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Appendix 3A
BHE Cluster System Impact Study

This Appendix is filed under a request for confidential designation

Appendix 3A BHE Cluster System Impact Study have been provided under a request for confidentiality.

Appendix 3B
CALENERGY 230KV OHL EMF Study

CALENERGY 230KV OHL EMF STUDY
Black Rock, Morton Bay and Elmore North 230kV lines
(Final)

January 30, 2023

Prepared for:
Berkshire Hathaway Energy Renewables (BHER)

Prepared by:
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Project Number:
133560716

Rev#	Date	Description	Prepared By	Reviewed By	Independent Review	Approved By
A	Dec 5, 2022	Draft	A. Tashakori			
0	Jan 25, 2023	Final	A. Tashakori	Nathan Dueck		Hassan Fayaz

The conclusions in the Report entitled CALENERGY 230KV OHL EMF STUDY are Stantec's professional opinion, as of the time of the Report, and concerning the scope described in the Report. The opinions in the document are based on conditions and information existing at the time the scope of work was conducted and do not take into account any subsequent changes. The Report relates solely to the specific project for which Stantec was retained and the stated purpose for which the Report was prepared. The Report is not to be used or relied on for any variation or extension of the project, or for any other project or purpose, and any unauthorized use or reliance is at the recipient's own risk.

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Prepared by: Tashakori, Amir — Digitally signed by Tashakori, Amir Date: 2023.01.30 14:12:14 -05'00'

Signature

Amir Tashakori

Printed Name

Reviewed by: Dueck, Nathan — Digitally signed by Dueck, Nathan Date: 2023.01.30 13:25:55 -06'00'

Signature

Nathan Dueck

Printed Name

Approved by: Fayaz, Hassan — Digitally signed by Fayaz, Hassan Date: 2023.01.31 12:24:22 -05'00'

Signature

Hassan Fayaz

Printed Name

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Executive Summary

We are pleased to provide an EMF study for the 230kV OHL transmission line at 3 different locations. All data used for the study was provided by the client or typical data is used. The scope of our calculations was summarized in report Section 1.1.

Soil resistivity test measurements were provided at locations along the transmission line. measurements are done in the field by using the Wenner 4 pin method with a maximum span of 40' along lab tests. As measurements show, soil resistivity is very low (around 2ohmm) and for the current study 50ohm.m is assumed.

All calculations were prepared using CDEGS software engineering module SESEnviro plus, Environment impact analysis tool version 17.1.9978 by SafeEngServices & technologies ltd.

The input data including soil resistivity and the tower diagram used for modeling are appended to the Final report as appendix A. The computed field levels in form of diagrams are appended to the final revision of the report as appendix B, and C. references are added duly in the report. The specific (requested) computed levels are presented in table 5-1 and table 5-2.

In addition, in current revision of the report, impact of the soil resistivity on the line EMF parameters is studied and presented in the form of a of table and diagrams.

1 Introduction

The EMF study was completed for 3 locations of Black Rock, Morton Bay, and Elmore North. For all these locations tower structures are similar, but the conductor and electrical load (current) are different. The Black Rock project uses a smaller conductor and has a lower current and Morton Bay and Elmore North have the same conductor and load.

All calculations were prepared using CDEGS software engineering module SESEnviro plus, Environment impact analysis tool version 17.1.9978 by SafeEngServices & technologies ltd. This module calculates the electric field, magnetic field, radio interference, and audio noise of overhead transmission lines created by the power frequency voltage and current of the lines and corona.

1.1 Scope of Work

The scope of work is computing the EMF parameters caused by the transmission line Voltage, current, and corona at the center of the transmission line. The EMF parameters included in the study are:

- Electric Field (kV/m)
- Radio Interference (dB uV/m)
- Magnetic Induction (Gauss)

2 Study Data and Assumptions Details

2.1 Overhead Line Tower and Conductor

Design inputs are provided by the client for the 3 sites including the tower dimensions, conductors, and currents. Figure 2 1 shows the input and assumptions for the phase conductors and ground wire height and sag as used in the modeling and the study. Figure 2 2 shows the phase conductors' information. The ground wire is assumed to be Alumoweld 19 no 6 (shown in Figure 2 3).

Wires' sag and wires' installation height are not provided, and the numbers shown in Figure 2 1 are typical numbers assumed for the current study.

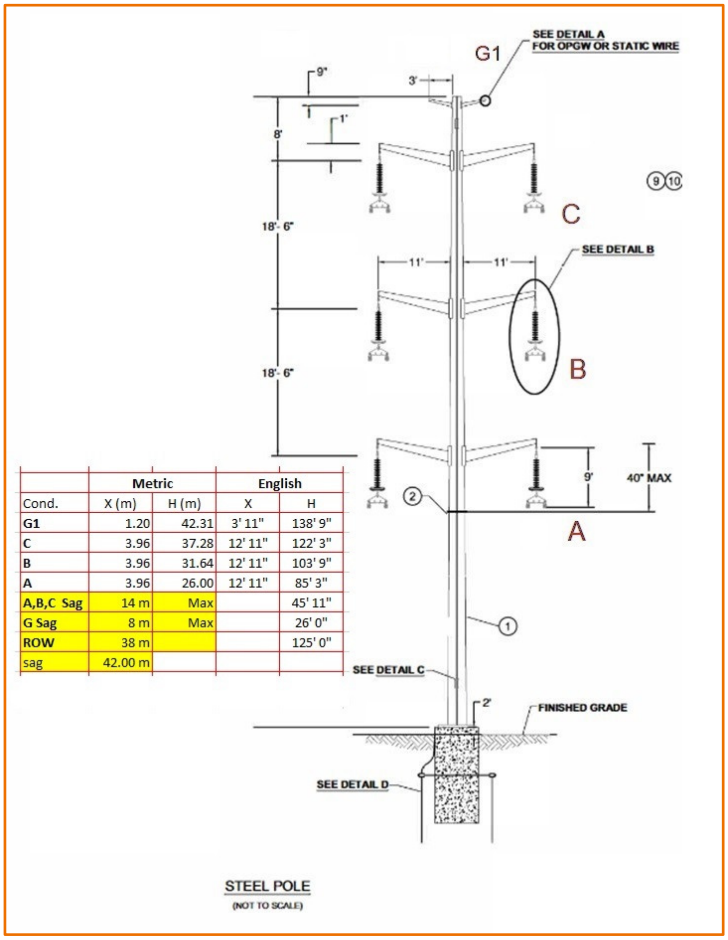

Figure 1: typical transmission tower used for the study (Provided by BHER)

Project Details	Black Rock	Morton Bay	Elmore North
Line voltage and ampacity	230kV, 234A	230kV, 437A	230kV, 437A
Tower head configuration	Single circuit tubular steel pole with vertical phase spacing		
Conductor information	397 ACSR	1113 ACSR	1113 ACSR
Conductor bundle information	Not applicable		
Mid-span height of the transmission line	40 feet at midspan		

Figure 2: Phase conductors' information (Provided by BHER)

Alumoweld Strand ASTM B-416

NUMBER & SIZE OF WIRES	NOMINAL WIRE DIAMETER		NOMINAL STRAND DIAMETER		BREAKING LOAD		WEIGHT		RESISTANCE		CROSS SECTION	
AWG	IN	MM	IN	MM	LB	KG	LB/1000 FT	KG/KM	OHMS/1000 FT@68ºF	OHMS/ KM@20ºC	SQ IN	MM^2
37 No. 6	0.1620	4.115	1.130	28.70	120,200	54,500	2222.00	3307.0	0.05356	0.1757	0.7629	492.20
37 No. 7	0.1443	3.665	1.010	25.70	100,700	45,690	1762.00	2623.0	0.06754	0.2216	0.6050	390.30
37 No. 8	0.1285	3.264	0.899	22.80	84,200	38,190	1398.00	2080.0	0.08516	0.2794	0.4798	309.50
37 No. 9	0.1144	2.906	0.801	20.30	66,770	30,290	1108.00	1649.0	0.10740	0.3523	0.3805	245.50
37 No.10	0.1019	2.588	0.713	18.10	52,950	24,020	879.00	1308.0	0.13540	0.4443	0.3017	194.70
19 No. 5	0.1819	4.620	0.910	23.10	73,350	33,270	1430.00	2129.0	0.08224	0.2698	0.4940	318.70
19 No. 6	0.1620	4.115	0.810	20.60	61,700	27,990	1134.00	1688.0	0.10370	0.3402	0.3917	252.70
19 No. 7	0.1443	3.665	0.721	18.30	51,730	23,460	899.50	1339.0	0.13080	0.4290	0.3107	200.40

continued →

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1

Figure 3: Assumed ground wire information

2.2 Soil resistivity

RF Yeager Engineering company did soil resistivity measurements in the field and in the lab in October 2022. The electrical resistivity of the soil was determined by using the Wenner 4 pin method in accordance with ASTM G57 standards. Six readings were obtained and recorded for each assessment site based on pin spacings of 40, 20, 15, 10, 5, and 2.5 feet. In the lab also soil resistivity is measured for these sites and soil resistivity is found to be below 50 Ohm.m. to a depth of 40ft. for the current study soil resistivity is assumed to be 50 Ohm.m. Please note that the soil resistivity is indicated as Ohm.CM in the RF Yeager report and if this unit is correct then the resistivity is found to be very low. e.g at depth of 40ft about 0.77Ohm.m. For our study we have considered a reasonable low resistivity of 50 Ohm.m rather than this very low resistivity. In addition, the impact of low soil resistivity is computed and presented in Section 5.1.

2.3 Sites Condition

All 3 sites are in California state near Calipatria. The altitude of the Calipatria is about sea level and for the current study of the sites, it is assumed +50m which is a little conservative. Based on some available data, the average maximum annual temperature is around 31°C and the average minimum annual temperature is around 13°C for current study sites temperature is considered 25°C which is a typical figure and is selected by default by the software.

3 Methodology

The study is done by using CDEGS, SESEnviro plus module, and for radio interference computation, the built-in method of BPA is used. According to the software documents, the references for the BPA method are:

BPA (USA)

1. V.L. Chartier, "Comprehensive Empirical Formulas For Predicting EMI from Overhead Power Line Corona.", Proc. Of the 1988 Japan Seminar on Electromagnetic Interference in Highly Advance Social Systems, Honolulu, Hi, pp. 5.1-5.6, sponsored by the NFS and the Japan Society for the Promotion of Science.
2. P. Sarma Maruvada, "Corona Performance of High-Voltage Transmission Lines ", Research Studies Press Ltd, ISBN 0 86380 254 0, 310 p., 2000.

All required parameters are computed at 1 m above the ground and in the line's center passing through the tower center, and 4 m off the tower center below the phase wires. As expected, most of the parameters are higher at the location right below the phase conductors.

The meteorological conditions that characterize the corona parameters for the evaluation are defined here. The study is done for two different rain conditions: heavy rain and no rain. These two conditions are explained below:

- **Heavy Rain**: Heavy rain condition is defined as a rate of rain of 17.78 mm/h or 0.7 inches/hour

- **Fair-Weather**: Describes dry conductors' conditions.

4 Acceptable Limits

Evaluation of the results is not in the scope of work and the requirement is not provided.

5 Study Results

EMF study is done for computing the field levels at two points:

- Center of the line which is passing through the center of the towers and
- At a point below the phase conductors

Fields are computed at 1 meter above the ground and at the midspan which is the minimum distance between the phase conductors and the observing points.

Table 5-1: Black Rock 230kV line computed EMF parameters

Parameter	Unit	Condition	At center of the transmission line	Below the phases[1]
AC Electric Field	kV/m		1.44	1.7
Radio interference	dB/1uV/m	Heavy rain	76.08	76.38
		Fair (dry condition)	54.47	54.78
AC magnetic field	Milli Gauss		19.25	20.84

Note:
1- below the phases is 4m off the line center
2- See Appendix B for diagrams

Table 5-2: Morton Bay and Elmore North 230kV line computed EMF parameters

Parameter	Unit	Condition	At center of line	Below the phases[1]
AC Electric Field	kV/m		1.51	1.78
Radio interference	dB/1uV/m	Heavy rain	64.55	64.85
		Fair (dry condition)	42.95	43.25
AC magnetic field	Milli Gauss		34.83	37.72

Note:

1- below the phases is 4m off the line center

2- See Appendix C for diagrams

5.1 Impact of soil resistivity on EMF parameters

The EMF results will change if soil resistivity decreases. As stated earlier, for the purpose of this study, we have assumed the typical soil resistivity of 50 ohm.m, however if the very low resistivity in the provided geotechnical report is correct then higher EMF results should be expected. Below tables and diagrams show this effect for each one of the transmission lines:

Table 5-3: impact of the soil resistivity on EMF parameters (Black Rock)

Black Rock								
	at Center of Line				below phases			
Soil resistivity	AC elctrica field	Radio Interference Heavy rain	Radio Iterference, Fair (dry	AC magnetic field	AC elctrica field	Radio Interference Heavy rain	Radio Iterference, Ffair (dry	AC magnetic field
50	1.44	76.08	54.47	19.25	1.7	76.38	54.78	20.84
10	1.44	79.43	57.84	19.42	1.7	79.9	58.3	21.04
1	1.44	84.4	62.8	20.16	1.7	85.02	63.42	21.87
In percent relative to the soil resistivty of 50 ohm.m								
50	100%	100%	100%	100%	100%	100%	100%	100%
10	100%	104%	106%	101%	100%	105%	106%	101%
1	100%	111%	115%	105%	100%	111%	116%	105%

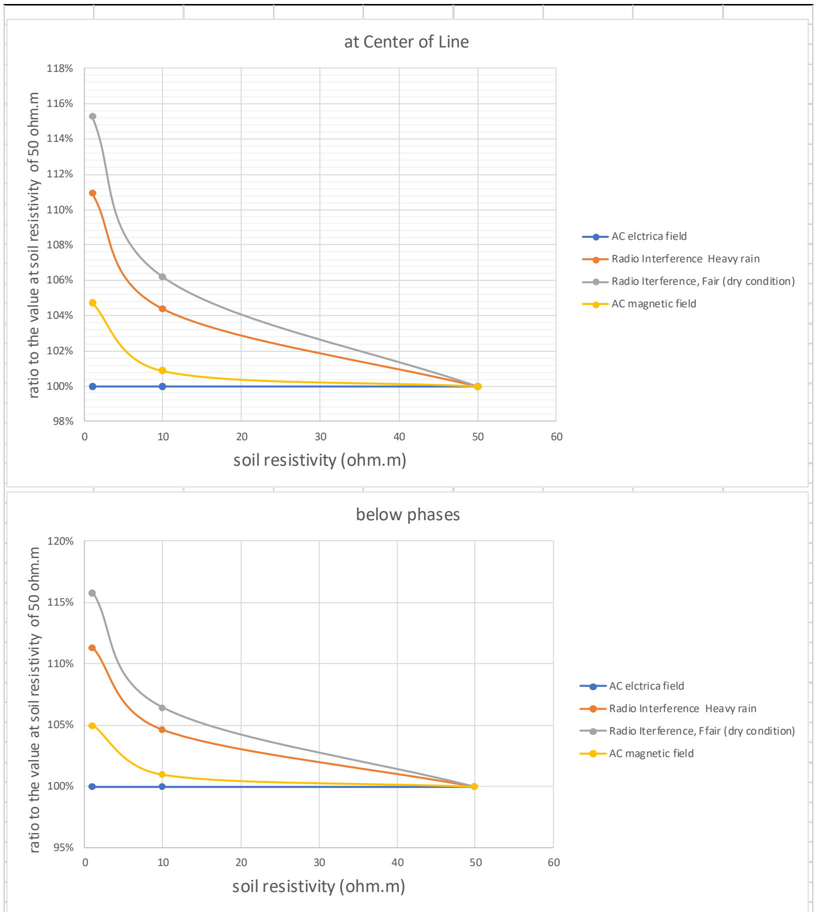


Figure 4: impact of the soil resistivity on EMF parameters (Black Rock)

Table 5-4: impact of the soil resistivity on EMF parameters (Morton Bay and Elmore North)

Morton Bay and Elmore North								
	at Center of Line				below phases			
Soil resistivity	AC elctrica field	Radio Interference Heavy rain	Radio Iterference, Fair (dry	AC magnetic field	AC elctrica field	Radio Interference Heavy rain	Radio Iterference, Fair (dry	AC magnetic field
50	1.51	64.55	42.95	34.83	1.78	64.85	43.25	37.72
10	1.51	68	46.41	35.08	1.78	68.46	46.86	38
1	1.51	73.08	51.48	36.24	1.78	73.69	52.09	39.34
In percent relative to the soil resistivty of 50 ohm.m								
50	100%	100%	100%	100%	100%	100%	100%	100%
10	100%	105%	108%	101%	100%	106%	108%	101%
1	100%	113%	120%	104%	100%	114%	120%	104%

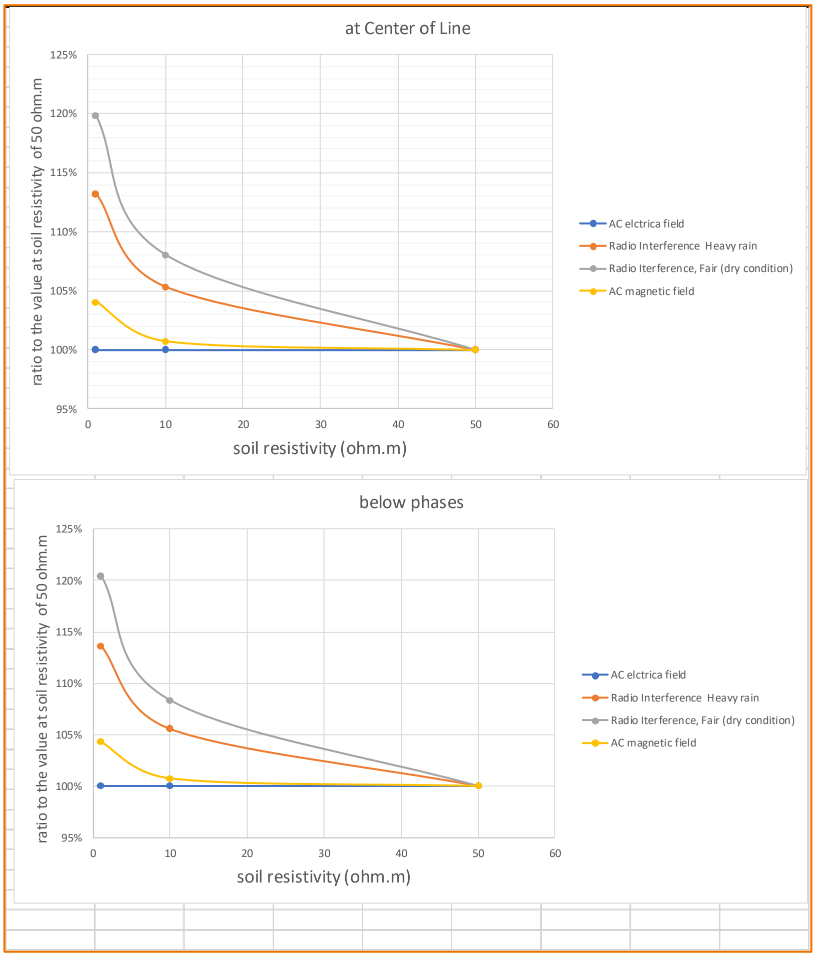


Figure 5: impact of the soil resistivity on EMF parameters (Morton Bay and Elmore North)

6 References

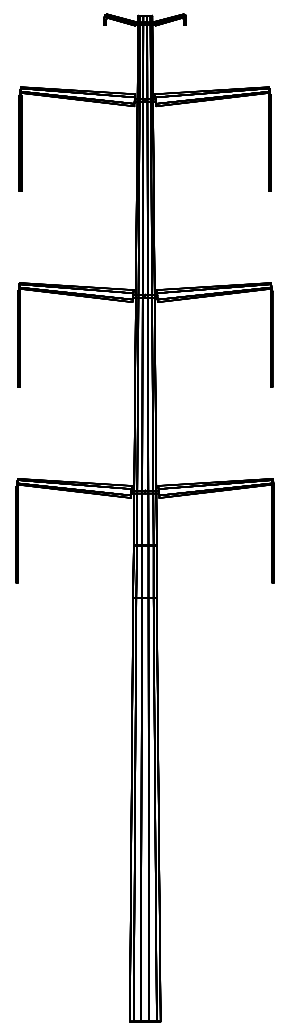
1- CALENERGY – Black Rock site soil assessment summary report by RFY eager engineering October 20, 2022

2- CALENERGY – Morton Bay site soil assessment summary report by RFY eager engineering October 20, 2022

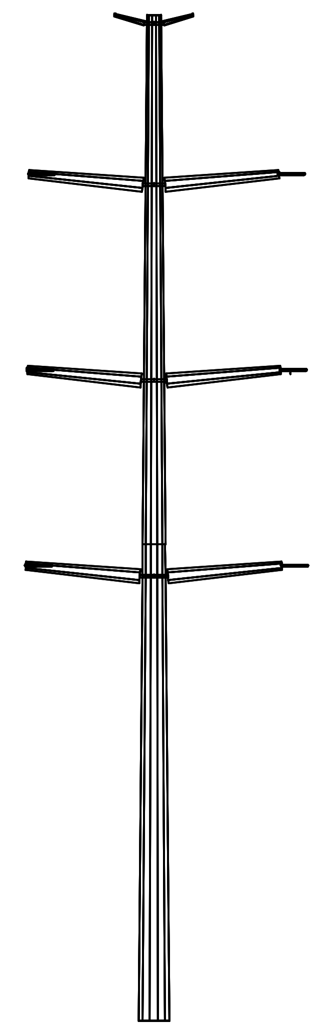
3- CALENERGY – Elmore North site soil assessment summary report by RFY eager engineering October 20, 2022

Appendix A Input data

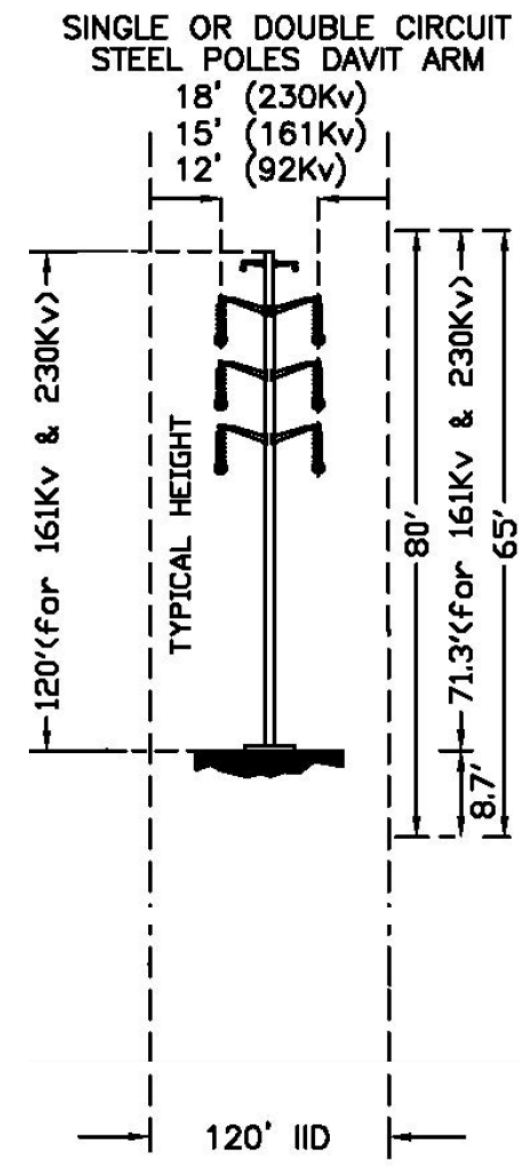
A.1 Transmission tower diagrams



TANGENT STRUCTURE



DEAD END STRUCTURE



230kV Steel Pole Typical Right of Way

REV.	BY	DESCRIPTION	DATE	APPR'D BY

IV POWER SOLUTIONS

1 Inch

Scale to Confirm 24"x36" Plot

ENGINEERING & ENERGY SOLUTIONS

SHEET TITLE:

230 KV TYP FRAMING

DRAWN BY:	JH	DRAWING No.	
CHECKED:	JG		
SCALE:			
JOB NO:		SHEET No.	1/1
DATE:	11/30/22	REV No.	1

A.2 Black Rock soil resistivity measurement

CALENERGY – BLACK ROCK SITE
SOIL ASSESSMENT SUMMARY REPORT

Presented To:

Landmark Consultants

Prepared by:

RF Yeager ENGINEERING

Project No. 22136

OCTOBER 20, 2022

INTRODUCTION

RFYeager Engineering Inc. (RFYeager Engineering) has completed an electrical and thermal resistivity assessment at the proposed CalEnergy Black Rock site near Calipatria, California. A chemical analysis of two (2) soil samples provided by Landmark was also conducted. The objective of this study is to determine the thermal and electrical resistivity, as well as to determine the corrosivity of the soil at the project site.

The location and numbering of the assessment sites is shown in Figure 1 at the end of this report. Figure 1 is based upon the site map provided by Landmark.

SCOPE

The electrical resistivity of the soil was determined by using the Wenner 4 pin method in accordance with ASTM G57 standards. Six readings were obtained and recorded for each assessment site based upon pin spacings of 40, 20, 15, 10, 5, and 2.5 feet. Readings were recorded at two locations within the Black Rock site boundaries. All resistivity readings were recorded utilizing a Soil Resistance Meter (Megger Model DET4T2).

The soil corrosivity was evaluated based on the results of the field soil electrical resistivity assessment and the chemical analyses of the two soil samples. The soil samples were obtained by Landmark from a depth of approximately 3 feet. The samples were analyzed for pH, soluble salts (chlorides and sulfates) as well as resistivity in the saturated condition.

The thermal resistivity was determined using a Decagon KD2 Pro Portable Thermal Properties Analyzer (KD2 Pro) outfitted with the 100 mm long, 2.4 mm diameter TR-1 sensor. The KD2 Pro works in accordance with ASTM D5334-08 using a transient heat method.

CONCLUSIONS

The following are significant conclusions resulting from this assessment:

1. The results of the field electrical resistivity assessment are provided in Table 1. Resistivity readings ranging from less than 77 ohm-cm to 393 ohm-cm. All readings fell within the "Very Corrosive" soil classification (see Discussion).

Table 1 – CalEnergy Black Rock Site Soil Electrical Resistivity Data Prepared by: RFYeager Engineering Test Date: 9.29.2022							
		Soil Resistivity (Ohm-cm)					
	Assessment Site	Ave. Soil Depth (feet)					
Test No.	**ID**	**40**	**20**	**15**	**10**	**5**	**2.5**
1	ER-1 (E/W Orientation)	<77[2]	77	86	153	192	239
	ER-1 (N/S Orientation)	<77	77	115	172	239	287
2	ER-2 (E/W Orientation)	<77	77	115	134	287	393
	ER-2 (N/S Orientation)	<77	77	115	172	278	345

1 - See Figure 1 for soil assessment location relative to project site
2 - Electrical resistivity below detectable level of field equipment

2. The chemical analysis results are provided in Table 2. Both samples contained very high concentrations of sulfates (i.e. greater than 1000 ppm). One of the two samples contain high chloride concentrations (i.e. greater than 300 ppm). The saturated soil resistivities of the two samples were very low at 270 ohm-cm and 180 ohm-cm, respectively. The pH readings were indicative of slightly alkaline soil conditions.

Table 2 – CalEnergy Black Rock Site Chemical Analysis Data Prepared by: RFYeager Engineering				
Sample ID[1]	**Min. Soil Box Resistivity[2] (ohm-cm)**	**Chloride Concentration[3] (ppm)**	**Sulfate Concentration[4] (ppm)**	**pH[5]**
1	270	260	2520	7.9
2	180	730	2040	7.8

1 - See Figure 1 for soil sample location. Soil sample taken from a depth of 3 feet
2 - Min. Electrical Resistivity - Miller Soil Box Method, Cal. Test 643
3 - Soluble Soil Chlorides - Cal. Test 422
4 - Soluble Sulfate Content - Cal. Test 417
5 - pH - Cal. Test 643

3. The data collected from the project site indicates that the soil should be considered as very aggressive to buried metallic utilities. This conclusion is based upon the low soil resistivities and high concentrations of soluble salts.

4. Overall, the data from project site indicates that the surrounding soil will support and promote metallic corrosion. Accordingly, supplemental corrosion control measures, such as cathodic protection, are recommended for any buried metallic utilities in order to prevent premature failure.

5. The soil thermal resistivity is provided in Table 3. The corresponding Time vs. Temperature graphs for each assessment site is provided in Appendix A.

Table 3 – CalEnergy Black Rock Site **Thermal Resistivity Data** Prepared by: RFYeager Engineering	
Sample ID[1]	**In-Situ Thermal Resistivity[2] (m $^{0}CW^{-1}$)**
TR1	0.67
TR2	0.87

1 - See Figure 1 for test location relative to project site
2 – ASTM D5334-08.

DISCUSSION

Electrical Resistivity Assessment

Soil electrical resistivity (inverse of conductivity) measures the ability of an electrolyte (soil) to support electrical current flow. The most common method of measuring soil electrical resistivity is the Wenner 4-Pin Method which uses four pins (electrodes) that are driven into the earth and equally spaced apart in a straight line. The Wenner 4-pin Method provides an average resistivity of a hemisphere (essentially) of soil whose radius is approximately equal to the pin spacing. For example, the electrical resistivity value obtained with the pins spaced at 5 feet apart is the average resistivity of a hemisphere of soil from the surface to a depth of 5 feet. By taking readings at different pin spacings (or depths), average soil electrical resistivity conditions can be obtained within areas at, above, and below trench zones.

Corrosion versus Resistivity

Corrosion is an electrochemical process, whereby the reaction rate is largely dependent upon the electrical conductivity of the surrounding electrolyte. Accordingly, the lower the electrical resistivity, then the greater the current flow and the greater the corrosion rate assuming all other factors are equal.

One common relationship between corrosivity and soil electrical resistivity used by corrosion engineers is provided below.

Corrosivity	Electrical Resistivity
Very Corrosive	0-1000 ohm-cm
Corrosive	1001-2000 ohm-cm
Fairly Corrosive	2001-5000 ohm-cm
Moderately Corrosive	5001-12000 ohm-cm
Slightly Corrosive	12001-30000 ohm-cm
Relatively Non-Corrosive	Greater than 30001 ohm-cm

Thermal Resistivity Assessment

Thermal resistivity of the soil was measured at two locations selected by Landmark within the Black Rock site. Assessments were conducted within test pits at a depth of approximately 2 feet. At each site, the thermal resistivity was measured three times with the average provided in Table 3. The assessment was conducted in general accordance with the standard method ASTM D5334-08 which calculates thermal resistivity by monitoring the dissipation of heat from a line heat source. The field assessment consists of inserting a thermal sensor into the soil with a known current and voltage applied. The corresponding temperature rise in the soil over a period of time is recorded. The thermal resistivity is obtained from an analysis of the time series temperature data during the heating and cooling cycle of the sensor.

For purposes of this report, the thermal resistivity values are provided as “data only” in order to assist others in the project design.

Thank you for this opportunity to provide these corrosion engineering services. Please contact me if you have any questions.

Randy J. Geving, PE
Registered Professional Engineer – Corrosion No.1060
RGeving@RFYeager.com, 760.715.2358

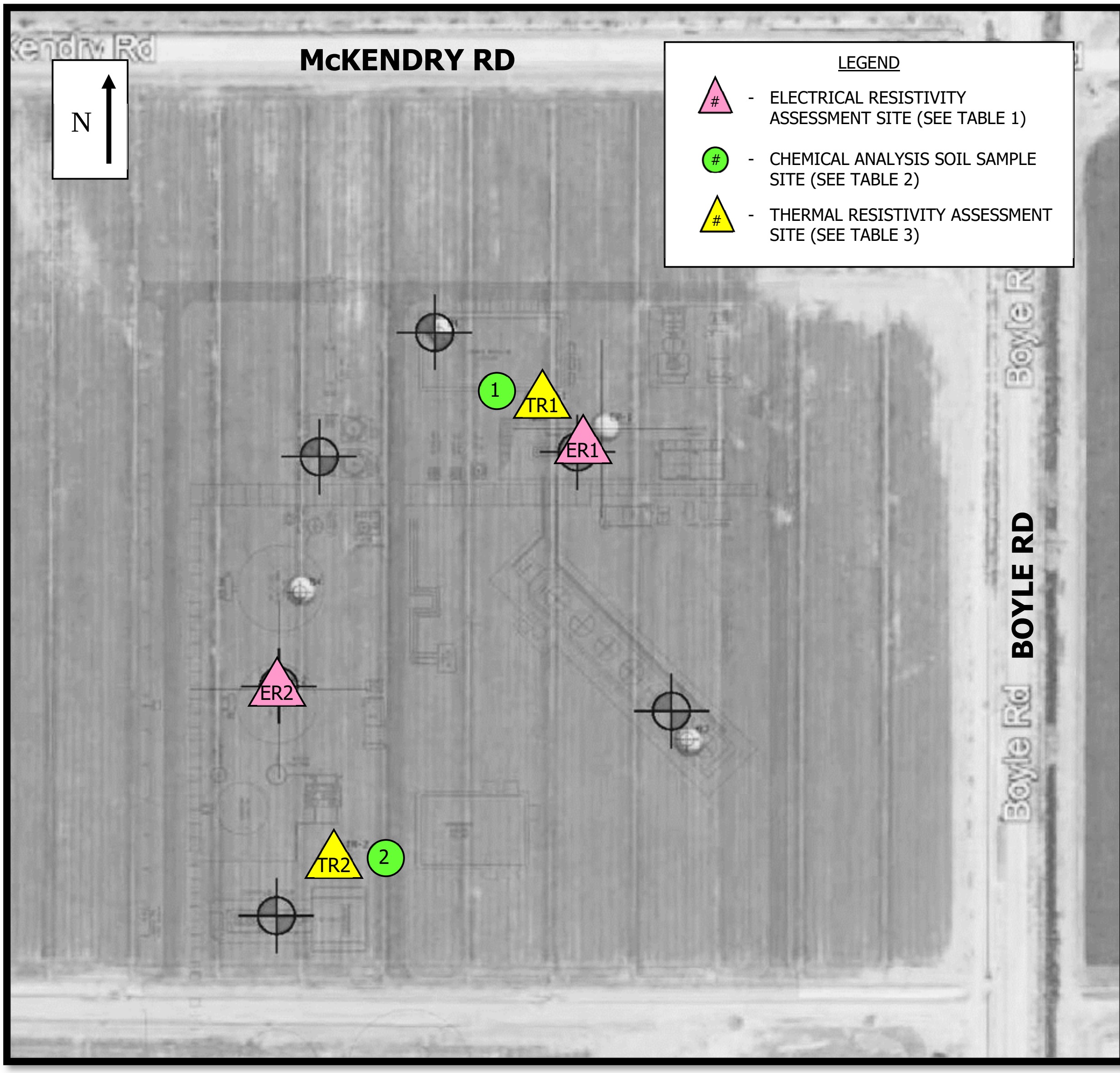


Figure 1 – CalEnergy Black Rock Assessment Locations

A.3 Elmore North soil resistivity measurement

CALENERGY – ELMORE NORTH SITE
SOIL ASSESSMENT SUMMARY REPORT

Presented To:

Landmark Consultants

Prepared by:

R F Yeager
ENGINEERING

Project No. 22136

OCTOBER 20, 2022

INTRODUCTION

RFYeager Engineering Inc. (RFYeager Engineering) has completed an electrical and thermal resistivity assessment at the proposed CalEnergy Elmore North site near Calipatria, California. A chemical analysis of two (2) soil samples provided by Landmark was also conducted. The objective of this study is to determine the thermal and electrical resistivity, as well as to determine the corrosivity of the soil at the project site.

The location and numbering of the assessment sites is shown in Figure 1 at the end of this report. Figure 1 is based upon the site map provided by Landmark.

SCOPE

The electrical resistivity of the soil was determined by using the Wenner 4 pin method in accordance with ASTM G57 standards. Six readings were obtained and recorded for each assessment site based upon pin spacings of 40, 20, 15, 10, 5, and 2.5 feet. Readings were recorded at two locations within the Elmore North site boundaries. All resistivity readings were recorded utilizing a Soil Resistance Meter (Megger Model DET4T2).

The soil corrosivity was evaluated based on the results of the field soil electrical resistivity assessment and the chemical analyses of the two soil samples. The soil samples were obtained by Landmark from a depth of approximately 3 feet. The samples were analyzed for pH, soluble salts (chlorides and sulfates) as well as resistivity in the saturated condition.

The thermal resistivity was determined using a Decagon KD2 Pro Portable Thermal Properties Analyzer (KD2 Pro) outfitted with the 100 mm long, 2.4 mm diameter TR-1 sensor. The KD2 Pro works in accordance with ASTM D5334-08 using a transient heat method.

CONCLUSIONS

The following are significant conclusions resulting from this assessment:

1. The results of the field electrical resistivity assessment are provided in Table 1. Resistivity readings ranging from less than 77 ohm-cm to 306 ohm-cm. All readings fell within the "Very Corrosive" soil classification (see Discussion).

Table 1 – CalEnergy Elmore North Site **Soil Electrical Resistivity Data** Prepared by: RFYeager Engineering Test Date: 9.29.2022							
		Soil Resistivity (Ohm-cm)					
	Assessment Site	**Ave. Soil Depth (feet)**					
Test No.	**ID**	**40**	**20**	**15**	**10**	**5**	**2.5**
1	ER-1 (E/W Orientation)	<77[2]	77	144	230	287	244
	ER-1 (N/S Orientation)	153	115	201	230	259	306
2	ER-2 (E/W Orientation)	153	115	172	192	201	225
	ER-2 (N/S Orientation)	<77	77	144	192	230	230

1 - See Figure 1 for soil assessment location relative to project site
2 - Electrical resistivity below detectable level of field equipment

2. The chemical analysis results are provided in Table 2. Both samples contained very high concentrations of sulfates (i.e. greater than 1000 ppm). The chloride concentrations of both samples were below the threshold considered indicative of corrosive soil (i.e. 300 ppm). The saturated soil resistivities of the two samples were very low at 270 ohm-cm and 250 ohm-cm, respectively. The pH readings were indicative of slightly alkaline soil conditions.

Table 2 – CalEnergy Elmore North Site **Chemical Analysis Data** Prepared by: RFYeager Engineering				
Sample ID[1]	**Min. Soil Box Resistivity[2] (ohm-cm)**	**Chloride Concentration[3] (ppm)**	**Sulfate Concentration[4] (ppm)**	**pH[5]**
1	270	210	2160	7.7
2	250	220	1920	7.8

1 - See Figure 1 for soil sample location. Soil sample taken from a depth of 3 feet
2 - Min. Electrical Resistivity - Miller Soil Box Method, Cal. Test 643
3 - Soluble Soil Chlorides - Cal. Test 422
4 - Soluble Sulfate Content - Cal. Test 417
5 - pH - Cal. Test 643

3. The data collected from the project site indicates that the soil should be considered as very aggressive to buried metallic utilities. This conclusion is primarily based upon the low soil resistivities and high concentrations of soil sample sulfates.

4. Overall, the data from project site indicates that the surrounding soil will support and promote metallic corrosion. Accordingly, supplemental corrosion control measures, such as cathodic protection, are recommended for any buried metallic utilities in order to prevent premature failure.

5. The soil thermal resistivity is provided in Table 3. The corresponding Time vs. Temperature graphs for each assessment site is provided in Appendix A.

Table 3 – CalEnergy Elmore North Site Thermal Resistivity Data Prepared by: RFYeager Engineering	
Sample ID[1]	**In-Situ Thermal Resistivity[2] (m $^{0}CW^{-1}$)**
TR1	1.14
TR2	1.01

1 - See Figure 1 for test location relative to project site
2 – ASTM D5334-08.

DISCUSSION

Electrical Resistivity Assessment

Soil electrical resistivity (inverse of conductivity) measures the ability of an electrolyte (soil) to support electrical current flow. The most common method of measuring soil electrical resistivity is the Wenner 4-Pin Method which uses four pins (electrodes) that are driven into the earth and equally spaced apart in a straight line. The Wenner 4-pin Method provides an average resistivity of a hemisphere (essentially) of soil whose radius is approximately equal to the pin spacing. For example, the electrical resistivity value obtained with the pins spaced at 5 feet apart is the average resistivity of a hemisphere of soil from the surface to a depth of 5 feet. By taking readings at different pin spacings (or depths), average soil electrical resistivity conditions can be obtained within areas at, above, and below trench zones.

Corrosion versus Resistivity

Corrosion is an electrochemical process, whereby the reaction rate is largely dependent upon the electrical conductivity of the surrounding electrolyte. Accordingly, the lower the electrical resistivity, then the greater the current flow and the greater the corrosion rate assuming all other factors are equal.

One common relationship between corrosivity and soil electrical resistivity used by corrosion engineers is provided below.

Corrosivity	Electrical Resistivity
Very Corrosive	0-1000 ohm-cm
Corrosive	1001-2000 ohm-cm
Fairly Corrosive	2001-5000 ohm-cm
Moderately Corrosive	5001-12000 ohm-cm
Slightly Corrosive	12001-30000 ohm-cm
Relatively Non-Corrosive	Greater than 30001 ohm-cm

Thermal Resistivity Assessment

Thermal resistivity of the soil was measured at two locations selected by Landmark within the Elmore North site. Assessments were conducted within test pits at a depth of approximately 2 feet. At each site, the thermal resistivity was measured three times with the average provided in Table 3. The assessment was conducted in general accordance with the standard method ASTM D5334-08 which calculates thermal resistivity by monitoring the dissipation of heat from a line heat source. The field assessment consists of inserting a thermal sensor into the soil with a known current and voltage applied. The corresponding temperature rise in the soil over a period of time is recorded. The thermal resistivity is obtained from an analysis of the time series temperature data during the heating and cooling cycle of the sensor.

For purposes of this report, the thermal resistivity values are provided as "data only" in order to assist others in the project design.

Thank you for this opportunity to provide these corrosion engineering services. Please contact me if you have any questions.

Randy J. Geving, PE
Registered Professional Engineer – Corrosion No.1060
RGeving@RFYeager.com, 760.715.2358

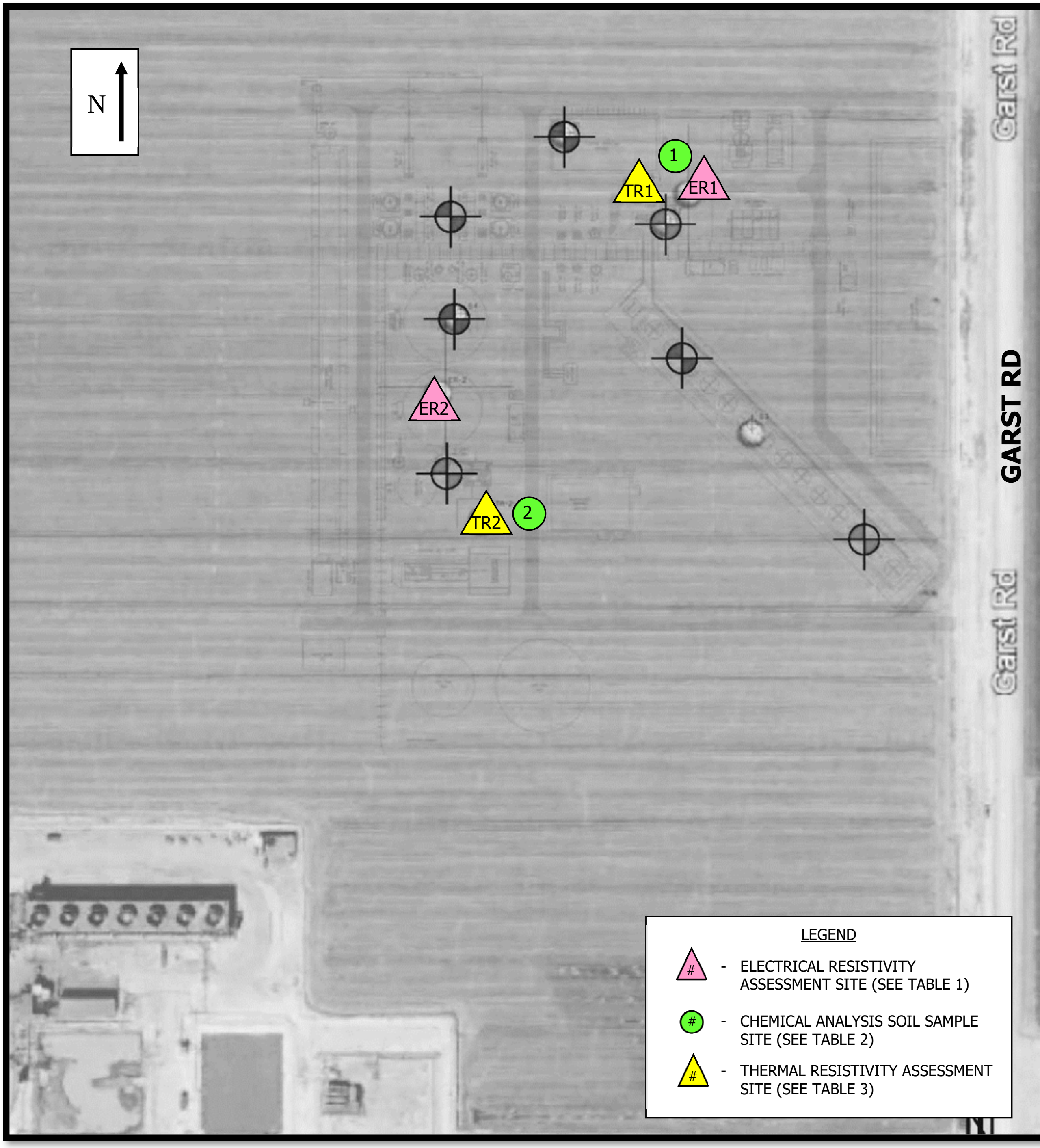


Figure 1 – CalEnergy Elmore North Assessment Locations

A.4 Morton Bay soil resistivity measurement

CALENERGY – MORTON BAY SITE
SOIL ASSESSMENT SUMMARY REPORT

Presented To:

Landmark Consultants

Prepared by:

R F Yeager
ENGINEERING

Project No. 22136

OCTOBER 20, 2022

INTRODUCTION

RFYeager Engineering has completed an electrical and thermal resistivity assessment at the proposed CalEnergy Morton Bay site near Calipatria, California. A chemical analysis of two (2) soil samples provided by Landmark was also conducted. The objective of this study is to determine the thermal and electrical resistivity, as well as to determine the corrosivity of the soil at the project site.

The location and numbering of the assessment sites is shown in Figure 1 at the end of this report. Figure 1 is based upon the site map provided by Landmark.

SCOPE

The electrical resistivity of the soil was determined by using the Wenner 4 pin method in accordance with ASTM G57 standards. Six readings were obtained and recorded for each assessment site based upon pin spacings of 40, 20, 15, 10, 5, and 2.5 feet. Readings were recorded at two locations within the Morton Bay site boundaries. All resistivity readings were recorded utilizing a Soil Resistance Meter (Megger Model DET4T2).

The soil corrosivity was evaluated based on the results of the field soil electrical resistivity assessment and the chemical analyses of the two soil samples. The soil samples were obtained by Landmark from a depth of approximately 3 feet. The samples were analyzed for pH, soluble salts (chlorides and sulfates) as well as resistivity in the saturated condition.

The thermal resistivity was determined using a Decagon KD2 Pro Portable Thermal Properties Analyzer (KD2 Pro) outfitted with the 100 mm long, 2.4 mm diameter TR-1 sensor. The KD2 Pro works in accordance with ASTM D5334-08 using a transient heat method.

CONCLUSIONS

The following are significant conclusions resulting from this assessment:

1. The results of the field electrical resistivity assessment are provided in Table 1. Resistivity readings ranging from less than 77 ohm-cm to 148 ohm-cm. All readings fell within the "Very Corrosive" soil classification (see Discussion).

Table 1 – CalEnergy Morton Bay Site Soil Electrical Resistivity Data Prepared by: RFYeager Engineering Test Date: 9.30.2022							
Test No.	**Assessment Site ID**	**Soil Resistivity (Ohm-cm)**					
		Ave. Soil Depth (feet)					
		40	**20**	**15**	**10**	**5**	**2.5**
1	ER-1 (E/W Orientation)	<77[2]	77	86	115	134	139
	ER-1 (N/S Orientation)	<77	77	86	134	124	148
2	ER-2 (E/W Orientation)	<77	77	86	115	134	129
	ER-2 (N/S Orientation)	<77	77	86	134	144	134

1 - See Figure 1 for soil assessment location relative to project site
2 - Electrical resistivity below detectable level of field equipment

2. The chemical analysis results are provided in Table 2. Both samples contained very high concentrations of chlorides (i.e. greater than 300 ppm) and sulfates (i.e. greater than 1000 ppm). The saturated soil resistivities of the two samples were very low at 49 ohm-cm and 46 ohm-cm, respectively. The pH readings were indicative of slightly alkaline soil conditions.

Table 2 – CalEnergy Morton Bay Site Chemical Analysis Data Prepared by: RFYeager Engineering				
Sample ID[1]	**Min. Soil Box Resistivity[2] (ohm-cm)**	**Chloride Concentration[3] (ppm)**	**Sulfate Concentration[4] (ppm)**	**pH[5]**
1	49	10,890	7,220	7.6
2	46	10,470	7.6	8.7

1 - See Figure 1 for soil sample location. Soil sample taken from a depth of 3 feet
2 - Min. Electrical Resistivity - Miller Soil Box Method, Cal. Test 643
3 - Soluble Soil Chlorides - Cal. Test 422
4 - Soluble Sulfate Content - Cal. Test 417
5 - pH - Cal. Test 643

3. The data collected from the project site indicates that the soil should be considered as very aggressive to buried metallic utilities. This conclusion is based upon the low soil resistivities and high concentrations of soluble salts.

4. Overall, the data from project site indicates that the surrounding soil will support and promote metallic corrosion. Accordingly, supplemental corrosion control measures, such as cathodic protection, are recommended for any buried metallic utilities in order to prevent premature failure.

5. The soil thermal resistivity is provided in Table 3. The corresponding Time vs. Temperature graphs for each assessment site is provided in Appendix A.

Table 3 – CalEnergy Morton Bay Site Thermal Resistivity Data Prepared by: RFYeager Engineering	
Sample ID[1]	**In-Situ Thermal Resistivity[2] (m ^{0}CW^{-1})**
TR1	0.95
TR2	0.99

1 - See Figure 1 for test location relative to project site
2 – ASTM D5334-08.

DISCUSSION

Electrical Resistivity Assessment

Soil electrical resistivity (inverse of conductivity) measures the ability of an electrolyte (soil) to support electrical current flow. The most common method of measuring soil electrical resistivity is the Wenner 4-Pin Method which uses four pins (electrodes) that are driven into the earth and equally spaced apart in a straight line. The Wenner 4-pin Method provides an average resistivity of a hemisphere (essentially) of soil whose radius is approximately equal to the pin spacing. For example, the electrical resistivity value obtained with the pins spaced at 5 feet apart is the average resistivity of a hemisphere of soil from the surface to a depth of 5 feet. By taking readings at different pin spacings (or depths), average soil electrical resistivity conditions can be obtained within areas at, above, and below trench zones.

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Thermal Resistivity Assessment

Thermal resistivity of the soil was measured at two locations selected by Landmark within the Morton Bay site. Assessments were conducted within test pits at a depth of approximately 2 feet. At each site, the thermal resistivity was measured three times with the average provided in Table 3. The assessment was conducted in general accordance with the standard method ASTM D5334-08 which calculates thermal resistivity by monitoring the dissipation of heat from a line heat source. The field assessment consists of inserting a thermal sensor into the soil with a known current and voltage applied. The corresponding temperature rise in the soil over a period of time is recorded. The thermal resistivity is obtained from an analysis of the time series temperature data during the heating and cooling cycle of the sensor.

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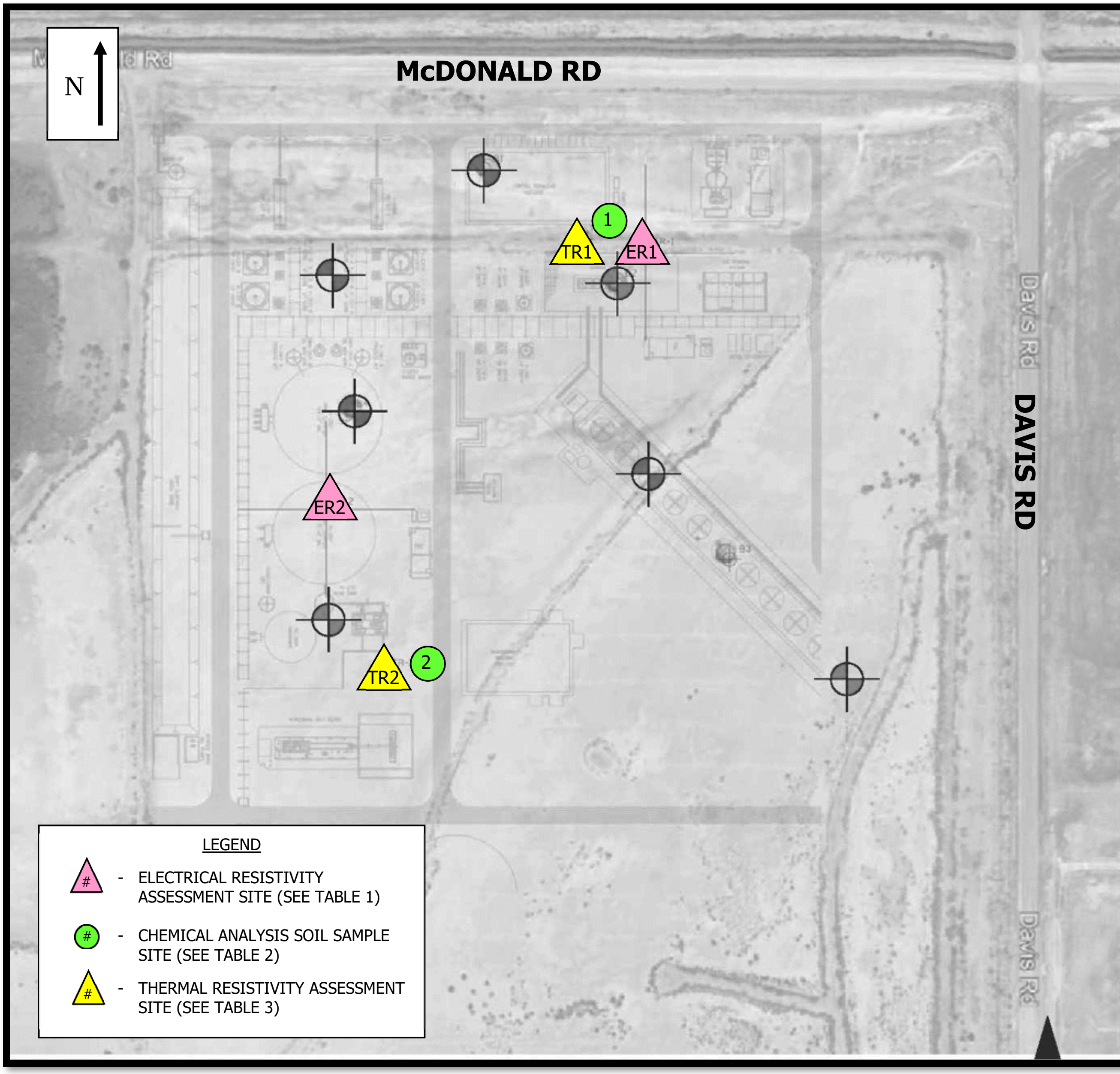

Figure 1 – CalEnergy Morton Bay Assessment Locations

Appendix B Analysis results Diagrams related to the table 5-1,

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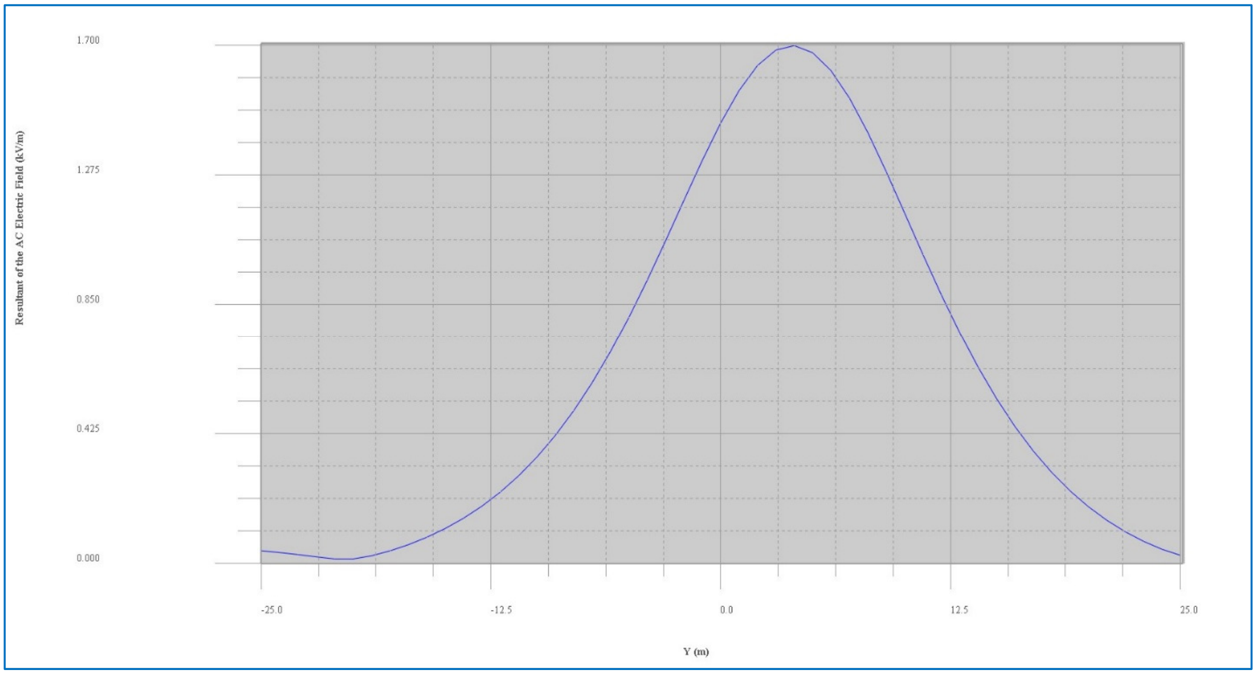
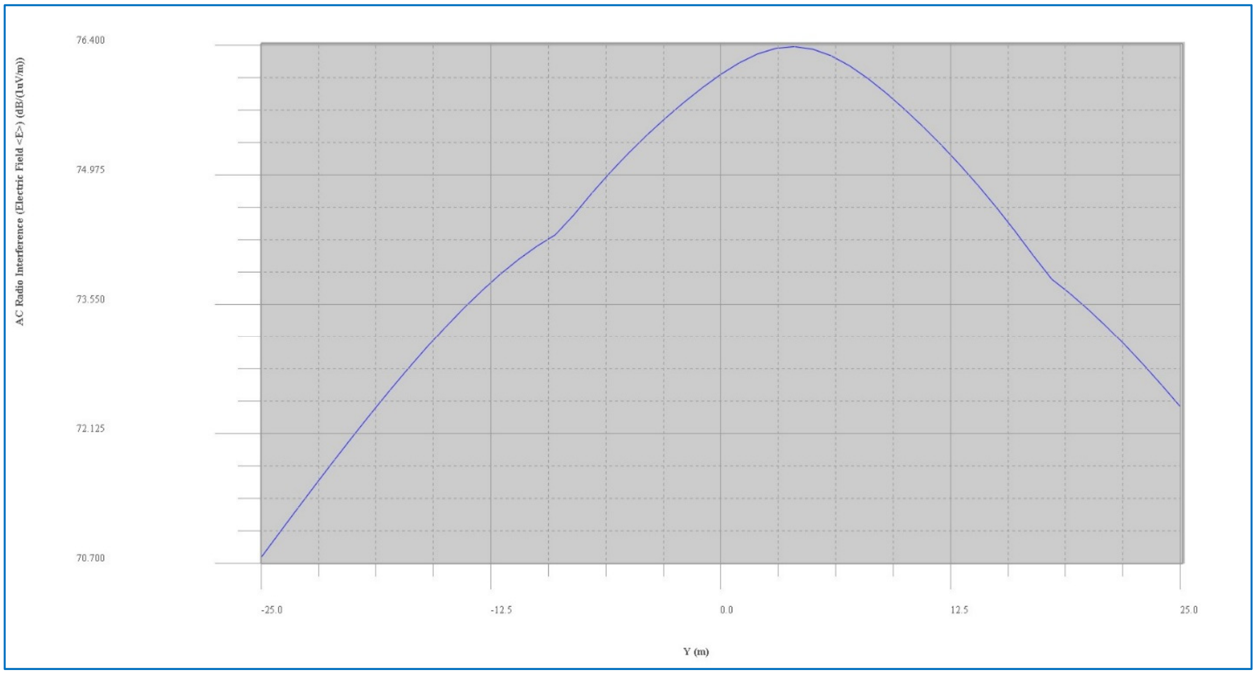


Appendix B - Figure 1 - AC Electric Field level at 1m above ground based on distance from transmission line center line



Appendix B - Figure 2 – Radio Interference level in heavy rain condition at 1m above ground based on distance from transmission line center line

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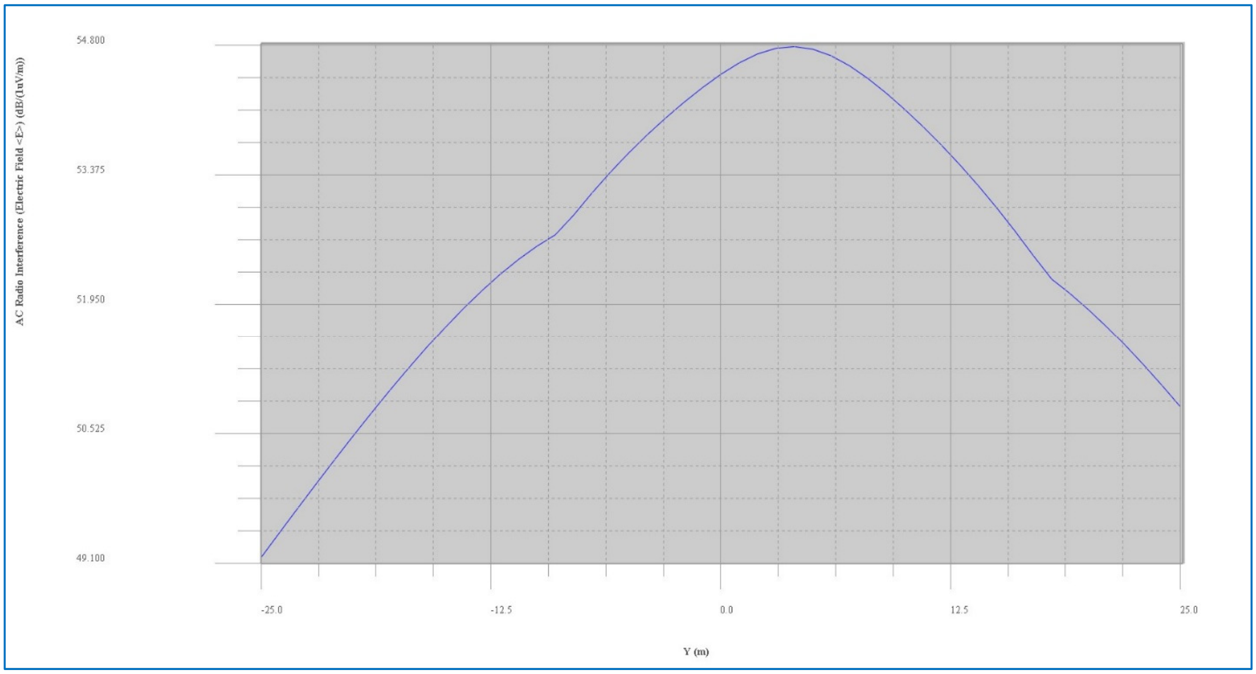
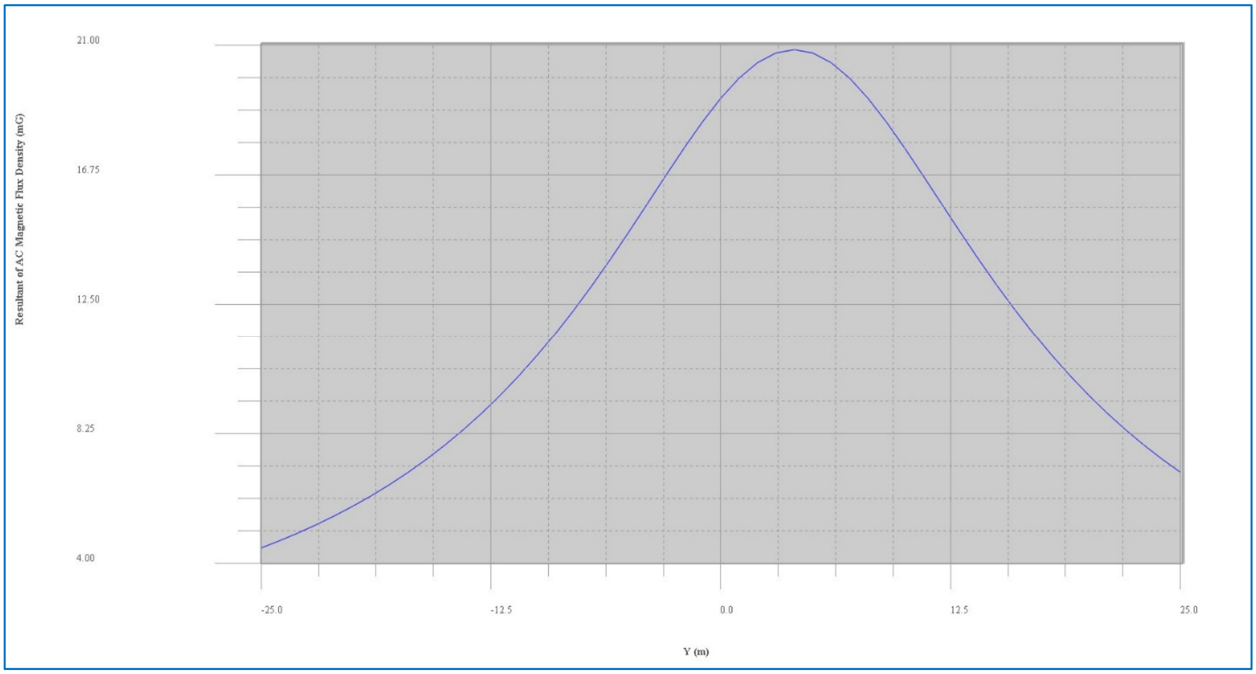
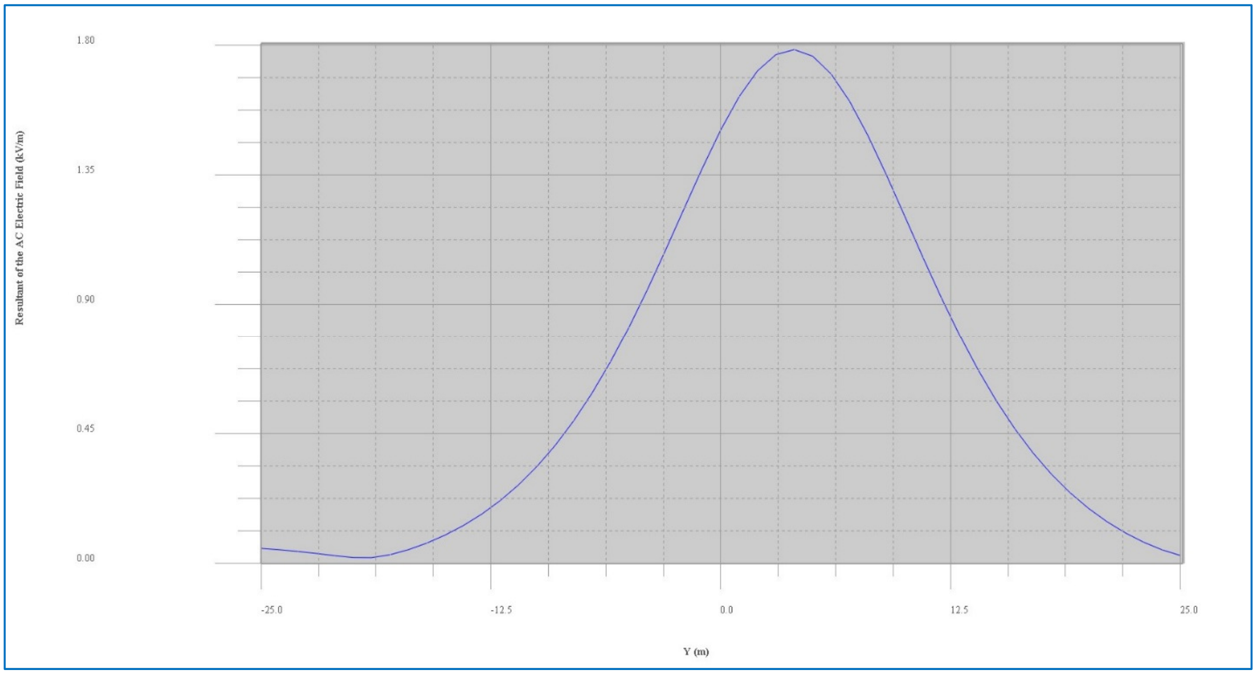


Appendix B - Figure 3 - Radio Interference level in dry condition at 1m above ground based on distance from transmission line center line

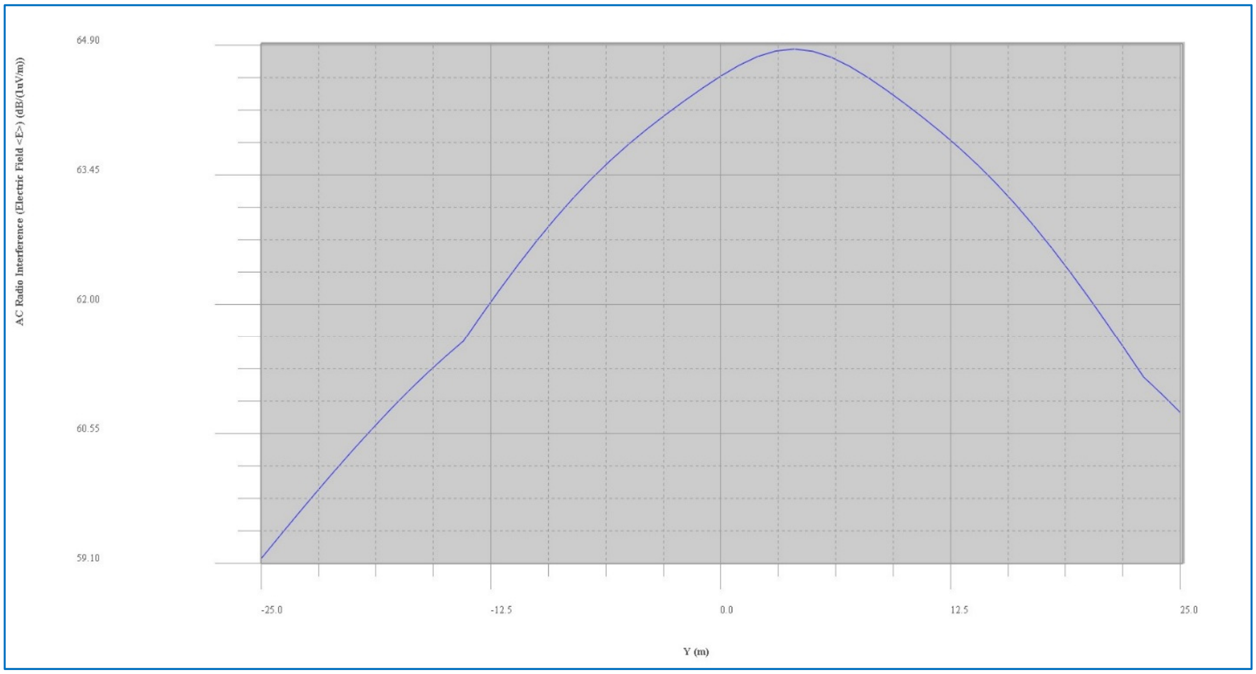


Appendix B - Figure 4 – Magnetic Field level at 1m above ground based on distance from transmission line center line

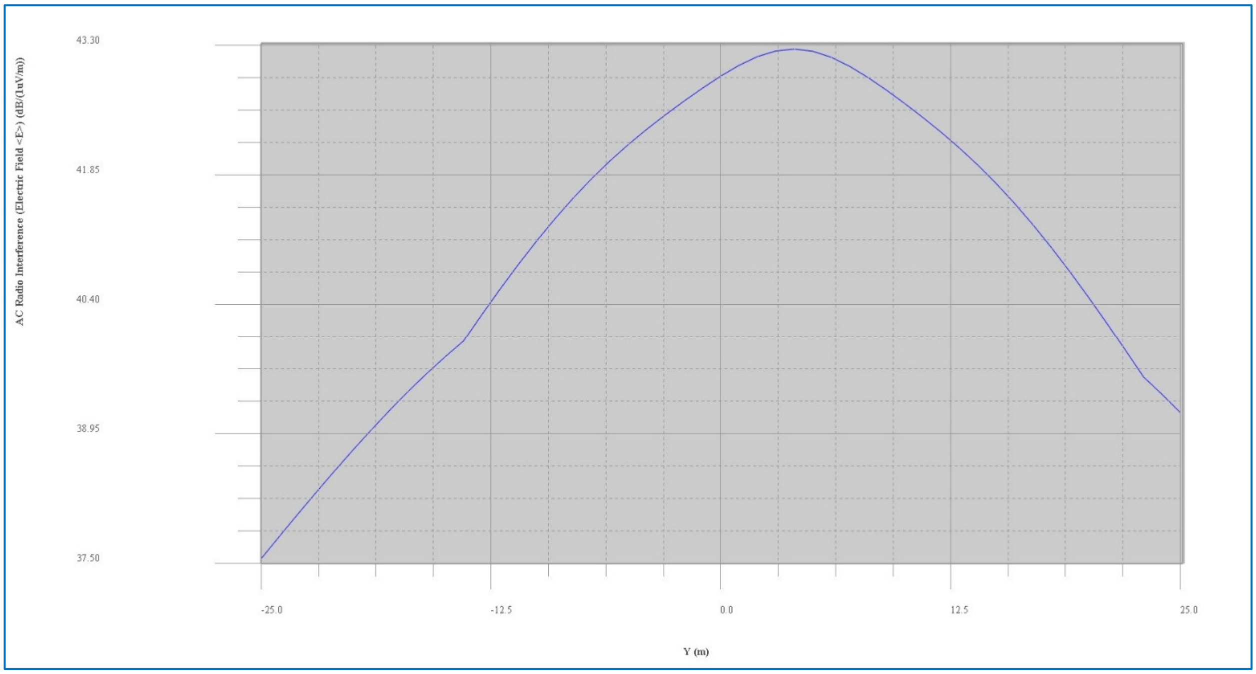
Appendix C Analysis results – Diagrams related to the table 5-2,



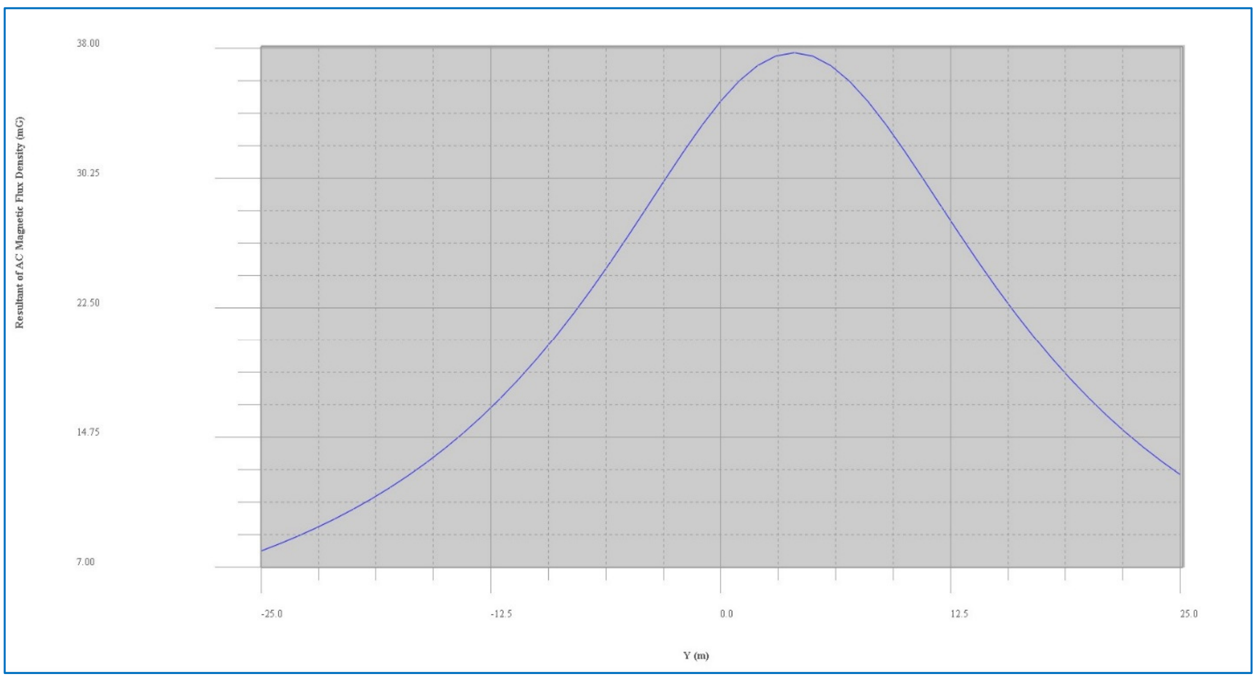
Appendix C - Figure 1: AC Electric Field level at 1m above ground based on distance from transmission line center line



Appendix C - Figure 2: Radio Interference level in heavy rain conditions at 1m above ground based on distance from transmission line center line



Appendix C - Figure 3 Radio Interference level in dry condition at 1m above ground based on distance from transmission line center line



Appendix C - Figure 4 – Magnetic Field level at 1m above ground based on distance from transmission line center line