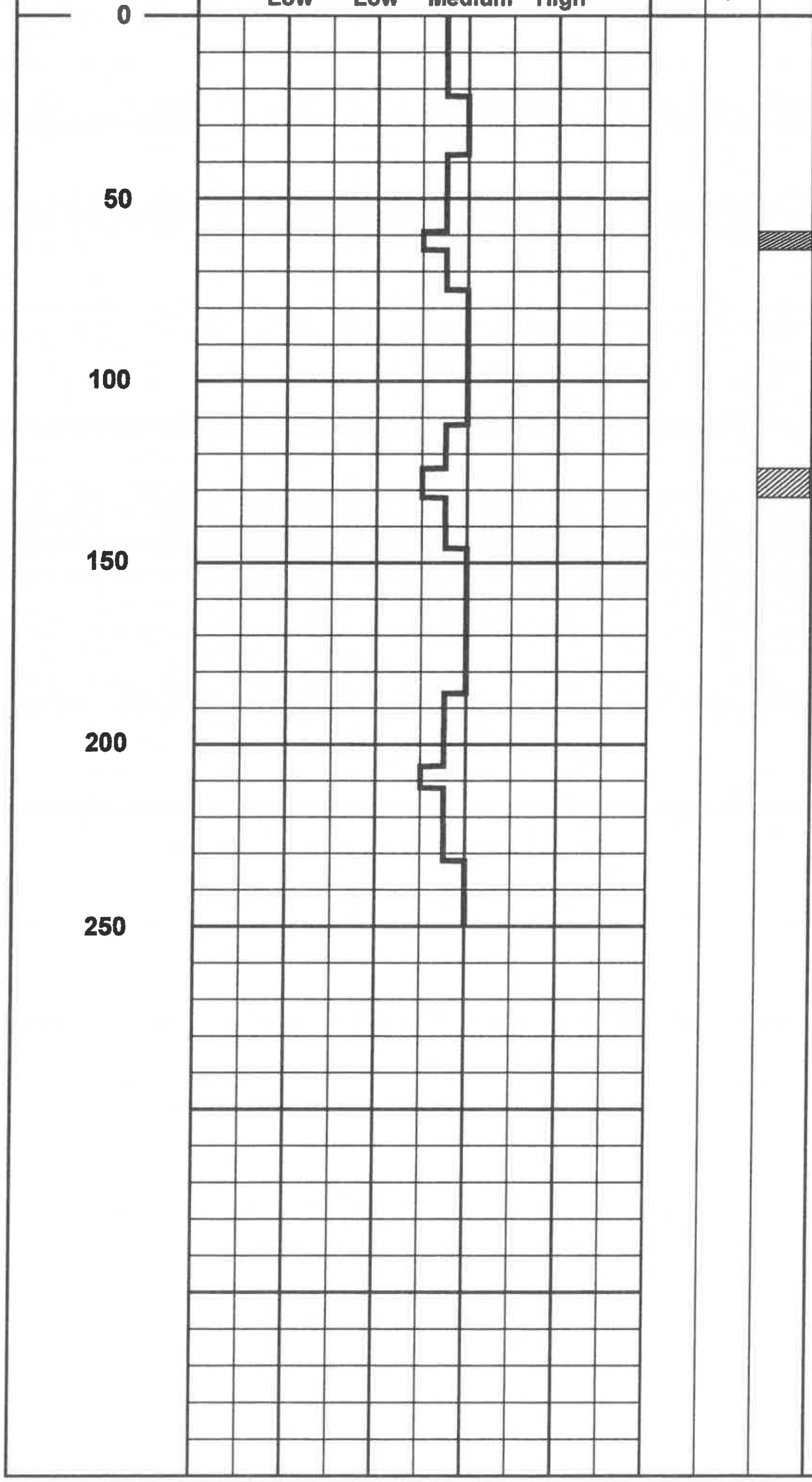
# ELECTROTELLURIC SOUNDING DC3-4

| | | | |
|---|---|---|---|
| Project No.: | G1876-01 | Record Date: | 08/04/2020 |
| Elevation: | 192 Feet | Record Time: | 12:48 |
| Page: | 01 of 01 | Record No.: | 4 |

| DEPTH | LITHOLOGY SIGNATURE (Very Low, Low, Medium, High) | CONTENT SIGNATURE (F, W) | SIGNATURE DEPTH | COMMENTS |
|---|---|---|---|---|




Signature depths: 22, 38, 59, 64, 75, 112, 124, 132, 146, 186, 206, 212, 232

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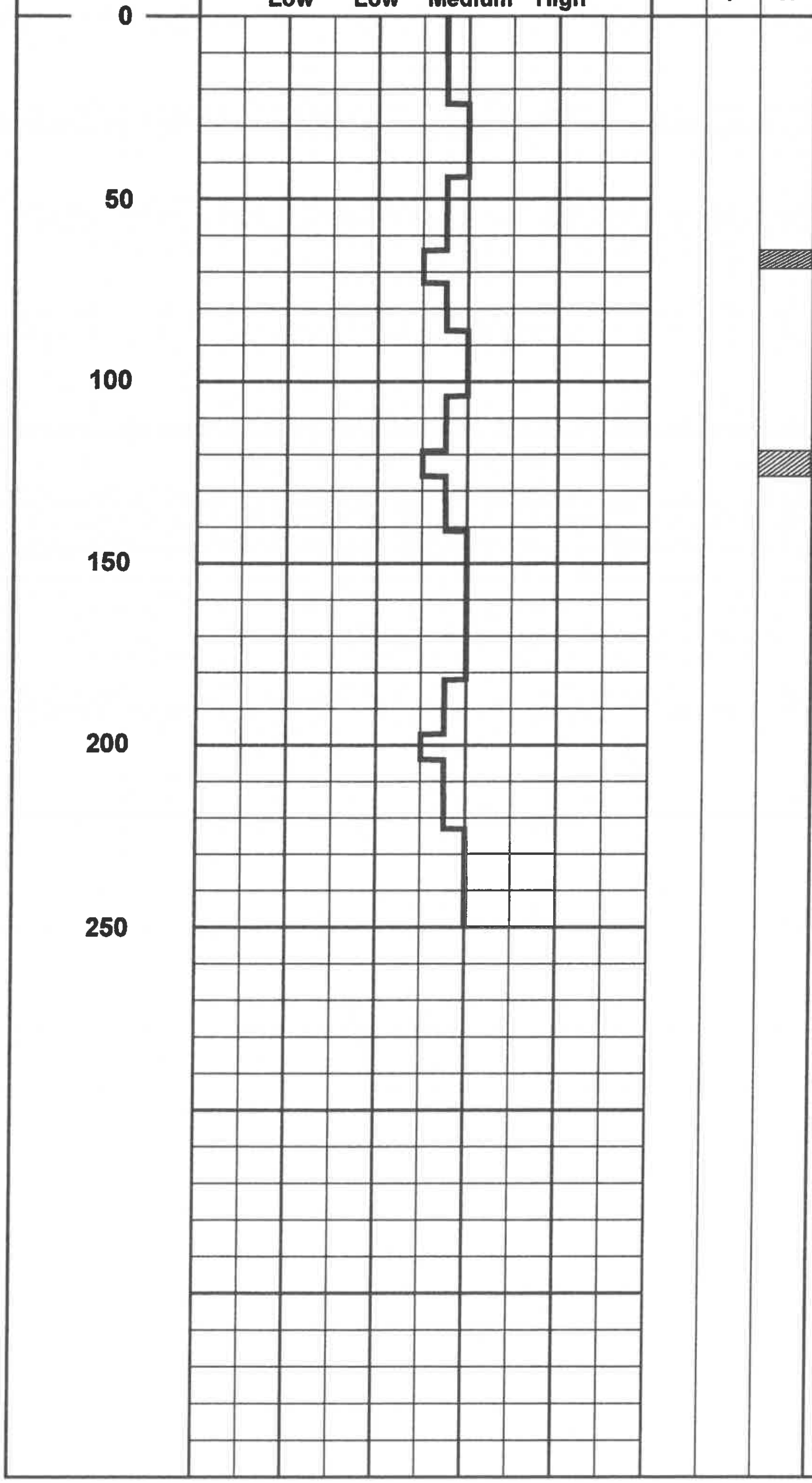
# ELECTROTELLURIC SOUNDING DC3-5

| | | | |
|---|---|---|---|
| Project No.: | G1876-01 | Record Date: | 08/04/2020 |
| Elevation: | 195 Feet | Record Time: | 13:04 |
| Page: | 01 of 01 | Record No.: | 5 |

| DEPTH | LITHOLOGY SIGNATURE (Very Low, Low, Medium, High) | CONTENT SIGNATURE (F, W) | SIGNATURE DEPTH | COMMENTS |
|---|---|---|---|---|




SIGNATURE DEPTH:
24
44
64
69
73
86
104
119
126
141
182
197
204
223

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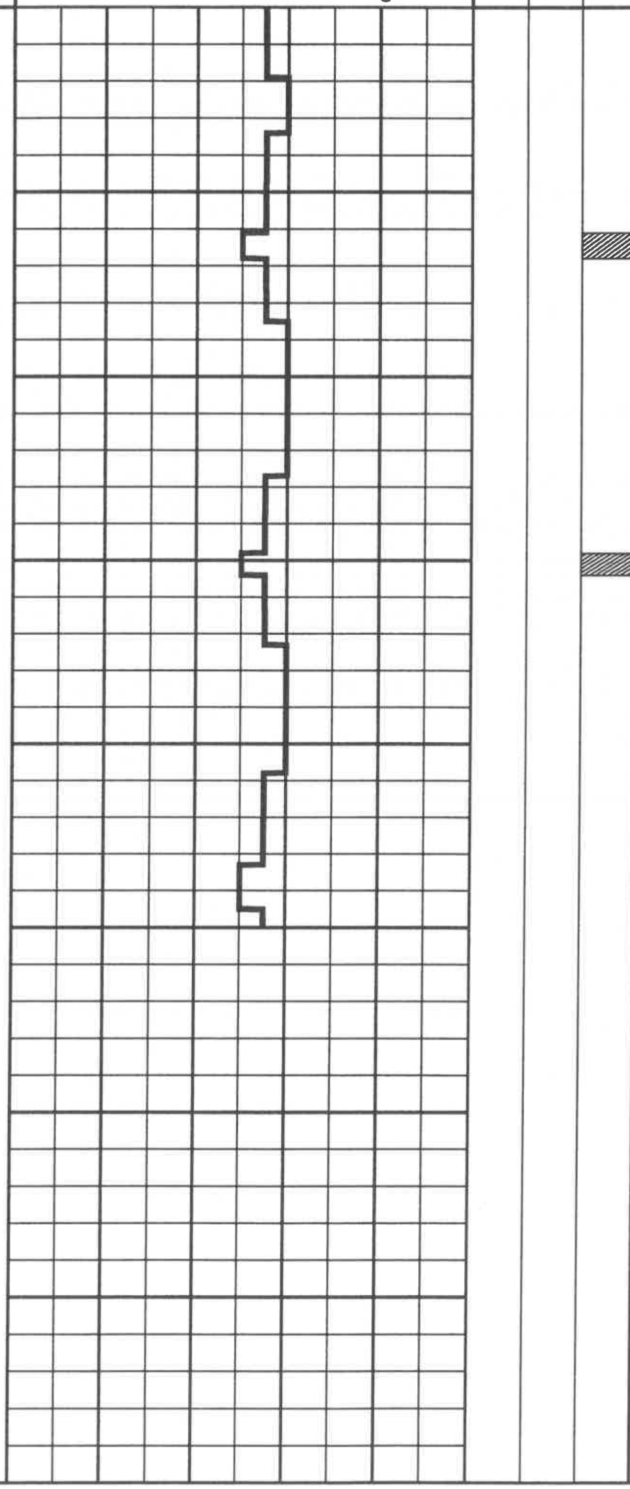
# ELECTROTELLURIC SOUNDING DC3-6

| | | | |
|---|---|---|---|
| Project No.: | G1876-01 | Record Date: | 08/04/2020 |
| Elevation: | 212 Feet | Record Time: | 13:34 |
| Page: | 01 of 01 | Record No.: | 6 |

| DEPTH | LITHOLOGY SIGNATURE (Very Low / Low / Medium / High) | CONTENT SIGNATURE (F / W) | SIGNATURE DEPTH | COMMENTS |
|---|---|---|---|---|
| 0 | | | | |
| | | | 19 | |
| | | | 34 | |
| 50 | | | | |
| | | W | 61 | |
| | | W | 68 | |
| | | | 85 | |
| 100 | | | | |
| | | | 127 | |
| | | W | 148 | |
| 150 | | W | 154 | |
| | | | 173 | |
| 200 | | | | |
| | | | 208 | |
| | | | 233 | |
| | | | 245 | |
| 250 | | | | |



# Surface NMR Survey

# SURFACE NMR SURVEY

Cosumnes River Basin

11 Feb 2021

Vista Clara, Inc.
info@vista-clara.com

# Executive Summary

This report summarizes results from surface NMR surveys performed by Vista Clara for EKI in November 2020. Data were acquired over the course of five days at eight sites between Elk Grove and Galt, CA. The surface NMR method allows direct detection of groundwater and characterization of water mobility. By adapting the survey design to environmental conditions, Vista Clara was successful in acquiring high-quality NMR data at most sites. Data at two sites were overwhelmed by electromagnetic noise interference. The data indicate significant hydrogeologic differences between sites as well as significant influence from magnetic geology. Influences from magnetic geology were assessed and mitigated by analyzing the NMR frequency and implemented patented CPMG acquisition sequences. Electrical conductivity data from time-domain EM surveys was used quantitatively to improve the accuracy of the depth inversion the surface NMR data and can be used qualitatively to aid in data interpretation. Sites where significant groundwater was detected generally showed a shallow zone of low NMR water detection and high resistivity consistent with unsaturated sands. Most sites show a transition at depth to increased detected NMR water and decreased resistivity which would be consistent with an increase in more permeable sands and possibly a high TDS contributing to the low resistivity. Zones showing particularly long T2* and/or long CPMG T2 values would be consistent with sands with anomalously high hydraulic conductivity. Quantified water contents across all sites are lower than expected, which may reflect the influence of magnetic geology or may indicate that mobile water is associated with spatially discrete features (e.g., paleochannels) that are smaller than the area of the detection loop. The surface NMR data indicate hydrogeologic structure that could influence managed aquifer recharge operations and resolve ambiguity that would confound interpretation of electrical resistivity data alone.

## Disclaimer

This report provides an explanation of the acquired geophysical data. Data are described with limited interpretation and without guarantee of reliability. Interpretations of the data in terms of hydrogeological characteristics have inherent uncertainty. Vista Clara is not responsible for incorrect determinations associated with the data interpretation. The results in this report should be interpreted in close consultation with a profession hydrogeologist who is familiar with the local geologic environment.

# Introduction

## Overview of the Surface NMR Method

Surface nuclear magnetic resonance (SNMR) employs the physics of nuclear magnetic resonance (NMR) to directly measure groundwater and obtain information about the pore environment of the subsurface. The technique measures the response of hydrogen nuclei *spins* when they are perturbed by a change in magnetic field. Nuclear magnetic resonance is used in medical resonance imaging (MRI) to detect and characterize hydrogen in biological tissue using superconducting magnets. In geophysics, surface NMR uses the Earth's magnetic field and surface coils to detect hydrogen in groundwater and characterize the properties of the water-bearing formation.

Prior to an NMR measurement, hydrogen spins in groundwater are preferentially aligned with the geomagnetic field and are at equilibrium. The aligned spins combine to create a small net nuclear magnetization, which can be described as a very small magnetic moment. In a surface NMR measurement, a wire loop is deployed on the ground and is used to excite the hydrogen nuclei from equilibrium and to measure their NMR response.

To excite the groundwater, an AC current pulse is circulated through the loop; the frequency of this pulse is tuned to the local NMR frequency of hydrogen. The *excitation pulse* causes the nuclear magnetization of the hydrogen to rotate away from the axis of the geomagnetic field. When the pulse is terminated, the magnetization will rotate (or *precess*) about the axis of the geomagnetic field as it returns to equilibrium. This precession of the nuclear magnetization generates a voltage that can be detected in the surface NMR loop. The precessing NMR signal decays over time as the hydrogen return (or *relax*) back to equilibrium.

The amplitude of the detected NMR signal is directly proportional to the amount of hydrogen that has been excited, and the decay time is related to the physical environment seen by the hydrogen. In non-magnetic geology, the decay time is correlated with pore size: water that is mobile in larger pores has a longer decay time, and water that is bound in smaller pores exhibits a shorter decay time. Detection of NMR signals is an unambiguous indication that groundwater is present, and the detection of signals with long decay time is an unambiguous indication that water is present in large pores.

In order to determine the distribution of water with depth, a surface NMR depth profile acquisition, or *sounding*, can performed. In a sounding, multiple measurements are acquired in which the energy of the excitation pulse, or *pulse moment*, is varied between measurements. The pulse moment is equal the product of the pulse current (which can vary from one to hundreds of amps) and the pulse duration (typically between 10 and 100 milliseconds). A large pulse excites water at greater depth and a small pulse excites water at shallower depth. By combining the full suite of NMR measurements made at a range of pulse moments into a geophysical inversion, the NMR signals are localized to specific depths and it is possible to obtain an estimated depth profile of subsurface NMR response.

## Data Products

The NMR depth profiles included in this report have three primary elements: Relaxation Time Distribution, Water Content Profile, and Hydraulic Conductivity Indicator.

The profiles are derived from a **1D depth inversion** that assumes a layered earth model under the loop. If discrete 2D or 3D features are present at a scale smaller than the loop (e.g., a paleochannel), the features will be observed in the depth-resolved data, weighted approximately by their areal extent relative to the area of the loop.

**The relaxation time distribution** conveys the amplitude and relaxation times (T2*) of the NMR signal observed at each depth. The relaxation time distribution can be qualitatively interpreted as a saturated pore size distribution, with energy at short T2* representing water in small pores and energy at long T2* representing water in larger pores.

**The water content profile** reflects the estimated volumetric water content at a given depth. The water content profile is subdivided into the fraction of water with relatively short T2* (classified as "bound") and the fraction with relatively long T2* (classified as "mobile"). The descriptions "bound" and "mobile" should be considered qualitative in terms of distinguishing more-mobile and less-mobile components, not as absolute distinctions.

**The hydraulic conductivity indicator (Krel)** is proportional to water content and relaxation time (relative pore size) at a given depth. For cases where pump testing data is available, the hydraulic conductivity indicator can be scaled as a quantitative indicator but should otherwise be considered as a qualitative indication of depths or locations with higher or lower hydraulic conductivity.

## Description of Exported Data

Results are presented in one folder for each site or station and contain ASCII text files and three types of image files (PNG bitmap images, EPS vector images, and FIG Matlab figure files).

The key graphic exported is named "GMRinversion.png." An example for an FID inversion is shown in Figure 1. The panels of this figure are as follows:

1. "Decay Time Distribution" – Color indicates the amount of signal. The X axis indicates the length of the measured T2* decay time.
2. "Water Content" – The envelope of this plot gives the volumetric water content as a percent. Color is shaded to correspond to the measured relaxation time.
    a. For FID data, the color shading corresponds to the T2* relaxation time. Only values between 10ms and 80ms are shaded; water contents with T2* times less than 10ms are clipped to magenta and water contents with T2* greater than 80ms are clipped to cyan. The red line indicates the water content that is at the noise level at each depth for this collection. If the total water content at any depth falls to the right of the red noise line, it is not a reliable result.
    b. For CPMG data, the color shading corresponds to the T2 relaxation time. Only values between 139ms and 800ms are shaded; water contents with T2 times less than 139ms are clipped to yellow and water contents with T2 greater than 800ms are clipped to green.
3. "Estimated K" – See description of 'Krel' earlier in this document.
4. "Conductivity Model" – If a conductivity model was used during the NMR inversion, the model is plotted here. For this project, the conductivity model is derived from Walk TEM measurements (see Appendix).

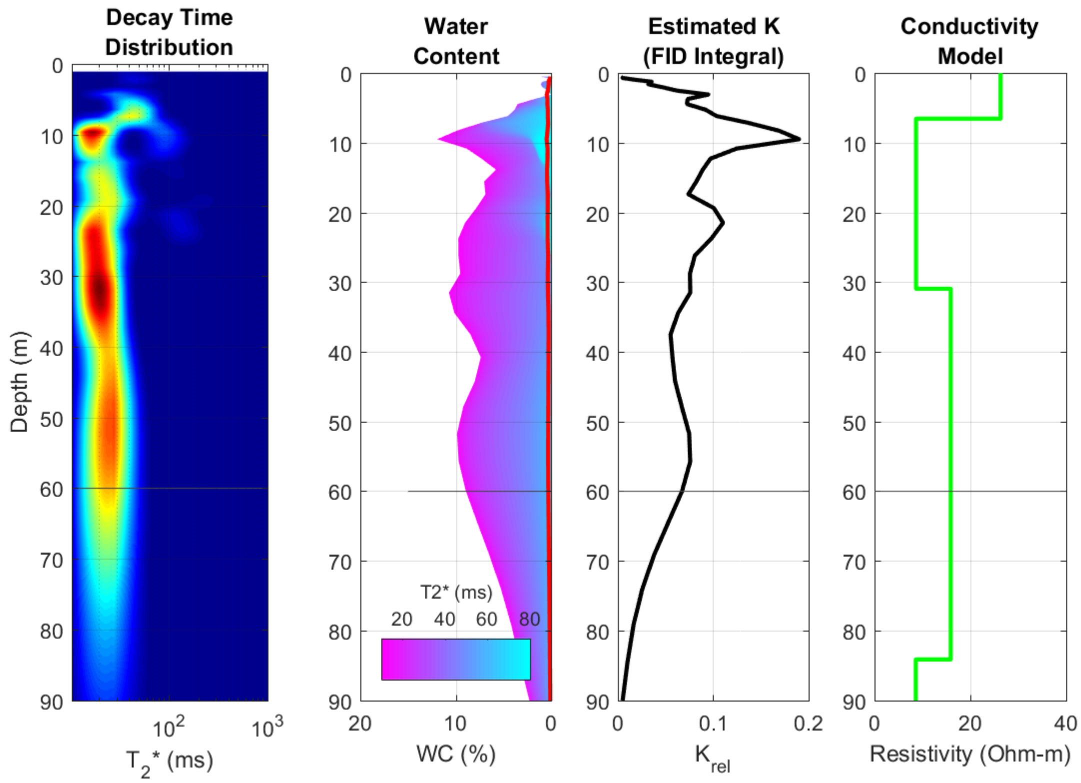



**Figure 1: Example data product for an FID inversion.**

# Data Collection

Between 9 and 13 November 2020, staff from Vista Clara and EKI made surface NMR soundings at 8 locations (Table 1). Ramboll and Vista Clara made Walk TEM measurements at 6 sites, and Ramboll made Towed TEM measurements at one site.

**Table 1: Dates of GMR measurements and sites visited.**

| Date | GMR Measurement |
|---|---|
| 9-Nov | Site 8 |
| 10-Nov | Site 9 |
| 11-Nov | Site 5a |
| 11-Nov | Site 7 |
| 12-Nov | Site 11 |
| 12-Nov | Site 2 |
| 13-Nov | Site 3 |
| 13-Nov | Site 10 |

Naming of GMR measurement sites followed EKI naming conventions.

GPS waypoints were collected at each GMR measurement site (Figure 2), and these locations will be provided as a Google Earth .KMZ file. For circular surface loops, a single GPS location indicates the center of the measurement loop. For figure-eight surface loops, two GPS locations indicate the center of the two circles that comprise the figure-eight.

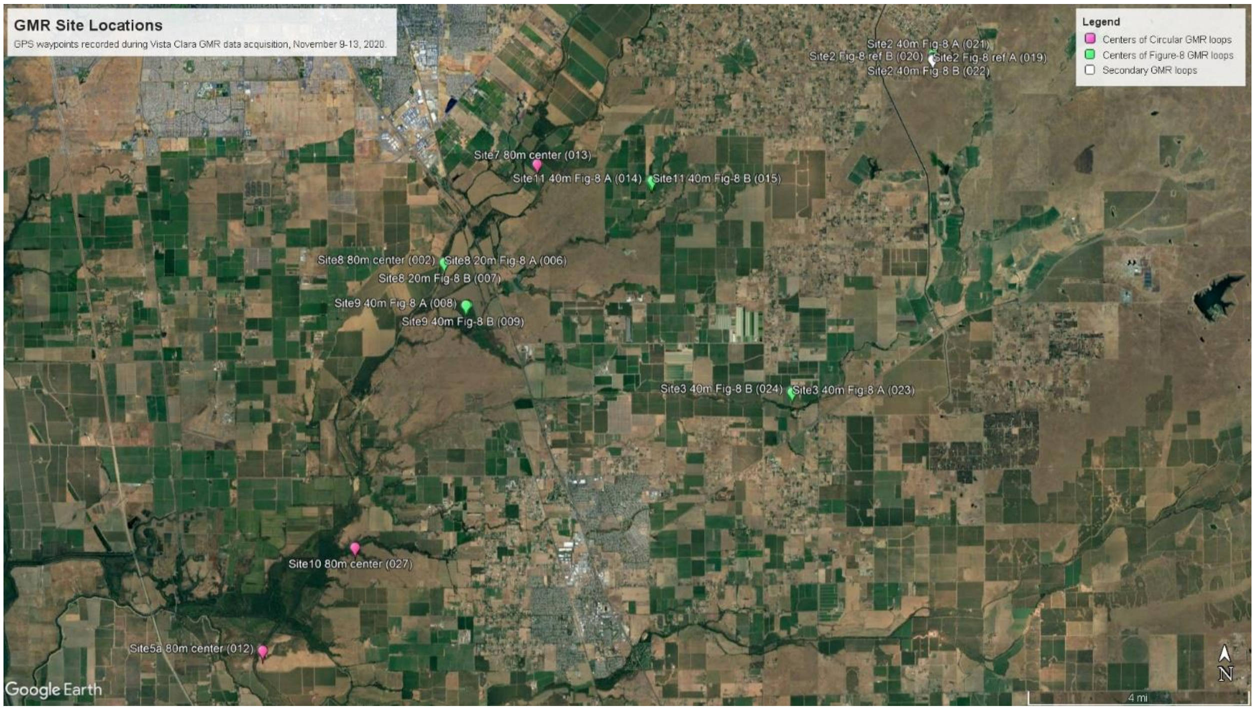



**Figure 2: GPS locations of GMR data collections. A Google Earth KMZ file of these locations is provided.**

## Survey Design

NMR surface loops geometries were chosen to maximize depth of investigation while keeping environmental interference to acceptable levels. (Larger, circular loops permit deeper investigation, but are more susceptible to interference from noise sources. Smaller loops and figure-eight loops are more resistant to environmental noise, at the cost of decreased depth of investigation.)

NMR acquisition pulse sequences were chosen to maximize depth of investigation, detection of water signals, and characterization of site hydrogeologic conditions.

Most pulse sequences used in the project were Free Induction Decay (FID), which measures the apparent relaxation time of the T2 NMR response (T2*). T2* is controlled by the pore size environment of the measured fluids, but also by the presence of magnetic geology, which has the effect of decreasing the NMR relaxation time, potentially causing fluids in large pores to present an NMR decay time similar to fluids in small pores.

A second pulse sequence (CPMG) was used at sites with sufficiently high SNR (Sites 10 and 5a). The CPMG sequence uses refocusing pulses to counter the effects of magnetic geology, potentially giving an indication of the presence of mobile water in large pores that would not be indicated in an FID measurement.

At some sites, multiple FID measurements were made with different excitation pulse lengths: a longer pulse length (e.g., 40 milliseconds) and a shorter pulse length (e.g., 15 milliseconds). Longer pulse moments allow for excitation of water at greater depths, increasing the maximum depth of investigation, but surface NMR measurements are unable to completely capture signals from fluids having a decay time shorter than or on the order of the excitation pulse length, leading to a possible underrepresentation of total water content. This underestimation is exacerbated by long excitation pulse lengths. Shorter excitation pulse lengths reduce this effect but come with the tradeoff of decreasing the maximum depth of investigation.

The maximum sensitive depth of a surface NMR measurement is largely controlled by the size of the loop and excitation pulse length but is also influenced by earth conductivity. If the subsurface has a relatively high electrical resistivity, the depth of sensitivity can be the same as the loop diameter. If the electrical resistivity is low, the depth of sensitivity will be reduced.

The areal sensitivity of a surface NMR measurement is roughly the area enclosed by the loop. That is, the final 1-D depth profile represents an average over roughly the areal extent of the loop. Therefore, the depth of investigation trades off with lateral resolution: investigation of deeper depths necessarily involves averaging over larger lateral extents.

## Equipment

The equipment used was a Vista Clara GMR system manufactured, owned, and operated by Vista Clara. The GMR is recognized as the most capable and sensitive surface NMR instrument on the market. It has a very efficient power architecture, ultra-short dead-time to detect short signals, and very low noise floor to detect small water volumes. The system also uses a multi-channel architecture that allows efficient noise cancellation required to remove interference from cultural noise, such as powerlines, that can otherwise be detrimental to NMR data.

The GMR equipment is deployed using two 12V deep cycle batteries and can be transported in off-highway vehicles. A team of two operated the system, with typical operation consisting of deploying and retrieving cable and monitoring data acquisition. Preliminary processing, inversion, and visualization of data is possible in the field.

# Data Processing

Processing of raw NMR data and generation of depth profiles is done using Vista Clara's proprietary software. Stacked data files are inverted for depth using an inversion algorithm that accounts for the loop geometry, ambient magnetic field strength and orientation, and the pulse moments generated by the instrument.

## Noise levels

Power lines are typically the largest noise source for surface NMR surveys. Due to the spatial variability of measurement sites in this project, every site presented a unique noise mitigation challenge. Some sites were close to low voltage power lines, high-tension transmission lines, or radio transmitter towers.

There are several methods for mitigating the effects of environmental noise in surface NMR surveys, including the use of smaller loops, figure-eight measurement coils, and reference loops. The multi-channel design of the GMR makes it particularly effective at noise cancellation, which allowed for usable results at sites that would otherwise not yield interpretable data.

## Depth Sensitivity

Depth sensitivity is modeled analytically during inversion. Depth sensitivity is a function of loop size, excitation pulse length, and ground resistivity. For this survey, due to the variations in loop sizes and local resistivities, depth sensitivity must be considered on a per-site basis. A depth resolution model is presented for each inversion.

## Conductivity model

Depth sensitivity in surface NMR measurements is influenced by ground conductivity. The depth inversion can take this effect into account by incorporating a layered conductivity model. This allows NMR energy to be assigned in depth more accurately.

Inversions presented in this document were calculated incorporating layered conductivity models provided by Walk TEM measurements. Some sites (9 and 11) did not have colocated TEM profiles and were inverted using the conductivity profile from the nearest TEM site.

## Inversion parameters

All inversions shown have a dimensionless regularization parameter of suited to the SNR level of the data. A correction is applied to all data to estimate and compensate for the NMR relaxation that occurs during the transmit pulse.

# Data Interpretation

Interpretation of surface NMR data is dependent on-site conditions and signal characteristics. The following factors should be considered in the interpretation of all data from the Cosumnes River project.

## Magnetic geology

Magnetic field inhomogeneity associated with magnetic geology can significantly influence the surface NMR response. Vista Clara was able to confirm the influence of magnetic geology through data analysis and specialized acquisition sequences. One indication of magnetic field inhomogeneity was the analyzed variation in the NMR frequency between sites. The observed NMR frequency is directly proportional to the average magnetic field at the site. Between Cosumnes River sites, the NMR frequency varied by more than 15Hz or almost 1%. The influence of magnetic geology was also confirmed through the acquisition of patented CPMG sequences and observation of an echo decay time T2 which is much longer than the FID decay time T2*.

Magnetic field inhomogeneity will influence the data in two ways. First, magnetic geology may result in some underestimation of water content because a component of water in anomalous magnetic fields will not be detected. Secondly, magnetic field inhomogeneity will shorten the FID decay time such that mobile water with long T2 will exhibit a T2* closer to that of bound water. Zones of highly mobile water will not be as readily distinguished in the FID or T2* distributions but will be highlighted in the CPMG echo signals and T2 results. Vista Clara conducted CPMG measurements at two sites with strong water signals, Site 5a and Site 10. The CPMG data are extremely valuable in that they confirm the T2 decay time is much longer than the T2* decay time and highlight zones with particularly mobile water.

## Influence of 2D/3D features

In reviewing the data products, it is important to consider the lateral extent of the loops and the potential for subsurface heterogeneity occurring at a smaller scale than the loop size. The data are inverted assuming a 1D layered subsurface. Spatially constrained features such as a narrow channel or lens may have very high water content within the feature (e.g. 30%), however, if the feature is small relative to the size of the loop (e.g. a 10m wide paleochannel in a 40m loop), the estimated water content will be scaled by the relative area of the loop (e.g. <8%).

## Layer Equivalence

The vertical resolution of the surface NMR method is on the order of one meter near the surface and several meters at the maximum depth of investigation. This resolution limit and the regularization of the inversion results in a layer equivalence. A thin layer with high water content (e.g., a thickness of 1 m and water content of 30%) will have an equivalent response to a thicker layer with a lower water content (e.g., a thickness of 3 m and water content of 10%). As such, low average water content values may be observed in a smoothed inversion due to detected water being present as discrete layers below the resolution limit.

## Bound Water Detection

For the loop geometries and acquisition parameters (pulse lengths) used in this survey, it is not possible to detect the fastest-decaying NMR signals associated with very bound water (i.e., water in clays). Detected signals should therefore be assumed to reflect water associated with pores in silt or fine-fine sand. Zones dominated by clay are most likely to be reflected as an absence of detected water.

## Interpretation of Resistivity Profiles

Electrical resistivity does not uniquely identify hydrogeologic characteristics and can be ambiguous to interpret in the absence of other data. For example, low resistivity may be associated with impermeable clays or with high permeability sands that are saturated with high TDS groundwater. In combination with surface NMR data, the electrical resistivity can offer improved interpretation. Zones with low surface NMR water detection and high resistivity would be consistent with unsaturated sands. Zones with low surface NMR water detection and low resistivity would be consistent with clays. Zones with high surface NMR water detection and high resistivity would be consistent with sands and low TDS pore fluid. Zones with high surface NMR water detection and low resistivity would be consistent with sands and high TDS pore fluid.

# Results

Results are presented in order from highest signal-to-noise ratio (SNR) to lowest. Higher SNR means less regularization is required in the inversion, allowing for finer depth resolution and greater confidence in the results.

## Site 5a

- Date of measurement: 11-Nov
- Loop geometry: 80m circle
- Acquisition sequence(s): 40ms FID & 15ms CPMG
- Noise levels: Low

Data Quality: QC results (Figure 3) show high data quality. Raw data, before electromagnetic interference (EMI) cancelation, are impact by significant powerline noise, but noise is effectively mitigated using reference coils. A strong water signal is observed in the FID dataset (upper left), shown as a clear decay in the time domain and as coherence in the phase plot. The NMR signal is also clearly visible in the stacked spectrum plots (lower left, red arrows). Plots on the right show the effects of noise cancellation. In the upper right, blue data are prior to noise cancellation and red are after noise cancellation. In the lower right, the upper plot is before noise cancellation (vertical bands are 60Hz power line harmonics) and the lower plot is after noise cancellation.

Data Interpretation: The upper 5m show high resistivity and low NMR water content which would be consistent with an unsaturated sand. Below 5m, resistivity decreases with substantial detection of NMR water, which would be consistent with the presence of permeable sands and possibly high TDS. Zones with especially mobile water are highlighted by relatively long T2* values and long T2 values from the CPMG data.

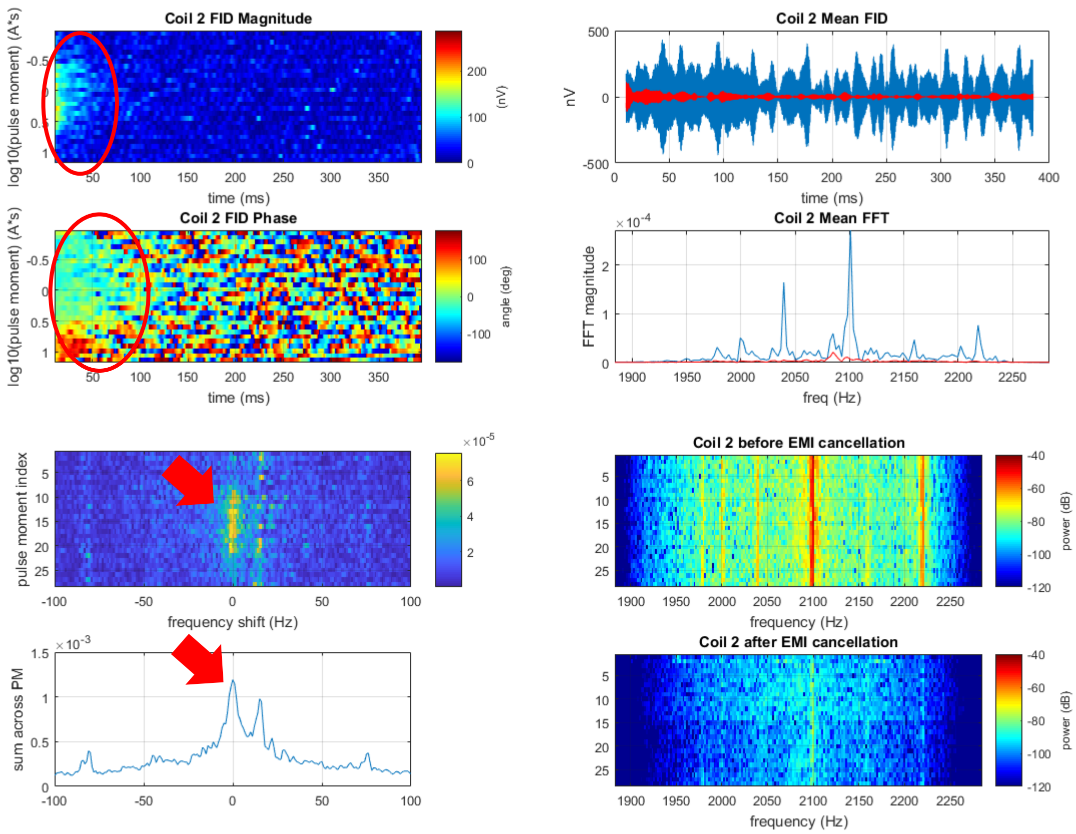



**Figure 3: Quality Control (QC) results for Site 5a (40ms FID).**

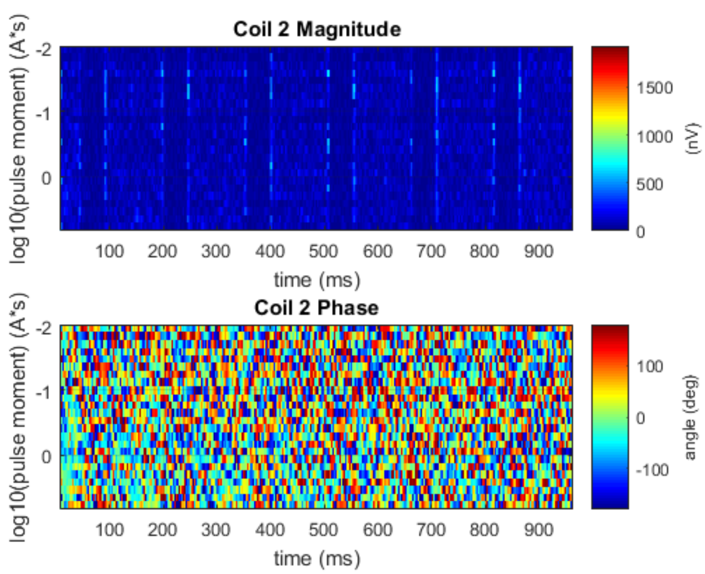



**Figure 4: CPMG (15ms) result shows detection of water with long decay times.**

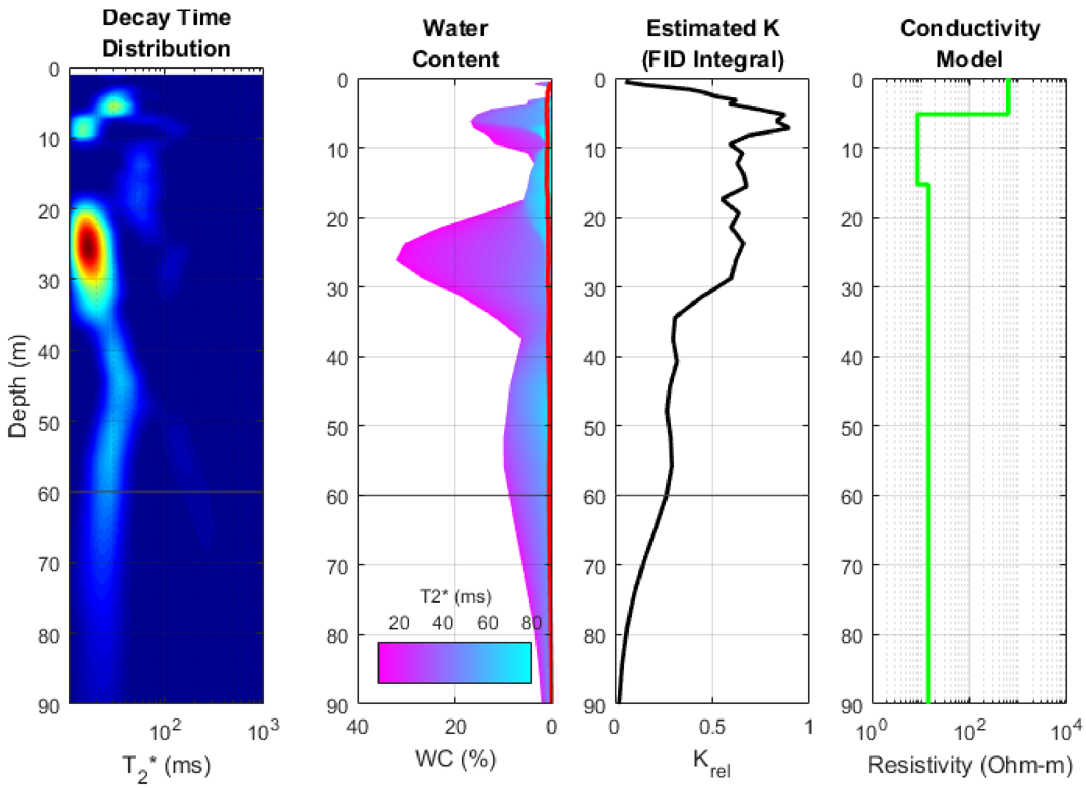



**Figure 5: Site 5a NMR depth profile (40ms FID). Grey line indicates maximum resolved depth.**

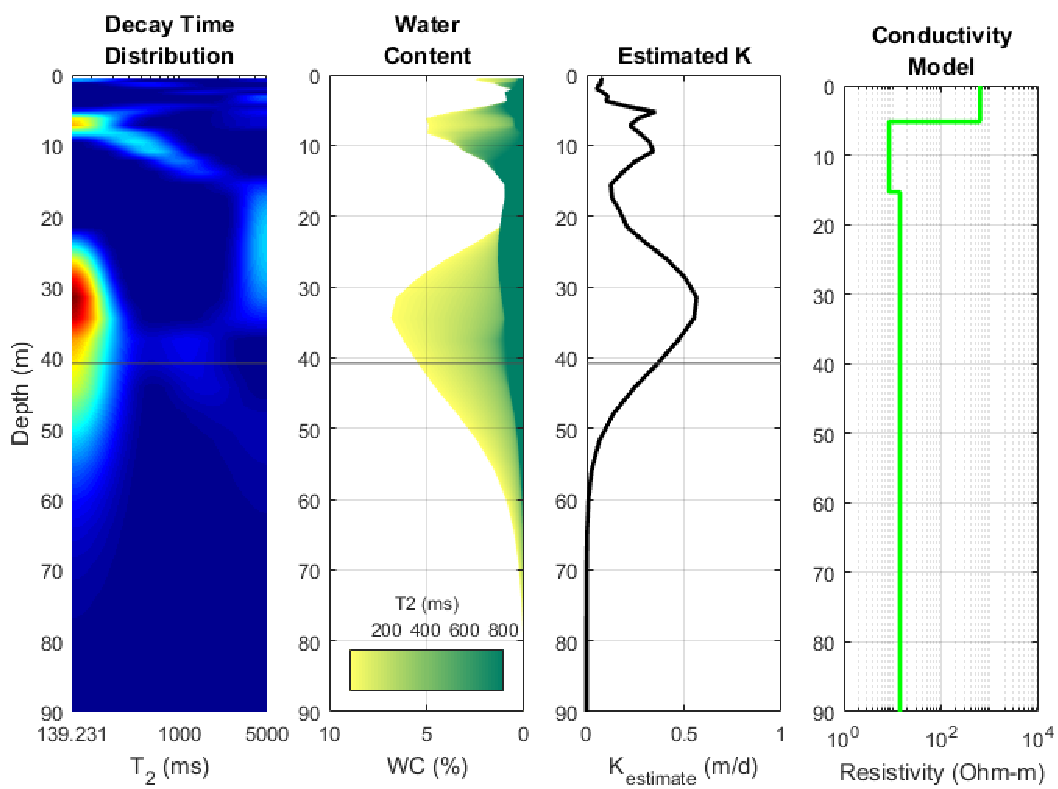



**Figure 6: Site 5a NMR depth profile (15ms CPMG). Grey line indicates maximum resolved depth.**

## Site 10

- Date of measurement: 13-Nov
- Loop geometry: 80m circle
- Acquisition sequence(s): 40ms FID, 15ms FID, 15ms CPMG
- Noise levels: Low

Data Quality: QC results show high data quality. Raw data before electromagnetic interference (EMI) cancelation shows only minor powerline interference, and noise is effectively mitigated using reference coils.

Data Interpretation: The upper 5m show high resistivity and low NMR water content which would be consistent with an unsaturated sand. Below 5m, resistivity decreases with substantial detection of NMR water, which would be consistent with the presence of permeable sands and possibly high TDS. Zones of especially mobile water are highlighted by relatively long T2* values and long T2 values from the CPMG data, especially around 10m.

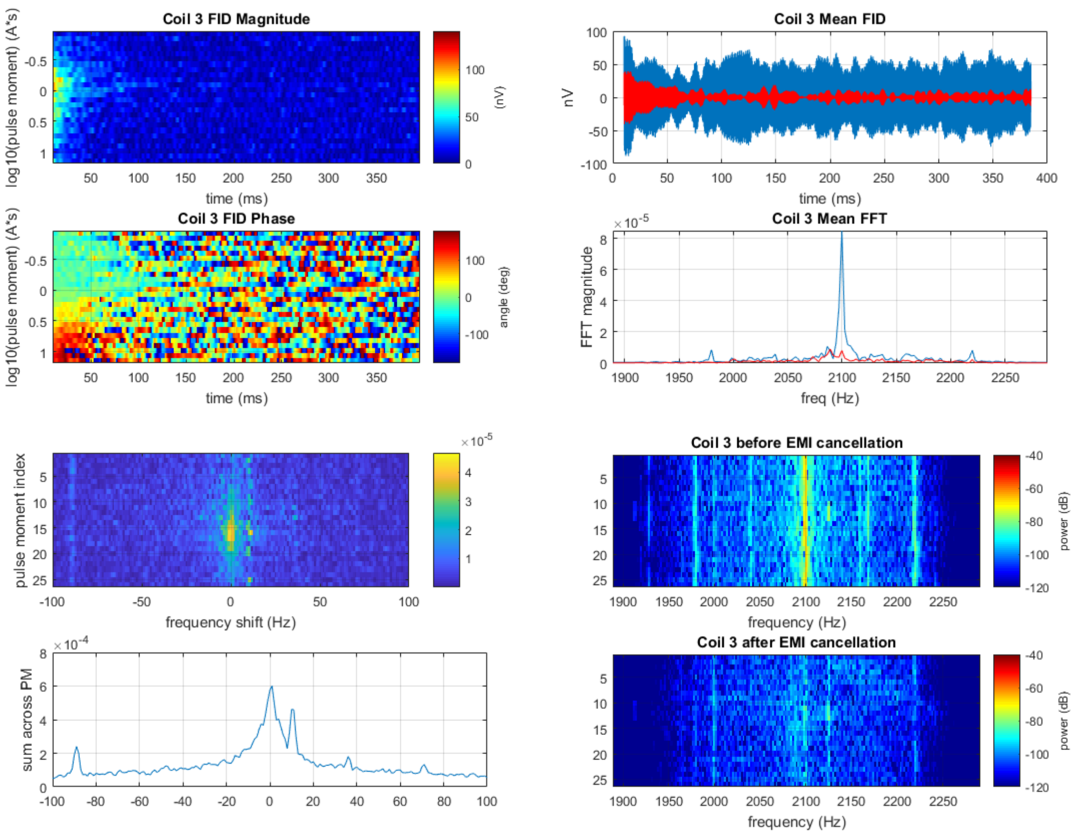



**Figure 7: Quality Control (QC) results for Site 10 (40ms FID).**

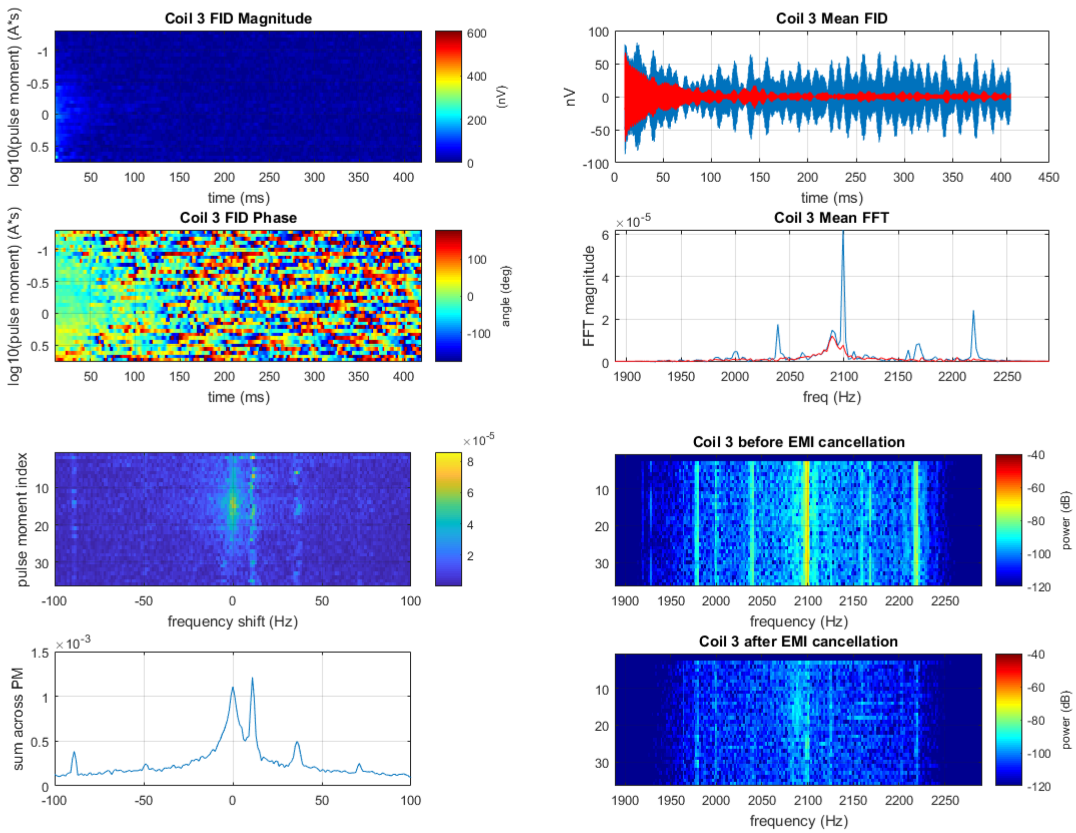



**Figure 8: Quality Control (QC) results for Site 10 (15ms FID).**

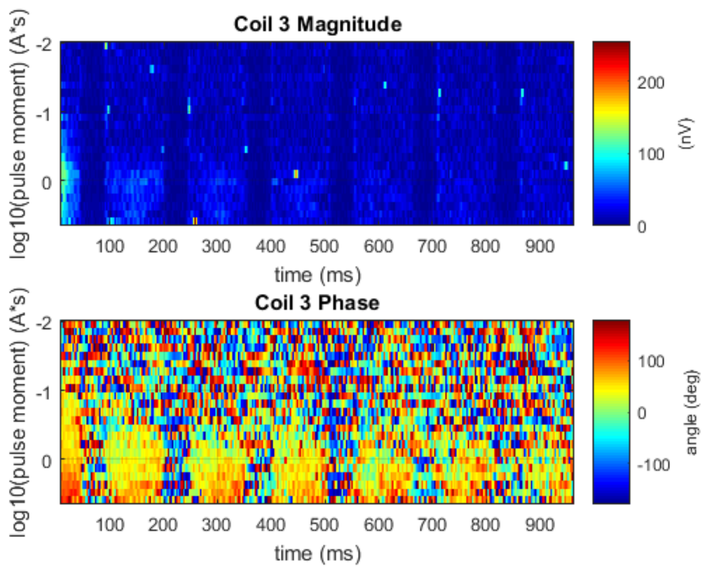



**Figure 9: CPMG (15ms) result shows unambiguous detection of significant quantities of water with long decay times deep in the measurement zone.**

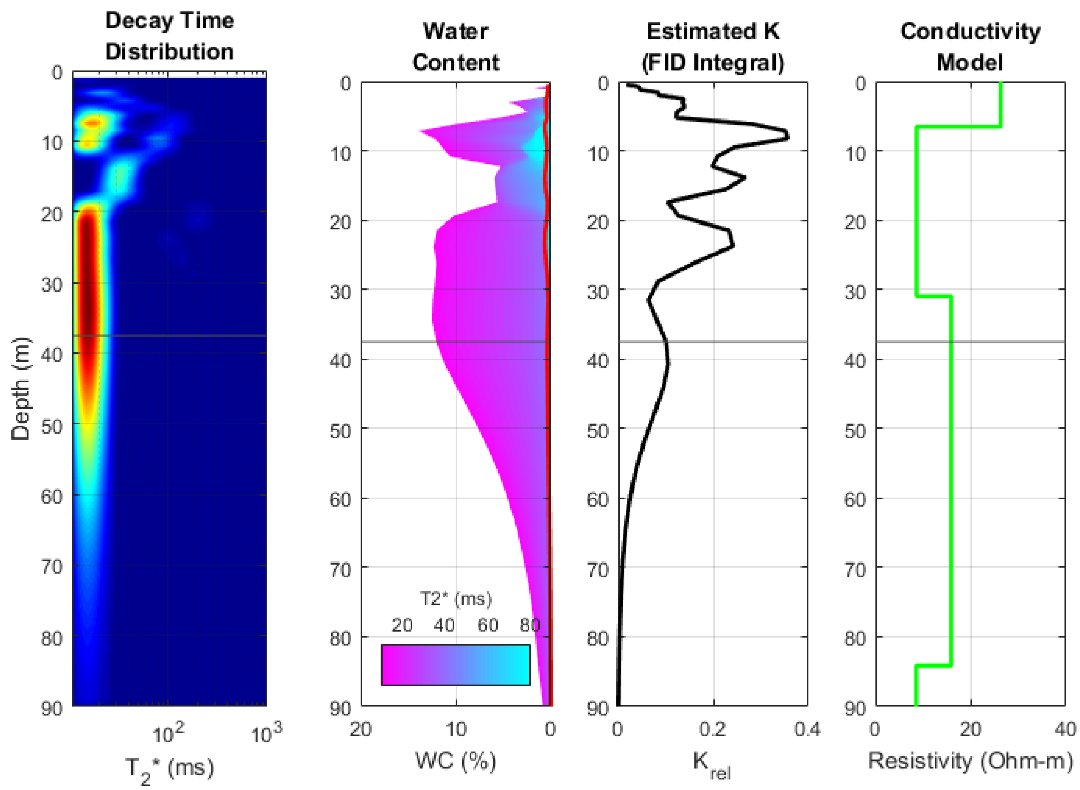



**Figure 10: Site 10 NMR depth profile (15ms FID).**

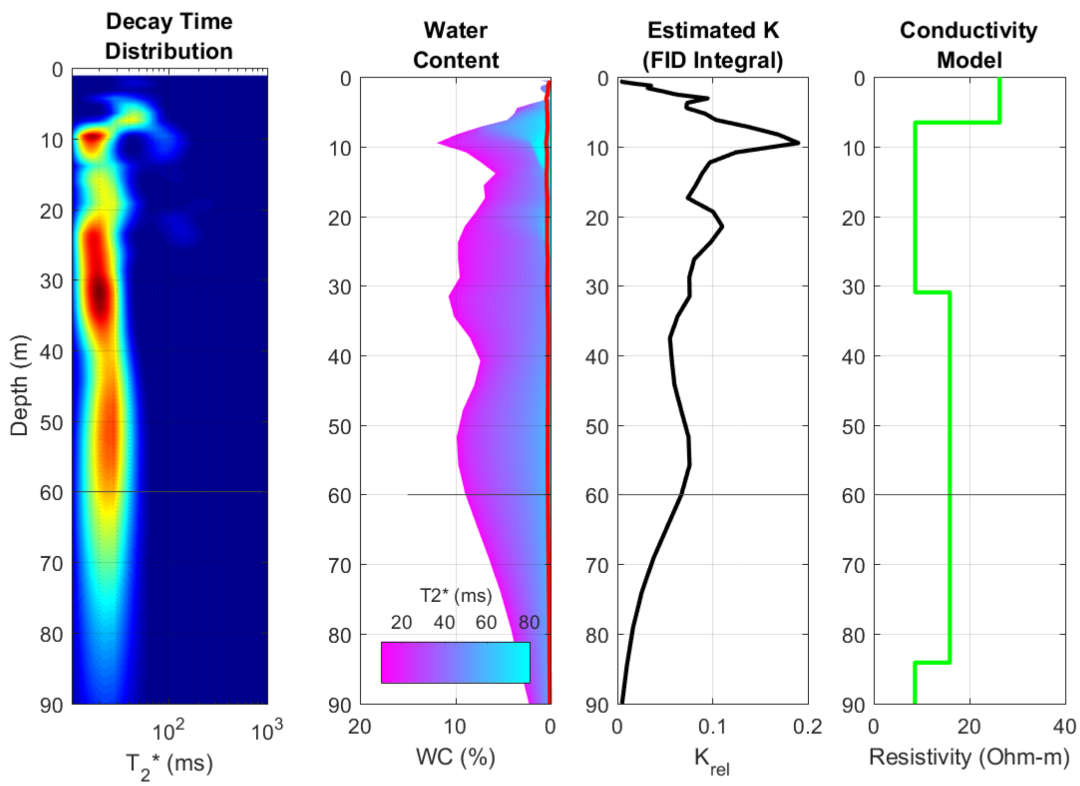



**Figure 11: Site 10 NMR depth profile (40ms FID).**

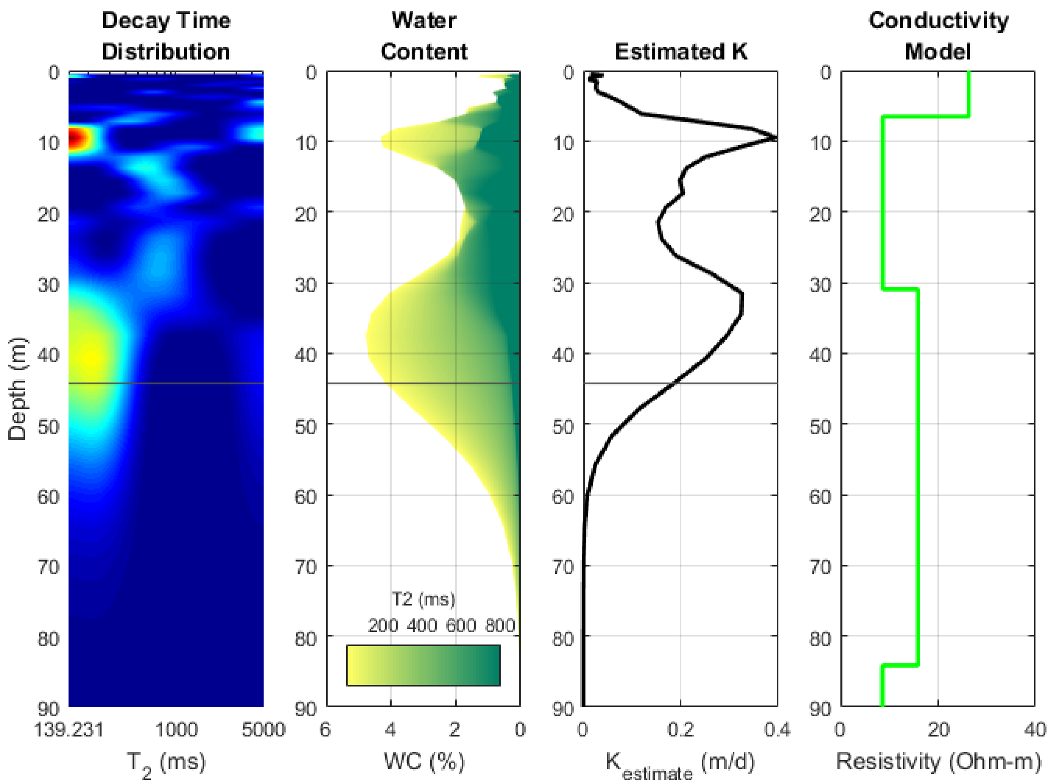



**Figure 12: Site 10 NMR depth profile (15ms CPMG).**

## Site 9

- Date of measurement: 10-Nov
- Loop geometry: 40m Figure-eight
- Acquisition sequence(s): 15ms FID & 40ms FID
- No TEM data acquired at this site (inversion uses conductivity model from the nearest TEM site, which is Site 8).
- Noise levels: Low

Data Quality: QC results show moderate data quality. Raw data before electromagnetic interference (EMI) cancelation shows only minor powerline interference, and noise is effectively mitigated using reference coils. A relatively weak NMR signal is detected.

Data Interpretation: The upper 5m show high resistivity and modest NMR water content which would be consistent with an unsaturated sand or possibly a thin perching of water in sand on top of clay. Below 5m, resistivity decreases with modest detection of NMR water, which would be consistent with the presence of some permeable sands and possibly high TDS. Compared to the prior two sites, less water is detected by surface NMR, which would be consistent with a lower prevalence of permeable sands. CPMG data are not available from this site.

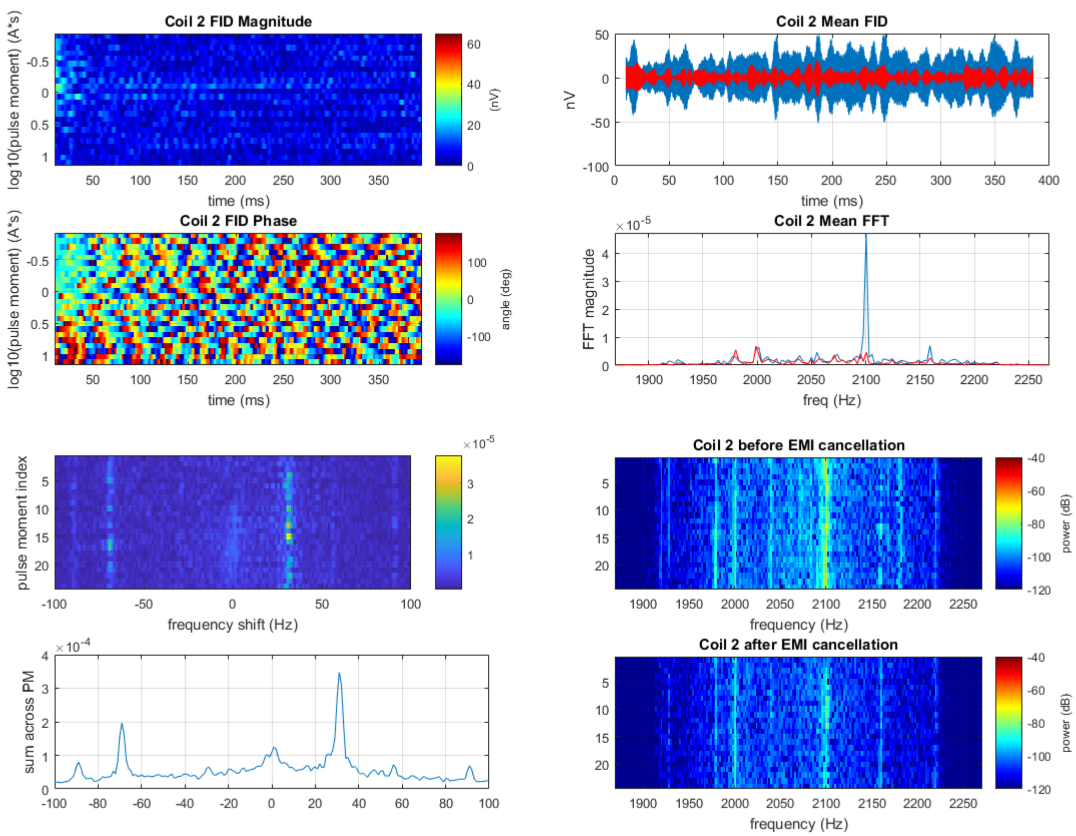



**Figure 13: Quality Control (QC) results for Site 9 (40ms FID).**

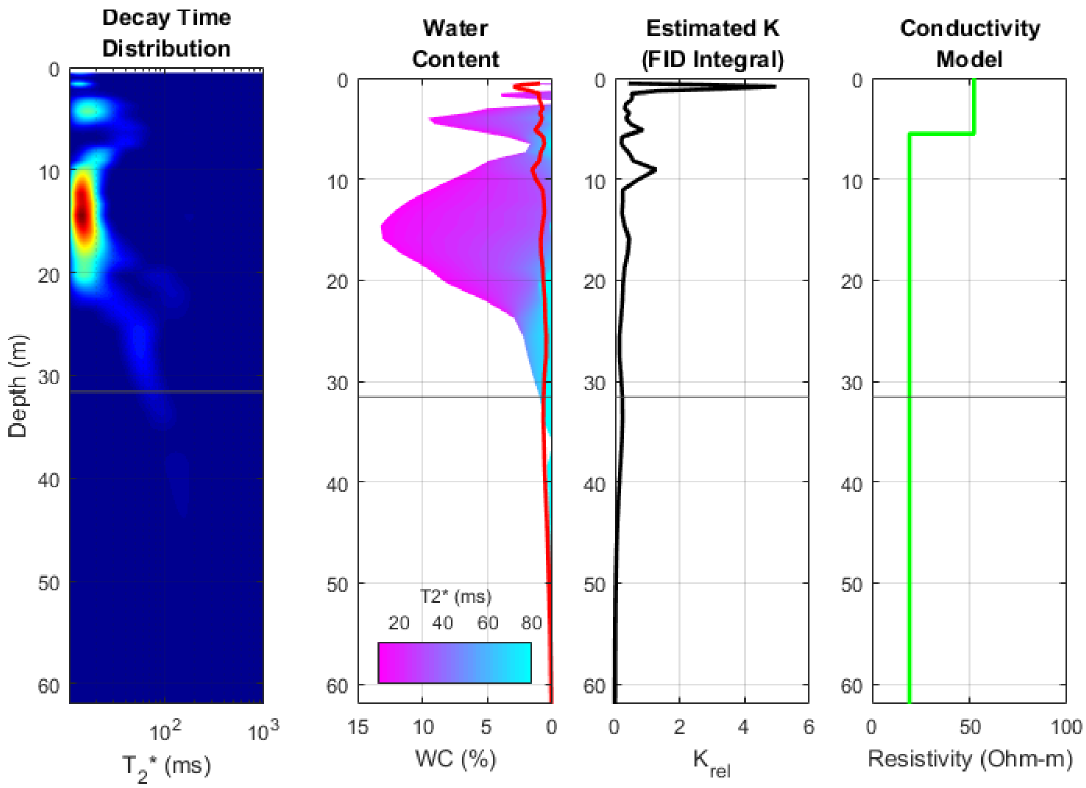



**Figure 14: Site 9 NMR depth profile (15ms FID). Grey line indicates maximum resolved depth. Conductivity model used for inversion (and shown at right) is the conductivity model obtained at Site 8.**

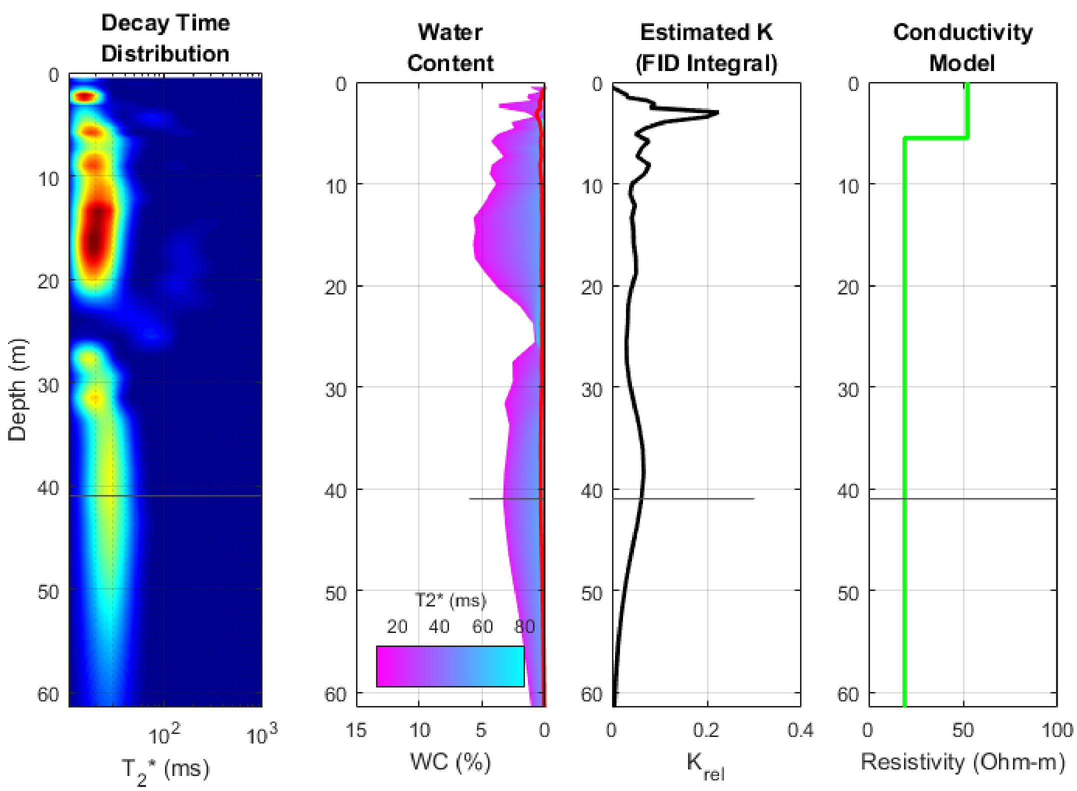



**Figure 15: Site 9 NMR depth profile (40ms FID).**

## Site 7

- Date of measurement: 11-Nov
- Loop geometry: 80m circle
- Acquisition sequence(s): 40ms FID
- Noise levels: Low

Data Quality: QC results show moderate data quality. Raw data before electromagnetic interference (EMI) cancelation shows only intermediate powerline interference, and noise is effectively mitigated using reference coils. A relatively small water content signal is detected.

Data Interpretation: The upper 10-15m show high resistivity and low NMR water content which would be consistent with an unsaturated sand. Below 5m, resistivity decreases with modest detection of NMR water, which would be consistent with the presence of some permeable sands and possibly high TDS. Zones with increased mobile water are highlighted by relatively long T2* values. Compared to the first two sites, less water is detected by surface NMR, which would be consistent with a lower prevalence of permeable sands.

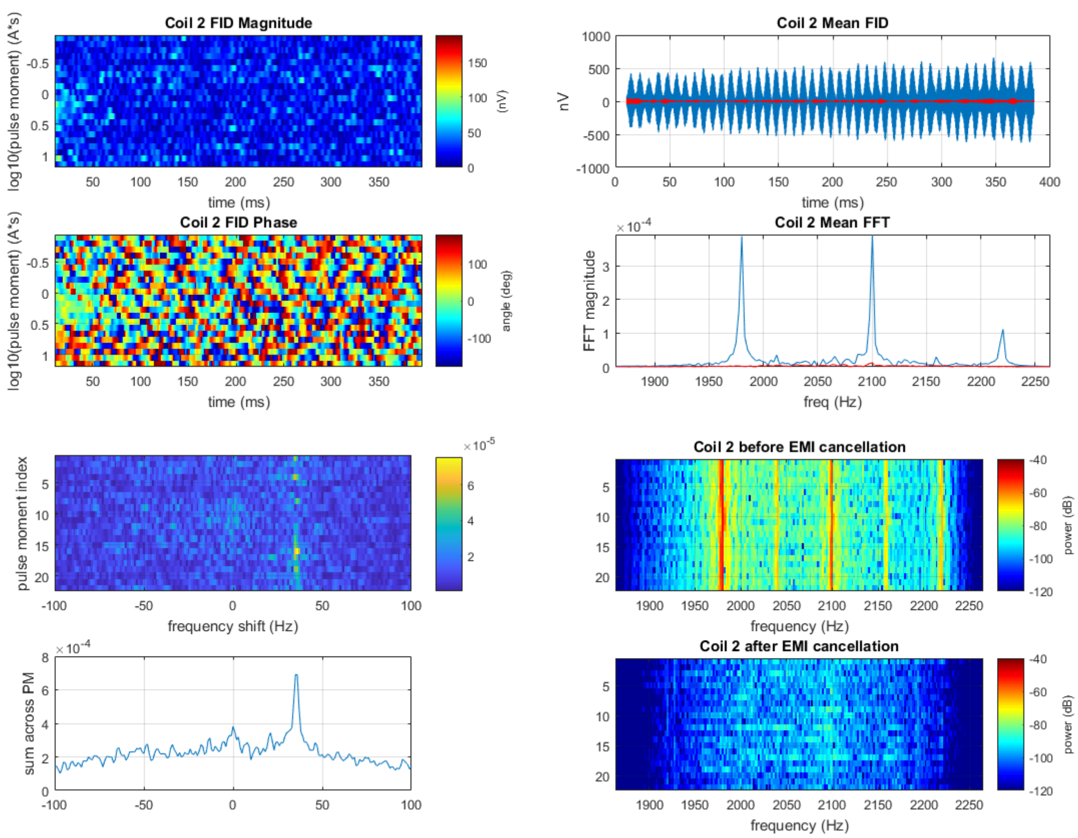



**Figure 16: Quality Control (QC) results for Site 7.**

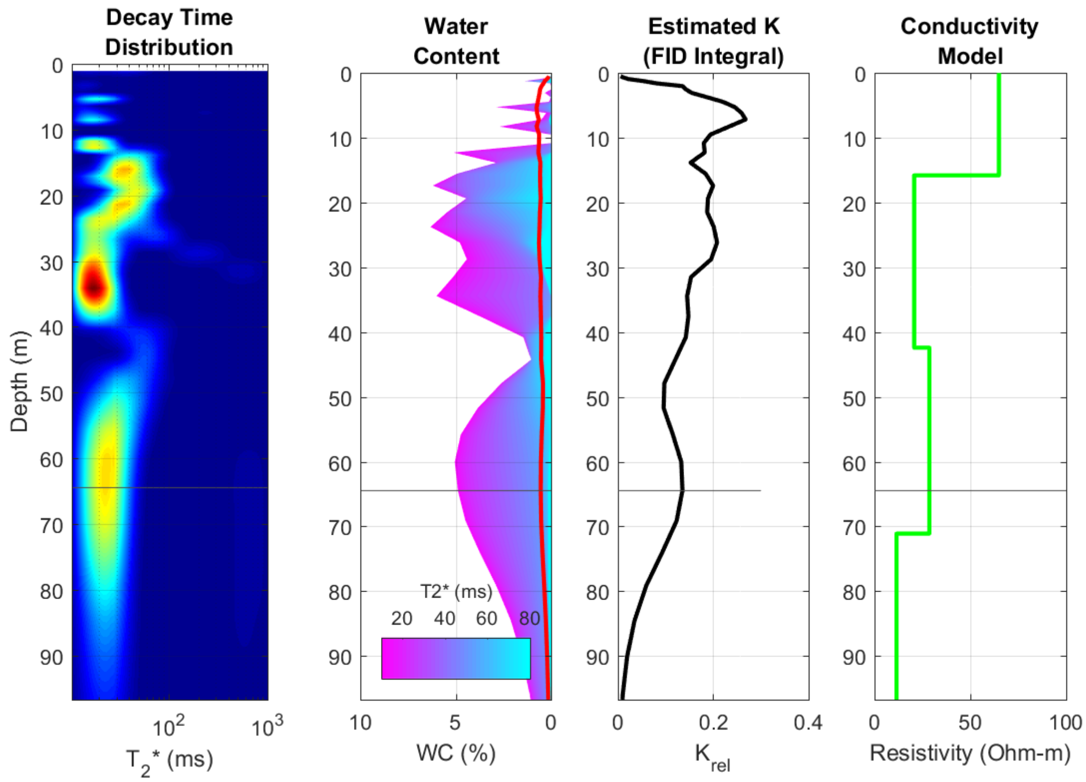



**Figure 17: Site 7 NMR depth profile.**

## Site 3

- Date of measurement: 11-Nov
- Loop geometry: 80m circle
- Acquisition sequence(s): 40ms FID & 15ms FID
- Noise levels: Low

Data Quality: QC results show high data quality, with low electromagnetic interference, but very little or no detection of groundwater.

Data Interpretation: Little or no water is detected at this site. Small estimated water signals show extremely short relaxation times, which would be consistent with a formation having very little mobile water or a very magnetic environment which dramatically limits detection of water.

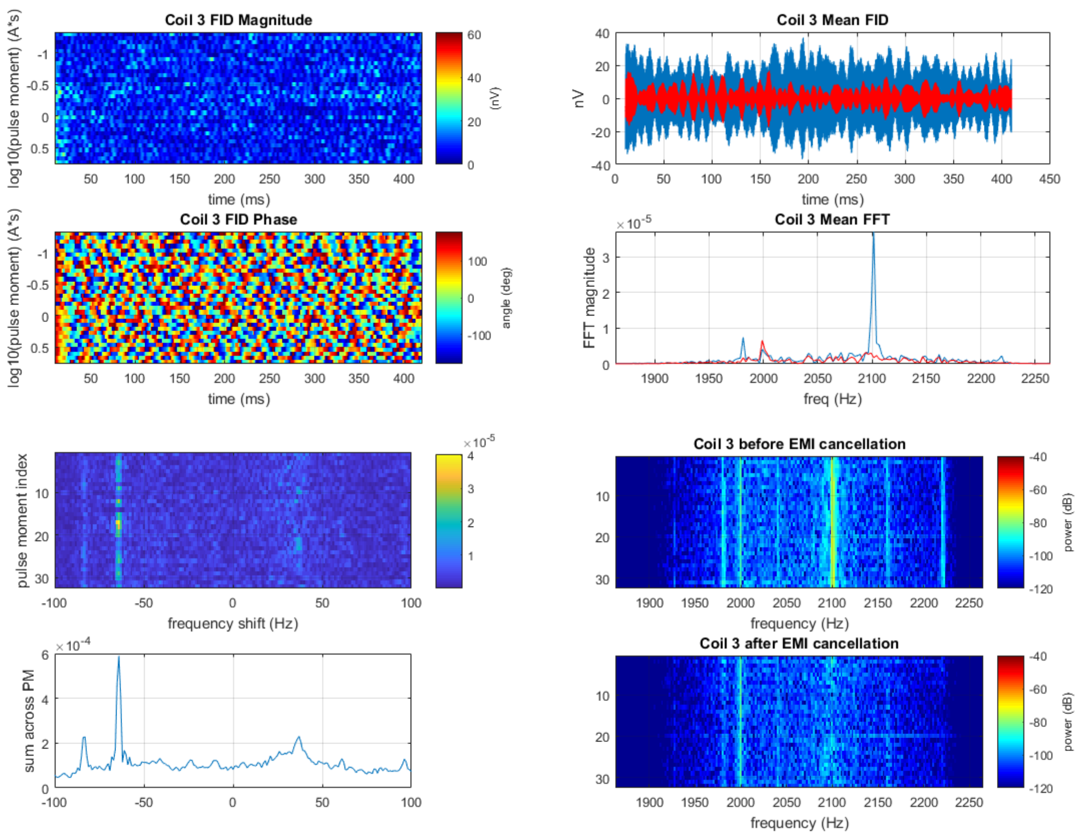



**Figure 18: Quality Control (QC) results for Site 3 (15ms FID).**

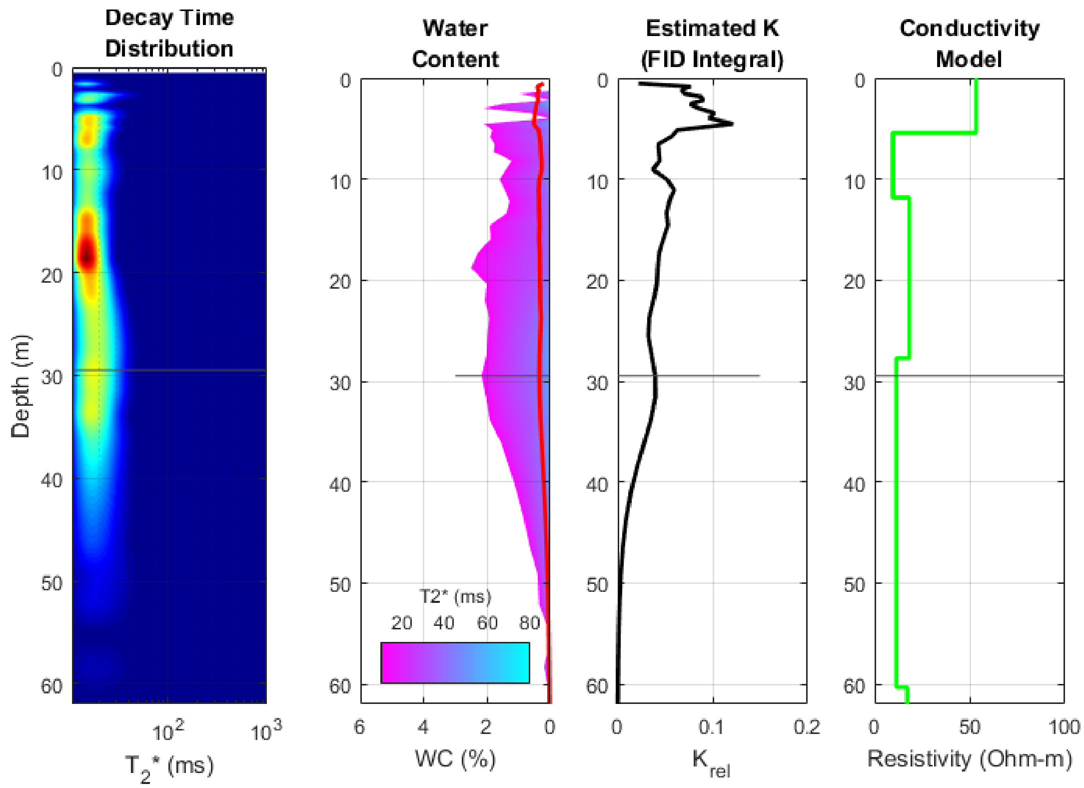



**Figure 19: Site 3 NMR depth profile (15ms FID).**

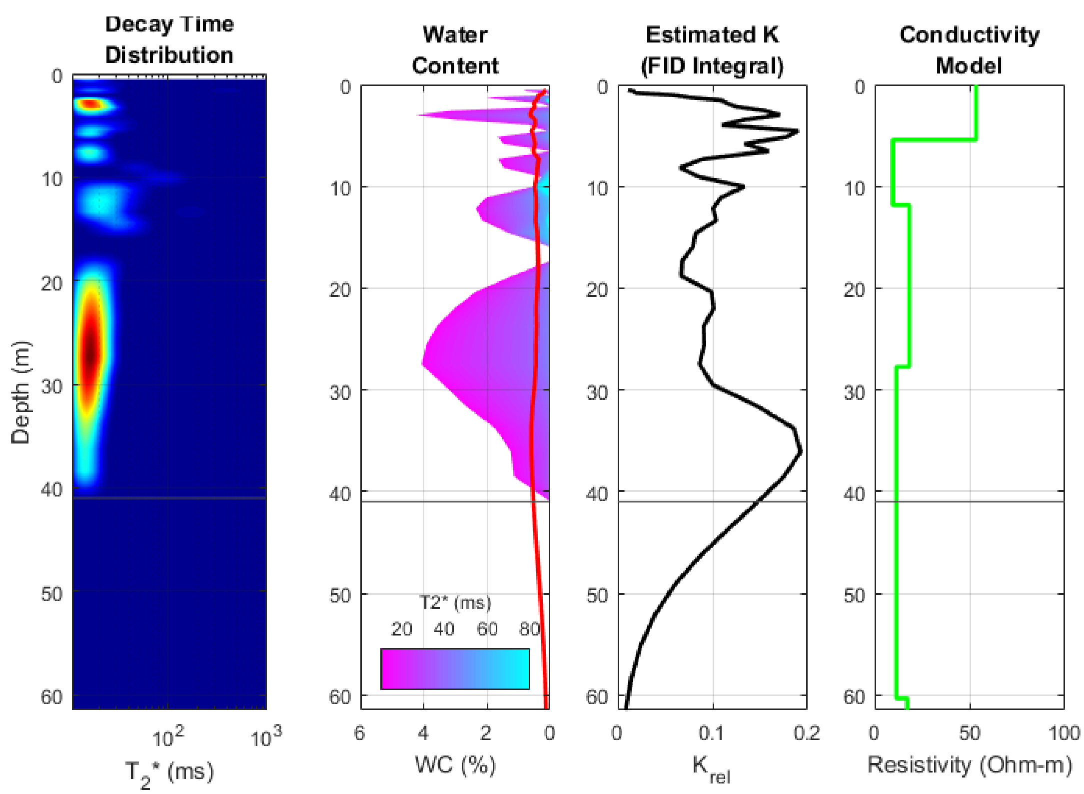



**Figure 20: Site 3 NMR depth profile (40ms FID).**

## Site11

- Date of measurement: 12-Nov
- Loop geometry: 40m Figure-eight
- Acquisition sequence(s): 40ms FID & 15ms FID
- No TEM data acquired at this site (inversion uses conductivity model from the nearest TEM site, which is Site7).
- Noise levels: Low

Data Quality: QC results show high data quality, with low electromagnetic interference, but very little or no detection of groundwater.

Data Interpretation: Little or no water is detected at this site. Small estimated water signals show extremely short relaxation times, which would be consistent with a formation having very little mobile water or a very magnetic environment which dramatically limits detection of water.

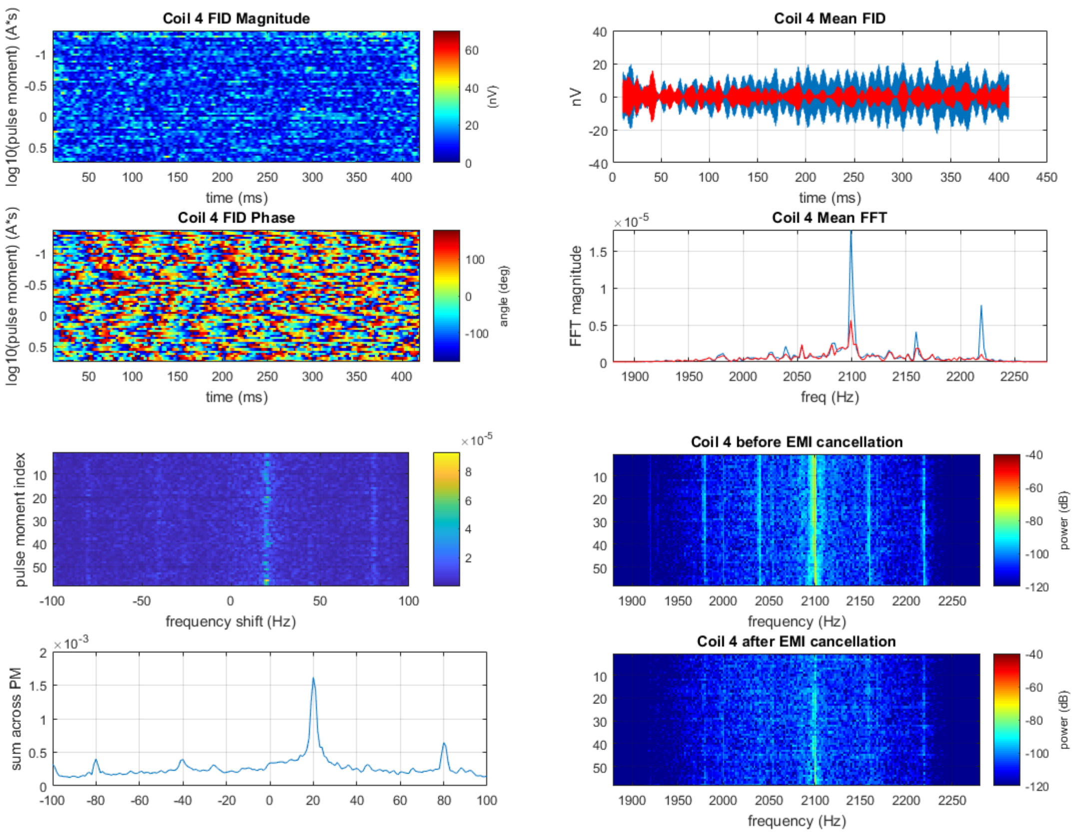



**Figure 21: Quality Control (QC) results for Site 11 (15ms FID).**

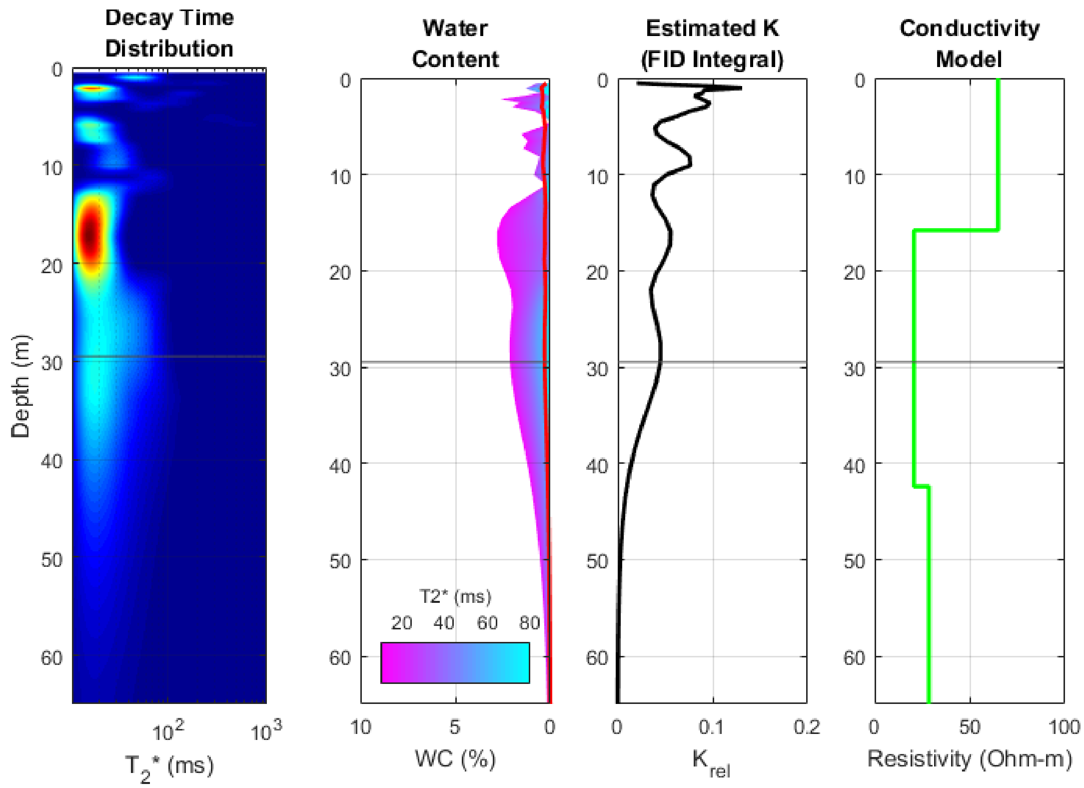



**Figure 22: Site 11 NMR depth profile (15ms FID).**

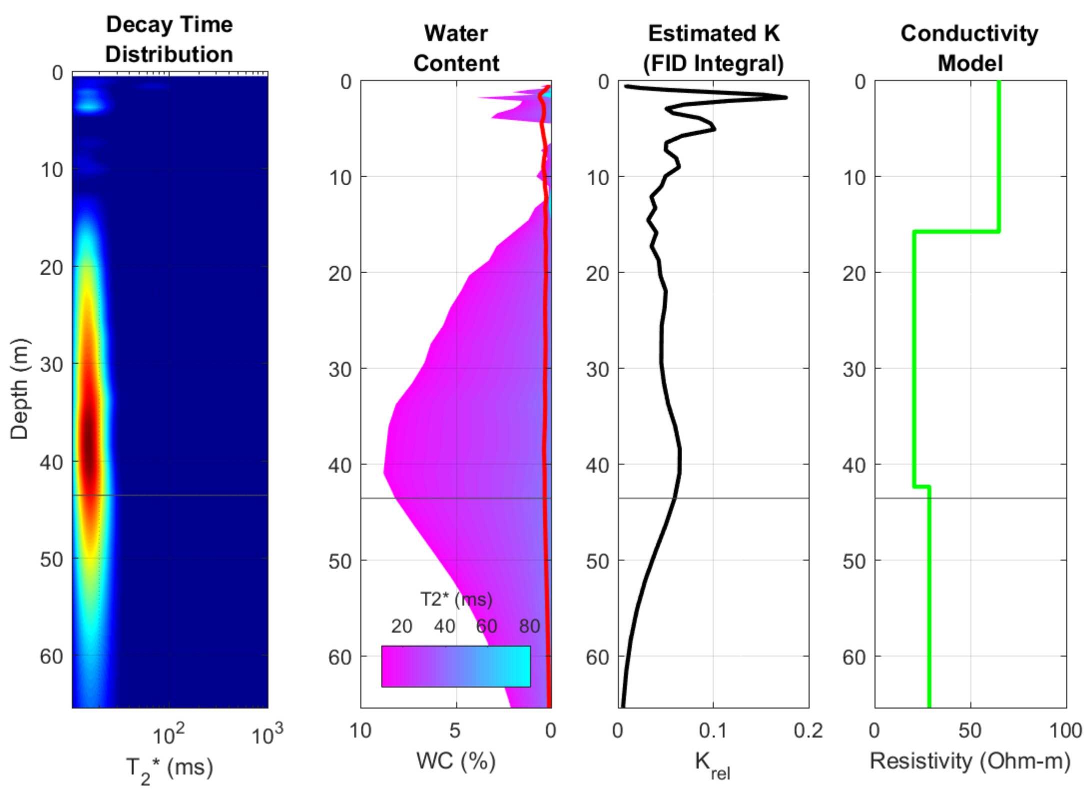



**Figure 23: Site 11 NMR depth profile (40ms FID).**

## Site 8

- Date of measurement: 9-Nov
- Loop geometry: 20m Figure-eight
- Acquisition sequence(s): 20ms FID
- Noise levels: High
- Due to excessive noise at this site, a reliable inversion is not possible, so no inversion is presented here.

Data Quality: QC results show poor data quality, with strong electromagnetic interference, which is mitigated by EMI cancellation but still overwhelms the ability to determine if groundwater signals are present.

Data Interpretation: Given the high noise levels, no inversion is presented for this site.

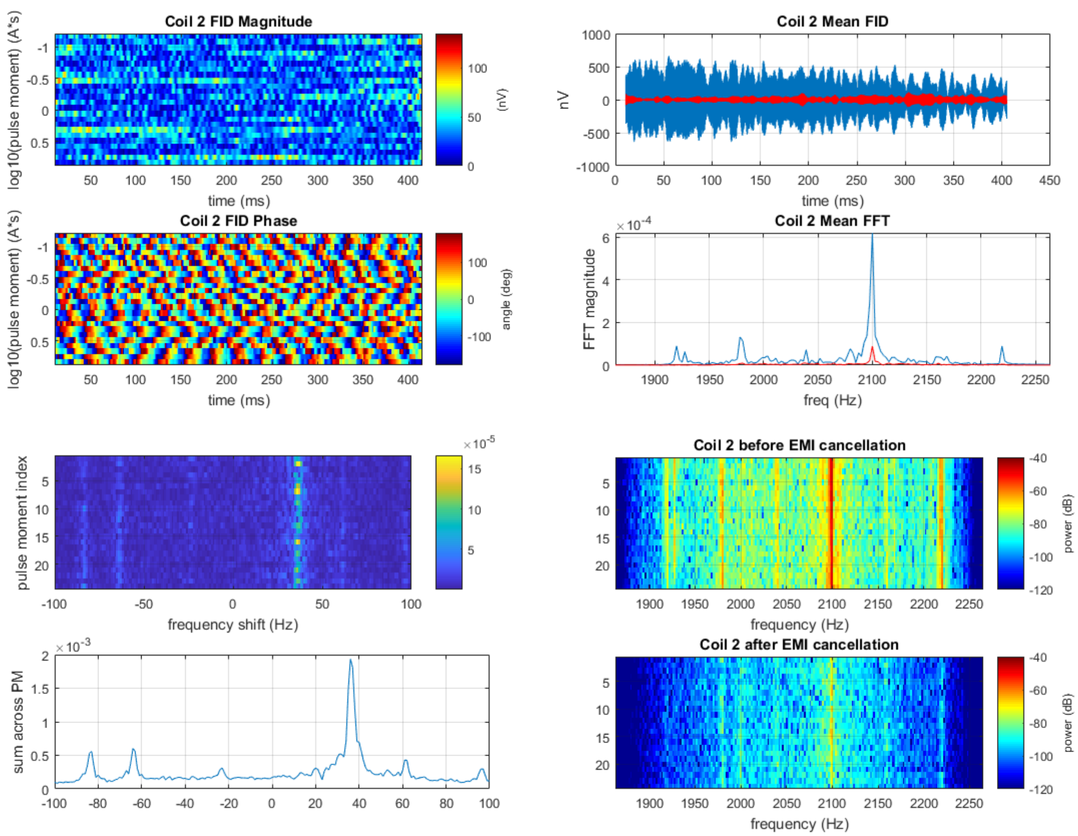



**Figure 24: Quality Control (QC) results for Site 8.**

## Site 2

- Date of measurement: 12-Nov
- Loop geometry: 80m circle
- Acquisition sequence(s): 40ms FID
- Noise levels: High
- Site notes: Proximity to radio transmitter towers may have caused the increased noise levels observed at this site.
- Due to excessive noise at this site, a reliable inversion is not possible, so no inversion is presented here.

Data Quality: QC results show poor data quality, with very strong electromagnetic interference, which is not substantially mitigated by EMI cancelation. Noise levels overwhelm the ability to determine if groundwater signals are present.

Data Interpretation: Given the high noise levels, no inversion is presented for this site.

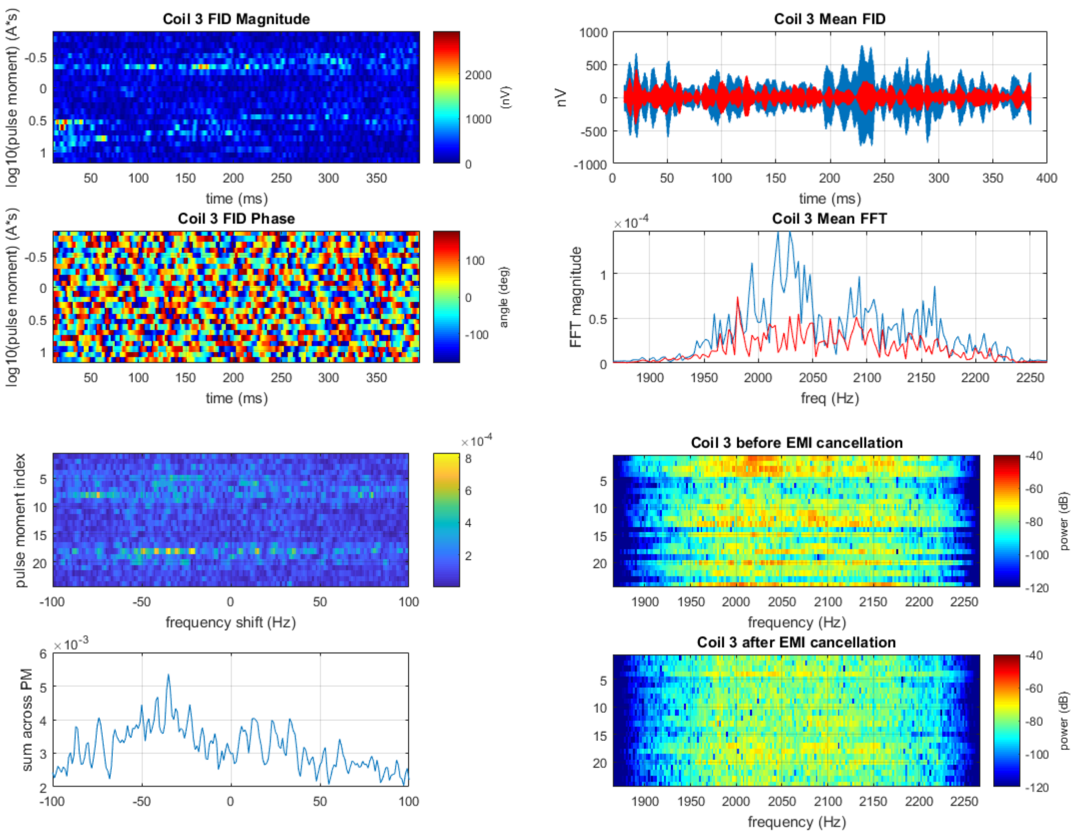



**Figure 25: Quality Control (QC) results for Site 2.**

# Appendix

## Exported Data Format for Surface NMR Data

The ASCII text files associated with the exported inversion have the suffix "_1d_inversion.txt." The format of first 11 columns of these files is as follows:

**Column 1:** Upper boundary of layer (m)

**Column 2:** Lower boundary of layer (m)

**Column 3:** Relative permeability (Krel), estimated as squared integral of demodulated FID signal

**Column 4:** Water content (fraction of 1.0)

**Column 5:** T2* (s) [for FID data] or T2 (s) [for spin echo or CPMG data]

**Column 6:** Frequency (Hz)

**Column 7:** Phase (radians)

**Column 8:** T1 (s) [for T1 dataset] or NaN [for all other datasets]

**Column 9:** Bound water content

**Column 10:** Mobile water content

**Column 11:** Total water content

The remaining columns contain inverted amplitude values for the multi-exponential distributions for the same depth levels corresponding to column 1 and column 2. The last row of the file contains the decay time values (in seconds) for each of the amplitudes values in the correspond column.

## Walk TEM Results

Results of Walk TEM data collections are presented in Table 2. Inversions computed by Ramboll.

**Table 2: Walk TEM layered resistivity models (resistivity in Ohm-m and thickness in meters).**

**EKI Cosumnes River Project - WalkTEM**

| Site | Date | UYMX | UTMY | Res1 | Thk1 | Res2 | Thk2 | Res3 | Thk3 | Res4 | Thk4 | Res5 | Thk5 | Res6 | Thk6 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 8 | 11/11/2020 | 644323 | 4245883 | 52.3 | 5.52 | 19.2 | 85.1 | 12.6 | 74.7 | 8.64 | Inf | | | | |
| 8a | 11/11/2020 | 644524 | 4245193 | 565 | 11.3 | 19.4 | 87.5 | 10.1 | Inf | | | | | | |
| 7 | 11/11/2020 | 646665 | 4248224 | 64.9 | 15.8 | 20.7 | 26.6 | 28.6 | 28.7 | 11.5 | 67.5 | 6.49 | Inf | | |
| 5a | 11/11/2020 | 639047 | 4233865 | 625 | 5.2 | 8.51 | 10.1 | 14.2 | 85.2 | 7.84 | Inf | | | | |
| 3 | 11/11/2020 | 654533 | 4241642 | 53.3 | 5.42 | 9.53 | 6.41 | 18.2 | 15.9 | 11.3 | 32.6 | 17.1 | 68.1 | 10.9 | Inf |
| 10 | 11/13/2020 | 641636 | 4236878 | 26.3 | 6.55 | 8.66 | 24.4 | 15.9 | 53.2 | 8.6 | Inf | | | | |

# TEM Geophysical Investigations
# Cosumnes tTEM & WalkTEM Surveys

Intended for

**EKI Environment & Water, Inc.**

**2827 Spafford Street**
**Davis, CA 95618**

**CC: Vista Clara, Inc.**
**12201 Cyrus Way, Suite 104**
**Mukilteo, WA 98275**

Document type

**Report**

Date

**February 2020**

# TEM GEOPHYSICAL INVESTIGATIONS COSUMNES
# tTEM & WalkTEM SURVEYS

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| Project no. | **1690019809** |
| Date | **2/10/2021** |
| Prepared by | **Ahmad-Ali Behroozmand** |
| Approved by | **Max Halkjær** |
| Description | **EKI Cosumnes TEM Investigations** |

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WATER

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CC: Dr. Dave Walsh
Vista Clara, Inc.
12201 Cyrus Way, Suite 104
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**TEM geophysical investigations Cosumnes**

Dear Mr. Walsh and Mr. Fio,

Ramboll is pleased to submit this report of the results of the geophysical investigations conducted within the Cosumnes Groundwater Sub-basin area, east of Sacramento, California.

Ramboll has completed geophysical investigation of the study area where the main purpose was to improve understanding of both the shallow and deep aquifer units, using the tTEM and WalkTEM geophysical techniques.

It has been a pleasure to conduct the study and we will remain available at your convenience to discuss this report or to answer any questions.

Yours sincerely,

**Ahmad-Ali Behroozmand, PhD**

Senior Geophysicist
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**Max Halkjær, M.Sc.**

Senior Geophysicist/Hydrogeologist
MAXH@ramboll.com

# CONTENTS

## FIGURES



## APPENDICES

## ABBREVIATIONS

| | |
|---|---|
| AOI | Area of Interest |
| ATV | All-Terrain Vehicle |
| BGS | Below Ground Surface |
| DEM | Digital Elevation Model |
| DOI | Depth of Investigation |
| EM | Electro-Magnetics |
| GERDA | Geophysical Relationship Database |
| GPS | Global Positioning System |
| HM | High Moment |
| Hz | Hertz |
| LM | Low Moment |
| M | Meter |
| NAN | Not A Number |
| QC | Quality Control |
| SCI | Spatially Constrained Inversion |
| TEM | Transient Electro Magnetics |
| tTEM | Towed-TEM |

# 1. INTRODUCTION

EKI Environment & Water, Inc. (EKI) has a contract with the County of Sacramento Public Works and Infrastructure for Developing a Groundwater Sustainability Plan – Cosumnes Groundwater Sub-basin, Contract No 81507. This project was conducted as part of managed aquifer recharge (MAR) studies and in response to a request by Vista Clara for towed-TEM (tTEM) and ground-based TEM (WalkTEM) geophysical services at various sites within the Cosumnes Groundwater Sub-basin area.

Two days of geophysical investigations using the time-domain electromagnetic (TEM) methods was conducted in the study area. The tTEM survey was performed at the Wohle's property. The WalkTEM data were acquired at pre-planned locations at six sites across the study area.

Through geophysical inversion, the TEM data were interpreted to smooth (multi-layer) and few-layer electrical resistivity models. The tTEM method provided a high-resolution representation of the variations in electrical resistivity along the paths where an all-terrain vehicle (ATV) pulled the sensor. The tTEM depth of investigation (DOI) extended to approximately 90 m (295 ft) below the ground surface (bgs). Similarly, the WalkTEM method provided a detailed representation of the variations in electrical resistivity at the measuring locations. The WalkTEM depth of investigation extended to depths of larger than 200 m (>650 ft) bgs.

The main sections of this report describe the field operation and the results of the tTEM and WalkTEM surveys in the study area. Appendix 1 contains a general introduction to the TEM method. Appendix 2 contains a detailed documentation of the tTEM and WalkTEM systems, including calibration of the system, repeated data acquires along a test lines, complete configuration of the system and information about processing and inversion parameters. Appendix 3 provides mean resistivity plan-view maps at different elevation intervals across the study area. Appendix 4 contains cross sectional illustrations of the results. Appendix 5 contains the WalkTEM results.

**Figure 1 The tTEM system in operation at Wohle's field.**

**Figure 2 The WalkTEM system in operation at Santo's Field I.**

# 2. FIELD WORK

The fieldwork consisted of one (1) day of tTEM and one (1) day of WalkTEM. The surveys were carried out by Ahmad-Ali Behroozmand and Andrew Li of Ramboll during November 10-11, 2020. The tTEM data collection was performed by towing the tTEM system behind an ATV using a specially designed sled frame with non-metallic parts to avoid potential interferences (Figure 3). The equipment was transported to and from the site with a box truck.

The tTEM system went through a detailed test and documentation at the National Danish Test site. The results are shown in Appendix 2. The test results demonstrate that the tTEM system reproduces the Danish Test and Reference site accurately.

**Figure 3 The tTEM transmitter sled setup at Wohle's Field.**

The WalkTEM data collection was performed by laying out a 40 m x 40 m (130 ft x130 ft) square-shaped transmitter loop, along with a receiver loop placed in the center of the transmitter loop for each measurement at pre-planned locations across the study area (Figure 4). These measurements are called 'soundings'.

Detailed information about the TEM methods and the tTEM & WalkTEM specifications can be found in Appendix 1 and Appendix 2, respectively.

**Figure 4 The WalkTEM instrument. A Ramboll staff is taking the GPS coordinates of the loop center.**

## 2.1 tTEM Data Collection

Prior to data acquisition, GIS layers containing geographic locations of the study area and tTEM lines were loaded into the tTEM navigation software, which enabled real-time tracking of the paths. This also allowed the operator to view the density of the data being collected and facilitate proper coverage of the site with the tTEM. During the tTEM survey, data quality and the entire system functionality were checked frequently by the operator.

A location map of the tTEM survey site is shown in Figure 5. Figure 6 shows location of the tTEM survey lines.

## 2.2 WalkTEM Data Collection

Prior to data collection, each pre-planned location was assessed carefully to ensure minimal EM noise interference from overhead powerlines, powered cables etc. Whenever the sounding locations were not optimal, it was moved to the nearest optimal location.

A location map of the WalkTEM soundings is shown in Figure 5.

## 2.3 Instrumentation issues

No instrument issues were encountered during the surveys.

## 2.4 Weather

The weather was sunny on November 10$^{th}$ (tTEM survey) and mostly cloudy on November 11$^{th}$ (WalkTEM survey). The weather was cool in the morning and warmer during the day, with temperature rising up to ~ 60 F.

## 2.5 Quality control during surveying

During start-up in the morning, Ramboll personnel assembled the tTEM system and carefully inspected the system to ensure that all parts including wires and bolts & knots were intact and secure. When the system was fully up and running, the GPS and TEM transmitter and receiver were checked.

While surveying, personnel uploaded the data to a cloud-based file server for quality control, preliminary processing, and archiving. At the end of the survey day, the data were quality controlled and a simple data processing and inversion was performed. The results demonstrated consistency and good signal to noise ratio. No problems were found during the quality control of the data.

A segment of tTEM lines (test line) was repeated during the survey. The results of the repeated survey line are shown in Appendix 2, which demonstrate high repeatability of the system and consistency of the inversion schemes.

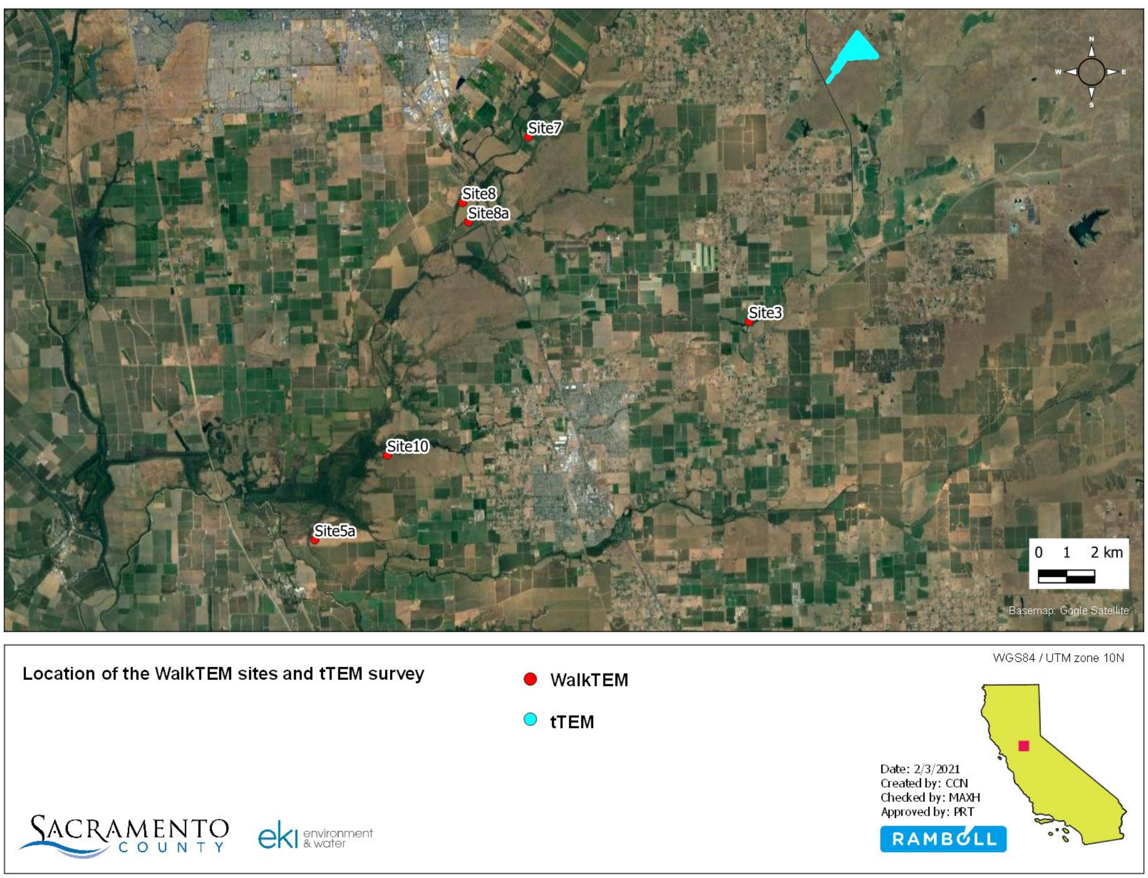



Figure 5 Location map of the WalkTEM sites and tTEM survey.

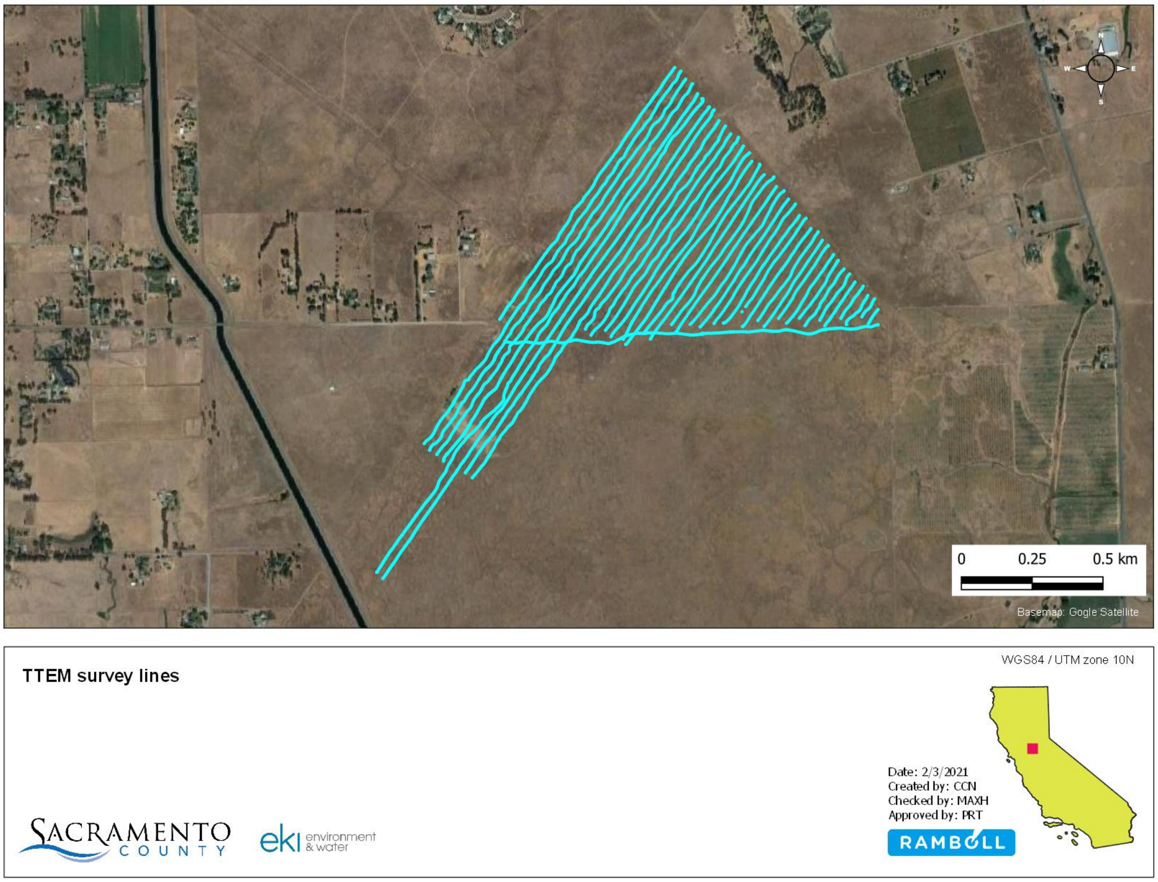



**Figure 6 Location map of the tTEM survey lines at Wohle's Site.**

# 3. PROCESSING AND INVERSION

The processing and inversion of the tTEM data were completed with the software package, Aarhus Workbench (https://hgg.au.dk/software/aarhus-workbench/). The workbench is a well-documented and technically sound software package used for processing and inversion of electromagnetic and geoelectrical data. We utilized an application that is specifically designed for processing and inversion of the tTEM data.

The tTEM data were collected with 282 Hz repetition frequency equivalent to 282 decay curves per second. The high number of data points allows for an advanced data processing scheme to achieve the best possible signal to noise ratio.

The processing and inversion of the WalkTEM data were completed with the software package, Aarhus SPIA (https://hgg.au.dk/software/spia/). The SPIA is a well-documented and technically sound software package used for processing and inversion of ground-based electromagnetic and geoelectrical data. We utilized an application that is specifically designed for processing and inversion of the WalkTEM data.

## 3.1 tTEM data processing steps

The collected tTEM data underwent the following processing steps:

1. Check if useful data have been mistakenly masked during the data acquisition process.
2. Import data to a Geophysical Relationship database (GERDA).
3. Check if data are masked at turning points to avoid data where the system is not aligned properly.
4. Check all secondary data to ensure they are within specifications and do not vary significantly along the lines.
5. Process GPS data.
6. Assign a standard uniform 3% noise to all data.
7. Define a standard processing scheme to automatically reject data and assign noise to the data.
8. Manually inspect each survey line. Data determined noisy that has not already been rejected in the previous step are removed. The noise can be due to overhead powerlines, buried power cables, metal fences, and other man-made sources. This is done for the individual soundings, as well as for a sequence of soundings along the survey line.
9. Assign elevation from a digital elevation model grid to each data point.
10. Average data along the lines using a trapezoidal filter, where more data from the late time gates are averaged compared to fewer data at the early time gates. This is to improve the signal to noise ratio for the data representing the deeper parts and to maintain the high resolution near-surface features along the line.
11. Develop a final processed dataset with a sounding distance of approximately 5 m (~ 16 ft)

More information about the tTEM data processing can be found in Appendix 2.

## 3.2 tTEM inversion steps

The entire processed tTEM data were then used together during the inversion and underwent the following steps:

1. Define horizontal and vertical constrains on the resistivities as well as the number of model layers and layer thicknesses.
2. Invert the processed data using the Spatially-constraint (SCI) approach (Viezzoli et al., 2008).
3. Present the data as depth slices. In case the depth slices reveal some distinct anomalies, the processing of the corresponding data is revisited (Step 3.1.1-8) and the data are re-inverted.
4. Calculate the depth of investigation (DOI) for each resistivity model, based on a sensitivity analysis of the model.

More information about the inversion process can be found in Appendix 2.

### 3.3 WalkTEM data processing steps

The collected WalkTEM data underwent the following processing steps:

1. Manually inspect each dataset for both low-moment (LM) and high-moment (HM) sounding curves.
2. Remove noisy data. The noise can be due to overhead powerlines, buried power cables, metal fences, and other man-made sources.
3. Assign a standard uniform 3% noise to all data.
4. Assign the transmitter loop center coordinate (acquired in the field) to the soundings.

### 3.4 WalkTEM inversion steps

The processed WalkTEM data were then used in the following inversion scheme:

1. Define vertical constrains on the resistivities as well as the number of model layers and layer thicknesses.
2. Invert the processed data for smooth (multi-layer) and layered resistivity models.
3. Present the data as line models. In case the results are not satisfactory, the inversion setup is revisited, and the data are re-inverted.
4. Calculate the depth of investigation (DOI), based on a sensitivity analysis of the model.

# 4. RESULTS

This section describes the results of the geophysical surveys. The measured data are modelled to represent the electrical resistivities at different depths, which can then be interpreted as lithology to get an understanding of the site geology. As discussed in the above sections, inversion of the tTEM data results in a 3D resistivity model of the study area, and inversion of the WalkTEM data results in 1D resistivity models at each sounding location.

The tTEM results are presented as cross sections, plan-view maps and 3D fence diagrams. Figure 7 shows a location map of the tTEM accepted and rejected data for inversion. Figure 8 shows a location map of the tTEM depth of investigation across the study area.

The WalkTEM results are presented as smooth (multi-layer) and blocky (few-layer) line models.

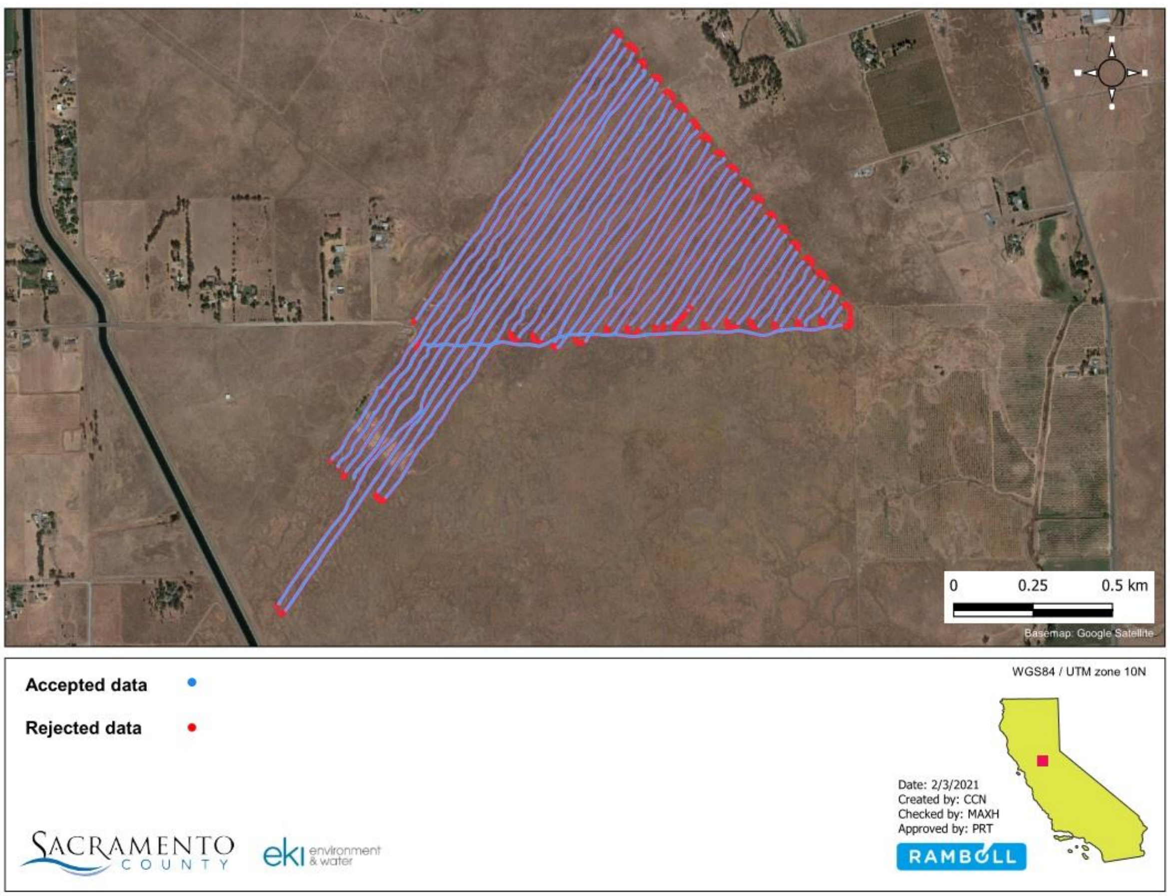



**Figure 7 Location map of the tTEM accepted and rejected data for inversion.**

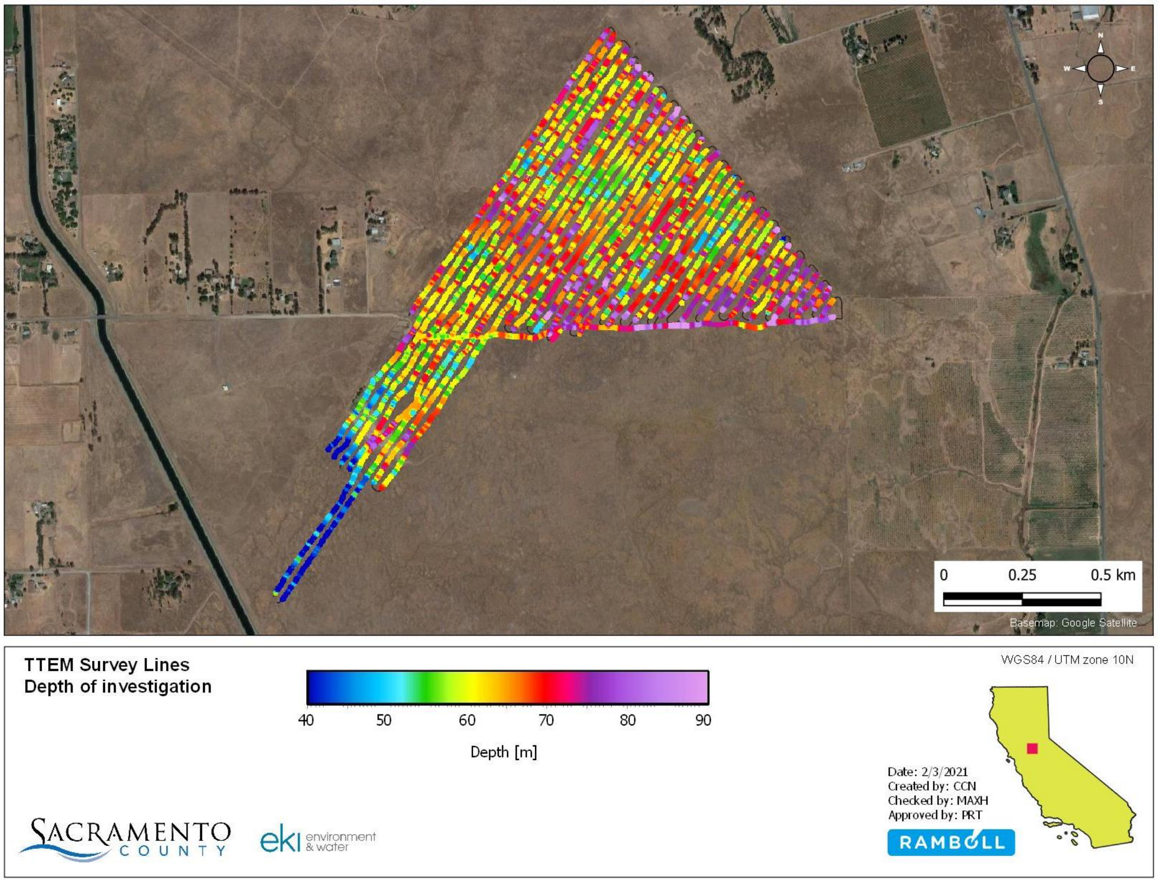



**Figure 8 Location map of the tTEM depth of investigation across the study area.**

## 4.1 Correlation between resistivity and lithology

The tTEM and the WalkTEM methods measures the electrical resistivity of the earth. To obtain the subsurface lithologic information, the measured electrical resistivities must be transformed into lithologies. Transforming resistivity to lithology is based on a general correlation between resistivity and sediment type. Figure 9 shows a general correlation, where low permeability clay has a low resistivity value, sandy clay typically has a medium-range resistivity value, and sand to coarse sand has a relatively large resistivity value. This correlation is a general assumption and the range of resistivity for each lithologic unit can vary between locations. The water quality within the vadose zone or in the aquifer can also impact the resistivity, i.e. the more saline the water, the lower the formation resistivity. Therefore, correlation with additional data sources (such as information from boreholes and water quality) and general geologic knowledge of the study area are crucial to obtain the most accurate description of the subsurface.

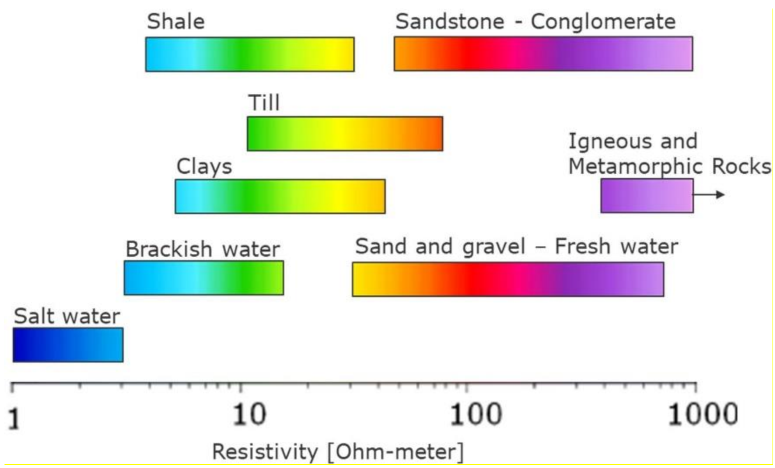



**Figure 9 General correlation between resistivity, type of sediments and rocks, and water of varying quality.**

In this project, the resistivity colormap was adjusted to represent the geologic variations across the study area. The adjusted color scale, used for all presentations in this report, is shown in Figure 10.

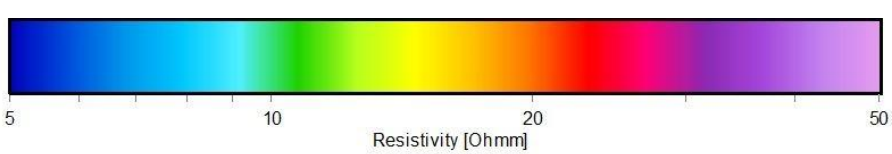



**Figure 10 Resistivity color scale used for all presentations in the report.**

### 4.2 Mean resistivity plan-view maps

Appendix 3 presents mean resistivity plan-view maps at different elevation intervals. In the elevation interval 25 m to 45 m a.m.s.l, i.e. at shallow depths where the resolution is higher, the resistivities are averaged over 2-m intervals. Afterwards, the resistivities are averaged over 5-m intervals. The mean resistivity maps illustrate detailed structures and provide insight about variations across the surveyed area at each interval.

### 4.3 Vertical sections

Appendix 4 presents vertical model sections slicing through the 3D resistivity model at different locations and directions across the study area. Detailed structural variations are observed along each section.

### 4.4 Fence diagrams

In the following figures the vertical sections are stitched together and visualized from different oblique angles. This serves to provide a three-dimensional visualization of the results.

In Figure 11, the model sections are seen from the east. To the east, the more resistive models indicate coarser materials. To the north, a significant decrease in electrical resistivities is observed. In Figures 12-15, the model sections are seen from the south east, north east, north, and north west, respectively.

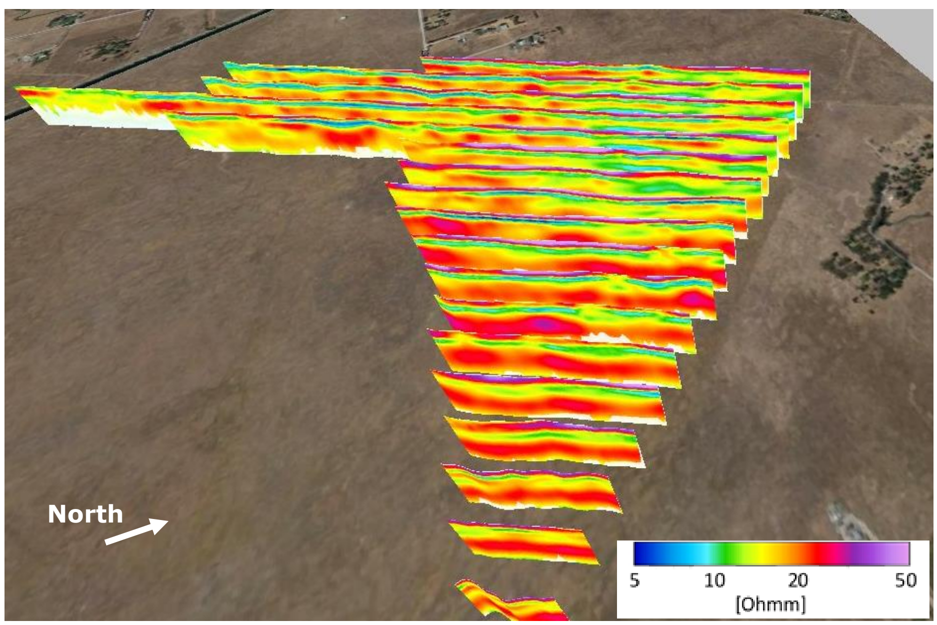



**Figure 11 The model results presented as a 3D fence diagram. Seen from the East.**

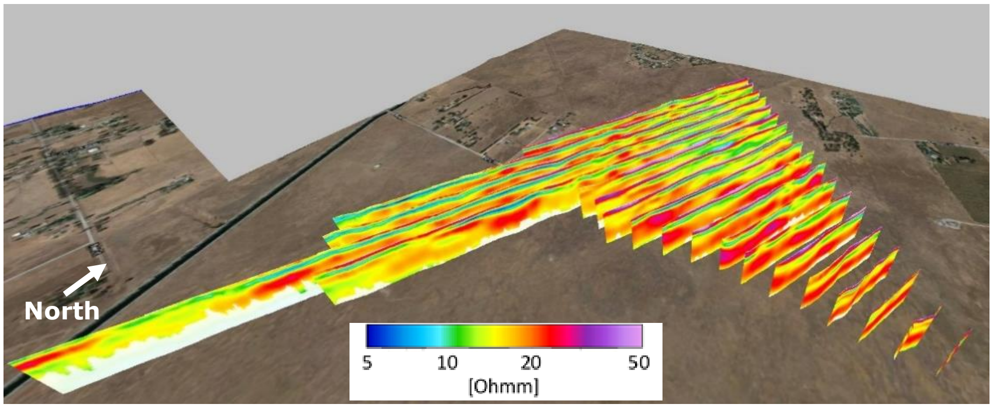



**Figure 12 The model results presented as a 3D fence diagram. Seen from the South East.**

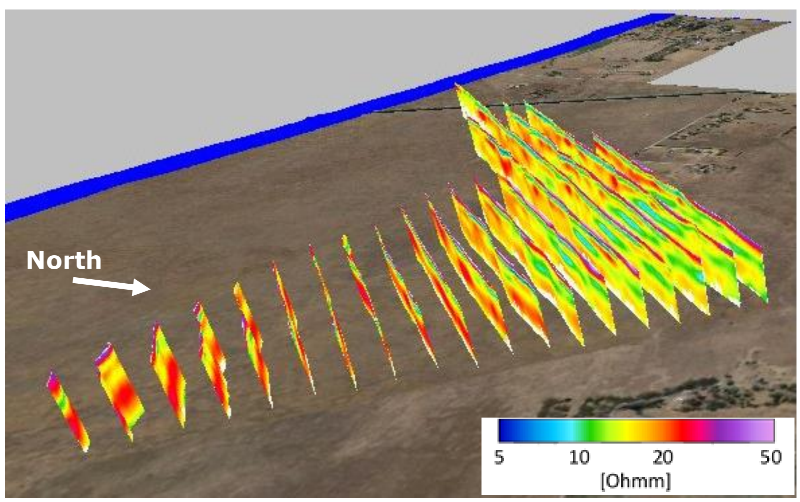



**Figure 13 The model results presented as a 3D fence diagram. Seen from the North East.**

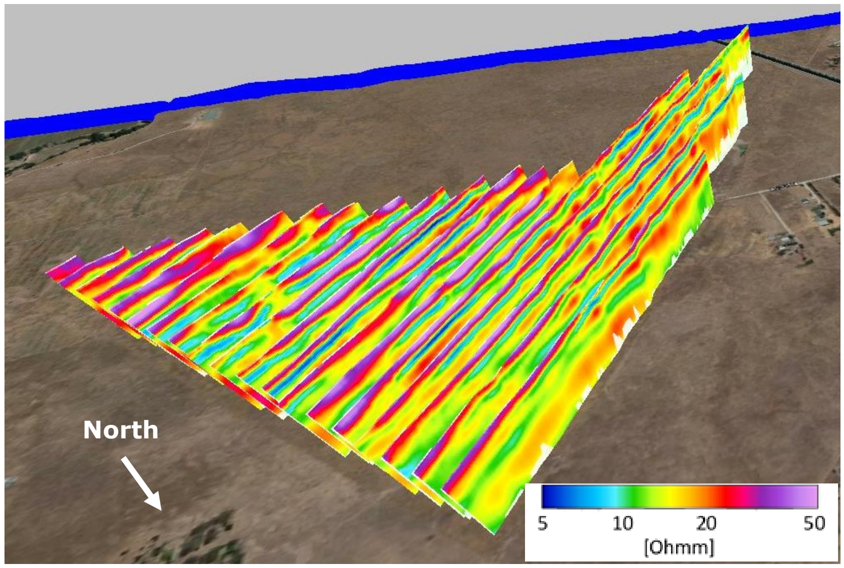



Figure 14 The model results presented as a 3D fence diagram. Seen from the North.

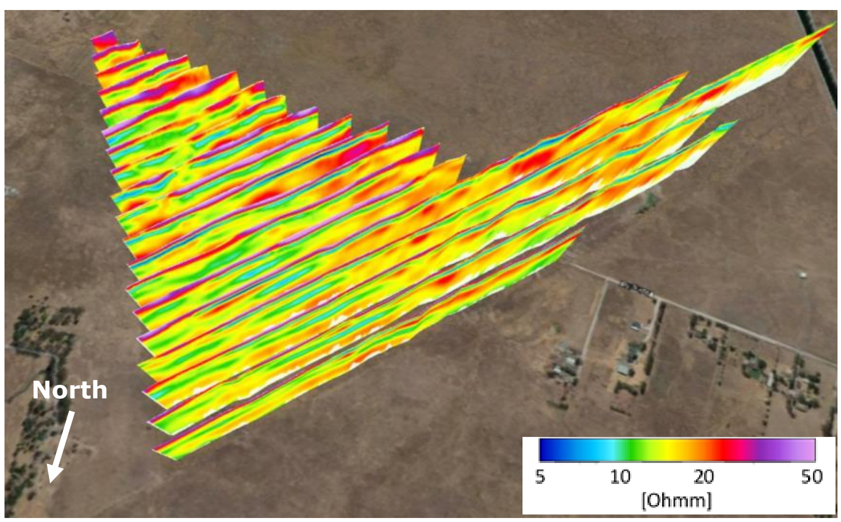



Figure 15 The model results presented as a 3D fence diagram. Seen from the North West.

# 5. DATA DELIVERABLES

The following data have been provided as part of the report.

1. Raw data as extracted from the instrument, including:
   A. Ascii files with information about the geographical coordinates, transmitted current and many other supporting data. All files are named YYYYMMDD_HHMMSS_MMM followed by three letters as an extension. The more crucial files have an extension SPS. Other files are primarily LOG files. One file with the extension LIN describes the start and end of each profile.
   B. Binary data files with the electromagnetic decay measurements. The top section of the binary file is an ascii section with all information about measurement cycles and settings in the instrument.
2. A GERDA Firebird database (https://eng.geus.dk/products-services-facilities/data-and-maps/national-geophysical-database-gerda/) with all the imported data, processed data, as well as the model results.
3. The report is delivered as a PDF file.

# 6. CONCLUSIONS AND RECOMMENDATIONS

## 6.1 Conclusions

The collected tTEM and WalkTEM data provide detailed subsurface information of the study area. The data are in good agreement with each other. The geophysical models map out the geologic layering and provide detailed information about homogeneity, continuity, and extent of each layer.

No hydrogeological interpretations are made as part of this report.

### 6.1.1 tTEM survey

High-quality tTEM data were acquired during this survey. Except for the southwestern part of the surveyed area, the tTEM models present a high resistivity layer in the top few meters. Below this layer, a thin conductive layer is identified. The conductive layer has a thickness of up to 10 m though in certain areas the layer becomes thin or disappear. These occasional discontinuities may indicate hydraulic pathways. In the deeper parts, e.g. 5-15m a.m.s.l., a conductive structure is observed towards north. The most resistive sediments are found in the eastern part of the triangle, in the interval 0-5m a.m.s.l.

### 6.1.2 WalkTEM

High-quality WalkTEM data were acquired at all study sites. The results of the WalkTEM survey suggests different geologic models across the study area. On the top, all WalkTEM models present a high resistivity layer with a thickness of approximately 5 m except for the models at sites 7 and 8a where the top layer is thicker. Below this layer, a conductive layer with resistivity values of below 10 ohm-m is observed at sites 3, 4 and 10. All models present a deep conductive layer with resistivities of 10 ohm-m or lower. The depth to this bottom layer varies between the sites.

## 6.2 Recommendations

The combination of tTEM and WalkTEM surveys is ideally suited for subsurface mapping of the survey area to gain detailed information of both shallow-to-intermediate and deep structures. For further investigations of the study area, the following activities are recommended:

- The tTEM results at Wohle’s site provide detailed 3D information of the subsurface. Such detailed information enables assessing the suitability of a site for managed aquifer recharge site. Additional tTEM surveys at potential recharge sites within the study area is recommended.

- To achieve a better understanding of the structural variations across the study area, an additional WalkTEM survey with a denser coverage of the entire study area, i.e. by filling the gaps between the surveyed WalkTEM data points, is recommended.

# APPENDIX 1
# THEORY - TEM

# TEM introduction and theory

Upon acquisition of the first ground-based TEM instrument in the early 1990's, Ramboll has been among the global pioneers when it comes to applying TEM methods for subsurface mapping. Over the last 20 years, the accuracy of the instruments and their ability to obtain information about aquifers and hydrogeological properties has improved significantly. The TEM method is now one of the most efficient geophysical technologies for groundwater investigations.

Within the last 15 years, airborne TEM systems have been developed and introduced. Using the airborne systems, the ability to survey large areas has been significantly improved. The towed TEM (tTEM) and WalkTEM systems are basically a downscaled version of the TEM system on an airborne platform named SkyTEM.

### TEM Theory

A direct current is injected in a transmitter loop. When the current stabilizes, the transmitter is abruptly turned off. By abruptly turning off the transmitter current, short-duration eddy currents are induced in the ground. The receiver coil located in the center of the transmitter loop (central loop configuration like WalkTEM) or outside the transmitter loop (off-set configuration like tTEM), measures the decaying magnetic field derived from the eddy currents.

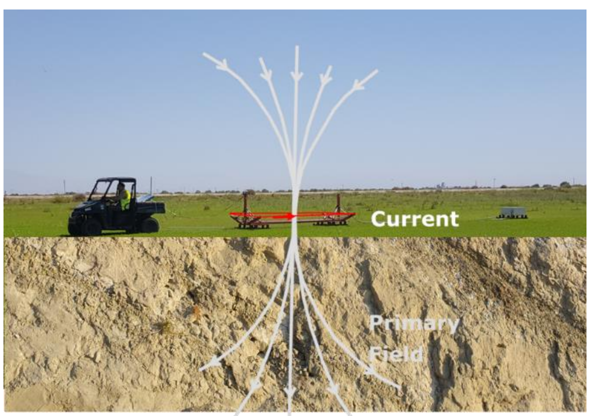



**Figure A1-1 The primary EM field generated by the current in the transmitter loop.**

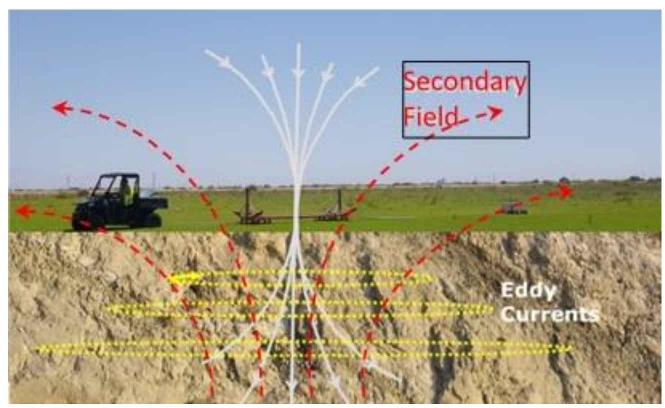



**Figure A1-2 When the current is turned off in the transmitter loop eddy currents are generated in the subsurface. The eddy currents create secondary magnetic fields that are measured with the receiver.**

### Noise in TEM data

TEM data are comprised of different type of noise components. Noise can cause bias signals and affect the depth of investigation and if not properly identified and removed, can result in incorrect geological and hydrological interpretations. The different sources of noise are described below:

1. Galvanic coupling is caused by the electromagnetic signal induced in a metal object, such as a metal pipe, metal fence or the loop, following the ground-wire through the power-masts to the ground as sketched below. The challenge is that the signal component caused by a

galvanic coupling can be hard to detect as the nature of the decay is similar to the response from the ground as illustrated in Figure A1-3. Galvanically-coupled data are identified by looking at the data along the survey lines while paying attention to the signal level and its correlation with potential coupling sources on the GIS map.

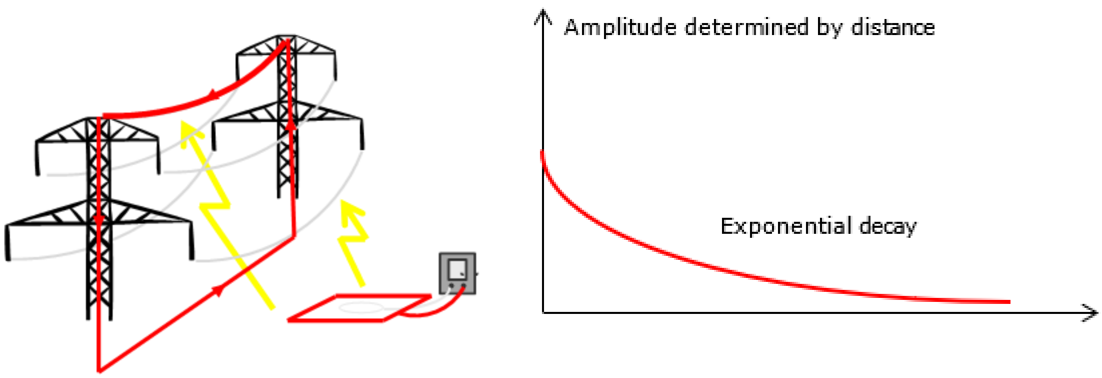



**Figure A1-3 Illustration showing the effects of galvanic coupling.**

2. Capacitive coupling is caused by the induced electromagnetic signal in an insulated installation such as a power cable. The noise creates an oscillating signal as illustrated in Figure A1-4. It is normally easy to distinguish capacitive coupling noise from the ground response.

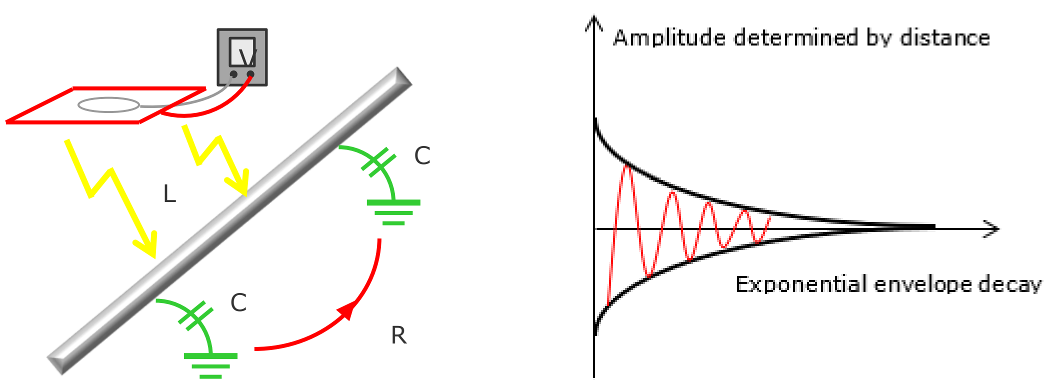



**Figure A1-4 Illustration showing the effects of capacitive coupling.**

3. Coherent noise from electrical powerlines has the same pattern as sketched for the capacitive coupling. It is often easy to identify these features during processing of the data.
4. Atmospheric noise is more random in nature and is typically handled by none-spike filtering and by simple averaging of the data. In case of a strong lightning or an electromagnetic storm the background noise can prevent the collection of data with satisfactory signal-to-noise ratio.

5. Motion induced noise due to vibrations in the receiver coil. Vibration of the receiver coil in the earth magnetic field will create a noise component. It is only a problem for moving systems, such as SkyTEM (airborne) or the tTEM system. This noise is minimized by suspending the receiver coil and keeping the survey speed within recommended limits (Figure A1-5).
6. Internal noise in the instrumentation.

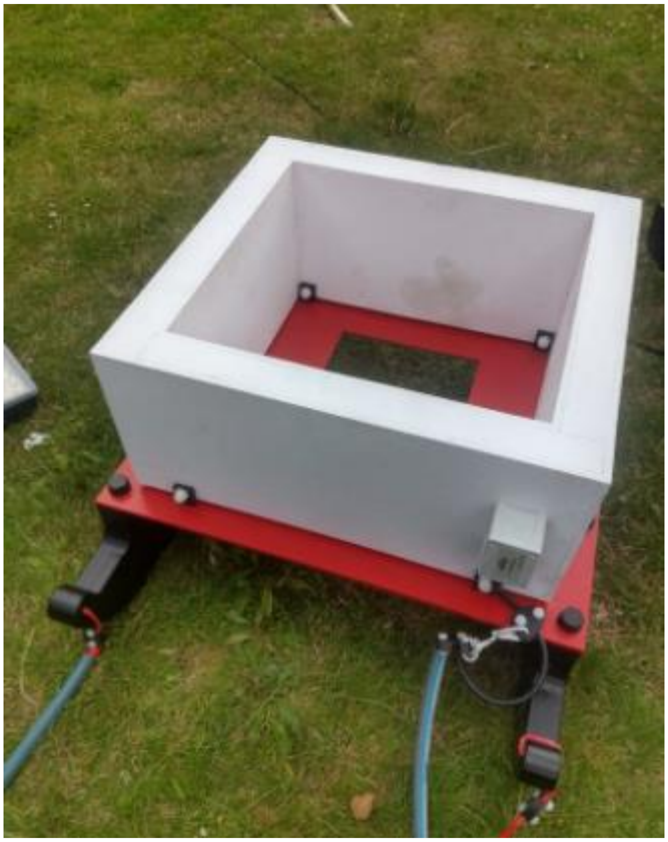


**Figure A1-5 The TEM Receiver coil is suspended to reduce motion induced noise.**

**Depth of investigation**

The depth of investigation (DOI) depends on the geological and hydrogeological settings within the survey area and the signal-to-noise ratio determined by the power of the transmitted electromagnetic field, internal noise in the instrumentation and the actual ambient noise during the survey.

The length of the TEM decay curves, i.e. how late in time the signal can be measured before reaching the noise level, determines the DOI. In Figure A1-6, the earth response (the green curves) reaches the noise floor for the system at ~ 500 $\mu s$. The depth of investigation can be increased by increasing the induced signal. This is typically done by injecting higher current, increasing the size of the transmitter loop and/or increasing the number of decay curves being averaged (stack size).

The DOI for the tTEM system is typically 60-80 m bgs. The DOI for the WalkTEM system is typically 200-300 m bgs. The DOI will be larger when the ground is more resistive and smaller when the ground is more conductive. During the inversion, the DOI is estimated for each resistivity model.

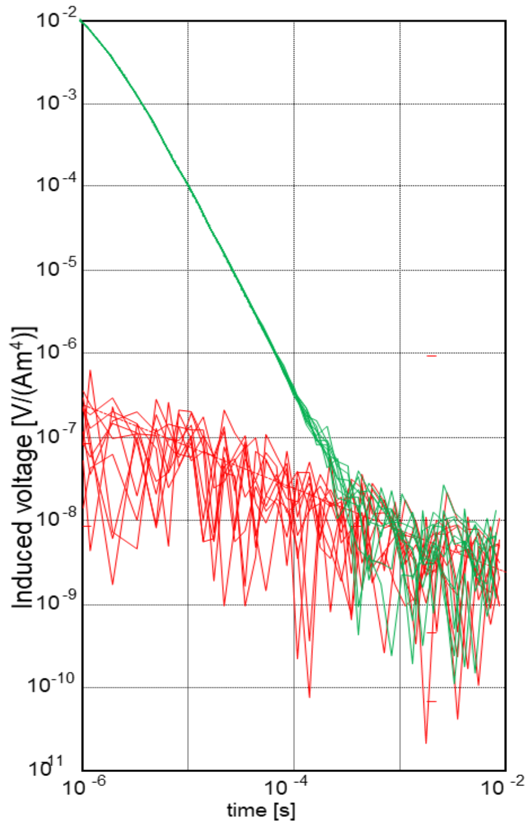



**Figure A1-6 An Example of decay curves created by a TEM system (Green curves) and the background noise floor (Red curves).**

## Inversion

The inversion process is the step where the measured voltage values are fitted with the TEM response of the geophysical model. The model is described by its layer thicknesses and corresponding electrical resistivities. The results are typically presented as smooth (multi-layer) resistivity models.

The processed data were inverted by applying a laterally constrained inversion (LCI) approach, where neighboring soundings are constrained in a multi-layered inversion scheme.

An in-depth description of the modelling scheme can be found in the references listed below.

## References

Selected references describing TEM systems like the tTEM and WalkTEM systems, the calibration of a TEM system at the national Danish Test site and the applied modeling technique.

*Auken, E., Foged, N., Larsen, J. J., Lassen, K. V. T, Kumar Maurya, P, Dath, S. M., and Eiskjær, T. T., 2019, tTEM — A towed transient electromagnetic system for detailed 3D imaging of the top 70 m of the subsurface, Geophysics, Vol. 84, NO. 1 (Jan-Feb 2019); P. E13–E22, 11 Figs., 1 Table. 10.1190/GEO2018-0355.1*

*Auken, E., Foged, N. and Sørensen, K., 2002, Model recognition by 1-D laterally constrained inversion of resistivity data: Proceedings – New Technologies and Research Trends Session, 8th meeting, EEGS-ES.*

*Auken, E., Christiansen, A. V., Jacobsen, B. H., Foged, N., and Sørensen, K. I., 2005, Piecewise 1D Laterally Constrained Inversion of resistivity data: Geophysical Prospecting, 53, 497–506.*
*Christiansen, A.V. and Auken, E., 2012, A global measure for depth of investigation: Geophysics, vol 77, No. 4, 171-177.*

*Auken, E., A.V. Christiansen, C. Kirkegaard, G. Fiandaca, C. Schamper, A.A. Behroozmand, et al. 2015. An overview of a highly versatile forward and stable inverse algorithm for airborne, ground-based and borehole electromagnetic and electric data. Explor. Geophys. 46:223–235. doi:10.1071/EG13097*

*Foged, N., E. Auken, A. V. Christiansen, and K. I. Sørensen, 2013, Test site calibration and validation of airborne and ground based TEM systems: Geophysics, 78, no. 2, E95–E106, doi: 10.1190/geo2012-0244.1.*

*McNeill, J. Electromagnetic Terrain Conductivity Measurement at Low Induction Numbers; Technical Report TN-6; Geonics Limited: Mississauga, ON, Canada, 1980*

*Sørensen, K. I., and Auken, E., 2004, SkyTEM – A new high-resolution helicopter transient electromagnetic system.: Exploration Geophysics, 35, 191–199.*

*Sørensen, K. I., 1997, The pulled array transient electromagnetic method: Proceedings of the 3rd Meeting of the Environmental and Engineering Geophysical Society, European Section, 135–138*

*Viezzoli, A., A. V. Christiansen, E. Auken, and K. I. Sørensen, 2008, Quasi-3D modeling of airborne TEM data by Spatially Constrained Inversion, Geophysics, 73, 3, F105-F113*

# APPENDIX 2
# INSTRUMENTATION, PROCESSING & INVERSION SETTINGS, AND REPEAT LINES

The towed-TEM (tTEM) and WalkTEM instruments are time-domain electromagnetic systems designed for hydrogeophysical and environmental investigations. The instruments were developed based on many years of research at Aarhus University in Denmark. The experience dates back to the development of the pulled-array TEM (PATEM) system and later the SkyTEM airborne system.

# tTEM instrument

This section describes the tTEM instrument, documentation for calibration, results of repeated lines within the survey area and the settings being applied for this specific survey. The information is provided to give an in-depth understanding of the data collection, processing and inversion.

### instrument setup

The tTEM system measures continuously while towed on the ground. It is designed to provide a very high near-surface resolution with very early time gates and a fast repetition frequency. The tTEM is based on an off-set loop configuration, with the receiver coil (Rx-coil) pulled ~ 8.0 m behind the transmitter coil (Tx-coil). The Rx-coil is horizontal, i.e. measuring the z-component of the magnetic fields.

An ATV or similar vehicle tows the tTEM-system. The distance between the ATV and the Tx coil is 3.0 m. The Tx-coil is a 2 m x 4 m loop suspended by the red beams, as shown on the photo in Figure A2-1. A GPS is located at the front of the Tx-frame for accurate positioning of the system. The Rx-coil is placed on a small sled. The transmitter electronics, receiver instrument, power supply etc. are carried on the back of the ATV.

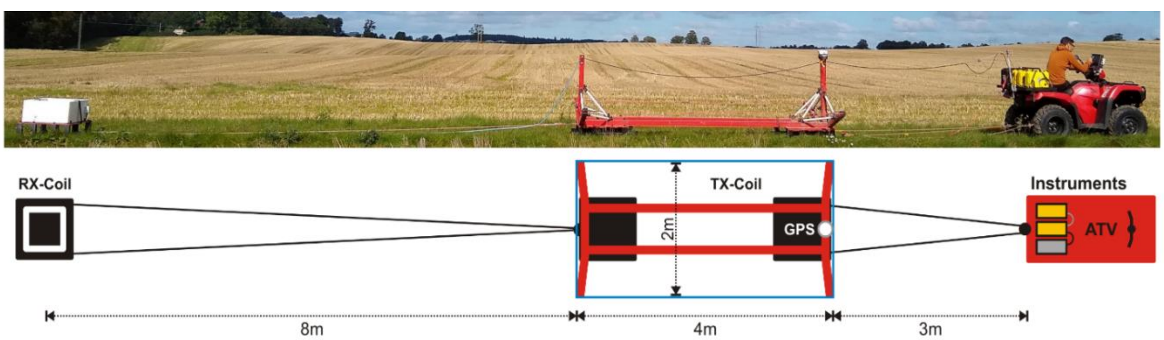



Figure A2-1 The tTEM system configuration.

### tTEM instrument IDs

For this survey, the instruments with ID's shown in Table A2-1 were used.

| Unit | ID1 | ID2 |
|---|---|---|
| TIB Receiver instrument | 13 | 20180843 |
| RC20 Receiver coil | | 20200217 |
| tTEM Transmitter | TX11 | 20200209 |
| Novatel Agstar GPS | | 20200640 |

**Table A2-1 ID's for the instrumentation used in this survey.**

### Device Positions, nominal

The positions and the geometry of the main components are listed in Table A2-2 and used in the processing and inversion scheme. As an example, the GPS coordinate is measured in the front of the transmitter frame, and then during the processing of the GPS data, the coordinates are shifted to reflect the actual focus point of the system. The geometry of the transmitter frame and the exact off-set of the receiver coil are used during the inversion of the data.

| Unit | X (m) | Y (m) | Z(m) |
|---|---|---|---|
| GP_Tx (GPS) | 2.00 | 0.00 | -1.20 |
| RxZ (Z-receiver coil) | -10.28 | 0.00 | -0.30 |
| Tx-Coil, center | 0.00 | 0.00 | -0.50 |
| Tx-Coil corner 1 | -2.00 | -1.00 | -0.50 |
| Tx-Coil corner 2 | 2.00 | -1.00 | -0.50 |
| Tx-Coil corner 3 | 2.00 | 1.00 | -0.50 |
| Tx-Coil corner 4 | -2.00 | 1.00 | -0.50 |

**Table A2-2 Nominal equipment, receiver and transmitter coils positioning. The origin is defined as the center of the transmitter coil. Z is positive downwards.**

### Transmitter waveform

The current in the transmitter loop is turned on and off in pulses. The direction of the current shifts from positive to negative in between each pulse. The two graphs below show the waveform for the low moment (LM) and the high moment (HM) as the current is turned off very rapidly. During the off times, i.e. when the current is turned off, the secondary magnetic fields from the eddy currents are measured in the receiver coil.

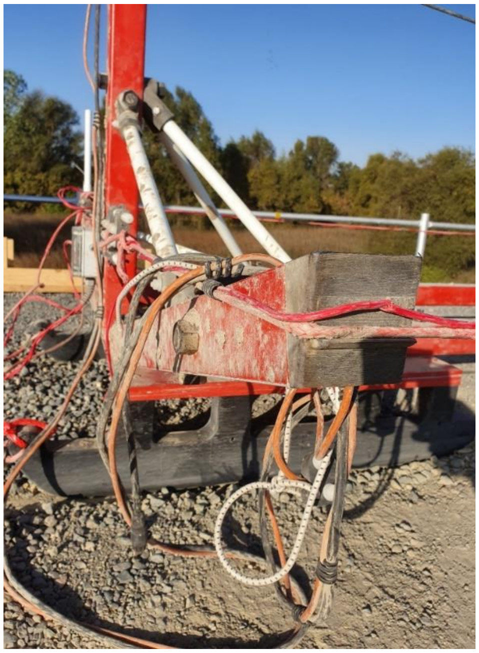


**Figure A2-2 Close-up photo showing the transmitter frame mounted on the sled**

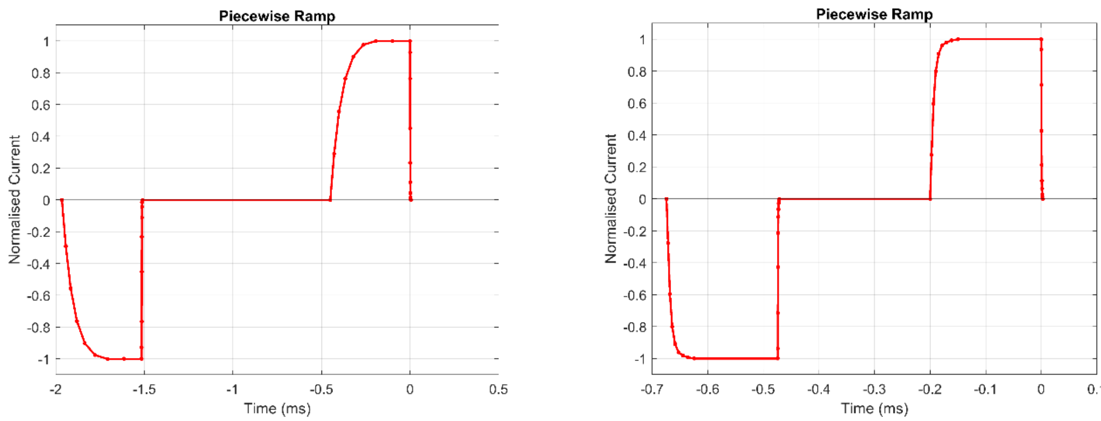



**Figure A2-3 Waveforms for the LM (left) and the HM (right). The red line segments indicate the piecewise linear modelling of the waveforms.**

The speed of the turn-off ramp of the low moment is critical for the resolution of the shallow subsurface. Figure A2-4 shows a closeup view of the ramp down on the low moment; the current is turned off within approximately 2 microsecond (µS).

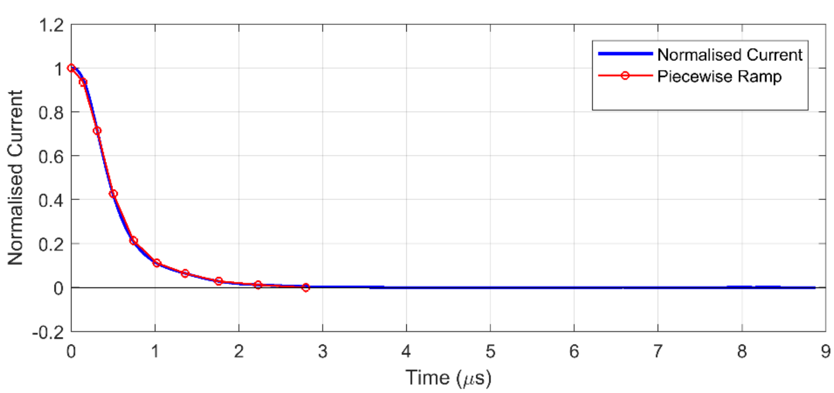



**Figure A2-4 Close-up on ramp down for LM. The red line segments indicate the piecewise linear modelling of the waveform.**

The transmitter waveforms for LM and HM, are listed as time and nominal amplitude. On-times are negative, and off-times are positive. The shape of the waveform is used in the inversion scheme. The actual waveforms are scaled by the current measurement just before the current is turned off.

| LM time | LM amplitude | HM time | HM amplitude |
|---|---|---|---|
| -6.7400e-04 s | -0.000 | -1.9650e-03 s | -0.000 |
| -6.7250e-04 s | -0.496 | -1.9483e-03 s | -0.316 |
| -6.7071e-04 s | -0.658 | -1.9279e-03 s | -0.532 |
| -6.6859e-04 s | -0.784 | -1.9030e-03 s | -0.710 |
| -6.6605e-04 s | -0.865 | -1.8725e-03 s | -0.845 |
| -6.6303e-04 s | -0.925 | -1.8351e-03 s | -0.933 |
| -6.5944e-04 s | -0.963 | -1.7894e-03 s | -0.981 |
| -6.5516e-04 s | -0.978 | -1.7334e-03 s | -1.001 |
| -6.5007e-04 s | -0.989 | -1.6650e-03 s | -1.000 |
| -6.4400e-04 s | -1.000 | -1.5150e-03 s | -1.000 |
| -4.7400e-04 s | -1.000 | -1.5148e-03 s | -0.967 |
| -4.7387e-04 s | -0.953 | -1.5146e-03 s | -0.859 |
| -4.7373e-04 s | -0.812 | -1.5143e-03 s | -0.662 |
| -4.7355e-04 s | -0.559 | -1.5139e-03 s | -0.381 |
| -4.7334e-04 s | -0.332 | -1.5135e-03 s | -0.155 |
| -4.7309e-04 s | -0.175 | -1.5131e-03 s | -0.053 |
| -4.7279e-04 s | -0.086 | -1.5125e-03 s | -0.017 |
| -4.7243e-04 s | -0.041 | -1.5118e-03 s | -0.007 |
| -4.7200e-04 s | -0.016 | -1.5110e-03 s | -0.000 |
| -4.7150e-04 s | -0.000 | -4.5000e-04 s | 0.000 |
| -2.0000e-04 s | 0.000 | -4.3333e-04 s | 0.316 |
| -1.9850e-04 s | 0.496 | -4.1294e-04 s | 0.532 |
| -1.9671e-04 s | 0.658 | -3.8799e-04 s | 0.710 |
| -1.9459e-04 s | 0.784 | -3.5745e-04 s | 0.845 |
| -1.9205e-04 s | 0.865 | -3.2009e-04 s | 0.933 |
| -1.8903e-04 s | 0.925 | -2.7438e-04 s | 0.981 |
| -1.8544e-04 s | 0.963 | -2.1844e-04 s | 1.001 |
| -1.8116e-04 s | 0.978 | -1.5000e-04 s | 1.000 |
| -1.7607e-04 s | 0.989 | 0.0000e+00 s | 1.000 |
| -1.7000e-04 s | 1.000 | 2.0384e-07 s | 0.967 |
| 0.0000e+00 s | 1.000 | 4.3584e-07 s | 0.859 |
| 1.2589e-07 s | 0.953 | 7.2384e-07 s | 0.662 |
| 2.6989e-07 s | 0.812 | 1.0598e-06 s | 0.381 |
| 4.5389e-07 s | 0.559 | 1.4598e-06 s | 0.155 |
| 6.6189e-07 s | 0.332 | 1.9398e-06 s | 0.053 |
| 9.0989e-07 s | 0.175 | 2.5078e-06 s | 0.017 |
| 1.2139e-06 s | 0.086 | 3.1878e-06 s | 0.007 |
| 1.5659e-06 s | 0.041 | 4.0000e-06 s | 0.000 |
| 1.9979e-06 s | 0.016 | | |
| 2.8000e-06 s | 0.000 | | |

**Table A2-3 Transmitter waveforms LM and HM.**

### Measurement cycle

The basic settings of the instrumentation are shown in Table A2-4.

| Parameter | LM | HM |
|---|---|---|
| Moment ID | 2 | 1 |
| No. of turns | 1 | 1 |
| Transmitter area (m2) | 8 m2 | 8 m2 |
| Tx Current | ~ 3 A | ~ 30 A |
| Tx Peak moment | ~ 24 Am2 | ~ 240 Am2 |
| Repetition frequency | 1008 Hz | 282 Hz |
| Raw Data Stack size | 366 | 282 |
| Raw Moment cyclus time | 0.22 s | 0.40 s |
| Tx on-time | 200 μs | 450 μs |
| Duty cycle | 42% | 30% |
| Turn-off time | 2.6 μs at 3 Amp | 4.5 μs at 30 Amp |
| Number of gates | 5 | 25 |
| Gate time interval (gate center time) | 4 μs – 30 μs | 10 μs – 900 μs |
| Front-gate time (nominal) | 2 μs | 4 μs |
| Front-gate delay | 2 μs | 2 μs |

**Table A2-4 Basic settings of the instrumentation.**

### Receiver coil

The receiver coil can be described by the following parameters. The parameters are used in the inversion scheme.

| Parameter | Value |
|---|---|
| Low pass filter frequency | 300 kHz |
| Low pass filter order | 1 |
| Effective area | $20m^2$ |

**Table A2-5 Receiver coil parameters.**

### Instrument Firmware versions

The firmware in the instruments have the version numbers described in the table below.

| Software | Version |
|---|---|
| PaPC | 4.1.1.8 |
| Navsys | 2.1.0.4 |
| TxProc | 2.10.0.30 |
| tTEM Log | 5.0.4.8 |
| NAV | 5.2.0.2 |

**Table A2-6 Instrument firmware versions.**

### Documentation of test and calibration

At the Danish national geophysical test-site near Aarhus, Denmark, the tTEM instrumentation described above was tested and calibrated. The purpose for the test and calibration is to document the performance of the instrument and to defined absolute calibration parameters.

The calibration is performed to establish the absolute time shift and data level to facilitate precise modeling of the data. No additional levelling or drift corrections are applied. To perform the calibration, all system parameters (transmitter waveform, low pass filters, etc.) must be known to allow accurate modeling of the tTEM setup. The calibration constants are determined by comparing a recorded tTEM response on the test site with the reference response. The reference response is calculated from the test site reference model for the used tTEM configuration.

Acceptable calibration was achieved with the calibration constants stated in Table A2-7. The calibration was performed on June 9, 2019. Calibration plots for both moments are shown in Figures A2-5 and A2-6. The scale factors of 1.01 and 1.03 (1% and 3%) are very acceptable. The time shift is deemed due to the delays in the electronics and inaccurately modelled waveforms. The obtained time shifts are very acceptable.

| Moment | Time Shift | Scale Factor |
|---|---|---|
| LM | -0.80 µs | 1.01 |
| HM | -0.70 µs | 1.03 |

**Table A2-7. Calibration constants.**

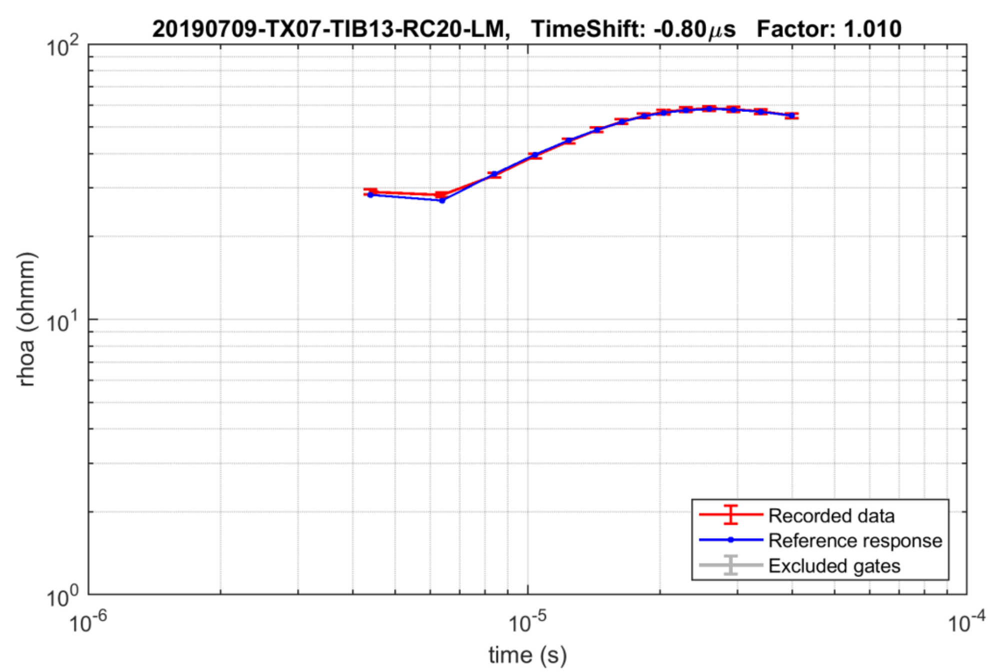



**Figure A2-5 Calibration plot for the LM. The red curve is the recorded data with calibration factors applied, and the blue curve is the forward response from the national geophysical test-site in Denmark.**

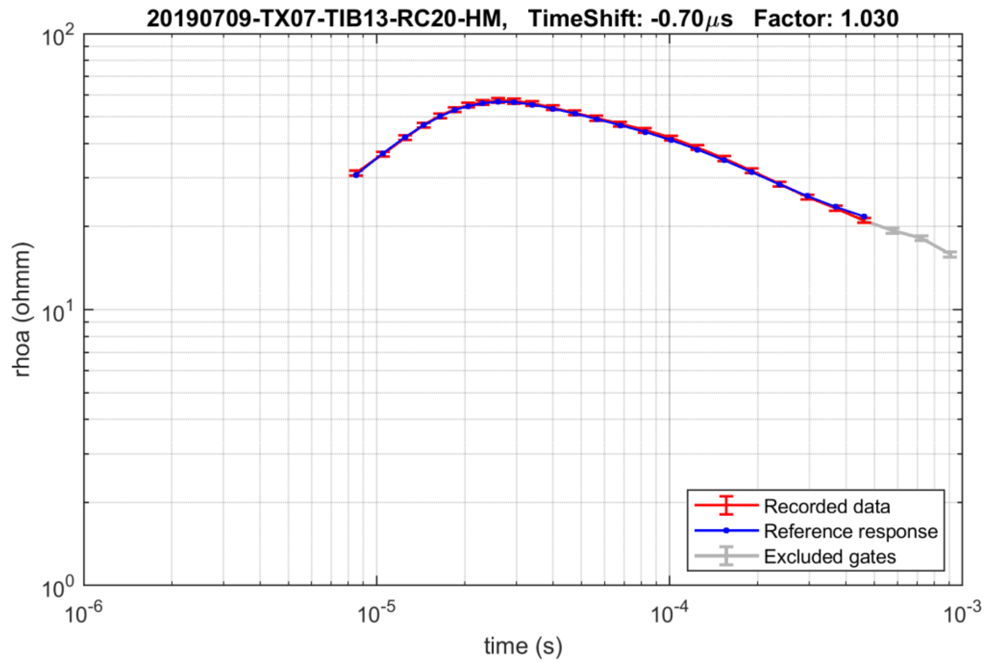



**Figure A2-6 Calibration plot for the HM. The red curve is the recorded data with calibration factors applied, and the blue curve is the forward response from the national geophysical test-site in Denmark.**

### Processing and Inversion Software settings

The processing and inversion are based on the Aarhus Workbench software, version 6.4.0.0. A 30-layer model has been applied. Table A2-8 lists the fixed layer thicknesses, depth to bottom of layer and the initial resistivity assigned to the model layers (a homogenous half space). For this survey, the initial resistivity values were obtained by first inverting each tTEM sounding data with homogeneous half-space earth model and the resulting values were used during the inversion.

| Layer | Thickness [Meter] | Depth [Meter] | Start value [Ohm-m] |
|---|---|---|---|
| 1 | 1.00 | 1.00 | 10 |
| 2 | 1.10 | 2.10 | 10 |
| 3 | 1.20 | 3.20 | 10 |
| 4 | 1.30 | 4.50 | 10 |
| 5 | 1.30 | 5.80 | 10 |
| 6 | 1.50 | 7.30 | 10 |
| 7 | 1.60 | 8.90 | 10 |
| 8 | 1.70 | 10.6 | 10 |
| 9 | 1.80 | 12.4 | 10 |
| 10 | 2.00 | 14.3 | 10 |
| 11 | 2.10 | 16.5 | 10 |
| 12 | 2.30 | 18.7 | 10 |
| 13 | 2.50 | 21.2 | 10 |
| 14 | 2.60 | 23.8 | 10 |

| Layer | Thickness [Meter] | Depth [Meter] | Start value [Ohm-m] |
|---|---|---|---|
| 15 | 2.90 | 26.7 | 10 |
| 16 | 3.10 | 29.8 | 10 |
| 17 | 3.30 | 33.1 | 10 |
| 18 | 3.60 | 36.7 | 10 |
| 19 | 3.90 | 40.5 | 10 |
| 20 | 4.20 | 44.7 | 10 |
| 21 | 4.50 | 49.1 | 10 |
| 22 | 4.80 | 53.9 | 10 |
| 23 | 5.20 | 59.1 | 10 |
| 24 | 5.60 | 64.7 | 10 |
| 25 | 6.00 | 70.8 | 10 |
| 26 | 6.50 | 77.3 | 10 |
| 27 | 7.00 | 84.3 | 10 |
| 28 | 7.60 | 91.9 | 10 |
| 29 | 8.10 | 100 | 10 |
| 30 | -- | | |

**Table A2-8 Outline of the 30-layer model.**

### GPS settings

The settings and the position of the GPS is shown in Table A2-9.

| Parameter | Value |
|---|---|
| Beat Time | 0.5 sec |
| Filter length | 7.0 sec |
| Polynomial order | 2 |
| Shift in x-direction | -4.965 m |

**Table A2-9 GPS processing.**

### Repeat line within the survey area

Within the survey area, a test line was surveyed repeatedly. This is to document that the system is not affected by drift or other problems with the instrumentation, as well as to show that the processing and inversion schemes are robust and consistent.

The modelling results along the test line are shown in the following figures. The results from the test line show high repeatability of the tTEM system and the inversion approach.

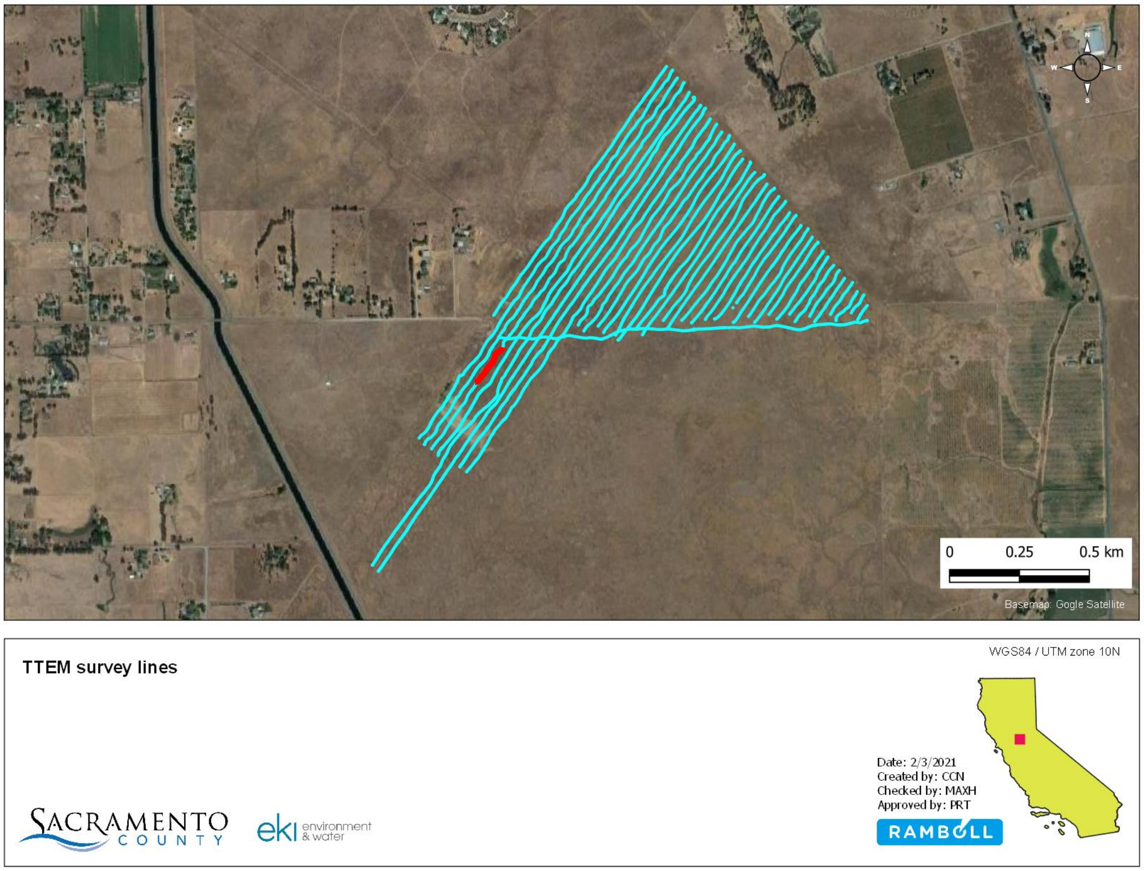



**Figure A2-7 Location map of the test line (red) conducted on the 10th of November 2020.**

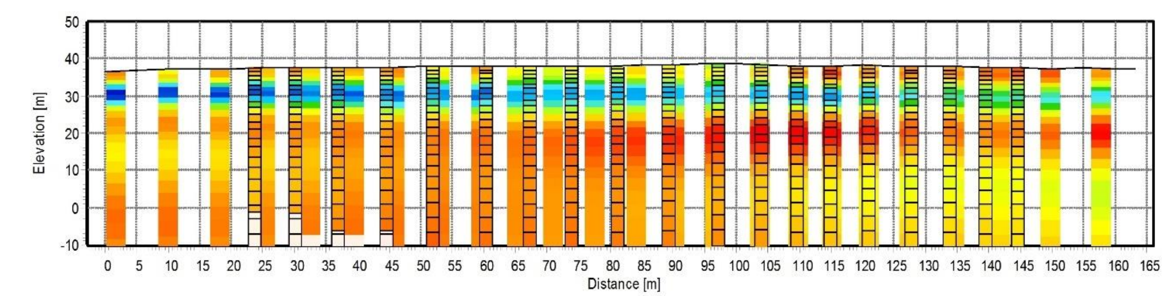



**Figure A2-8 Modeled soundings along the test line (165 m). Models with no outline are measured from 20:48:26 to 20:49:28 and models with black outlines are measured from 00:18:33 to 00:19:18. Both data sets are from November 10, 2020.**

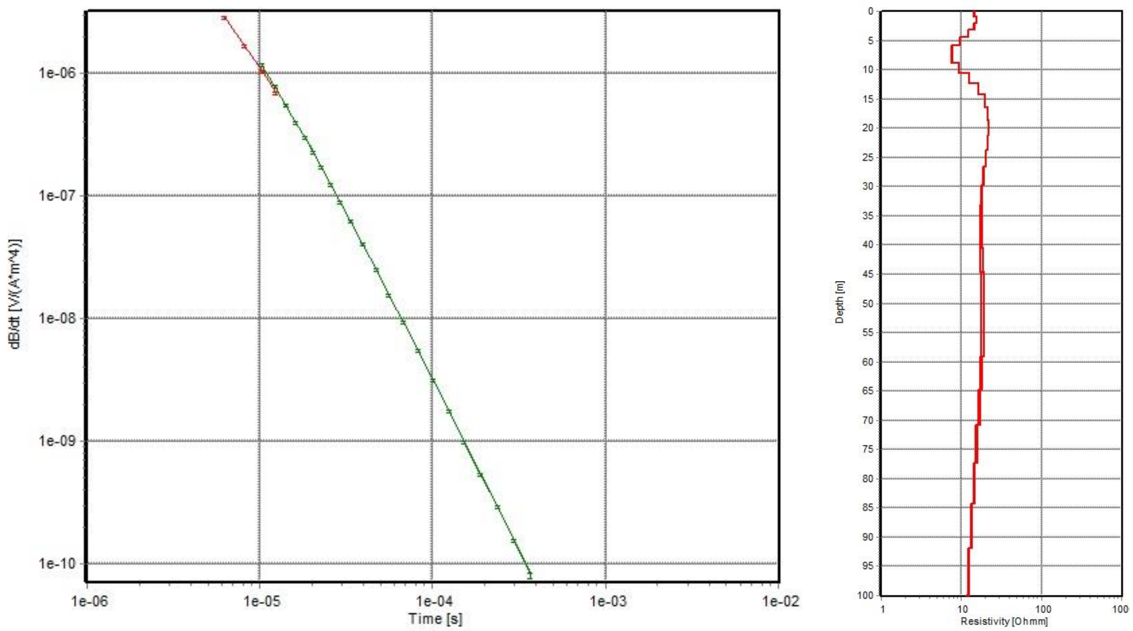



**Figure A2-9 Two co-located sounding curves (left; red – 2x LM, green – 2 x HM) and the corresponding resistivity models (right) along the test line, measured at 20:49:00 and 00:18:55, respectively. The sounding curves show excellent repeatability, which is also reflected in the model curves. Both data sets are from November 10, 2020.**

# WalkTEM instrument

This section describes the WalkTEM instrument setup and system specifications. The information is provided to give an in-depth understanding of the data collection, processing and inversion.

**WalkTEM instrument setup**

The WalkTEM field configuration used in this survey is named “central loop” configuration. It comprises a 40 m x 40 m (130 ft x 130 ft) square-shaped transmitter (Tx) loop, along with a 10 m x 10 m (33 ft x 33 ft) 2-turn receiver (Rx) loop placed in the center of the transmitter loop. The Tx and Rx loops are connected to the WalkTEM instrument, which is placed at the corner of the Tx loop. The instrument is supplied with a 12V external battery (Figure A2-10).

The instrument runs on a built-in windows computer. It also has a built-in keypad to ease operation of the system. The acquisition software is linked to a simplified inversion program that enables quick analysis of the data at the site.

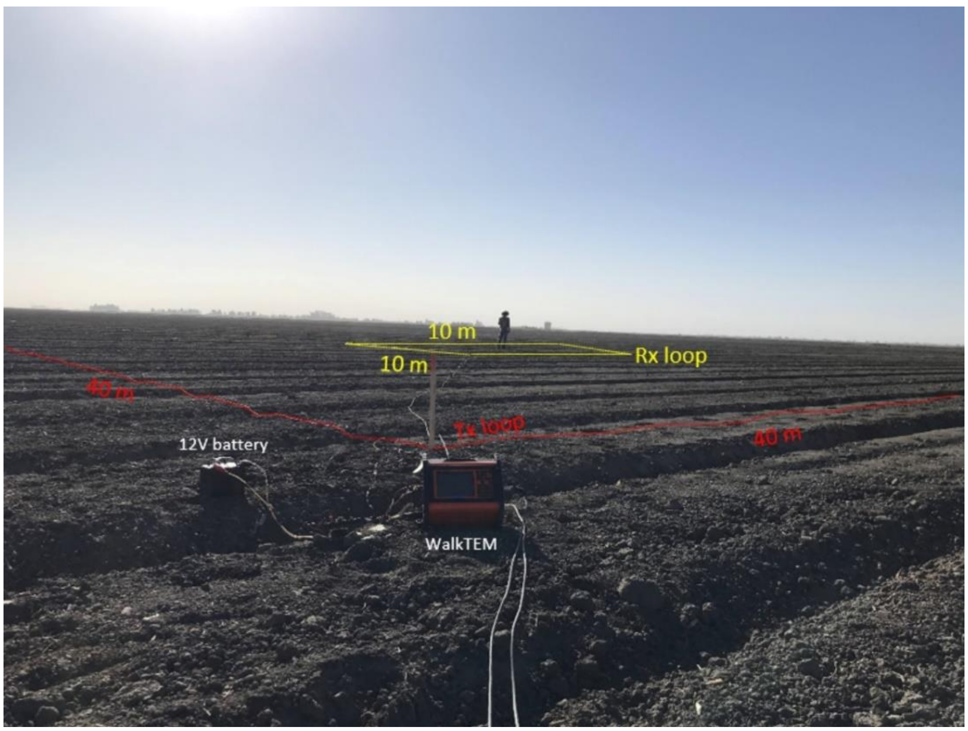



**Figure A2-10 The WalkTEM system configuration.**

**Measurement cycle**
The basic settings of the instrumentation are shown in Table A2-10. In this study, a measuring script consisting of 45 time gates was used to achieve maximum depth of investigation.

| Parameter | LM | HM |
|---|---|---|
| Moment ID | 2 | 1 |
| No. of turns | 1 | 1 |
| Transmitter area (m2) | 1600 m2 | 1600 m2 |
| Tx Current | ~ 1 A | ~ 8 A |
| Tx Peak moment | ~ 1600 Am2 | ~ 12800 Am2 |
| Number of gates | 25 | 32 |
| Gate time interval (gate center time) | 9.19 µs – 706 µs | 35 µs – 22.16 µs |

**Table A2-10 Basic settings of the instrumentation.**

**System calibration**
The WalktTEM instrumentation described above was tested and calibrated at the Danish national geophysical test-site near Aarhus, Denmark. The purpose for the test and calibration is to document the performance of the instrument and to defined absolute calibration parameters.

The calibration is performed to establish the absolute time shift and data level to facilitate precise modeling of the data. No additional levelling or drift corrections are applied. To perform the calibration, all system parameters (transmitter waveform, low pass filters, etc.) must be known to allow accurate modeling of the WalkTEM setup. The calibration constants are determined by comparing a recorded WalkTEM response on the test site with the reference response. The reference response is calculated from the test site reference model for the used WalkTEM configuration.

Acceptable calibration was achieved with the calibration constants stated in Table A211. The scale factors of 1.04 and 1.02 (4% and 2%) are very acceptable. The time shift is deemed due to the delays in the electronics and inaccurately modelled waveforms. The obtained time shifts are very acceptable.

| Moment | Time Shift | Scale Factor |
|---|---|---|
| LM | -1.70 µs | 1.04 |
| HM | -1.60 µs | 1.02 |

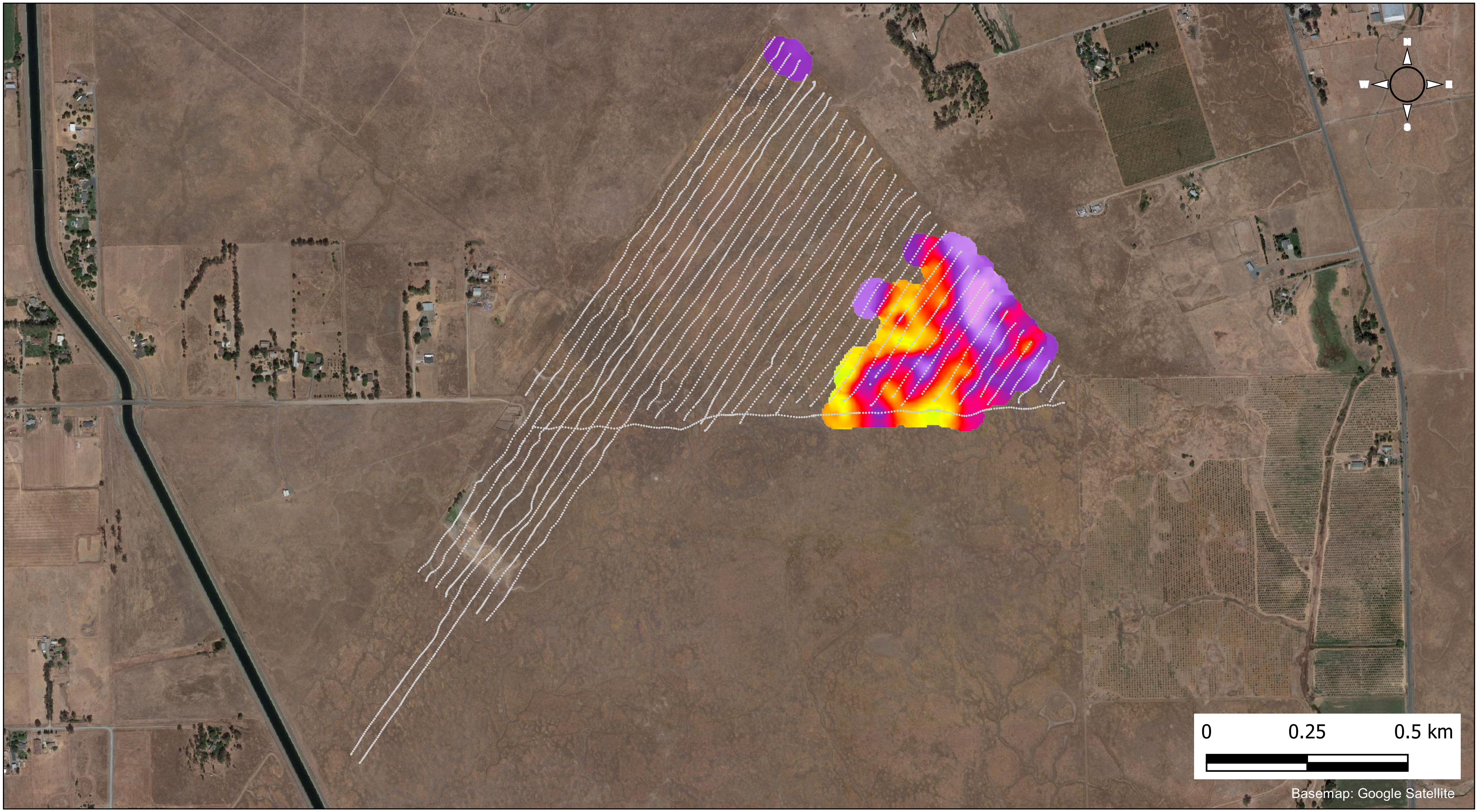
**Table A2-11. Calibration constants.**

**Processing and Inversion Software settings**
The processing and inversion are based on the Aarhus SPIA software, version 3.5.1.0. A 20-layer model has been applied. Table A2-12 lists the fixed layer thicknesses, depth to bottom of layer and the initial resistivity assigned to the model layers (a homogenous half space).

| Layer | Thickness [Meter] | Depth [Meter] | Start value [Ohm-m] |
|---|---|---|---|
| 1 | 4.30 | 4.30 | 50 |
| 2 | 4.86 | 9.16 | 50 |
| 3 | 5.48 | 14.64 | 50 |
| 4 | 6.19 | 20.84 | 50 |
| 5 | 6.99 | 27.83 | 50 |
| 6 | 7.89 | 35.72 | 50 |
| 7 | 8.91 | 44.63 | 50 |
| 8 | 10.06 | 54.69 | 50 |
| 9 | 11.36 | 66.05 | 50 |
| 10 | 12.82 | 78.87 | 50 |
| 11 | 14.48 | 93.35 | 50 |
| 12 | 16.34 | 109.69 | 50 |
| 13 | 18.45 | 128.14 | 50 |
| 14 | 20.83 | 148.97 | 50 |
| 15 | 23.52 | 172.49 | 50 |
| 16 | 26.55 | 199.04 | 50 |
| 17 | 29.98 | 229.02 | 50 |
| 18 | 33.84 | 262.86 | 50 |
| 19 | 38.21 | 301.07 | 50 |
| 20 | -- | -- | 50 |

**Table A2-12 Outline of the 25-layer model.**

# APPENDIX 3
# MEAN RESISTIVITY PLAN-VIEW MAPS




**Mean Resistivity**
**Elevation interval 43 to 45 m a.m.s.l**

Resistivity [Ohmm]: 5, 10, 20, 50

WGS84 / UTM zone 10N

Date: 2/3/2021
Created by: CCN
Checked by: MAXH
Approved by: PRT

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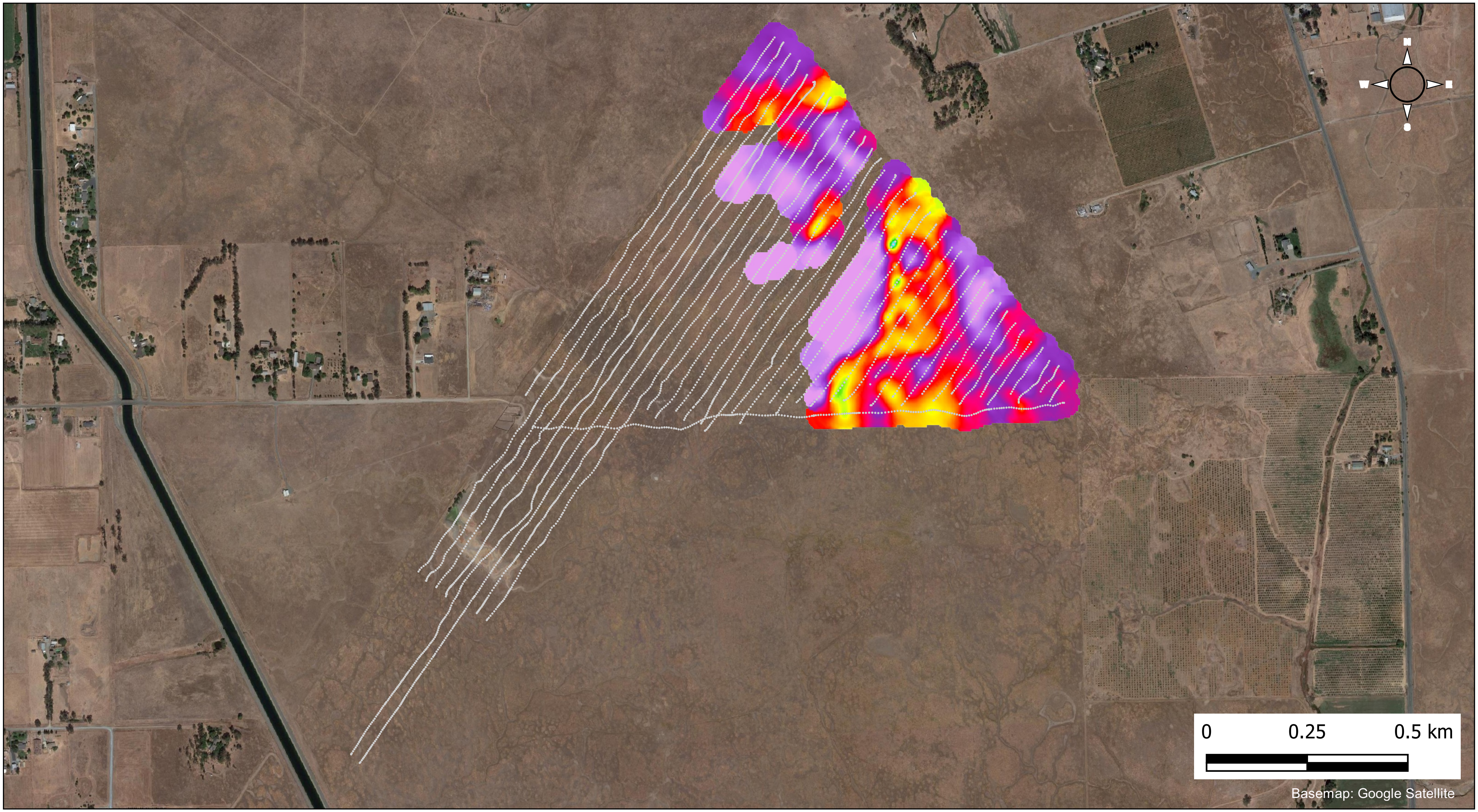
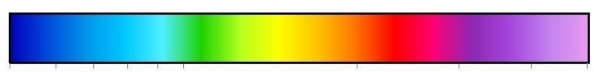



**Mean Resistivity**
**Elevation interval 41 to 43 m a.m.s.l**




WGS84 / UTM zone 10N

Date: 2/3/2021
Created by: CCN
Checked by: MAXH
Approved by: PRT

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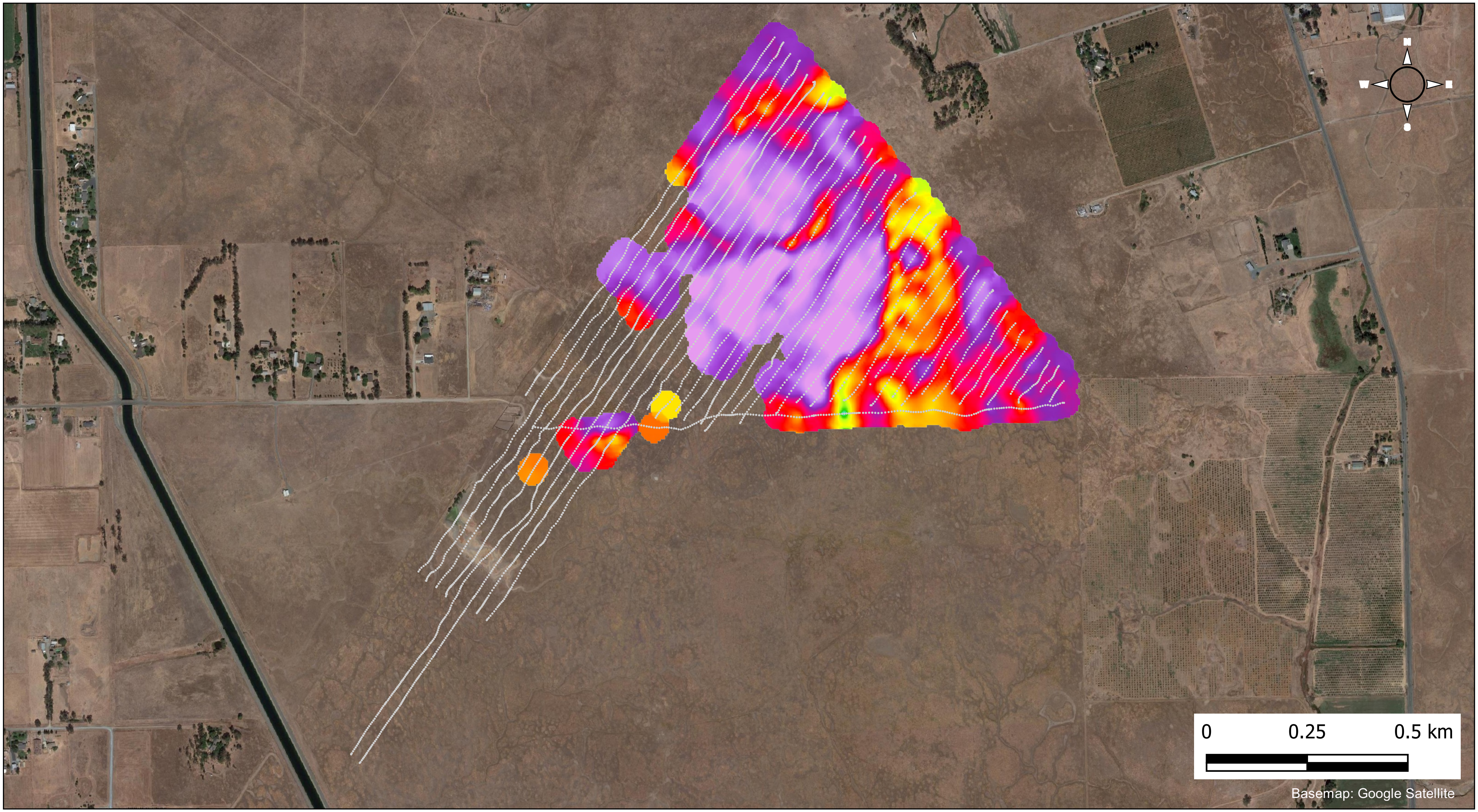
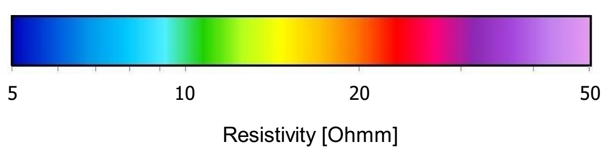



**Mean Resistivity**
**Elevation interval 39 to 41 m a.m.s.l**

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Date: 2/3/2021
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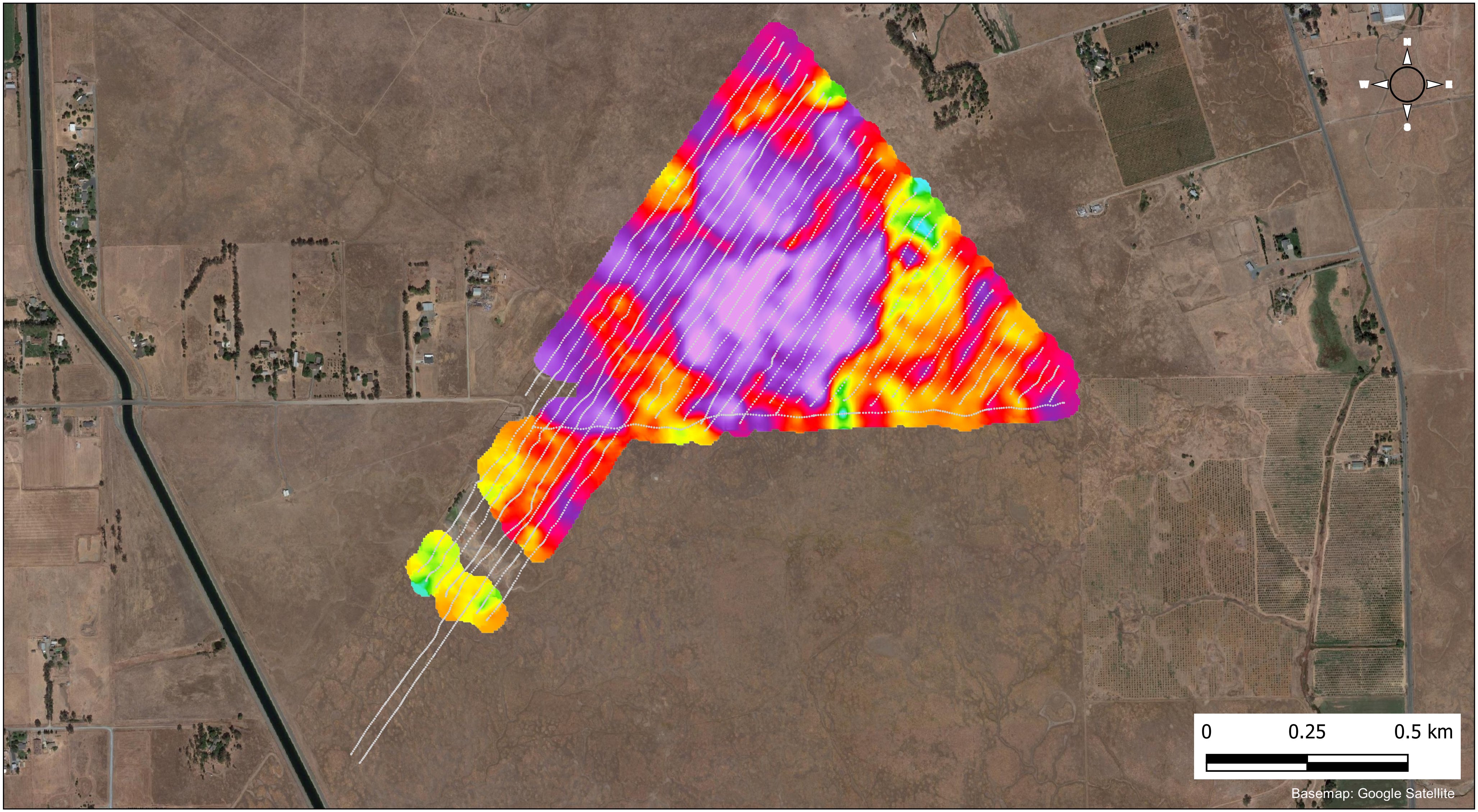


**Mean Resistivity**
**Elevation interval 37 to 39 m a.m.s.l**

5 10 20 50

Resistivity [Ohmm]

WGS84 / UTM zone 10N

Date: 2/3/2021
Created by: CCN
Checked by: MAXH
Approved by: PRT

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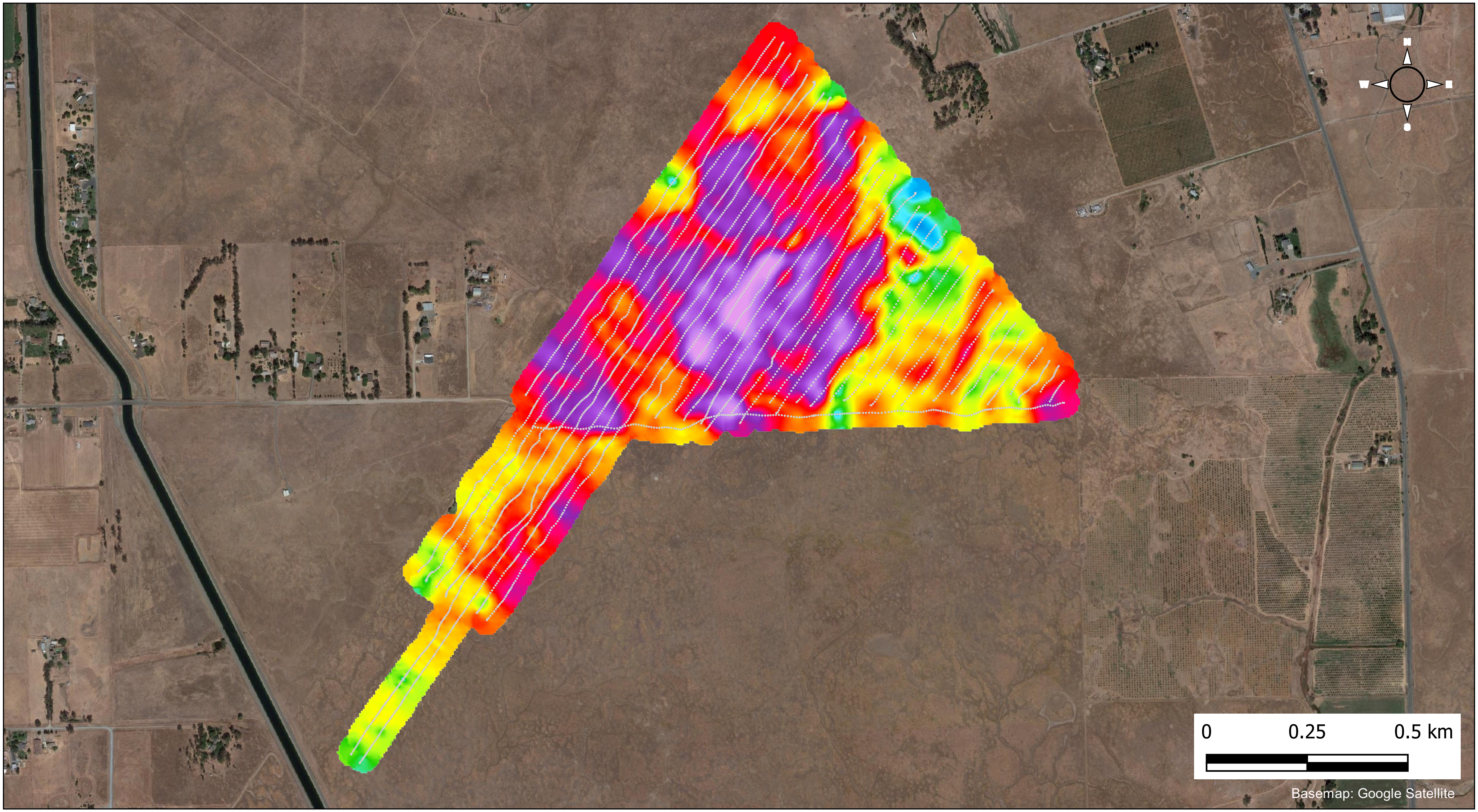
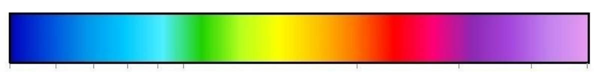



**Mean Resistivity**
**Elevation interval 35 to 37 m a.m.s.l**




WGS84 / UTM zone 10N

Date: 2/3/2021
Created by: CCN
Checked by: MAXH
Approved by: PRT

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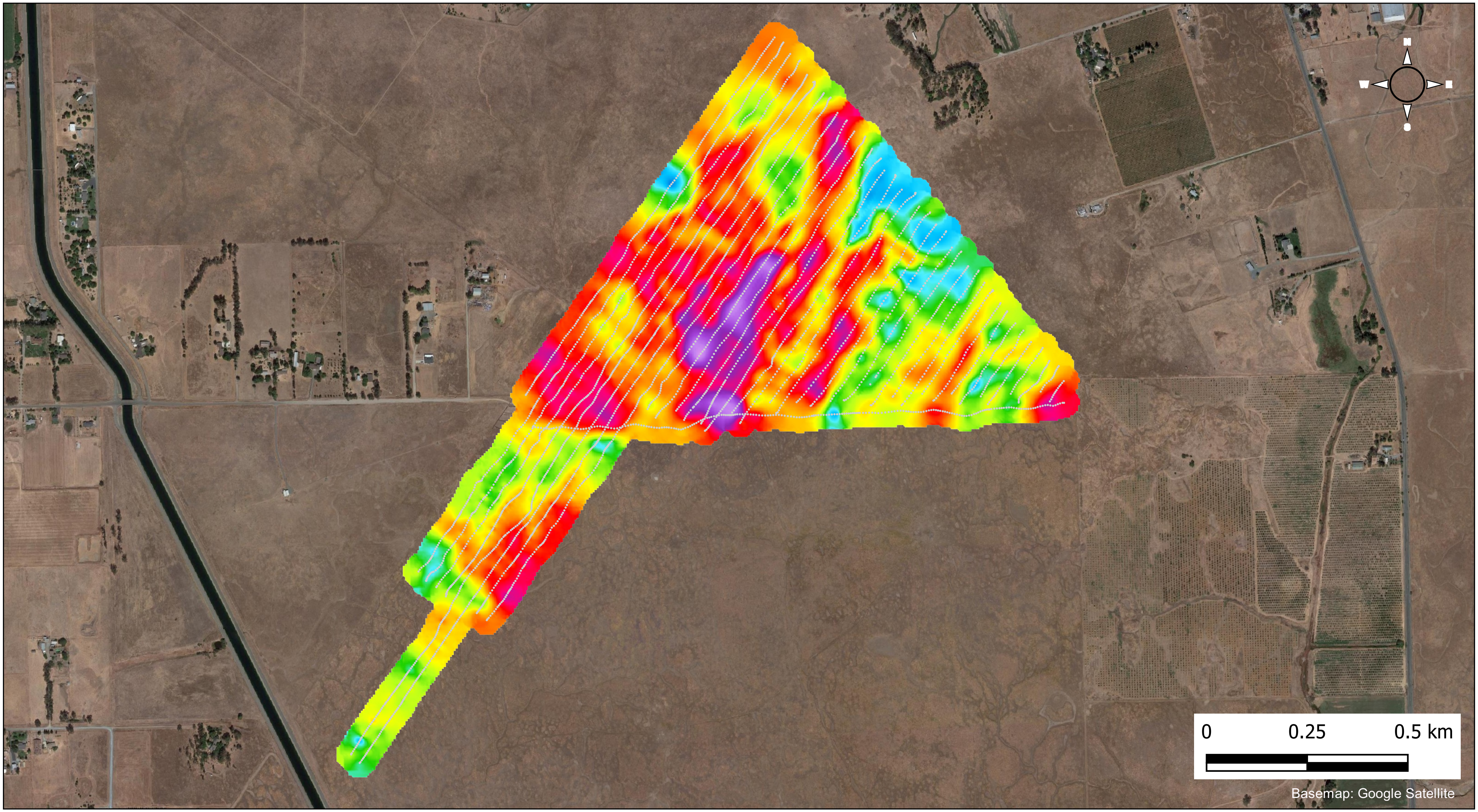


**Mean Resistivity**
**Elevation interval 33 to 35 m a.m.s.l**

5 10 20 50

Resistivity [Ohmm]

WGS84 / UTM zone 10N

Date: 2/3/2021
Created by: CCN
Checked by: MAXH
Approved by: PRT

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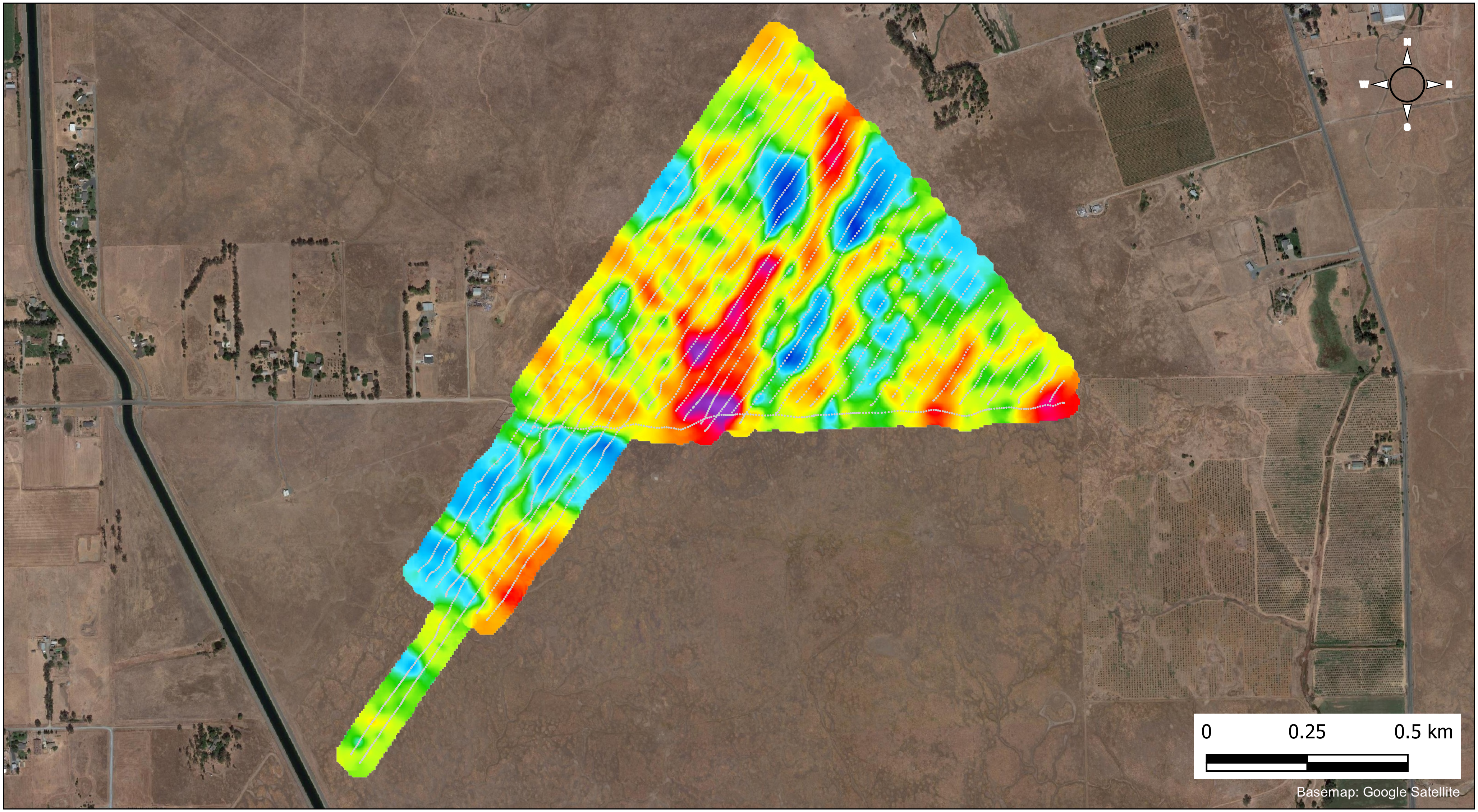


**Mean Resistivity**
**Elevation interval 31 to 33 m a.m.s.l**

5 10 20 50

Resistivity [Ohmm]

WGS84 / UTM zone 10N

Date: 2/3/2021
Created by: CCN
Checked by: MAXH
Approved by: PRT

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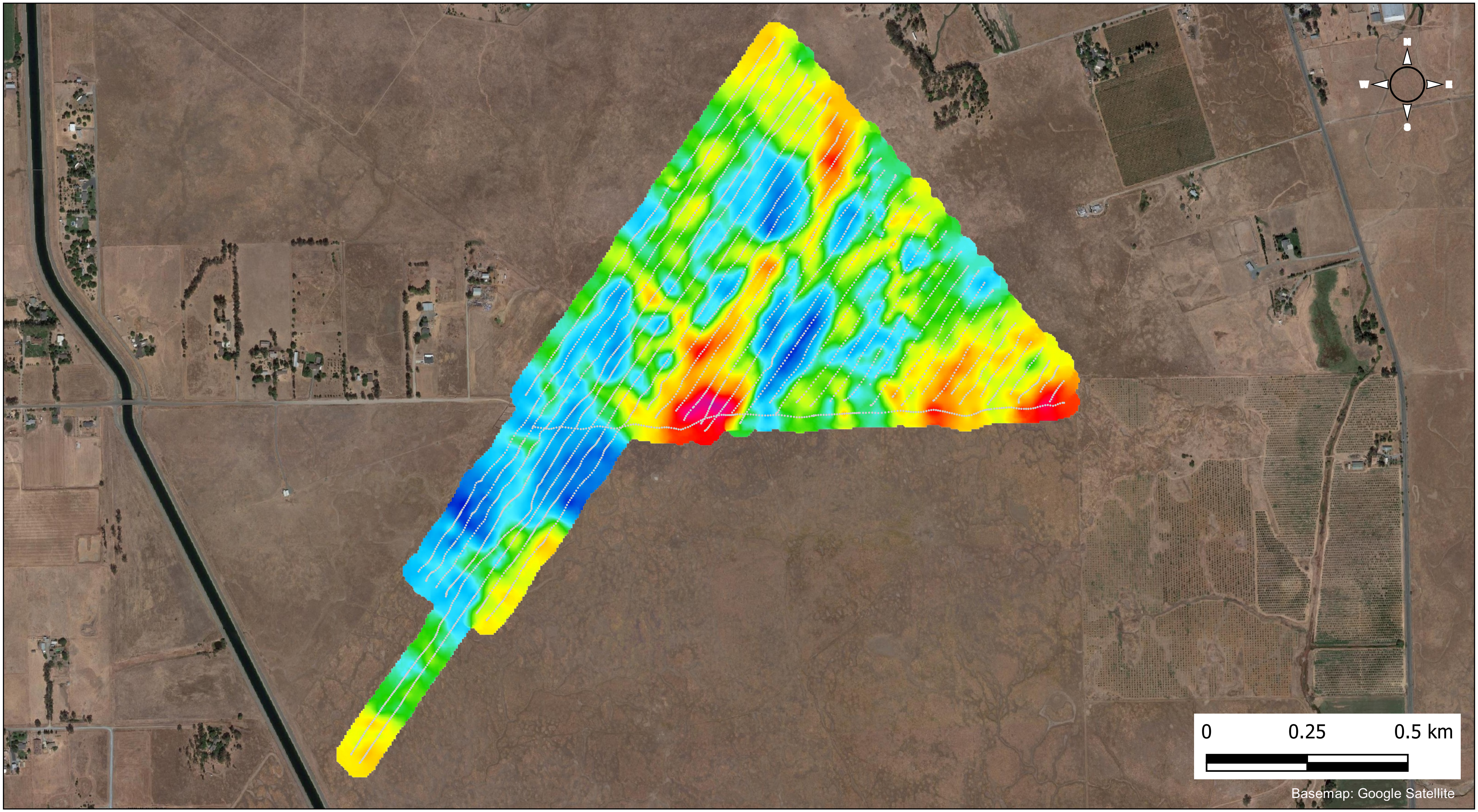
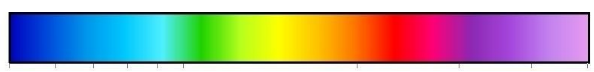



**Mean Resistivity**
**Elevation interval 29 to 31 m a.m.s.l**




WGS84 / UTM zone 10N

Date: 2/3/2021
Created by: CCN
Checked by: MAXH
Approved by: PRT

RAMBOLL

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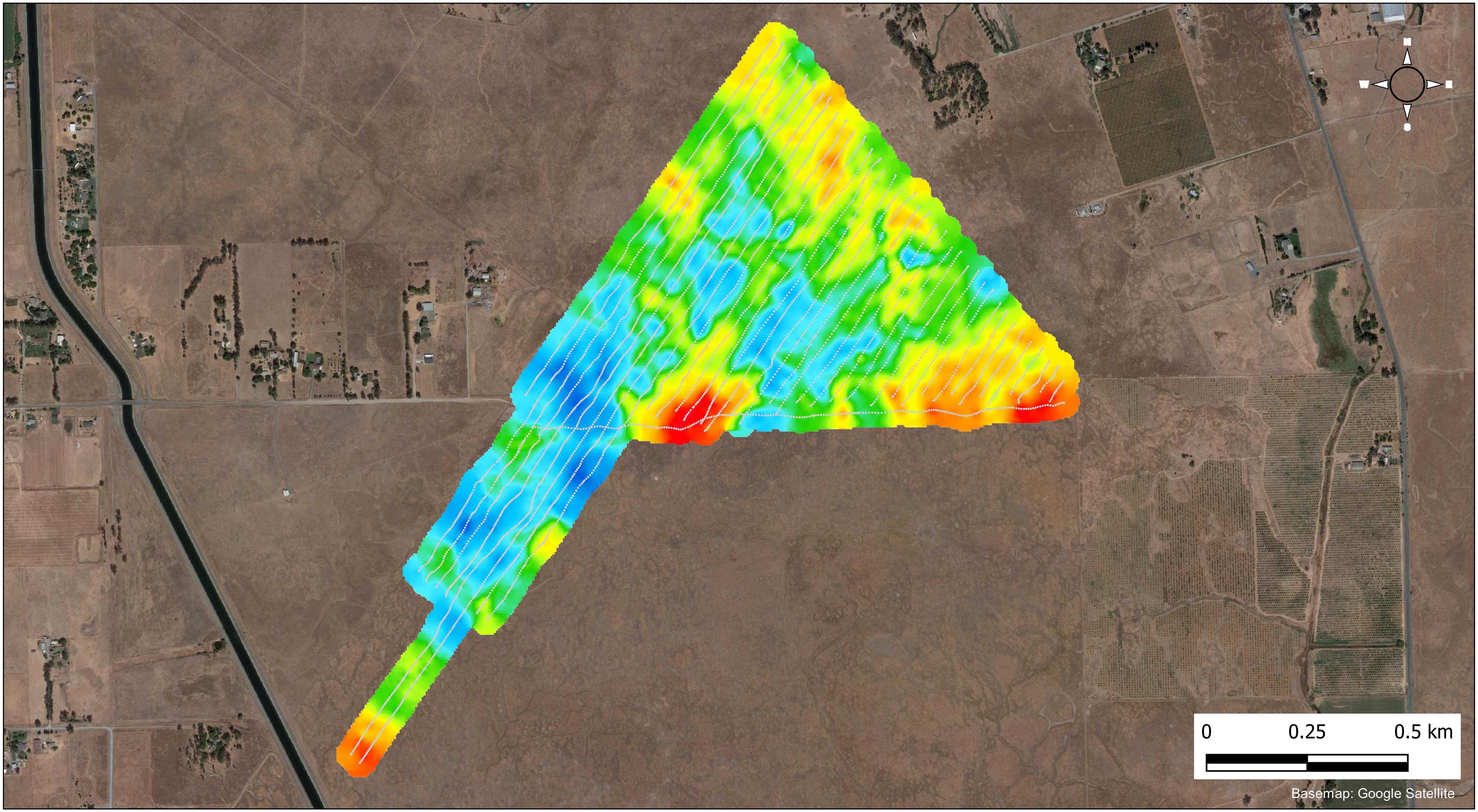
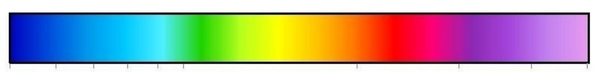



**Mean Resistivity**
**Elevation interval 27 to 29 m a.m.s.l**




WGS84 / UTM zone 10N

Date: 2/3/2021
Created by: CCN
Checked by: MAXH
Approved by: PRT

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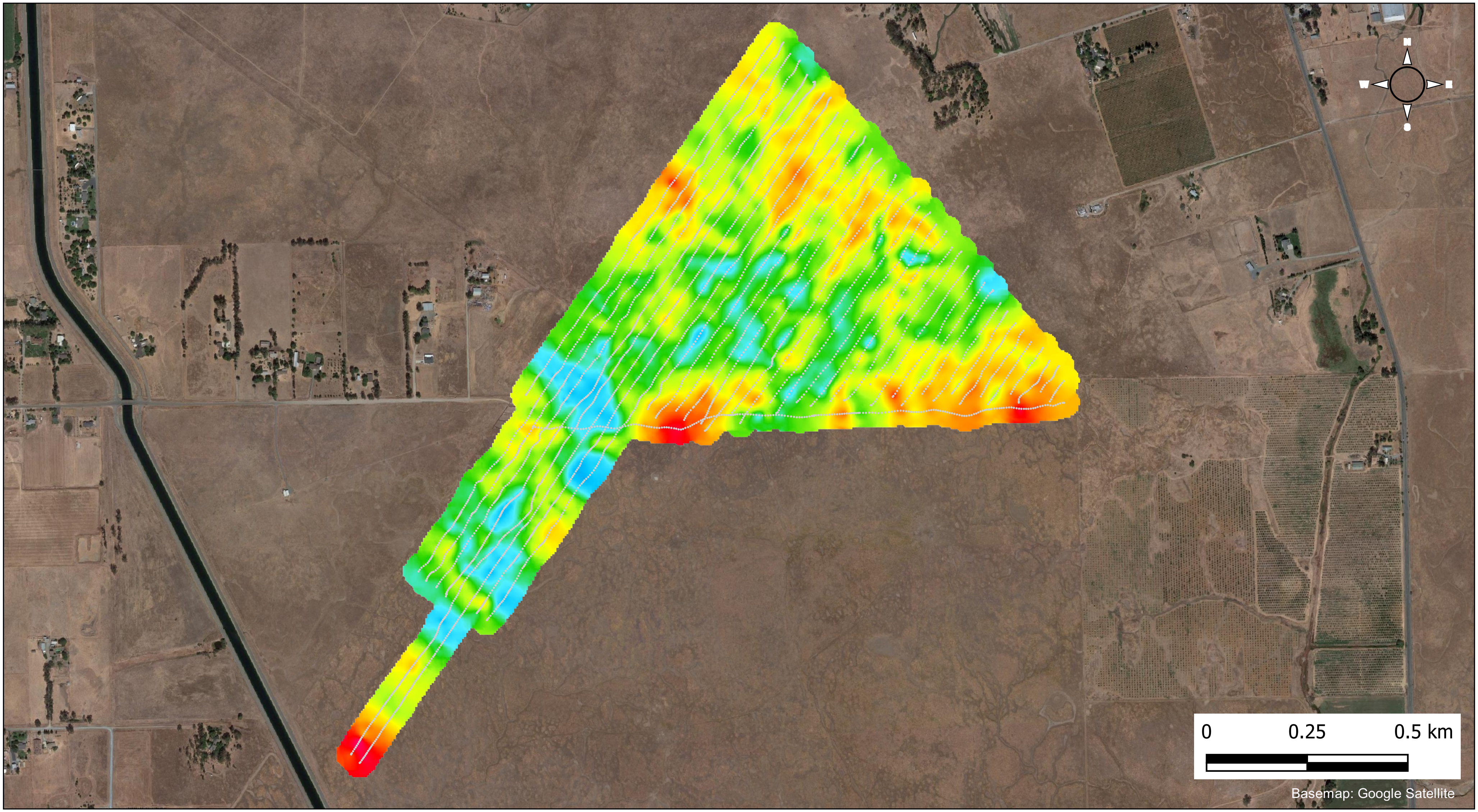
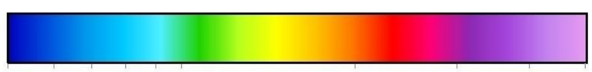



**Mean Resistivity**
**Elevation interval 25 to 27 m a.m.s.l**




WGS84 / UTM zone 10N

Date: 2/3/2021
Created by: CCN
Checked by: MAXH
Approved by: PRT

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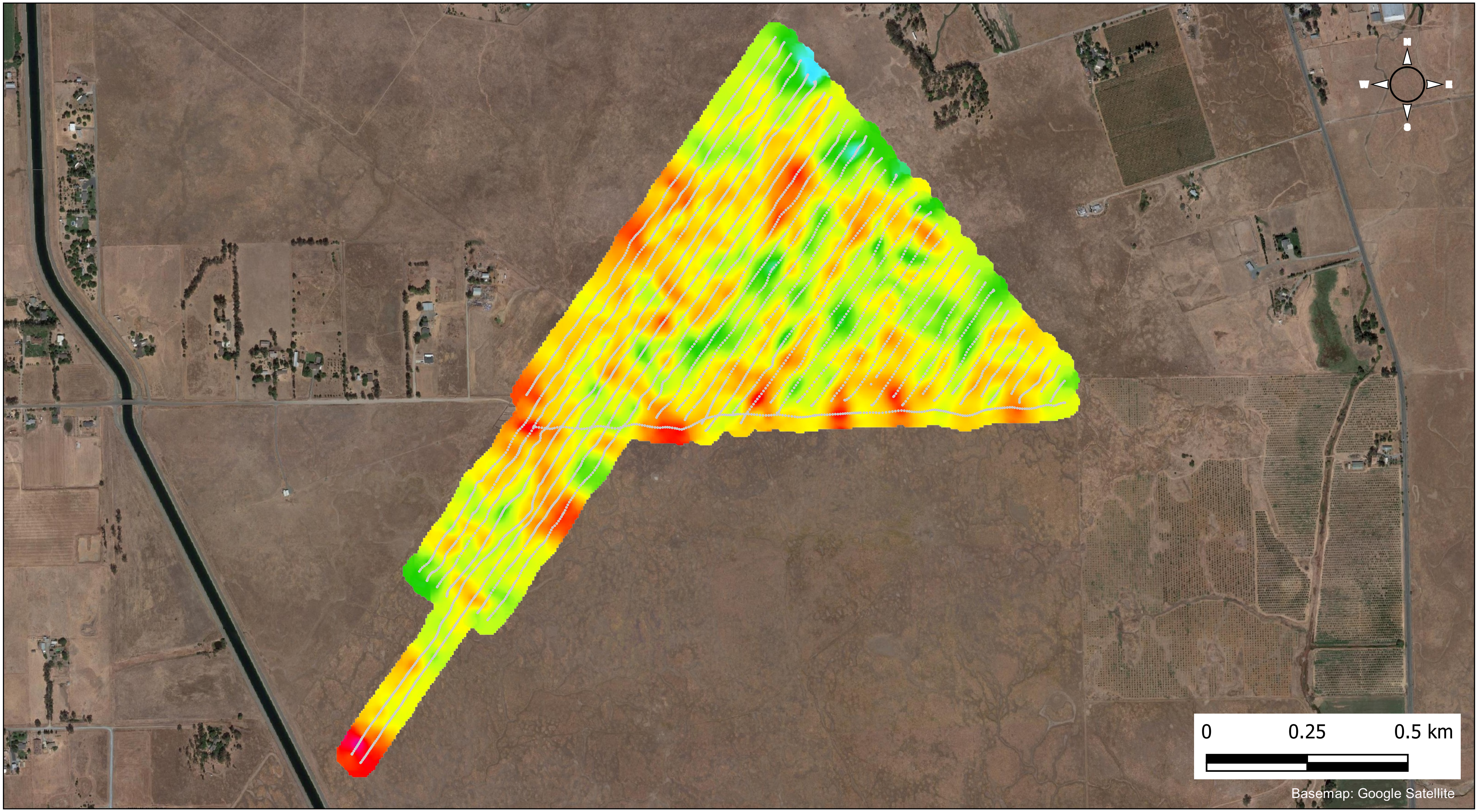
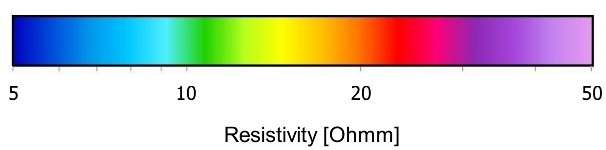



**Mean Resistivity**
**Elevation interval 20 to 25 m a.m.s.l**

WGS84 / UTM zone 10N




Date: 2/3/2021
Created by: CCN
Checked by: MAXH
Approved by: PRT

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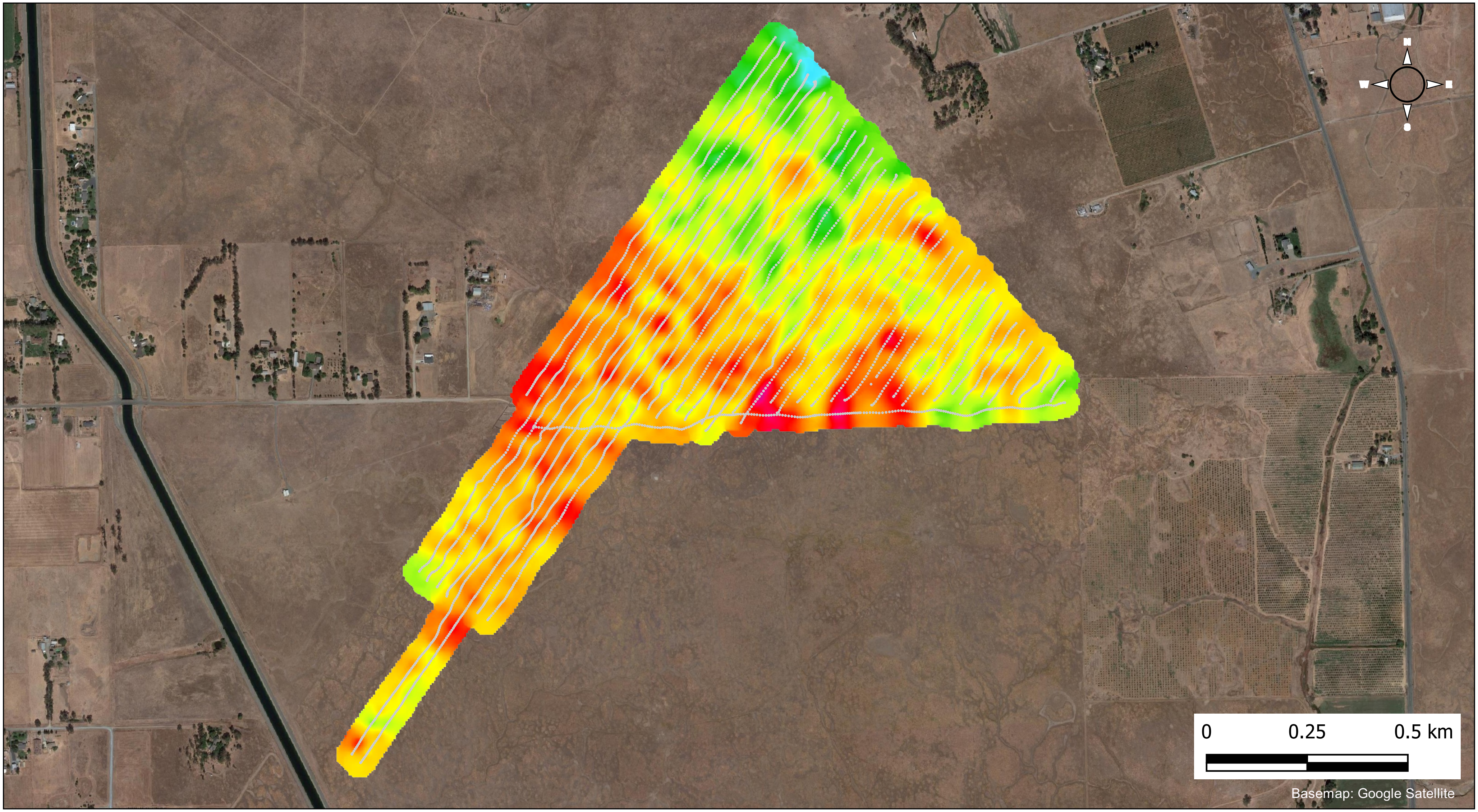


**Mean Resistivity**
**Elevation interval 15 to 20 m a.m.s.l**

5 10 20 50

Resistivity [Ohmm]

WGS84 / UTM zone 10N

Date: 2/3/2021
Created by: CCN
Checked by: MAXH
Approved by: PRT

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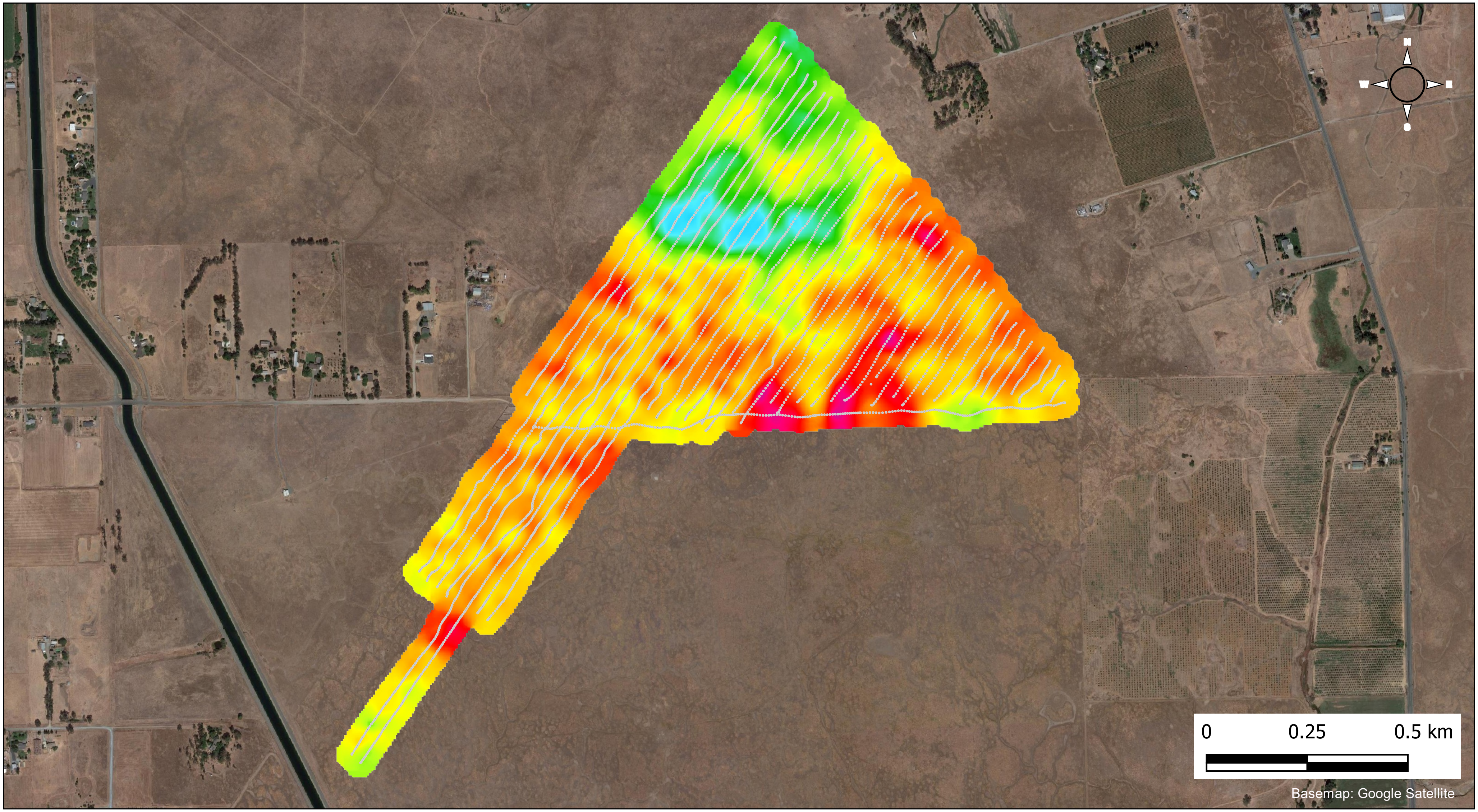
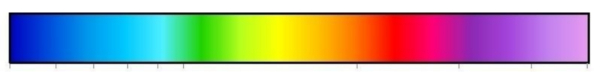



**Mean Resistivity**
**Elevation interval 10 to 15 m a.m.s.l**




WGS84 / UTM zone 10N

Date: 2/3/2021
Created by: CCN
Checked by: MAXH
Approved by: PRT

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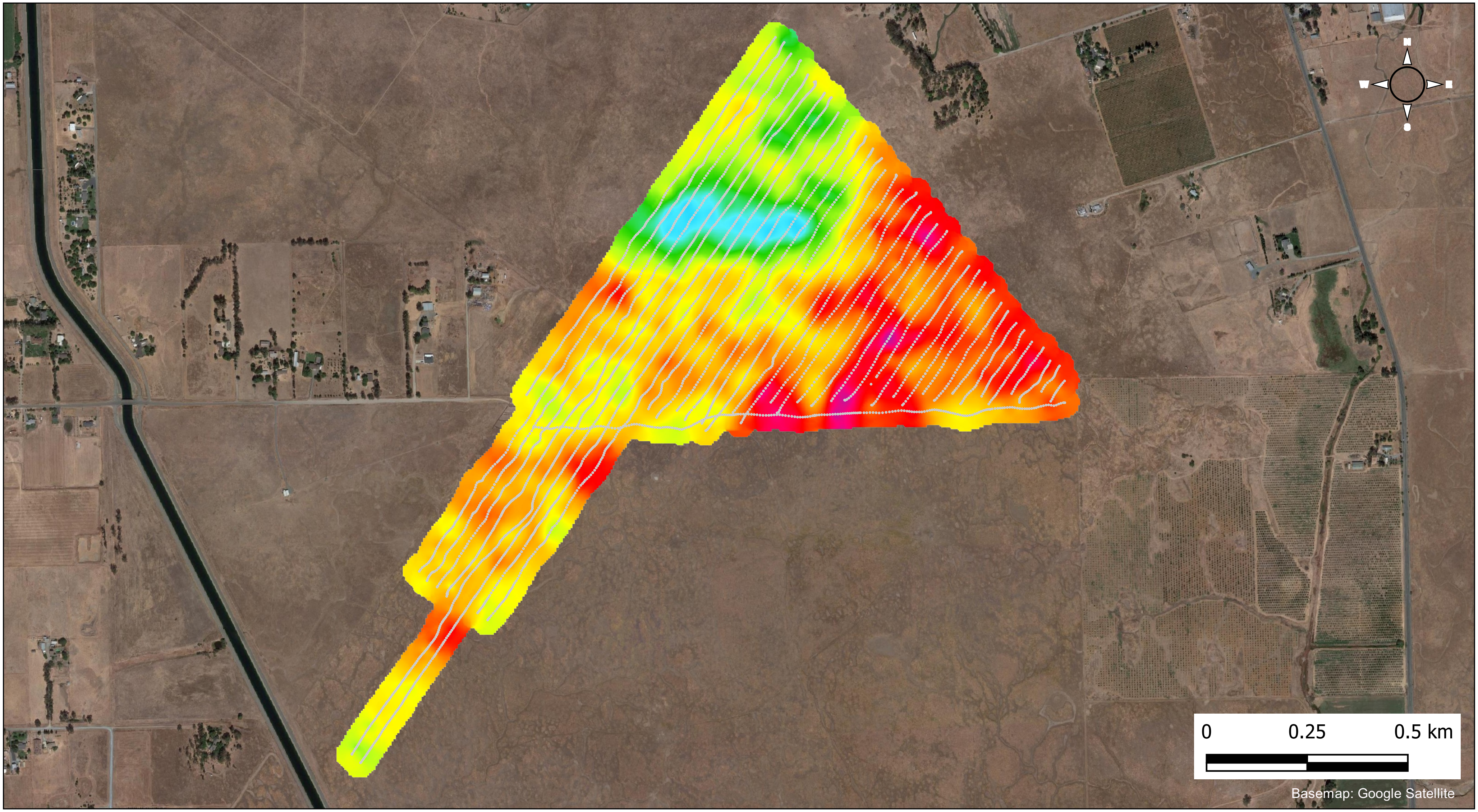
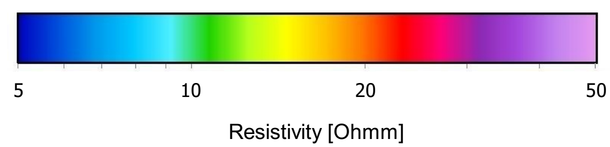



**Mean Resistivity**
**Elevation interval 5 to 10 m a.m.s.l**




WGS84 / UTM zone 10N

Date: 2/3/2021
Created by: CCN
Checked by: MAXH
Approved by: PRT

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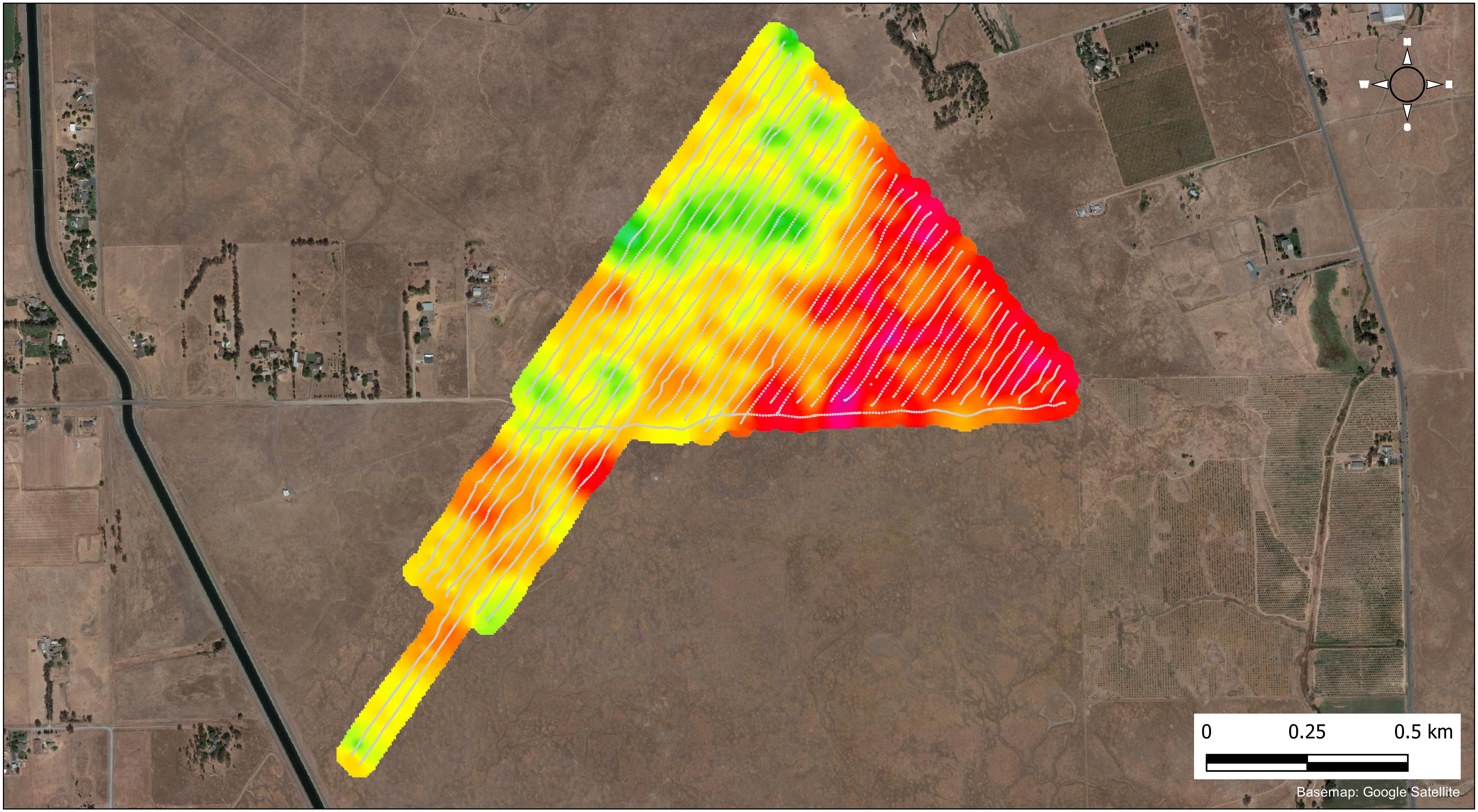
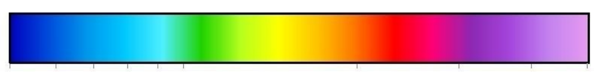



**Mean Resistivity**
**Elevation interval 0 to 5 m a.m.s.l**




WGS84 / UTM zone 10N

Date: 2/3/2021
Created by: CCN
Checked by: MAXH
Approved by: PRT

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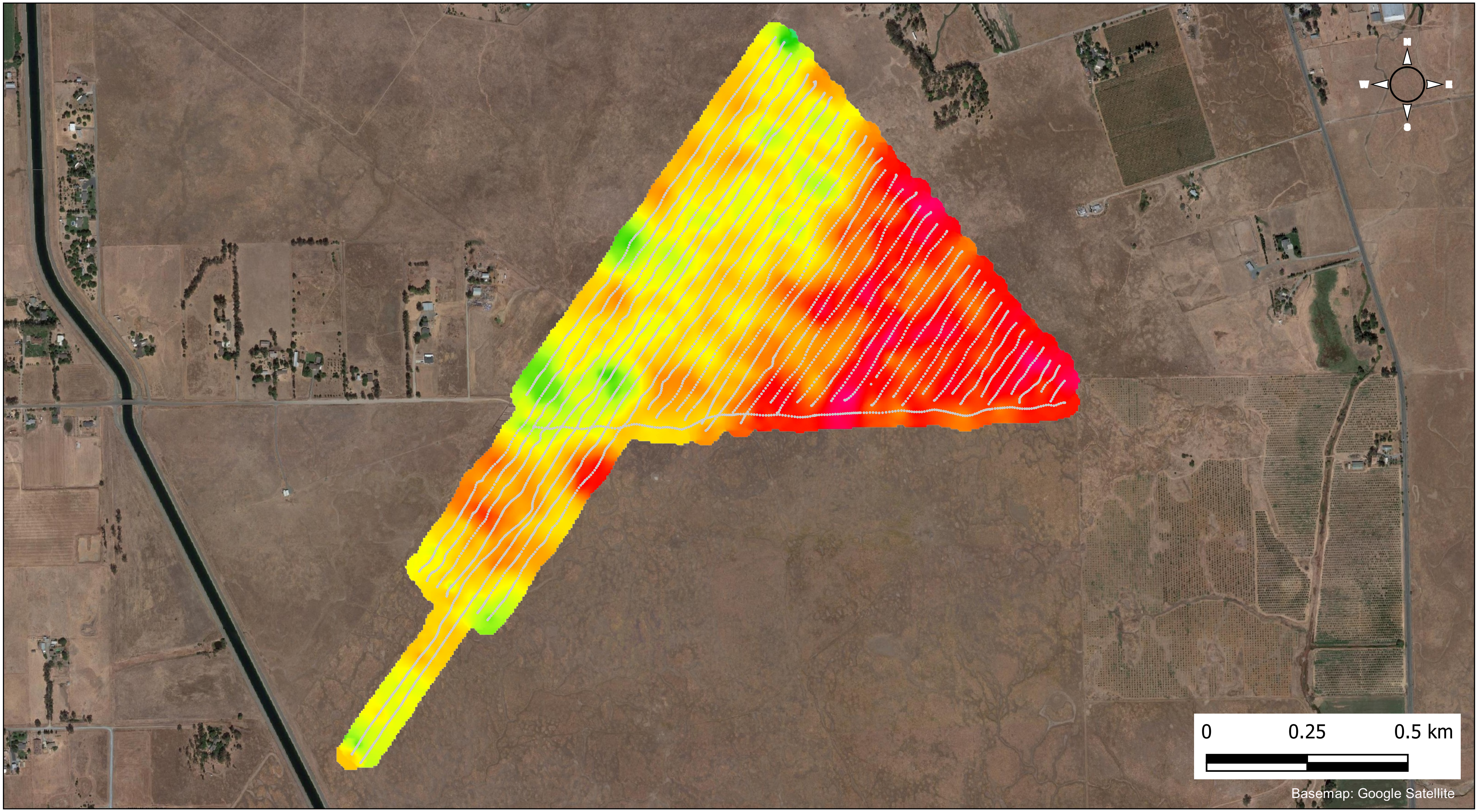
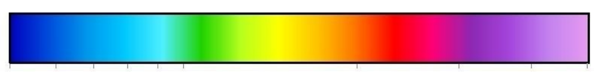
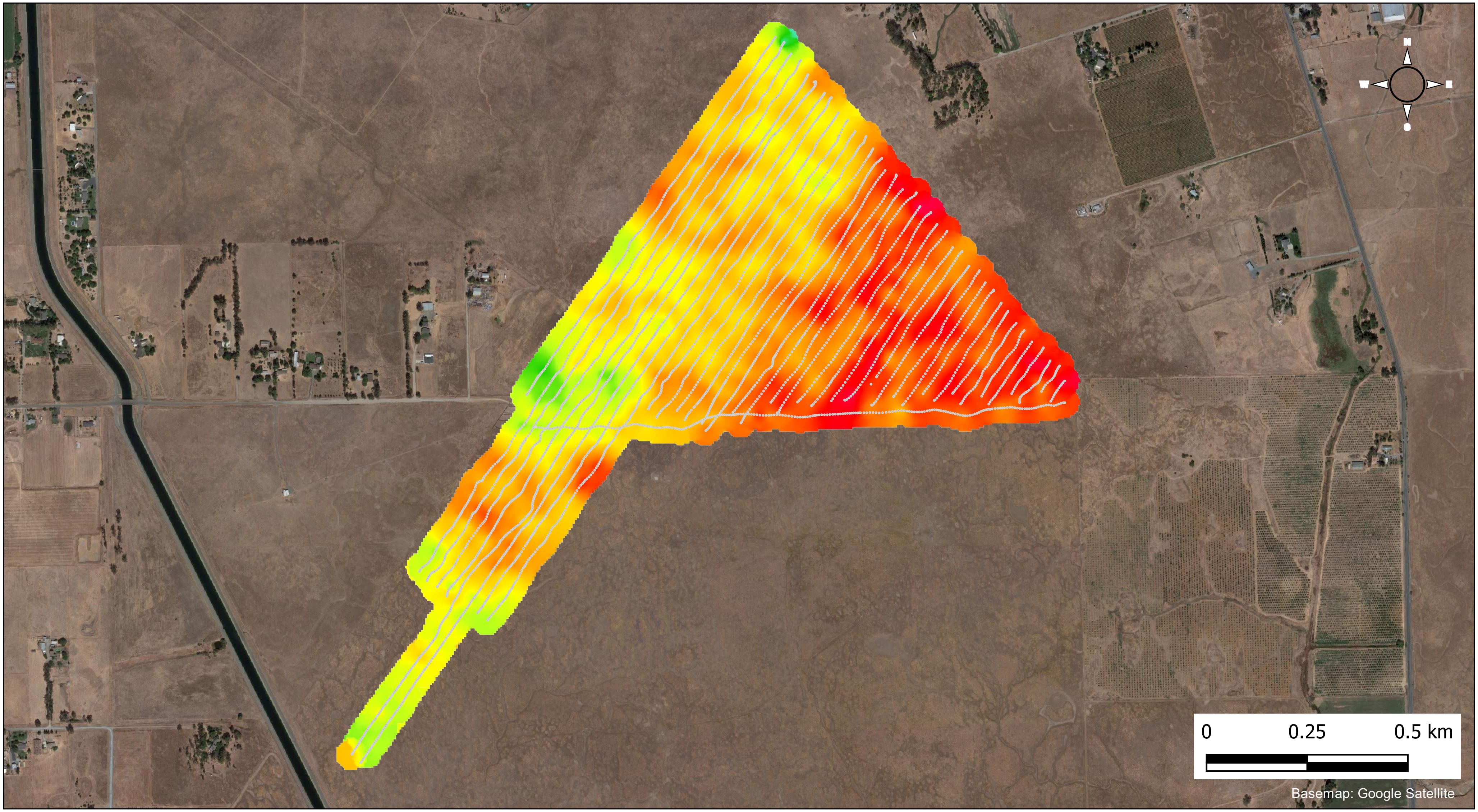



**Mean Resistivity**
**Elevation interval 0 to 5 m b.m.s.l**

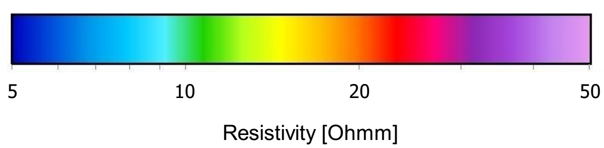



WGS84 / UTM zone 10N

Date: 2/3/2021
Created by: CCN
Checked by: MAXH
Approved by: PRT

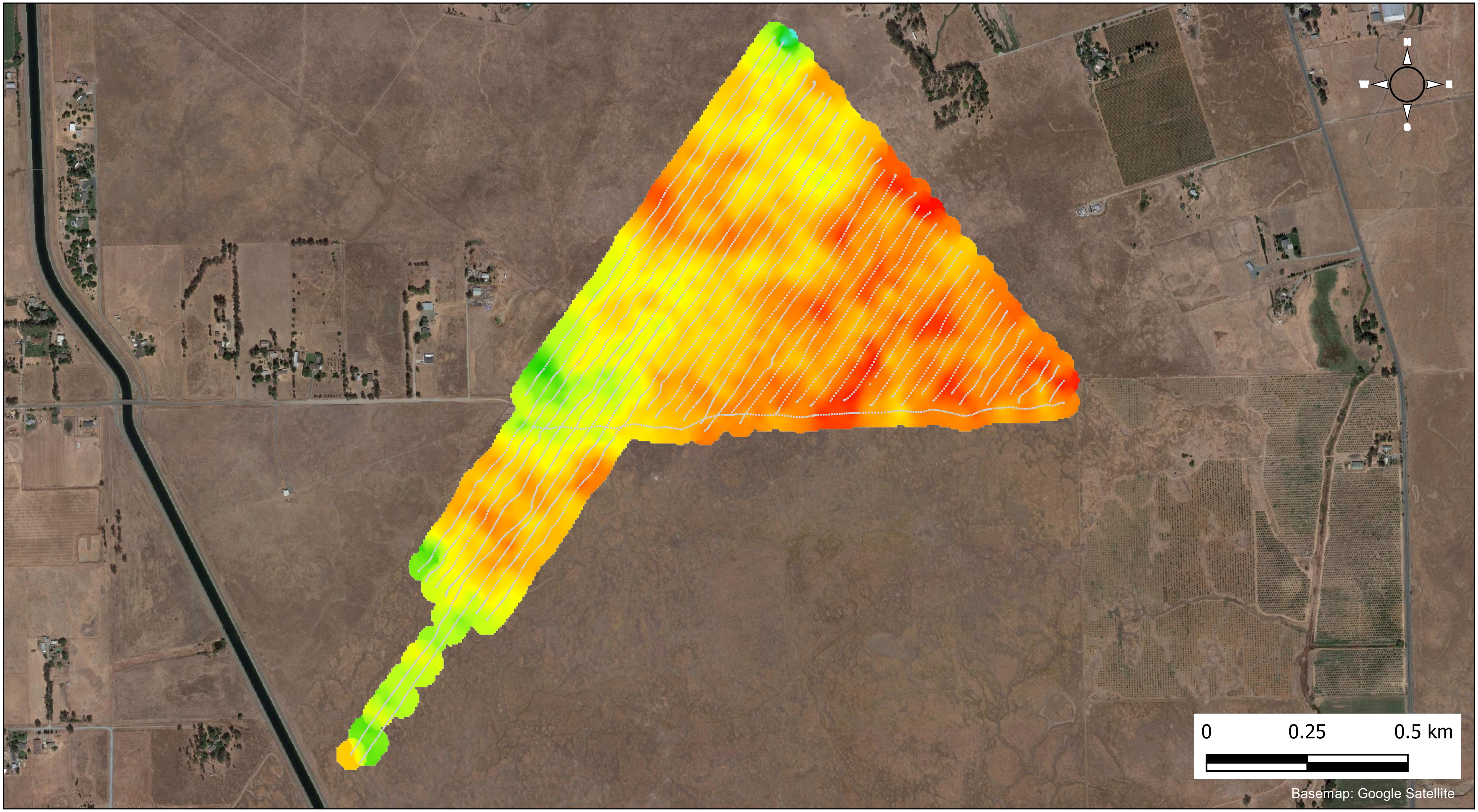



**Mean Resistivity**
**Elevation interval 5 to 10 m b.m.s.l**

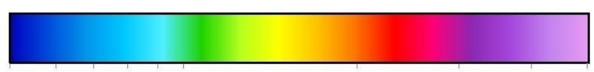



WGS84 / UTM zone 10N

Date: 2/3/2021
Created by: CCN
Checked by: MAXH
Approved by: PRT




**Mean Resistivity**
**Elevation interval 10 to 15 m b.m.s.l**




WGS84 / UTM zone 10N

Date: 2/3/2021
Created by: CCN
Checked by: MAXH
Approved by: PRT

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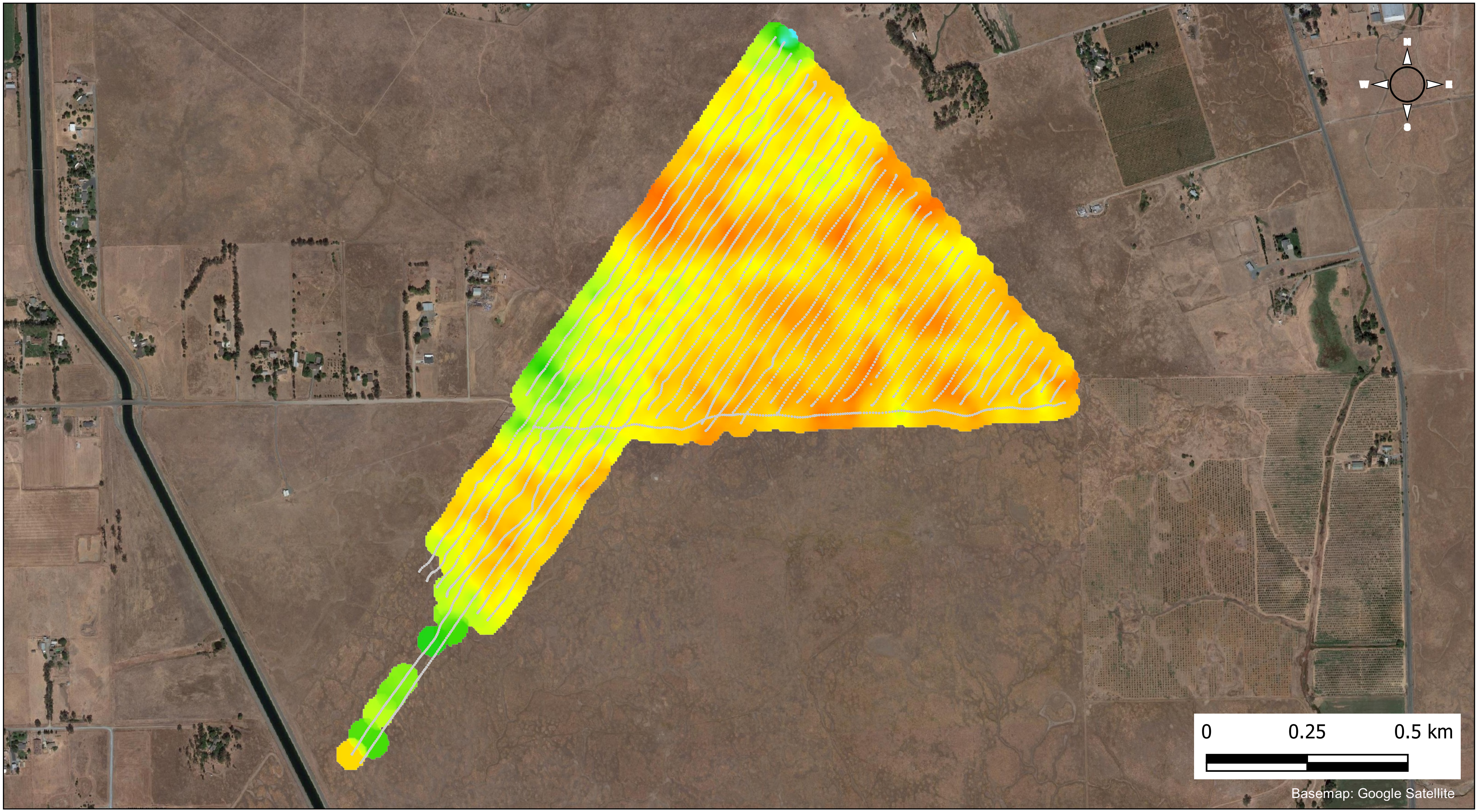
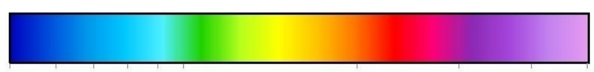
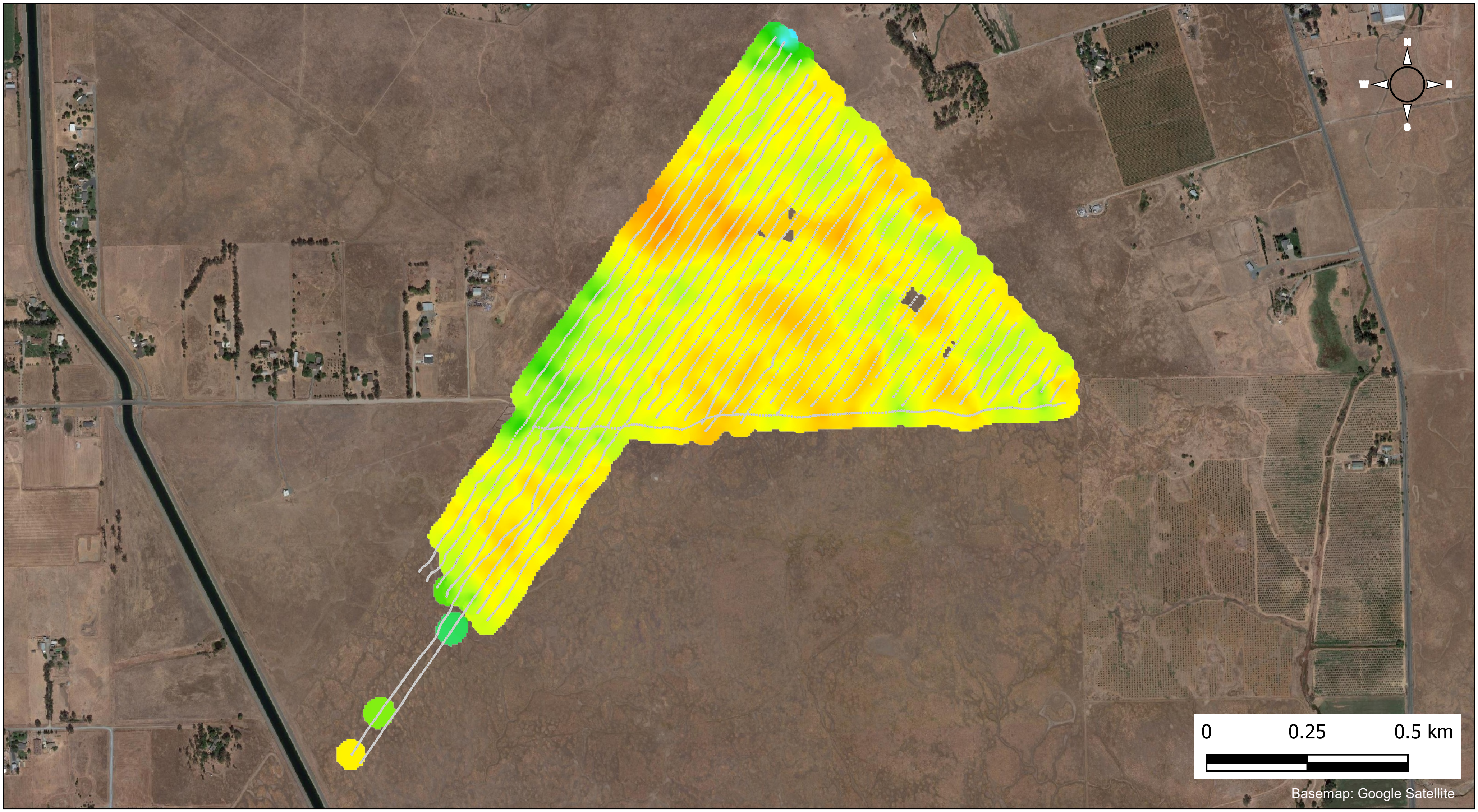



**Mean Resistivity**
**Elevation interval 15 to 20 m b.m.s.l**

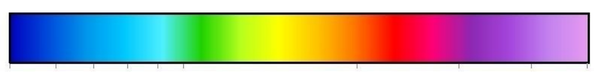



WGS84 / UTM zone 10N

Date: 2/3/2021
Created by: CCN
Checked by: MAXH
Approved by: PRT




**Mean Resistivity**
**Elevation interval 20 to 25 m b.m.s.l**




WGS84 / UTM zone 10N

Date: 2/3/2021
Created by: CCN
Checked by: MAXH
Approved by: PRT

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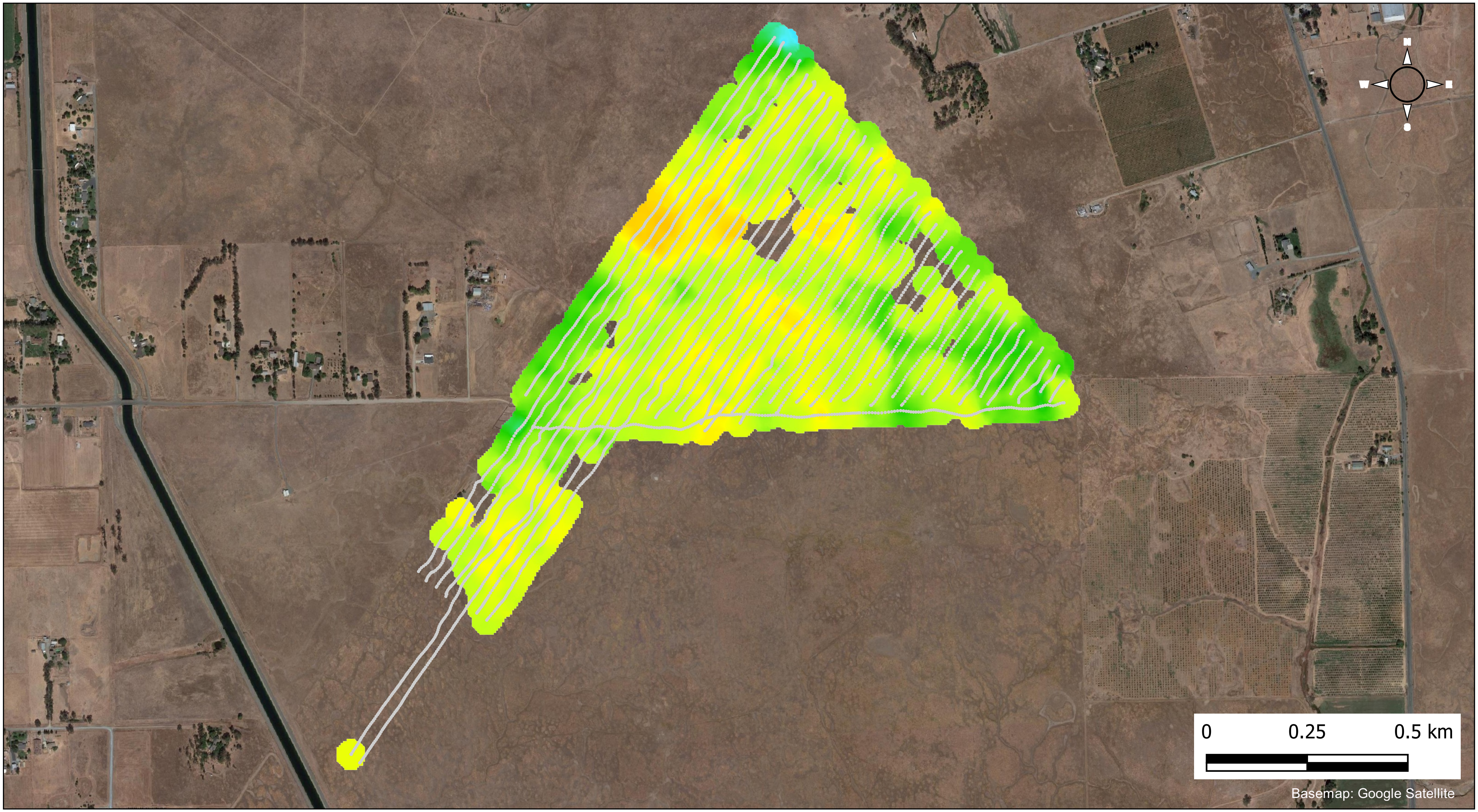


**Mean Resistivity**
**Elevation interval 25 to 30 m b.m.s.l**

5 10 20 50

Resistivity [Ohmm]

WGS84 / UTM zone 10N

Date: 2/3/2021
Created by: CCN
Checked by: MAXH
Approved by: PRT

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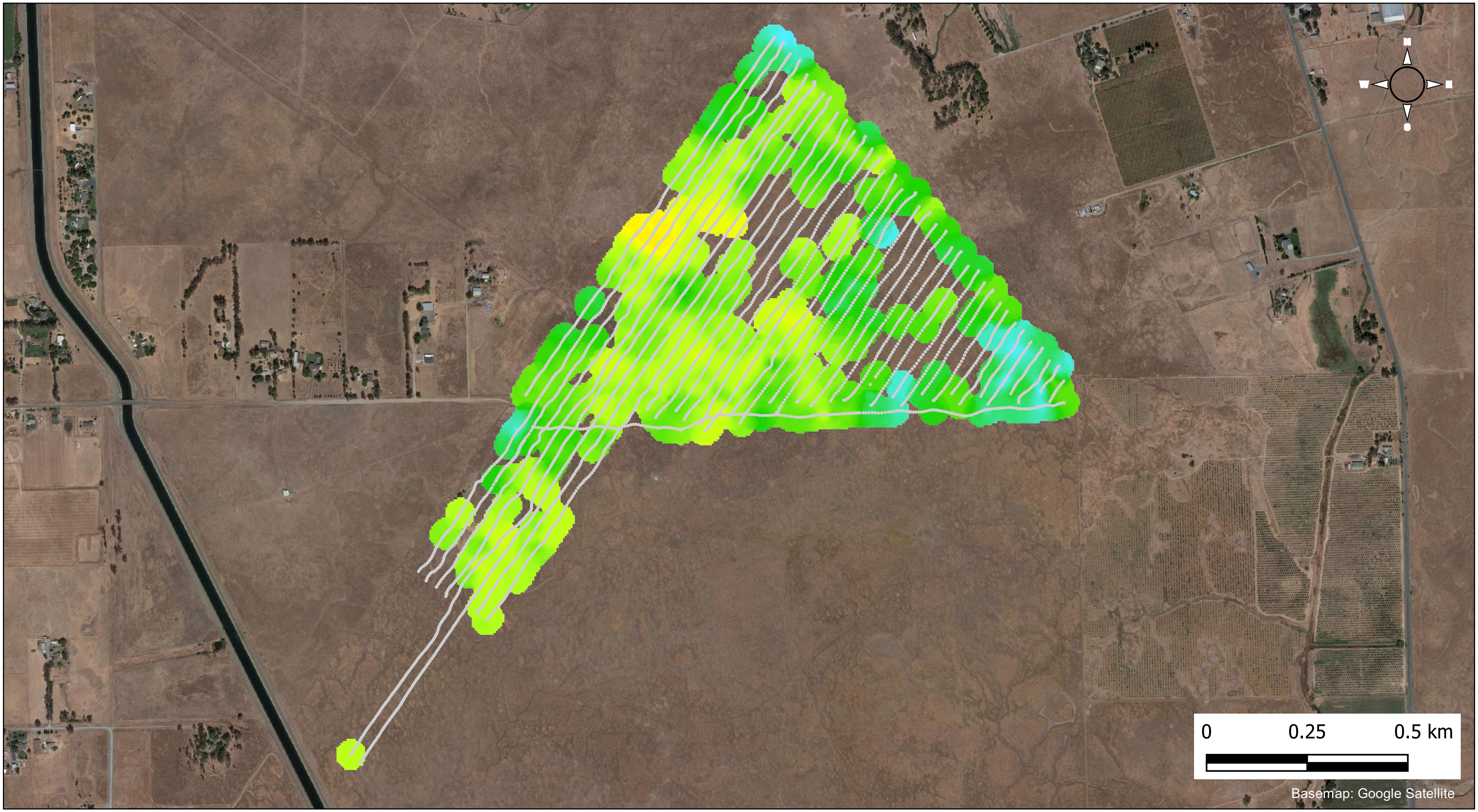


**Mean Resistivity**
**Elevation interval 30 to 35 m b.m.s.l**

5 10 20 50

Resistivity [Ohmm]

WGS84 / UTM zone 10N

Date: 2/3/2021
Created by: CCN
Checked by: MAXH
Approved by: PRT

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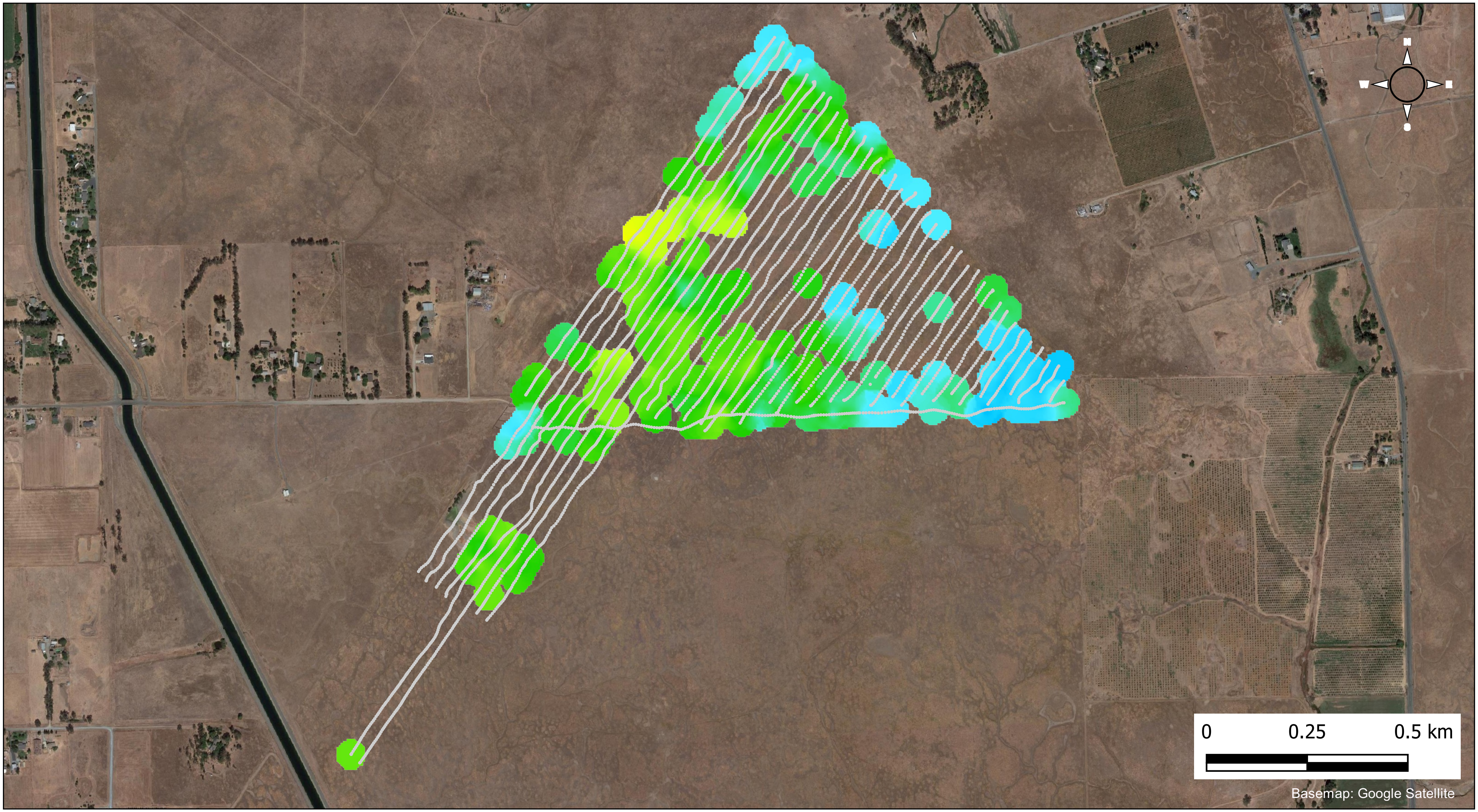
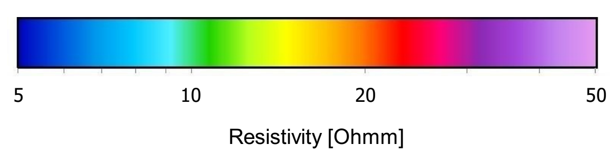



**Mean Resistivity**
**Elevation interval 35 to 40 m b.m.s.l**




WGS84 / UTM zone 10N

Date: 2/3/2021
Created by: CCN
Checked by: MAXH
Approved by: PRT

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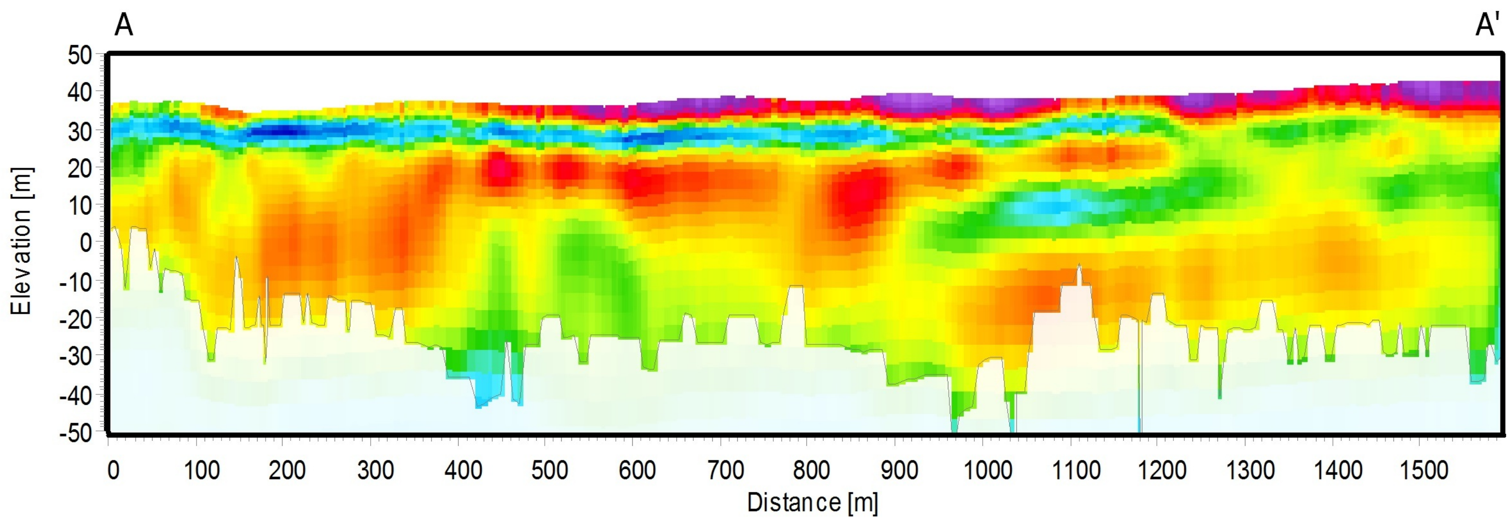
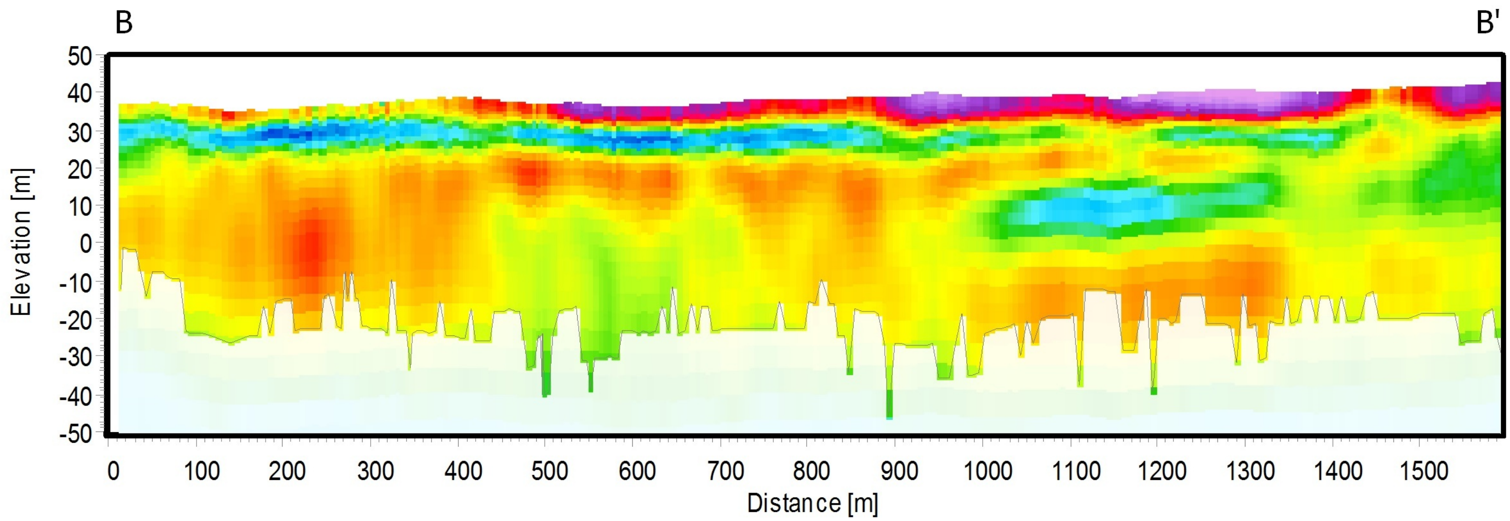
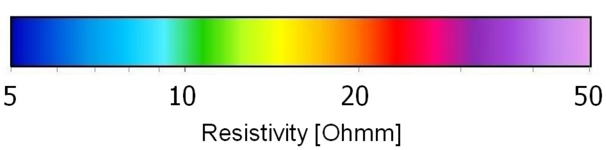
# APPENDIX 4
# VERTICAL SECTIONS

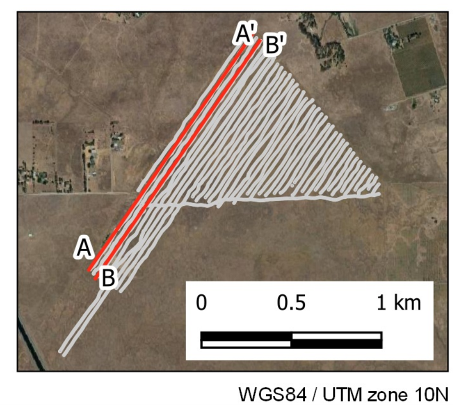



**Model sections**




Date: 2/05/2021
Created by: CCN
Checked by: MAXH
Approved by: PRT

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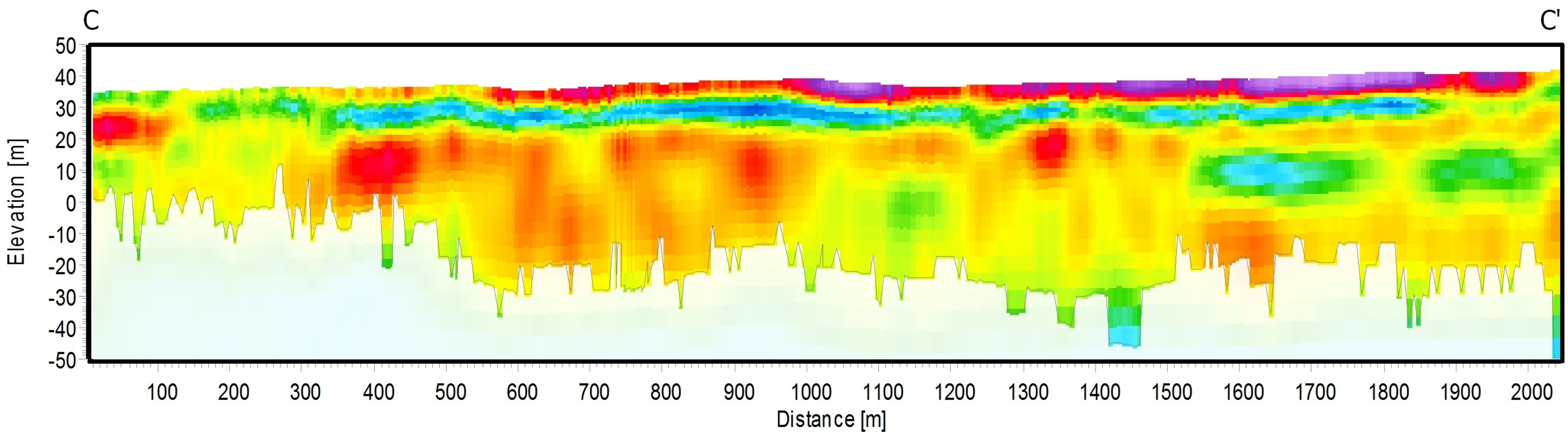
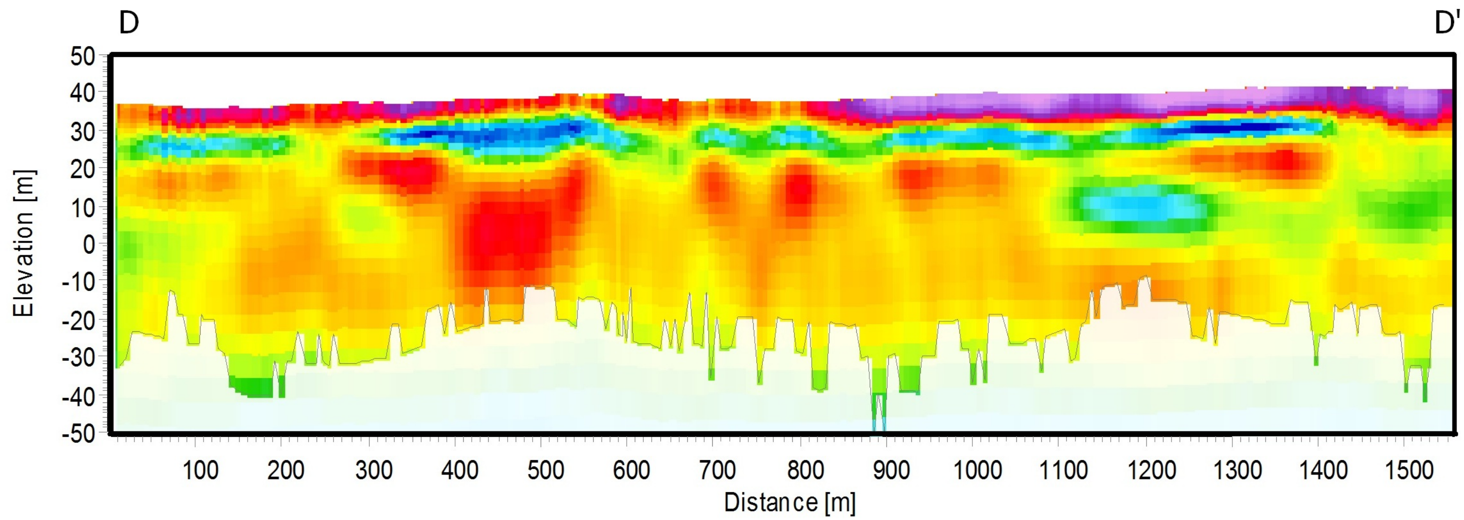
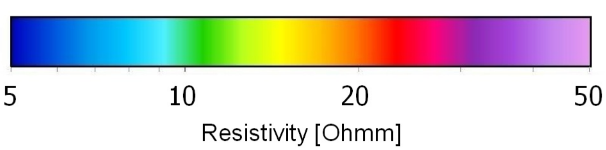
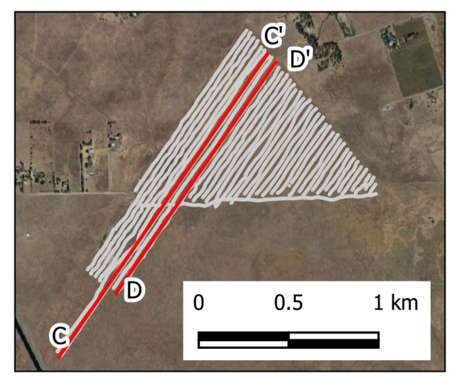



**Model sections**




Date: 2/05/2021
Created by: CCN
Checked by: MAXH
Approved by: PRT

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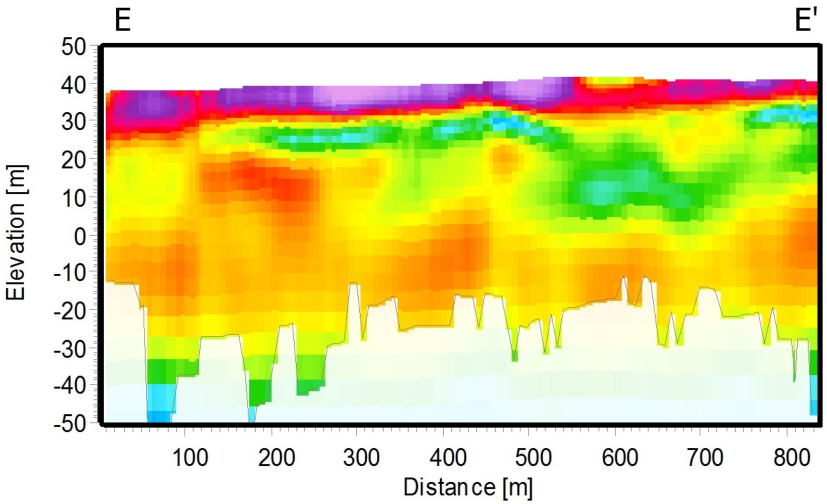
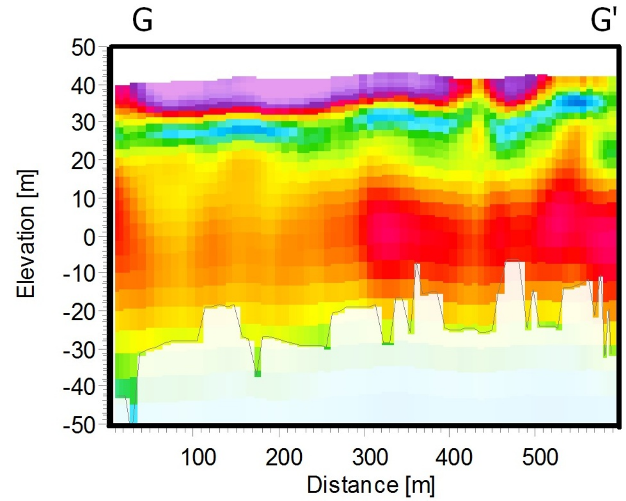
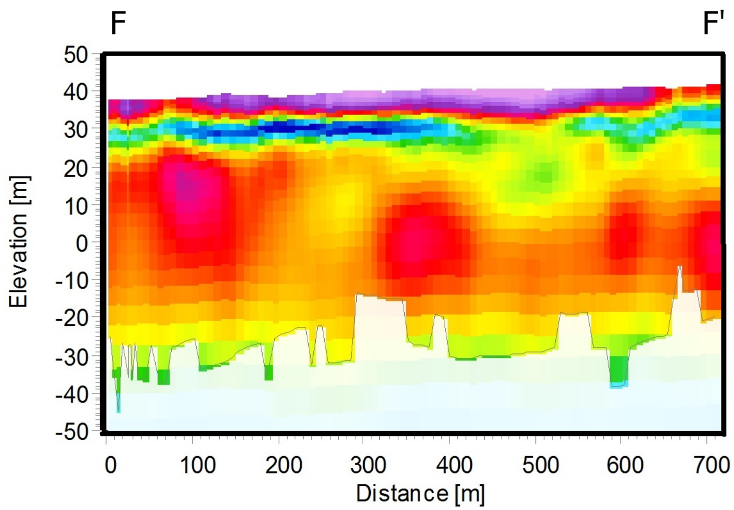
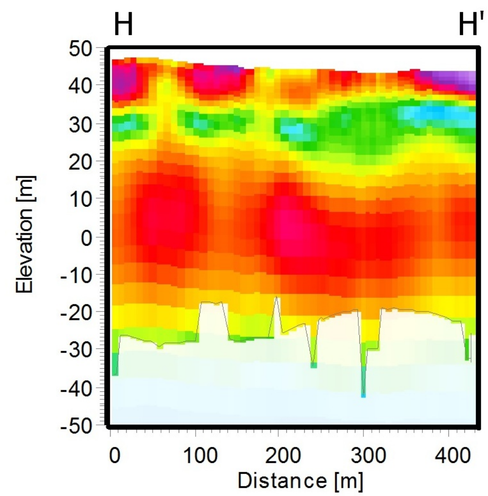
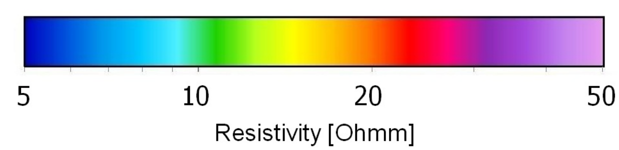


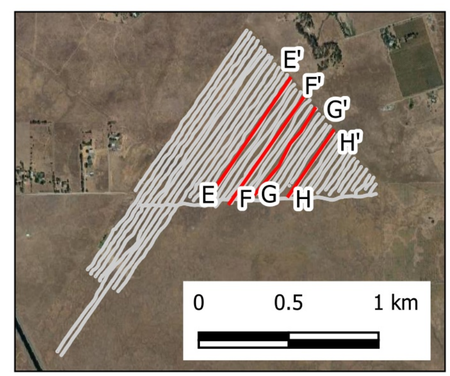



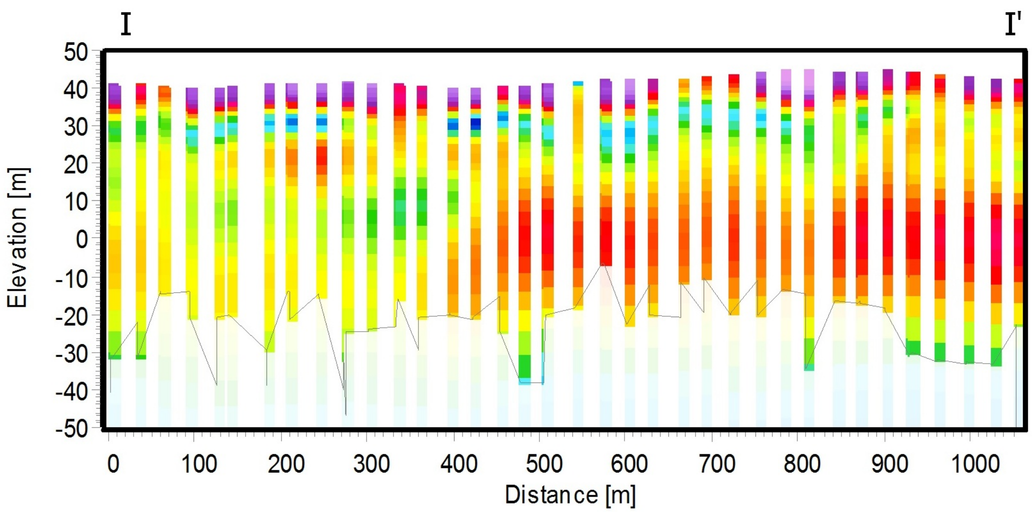

**Model sections**

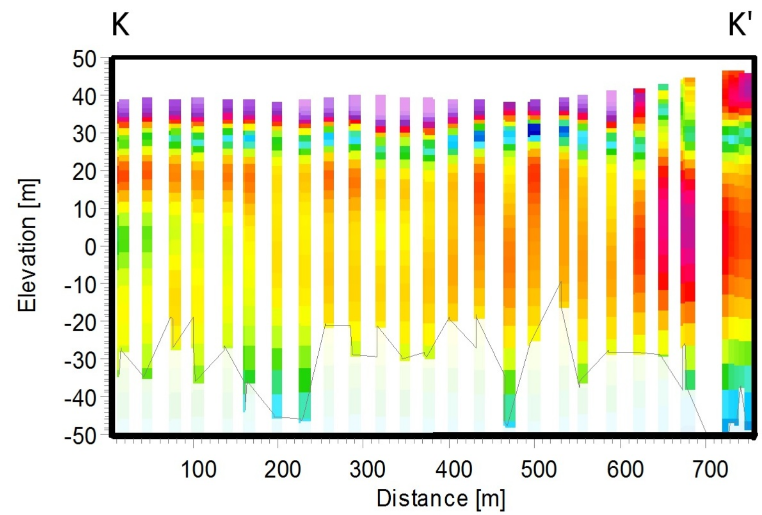


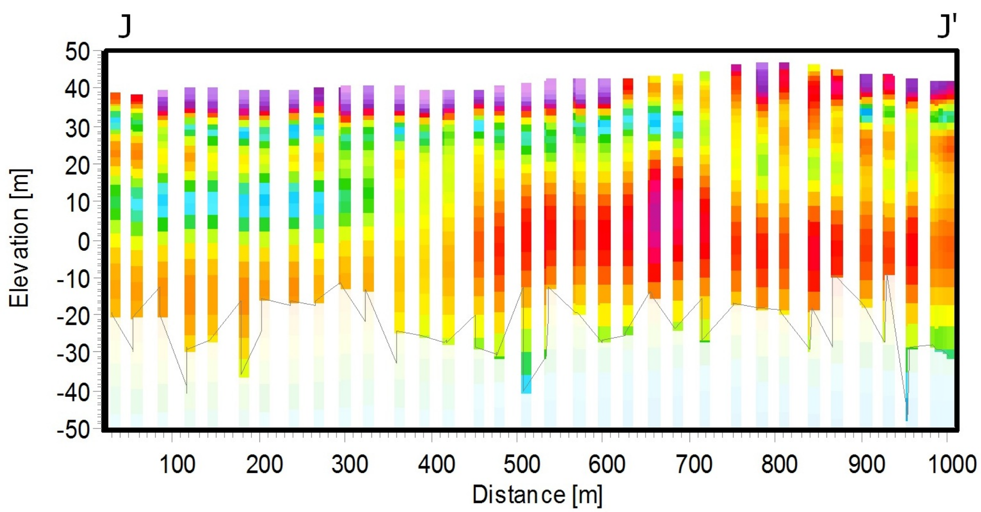

Date: 2/05/2021
Created by: CCN
Checked by: MAXH
Approved by: PRT

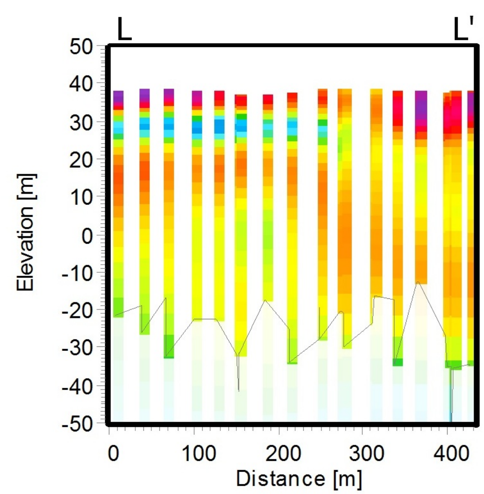



WGS84 / UTM zone 10N

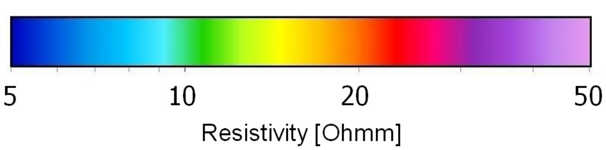



**Model sections**




Date: 02/05/2021
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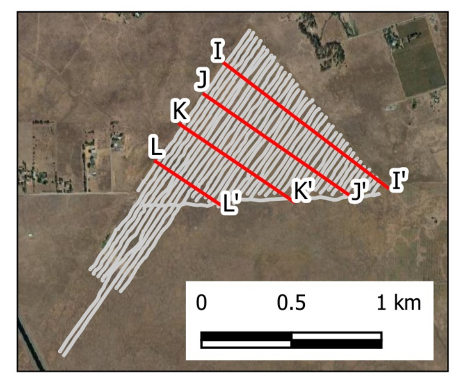
Checked by: MAXH
Approved by: PRT



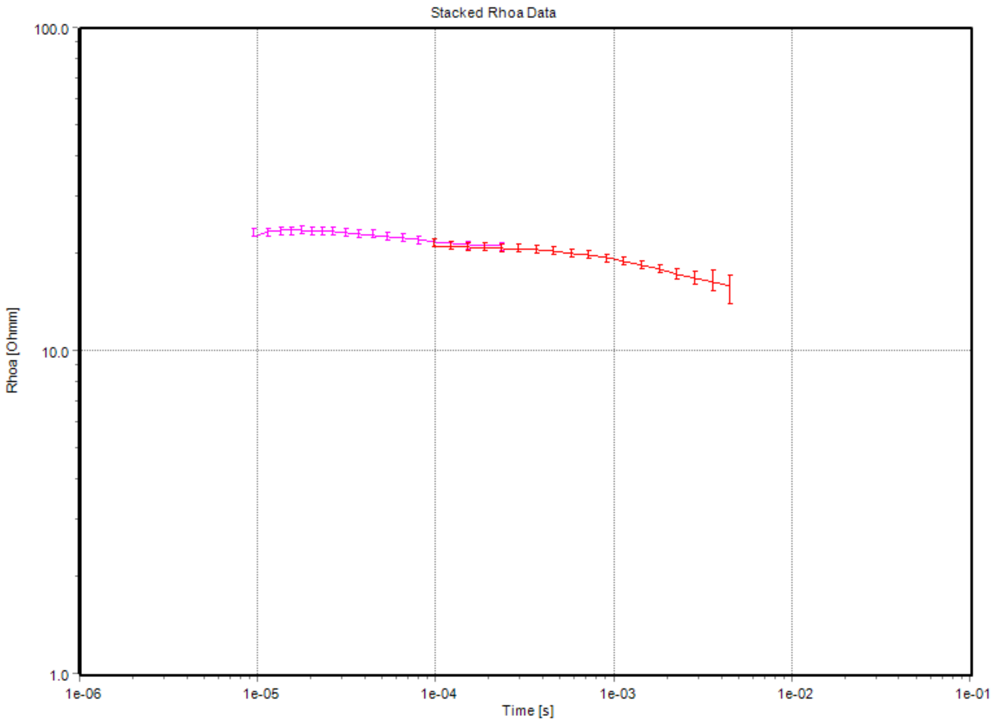

WGS84 / UTM zone 10N

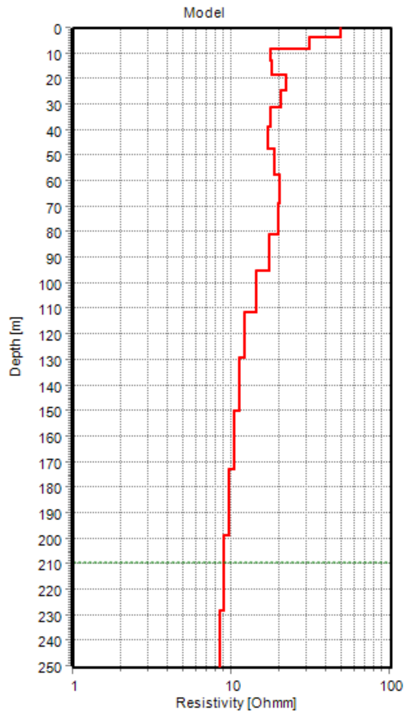
# APPENDIX 5
# WALKTEM RESULTS

## WalkTEM Station: W01 (Project site 8) – smooth model

**UTMX:** 644323 **Data Residual:** 0.2 **Database Name:** Project46.gdb

**UTMY:** 4245883 **DOI:** 209 m **EPSG:** WGS 84 UTM zone 10N (epsg: 32610)

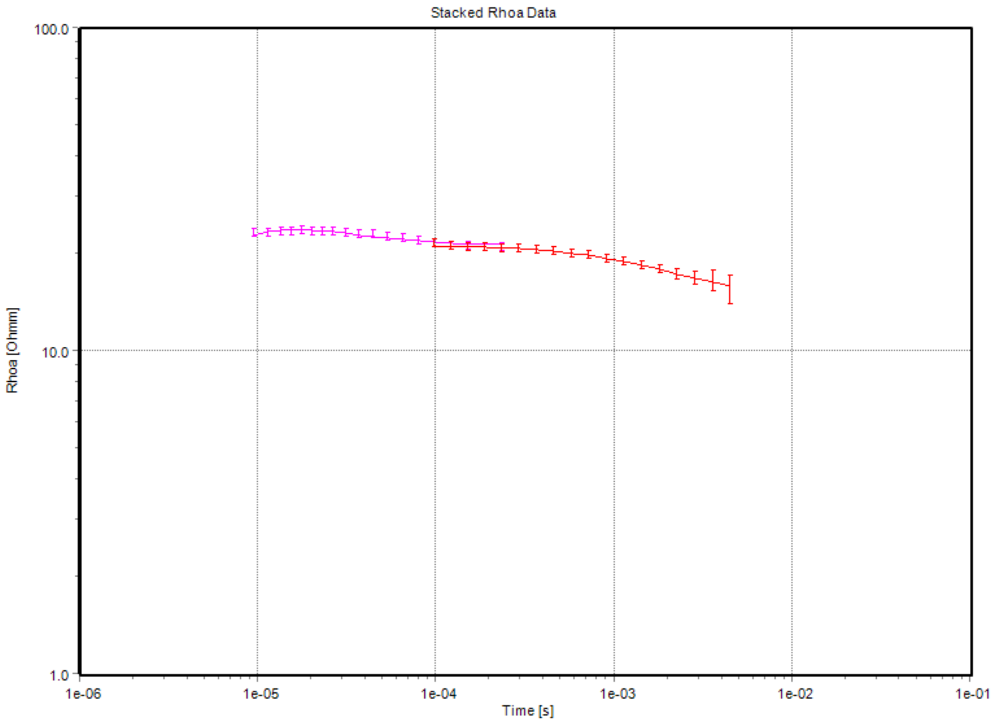


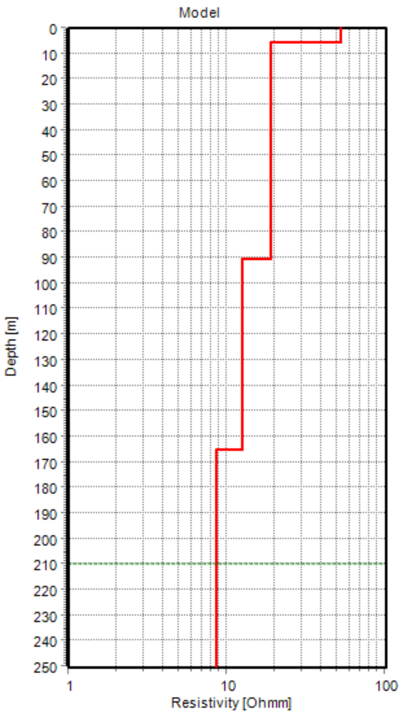



## WalkTEM Station: W01 (Project site 8) – layered model

**UTMX:** 644323 **Data Residual:** 0.3 **Database Name:** Project46.gdb

**UTMY:** 4245883 **DOI:** 210 m **EPSG:** WGS 84 UTM zone 10N (epsg: 32610)

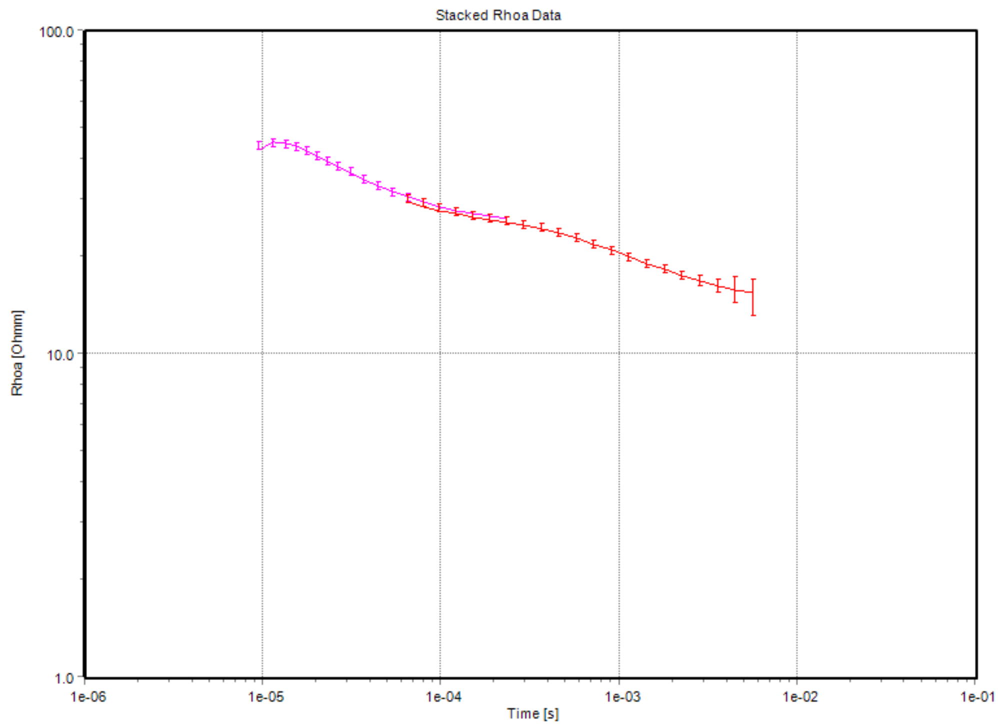


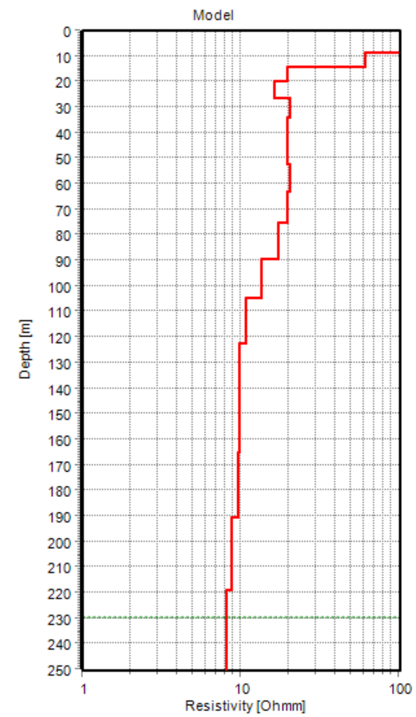



## WalkTEM Station: W02 (Project site 8a) – smooth model

**UTMX:** 644524 **Data Residual:** 0.3 **Database Name:** Project46.gdb

**UTMY:** 4245193 **DOI:** 230 m **EPSG:** WGS 84 UTM zone 10N (epsg: 32610)

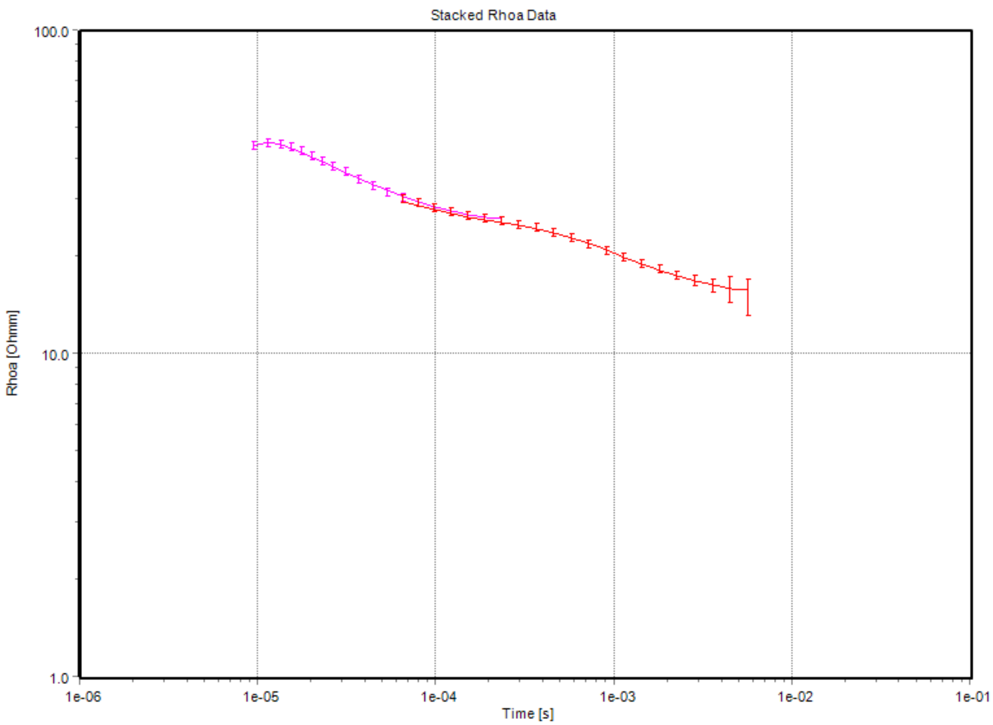


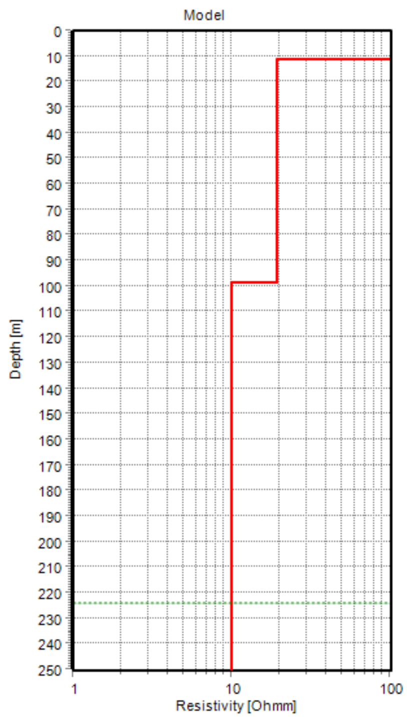



## WalkTEM Station: W02 (Project site 8a) – layered model

**UTMX:** 644524 **Data Residual:** 0.3 **Database Name:** Project46.gdb

**UTMY:** 4245193 **DOI:** 224 m **EPSG:** WGS 84 UTM zone 10N (epsg: 32610)

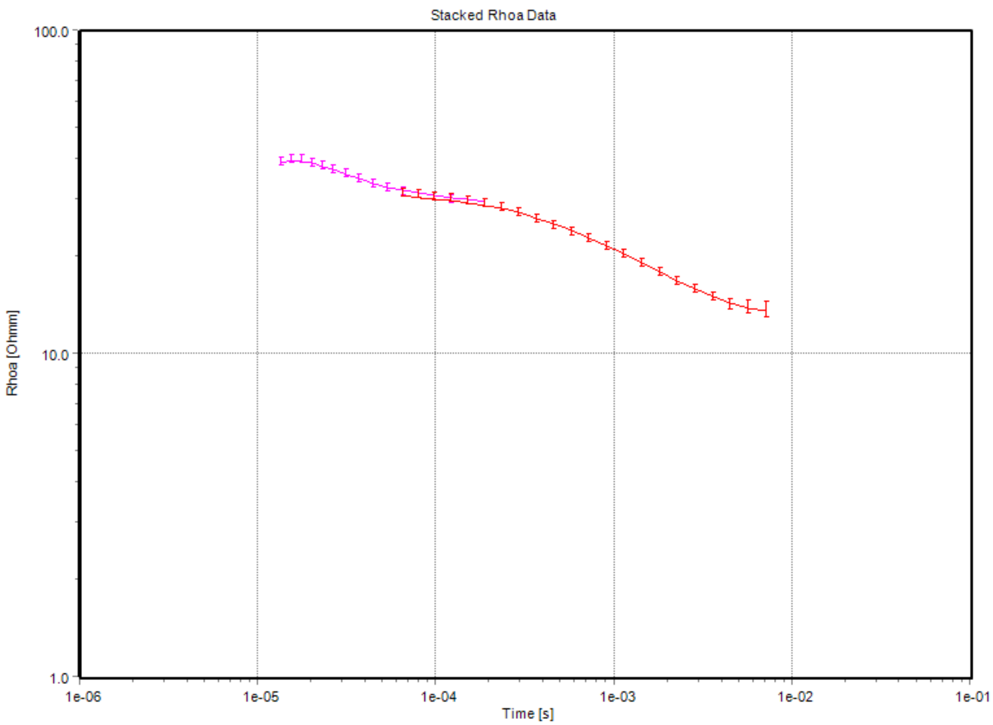


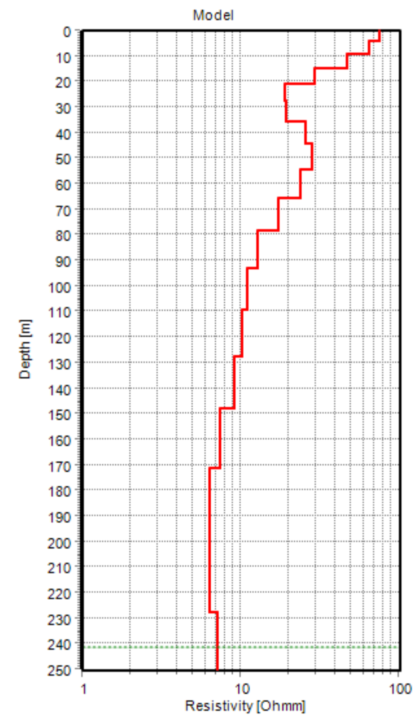



## WalkTEM Station: W03 (Project site 7) – smooth model

**UTMX:** 646665 **Data Residual:** 0.3 **Database Name:** Project46.gdb

**UTMY:** 4248224 **DOI:** 241 m **EPSG:** WGS 84 UTM zone 10N (epsg: 32610)

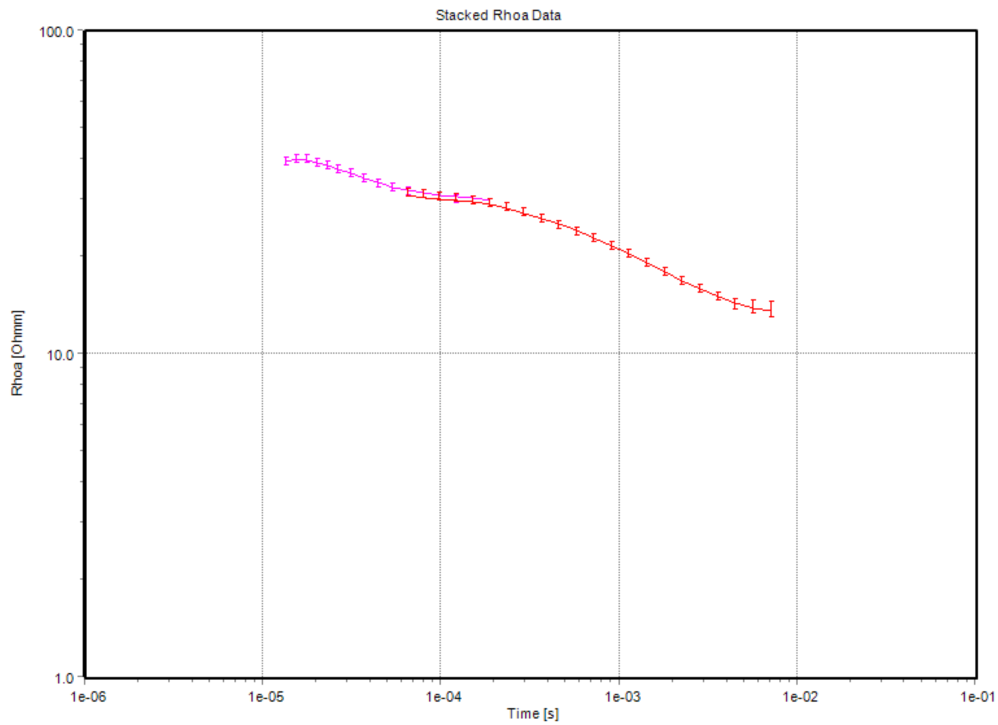


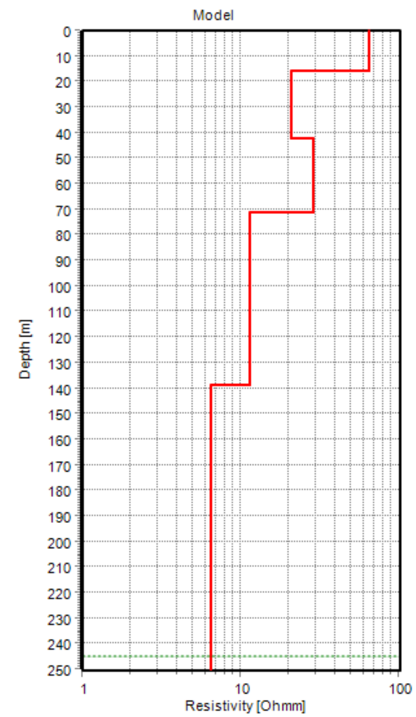



## WalkTEM Station: W03 (Project site 7) – layered model

**UTMX:** 646665 **Data Residual:** 0.3 **Database Name:** Project46.gdb

**UTMY:** 4248224 **DOI:** 245 m **EPSG:** WGS 84 UTM zone 10N (epsg: 32610)

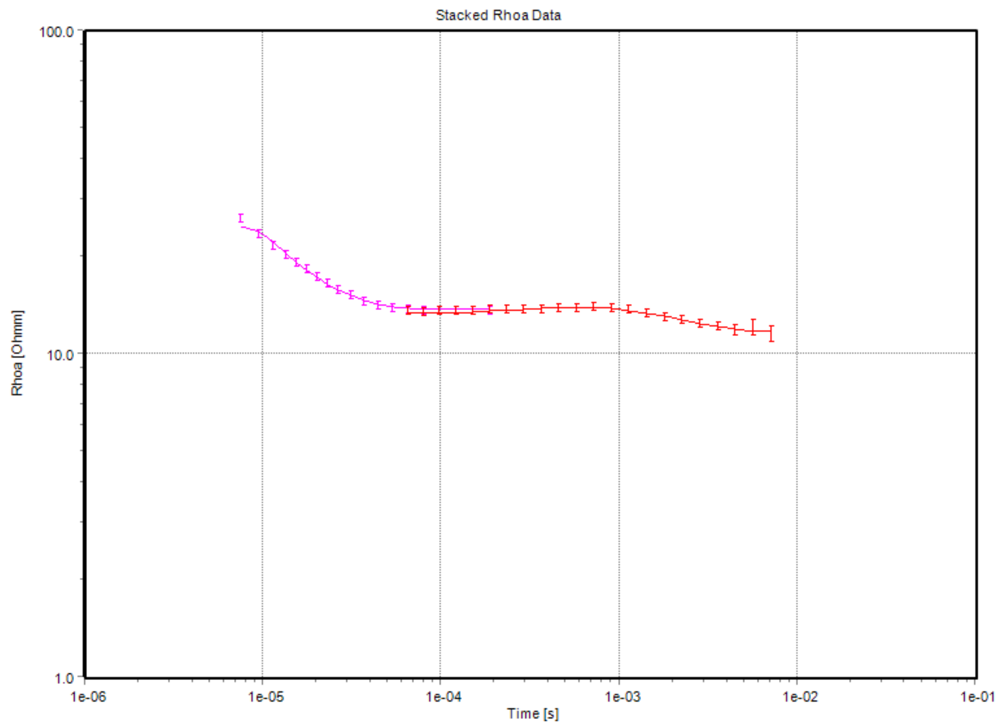


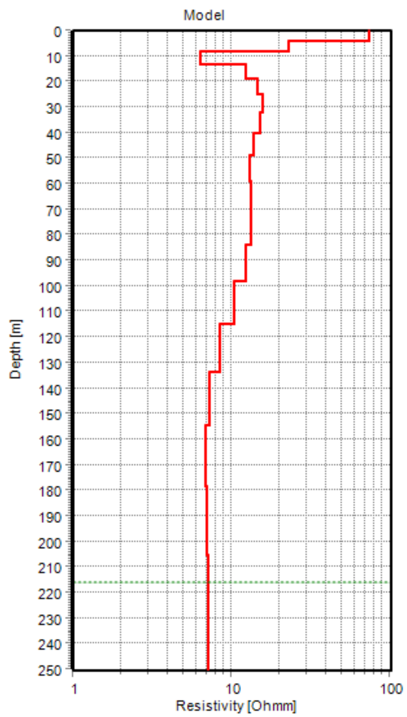



## WalkTEM Station: W04 (Project site 5a) – smooth model

**UTMX:** 639047 **Data Residual:** 0.4 **Database Name:** Project46.gdb

**UTMY:** 4233865 **DOI:** 216 m **EPSG:** WGS 84 UTM zone 10N (epsg: 32610)



## WalkTEM Station: W04 (Project site 5a) – layered model

**UTMX:** 639047

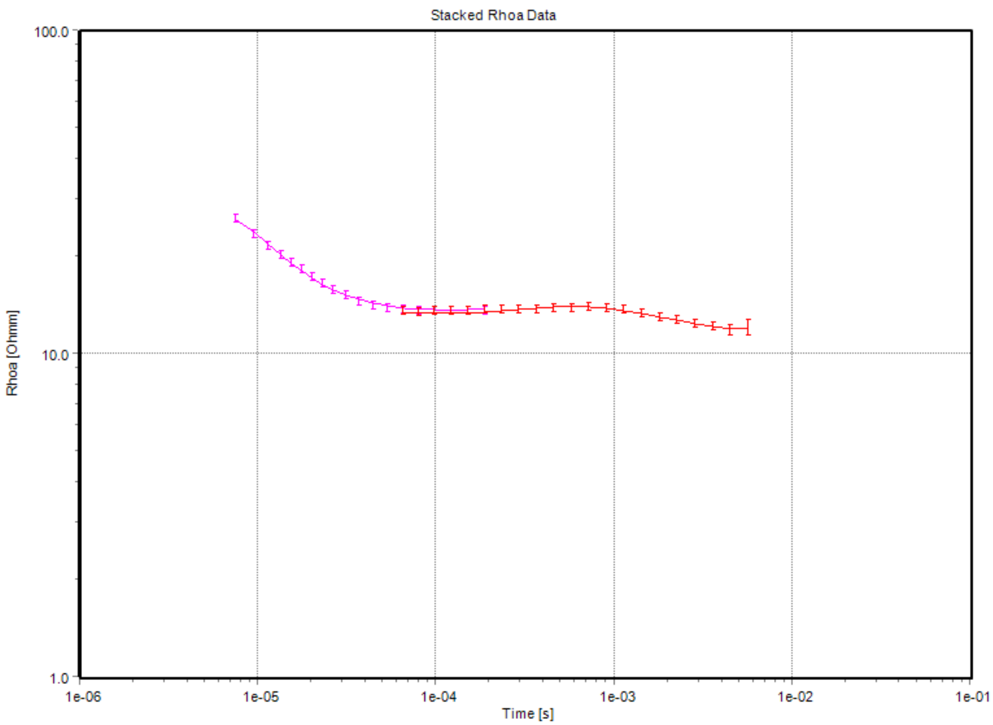
**Data Residual:** 0.3

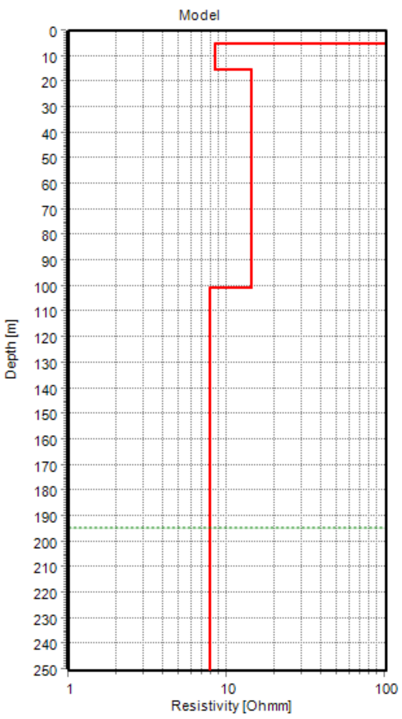
**Database Name:** Project46.gdb

**UTMY:** 4233865

**DOI:** 195 m

**EPSG:** WGS 84 UTM zone 10N (epsg: 32610)

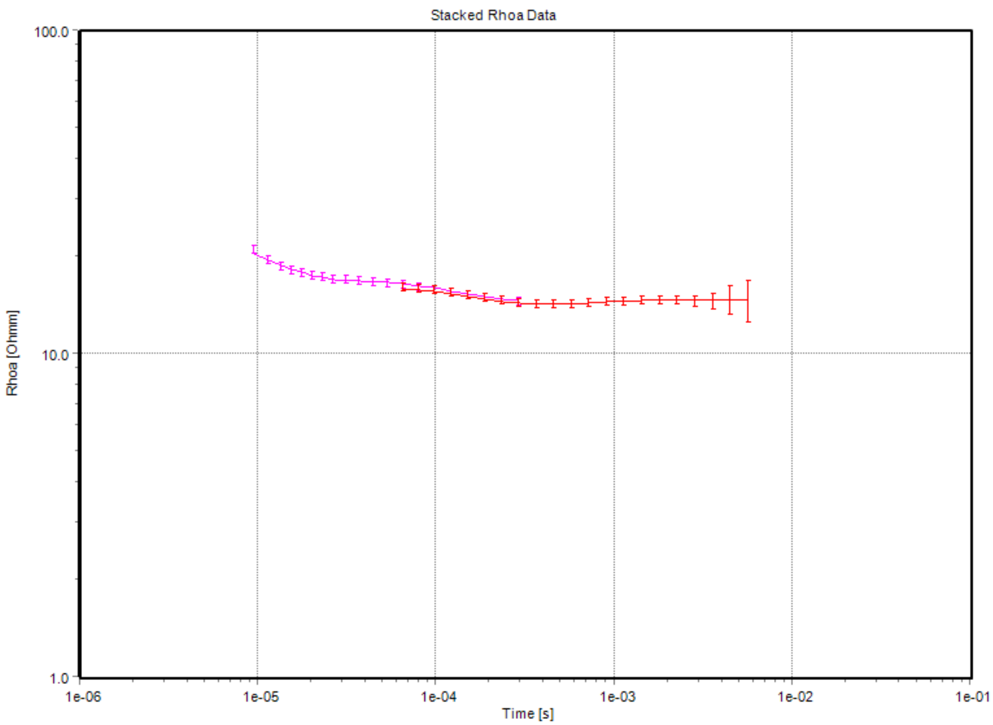


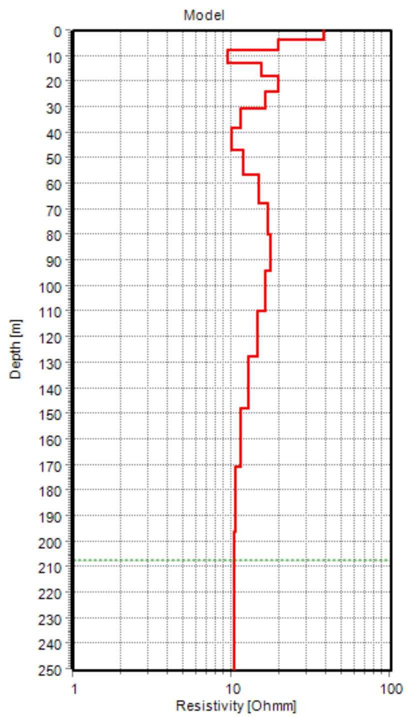



## WalkTEM Station: W05 (Project site 3) – smooth model

**UTMX:** 654533 **Data Residual:** 0.3 **Database Name:** Project46.gdb

**UTMY:** 4241642 **DOI:** 207 m **EPSG:** WGS 84 UTM zone 10N (epsg: 32610)



## WalkTEM Station: W05 (Project site 3) – layered model

**UTMX:** 654533

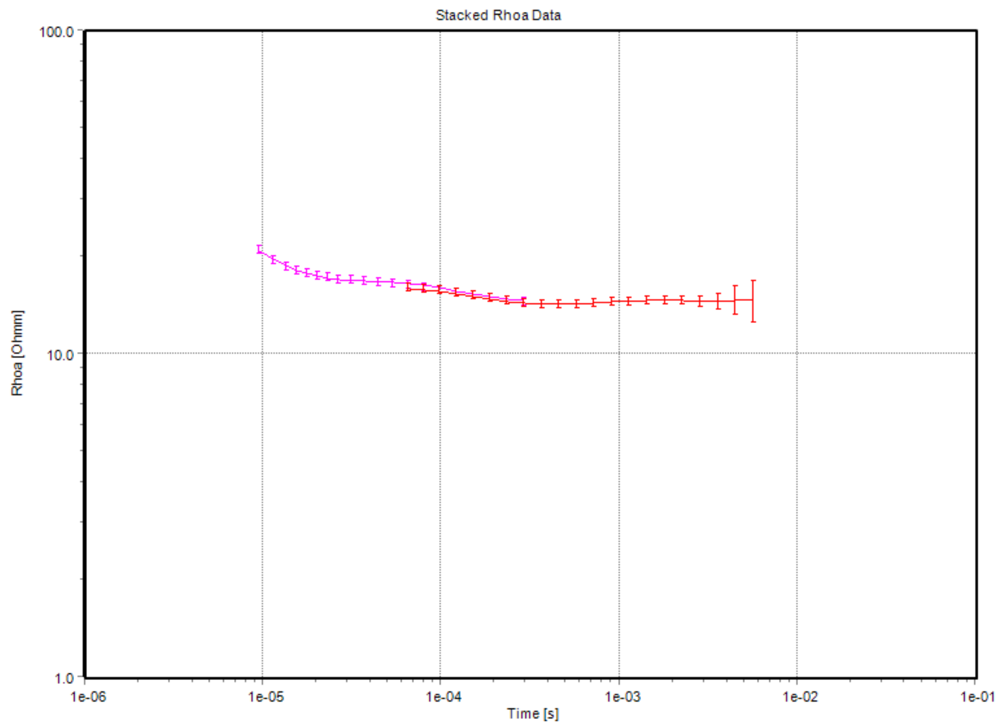
**UTMY:** 4241642

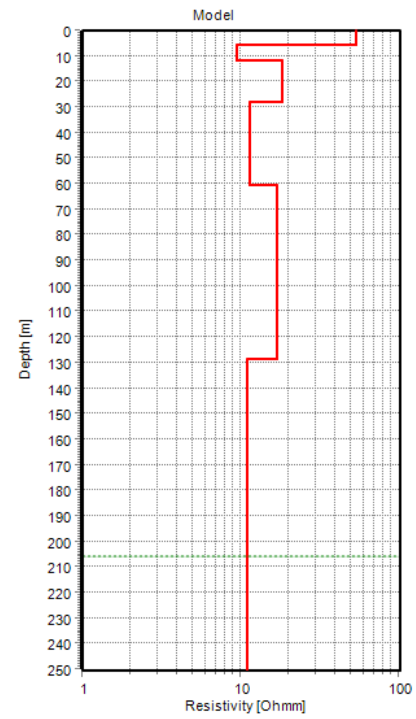
**Data Residual:** 0.2

**DOI:** 206 m

**Database Name:** Project46.gdb

**EPSG:** WGS 84 UTM zone 10N (epsg: 32610)



## WalkTEM Station: W06 (Project site 10) – smooth model

**UTMX:** 641636

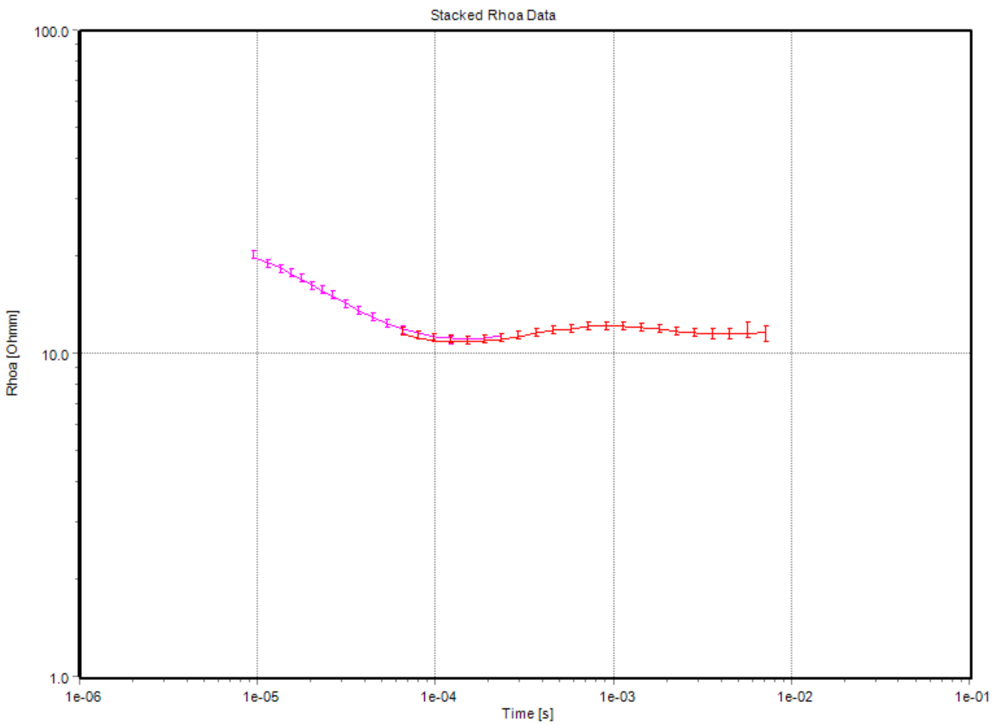
**Data Residual:** 0.3

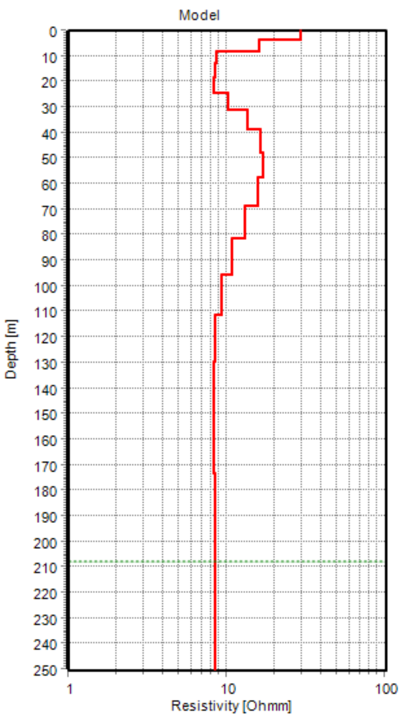
**Database Name:** Project46.gdb

**UTMY:** 4236878

**DOI:** 208 m

**EPSG:** WGS 84 UTM zone 10N (epsg: 32610)



## WalkTEM Station: W06 (Project site 10) – layered model

**UTMX:** 641636 **Data Residual:** 0.3 **Database Name:** Project46.gdb

**UTMY:** 4236878 **DOI:** 207 m **EPSG:** WGS 84 UTM zone 10N (epsg: 32610)