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Via Electronic Mail and U.S. Mail

April 18, 2018

New Hampshire Site Evaluation Committee
Ms. Pamela Monroe, Administrator
21 South Fruit Street, Suite 10
Concord, NH 03301

New Hampshire Public Utilities Commission
Randall S. Knepper, P.E.,
Director, Safety Division
21 South Fruit Street, Suite 10
Concord, NH 03301

Re: SEC Docket No. 2015-05: Public Service Company of New Hampshire d/b/a Eversource Energy ("PSNH") and New England Power Company d/b/a National Grid ("NEP"): Joint Application for a Certificate of Site and Facility for the Merrimack Valley Reliability Project – Memorandum on Magnetic Field Meter Calibration

Dear Ms. Monroe and Mr. Knepper:

Enclosed for filing in the above-captioned docket, please find the Joint Applicants' Memorandum on Magnetic Field Meter Calibration to explain a potential calibration issue associated with the magnetic field measurements taken in January 2017. The Applicants will complete its required post-construction measurements consistent with the Committee's November 29, 2016 Order on Applicant's Motion for Clarification and Amended Order of Certificate of Site and Facility this summer.

Please do not hesitate to contact me with any questions.

Sincerely,

Adam M. Dumville

cc: SEC Distribution List
Mr. Robert J. Wyatt, NH PUC
Assistant Director, Safety Division

Electrical Engineering and Computer Science Practice

Exponent®

Eversource / National Grid Merrimack Valley Reliability Project

Memorandum – Magnetic Field Meter Calibration

Eversource / National Grid Merrimack Valley Reliability Project

Pre-Construction Measurements of Electric and Magnetic Field Levels

Prepared for

New Hampshire Public Utilities Commission
21 South Fruit Street
Concord, NH 03301

On behalf of

Public Service of New Hampshire
PSNH Energy Park
780 N Commercial Street
Manchester, NH 03101

and

National Grid
40 Sylvan Road
Waltham, MA 02451

Prepared by

Exponent
17000 Science Drive, Suite 200
Bowie, MD 20715

April 17, 2018

1406734.001 - 2398

Background

National Grid and Eversource submitted *"Eversource / National Grid Merrimack Valley Reliability Project Pre-Construction Measurements of Electric and Magnetic Field Levels"* (Exponent Report) to the New Hampshire Site Evaluation Committee (NHSEC) and the New Hampshire Public Utilities Commission to fulfill the November 29, 2016 amended NHSEC Order regarding a condition for pre-construction measurements of electric and magnetic fields (EMF). The report included measurements of EMF at 16 separate locations along the route of the MVRP transmission line, all of which were performed in January, 2017. The magnetic field measurements on these site visits were taken with an EMDEX II meter manufactured by Entertech Consultants.

Exponent's magnetic field meter is returned to EMDEX LLC every year for a calibration check, and in the past, was found to be within the manufacturer's specification. When the meter was returned for calibration in the fall of 2017, it was determined that the performance of the meter was outside of the ± 2% range of accuracy guaranteed by Entertech. Specifically, the EMDEX II under reported the magnetic field level measured by the x-axis coil (B_x) by up to 6%, by the y-axis coil (B_y) by up to 10%, and by the z-axis coil (B_z) by up to 19%.[1] The magnetic fields in the Exponent Report are expressed as the resultant of the magnetic fields measured by each coil computed as $\sqrt{B_x^2 + B_y^2 + B_z^2}$. It is unknown when the deviation from the manufacturer's calibrated performance occurred. The MVRP measurements were taken during January, 2017 approximately 6 months after the last calibration check. While we cannot ascertain when the calibration of the meter fell outside the ± 2% range of accuracy, the measurements taken in January 2017 may have been made when the meter was out-of-calibration.

We have reviewed the Exponent Report to determine which magnetic field measurements potentially might have been affected if the meter was out-of-calibration, and in an abundance of caution evaluated the potential effect on the measurements if the unit was out-of-calibration at the time the measurements were taken. The results are discussed below.

[1] The electric field measurements were found to be within the manufacturer's specification.

Pre-Construction Magnetic Field Levels

The magnetic field measurements are summarized most succinctly in Appendix A, Table A-1 and are reproduced below.[2] Table entries potentially affected by the out-of-calibration are shown in red font within ( ). Above each of these values we show the scaled values (based upon the application of potential calibration deviations to measured magnetic field value) in bold font within [ ]. **Hereafter, all references to scaled values refer to previously measured magnetic fields adjusted to reflect a change in the calibration that might have occurred prior to the January measurements.** These scaled values were obtained by assuming the maximum percent error in each axis and computing scaled magnetic field values. As noted in the Exponent Report:

> The measured EMF levels are generally similar to or lower than those calculated from models because of the conservative assumptions used in the modeling, which are designed to ensure that reported field levels represent a high but accurate estimate of the field levels being modeled. The differences observed between the measured and calculated profiles can be attributed to simplifications present in the modeling, such as the assumption of level terrain, longitudinally uniform geometry, the lack of induced currents in shieldwires, and the presence of conductive objects on and adjacent to the ROW that serve to reduce electric-field levels.

The scaled values at all locations are slightly higher but quite similar to the measured magnetic fields originally reported. The comments and characterization of the measured EMF levels compared to the calculated levels presented in the original Exponent Report remain the same even when the measured values are scaled to account for possible out-of-calibration.

[2] Graphical and tabular presentations of these measurements and of measurements made at road crossings selected by the New Hampshire Public Utility Commission are summarized in an appendex attached to this memorandum and include revised Figures 4-7 from the main body of the Exponent Report as well as potentially affected portions of Appendix A (Table A-1) Appendix B (Figures B-1, B-3, B-5, B7, B-9, B-11, B13, B-15, B-17, and B-19) and road crossings in Appendix E (Figures E-7 through E-12). An ‘s’ has been appended to the name of each of these tables or figures to clearly differentiate them from those in the Exponent Report. For example Table A-1 from the Exponent Report is shown as Table A-1s in the attached appendix.

Table 1. Original magnetic field values extracted from Appendix A, Table A-1 of the Exponent Report and scaled values assuming meter was out-of-calibration.

Section Number	Condition	Distance from Centerline of ROW		
		-ROW Edge	Max on ROW	+ROW Edge
8b	**Scaled Magnetic Field Values**	**[22]**	**[124]**	**[2.5]**
	Originally-Measured Field (1/12/2017)	(19)	(111)	(2.1)
8c	**Scaled Magnetic Field Values**	**[13]**	**[56]**	**[2.0]**
	Originally-Measured Field (1/16/2017)	(11)	(51)	(1.8)
8d	**Scaled Magnetic Field Values**	**[14]**	**[45]**	**[5.0]**
	Originally-Measured Field (1/13/2017)	(12)	(40)	(4.4)
9	**Scaled Magnetic Field Values**	**[19]**	**[72]**	**[5.5]**
	Originally-Measured Field (1/13/2017)	(16)	(64)	(4.7)
10	**Scaled Magnetic Field Values**	**[14]**	**[50]**	**[0.5]**
	Originally-Measured Field (1/25/2017)	(12)	(45)	(0.4)
11	**Scaled Magnetic Field Values**	n/a	**[60]**	**[15]**
	Originally-Measured Field (1/27/2017)		(54)	(13)
12	**Scaled Magnetic Field Values**	n/a	**[123]**	**[4.3]**
	Originally-Measured Field (1/20/2017)		(108)	(3.8)
13	**Scaled Magnetic Field Values**	**[24]**	**[123]**	**[7.6]**
	Originally-Measured Field (1/19/2017)	(20)	(110)	(6.5)
14	**Scaled Magnetic Field Values**	**[17]**	**[64]**	**[6.2]**
	Originally-Measured Field (1/20/2017)	(14)	(57)	(5.5)
15	**Scaled Magnetic Field Values**	**[20]**	**[88]**	**[8.2]**
	Originally-Measured Field (1/19/2017)	(17)	(79)	(7.2)

Conclusion

The EMDEX II magnetic field measurements included in the Exponent Report may have been outside the specified ± 2% range of accuracy of the magnetic field meter guaranteed by Entertech. If the measurements were taken when the meter was out-of-calibration, the potential inaccuracy leads only to a slight change in the reported magnetic field values and does not alter the overall conclusions of the Exponent Report.

The Exponent Report gave four conclusions, three of which related to magnetic field measurements and one related to modeling. While the measured magnetic field values will be increased slightly if calibration scaling is applied, none of the conclusions of the report are qualitatively affected by this scaling. The conclusions are excerpted below for reference.

> Measured magnetic-field levels are very similar to or lower than modeled levels and measured electric-field levels are consistently lower than modeled levels due to the shielding effect of trees, brush, terrain, and structures found on the ROW and beyond. **[Conclusion unchanged]**
>
> A comparison of the values calculated from the As-Measured – Adjusted to Peak Model to those provided in the Application at peak loading also show that the EMF levels from the existing transmission lines on the Project route are similar to or lower than those presented in the Application. The lower EMF values are primarily due to higher conductor heights at the measurement sites compared to lower conductor heights conservatively assumed in the Application. **[Conclusion unchanged and unaffected by measurement calibration]**
>
> The measured EMF levels are generally similar to or lower than those calculated from models because of the conservative assumptions used in the modeling, which are designed to ensure that reported field levels represent a high but accurate estimate of the field levels being modeled. The differences observed between the measured and calculated profiles can be attributed to simplifications present in the modeling, such as the assumption of level terrain, longitudinally uniform geometry, the lack of induced currents in shieldwires, and the presence of

conductive objects on and adjacent to the ROW that serve to reduce electric-field levels. **[Conclusion unchanged]**

Measured and calculated EMF levels at all locations on the Project route are far below health-based standards and guidelines developed by the International Commission on Non-Ionizing Radiation Protection and the International Committee for Electromagnetic Safety and were found to be below levels that would cause exceedance of Basic Restrictions on public exposure discussed in the Application. In addition the demonstrated agreement between modeling and measurements confirms the reasonableness of the input data used to model EMF from the existing lines (pre-construction) and accuracy of the modeling approach followed in the Application. **[Conclusion unchanged]**

Revised Figures from the Body of the Report

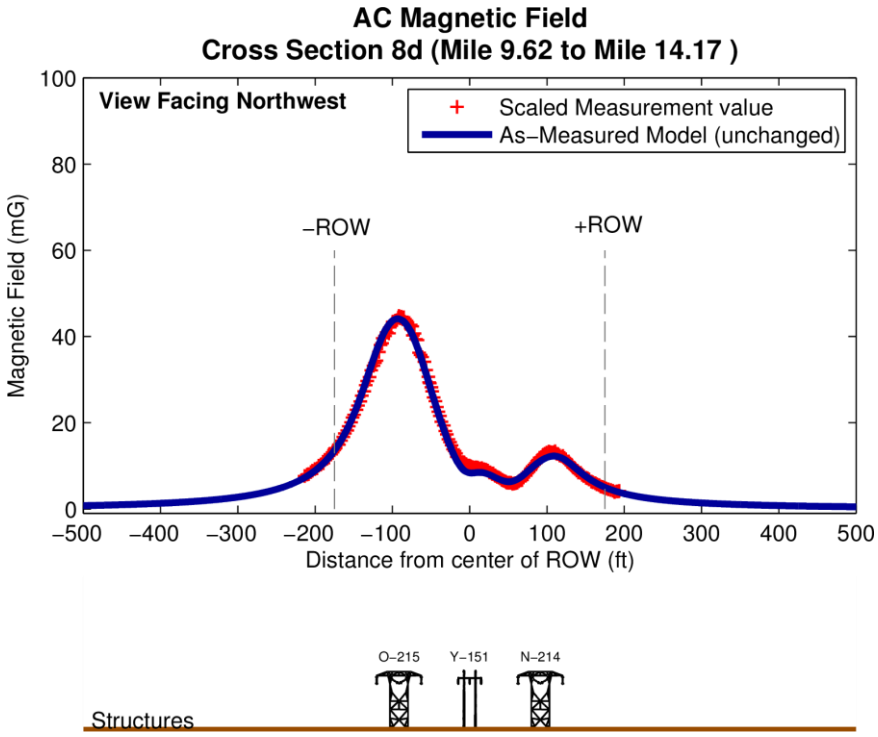

Figure 3s. Comparison of measurements at Site 3 (XS-8d) with calculations from the As-Measured Model (unchanged from the original Exponent Report).

Electric field measurements were unaffected by the calibration and so are not included here.

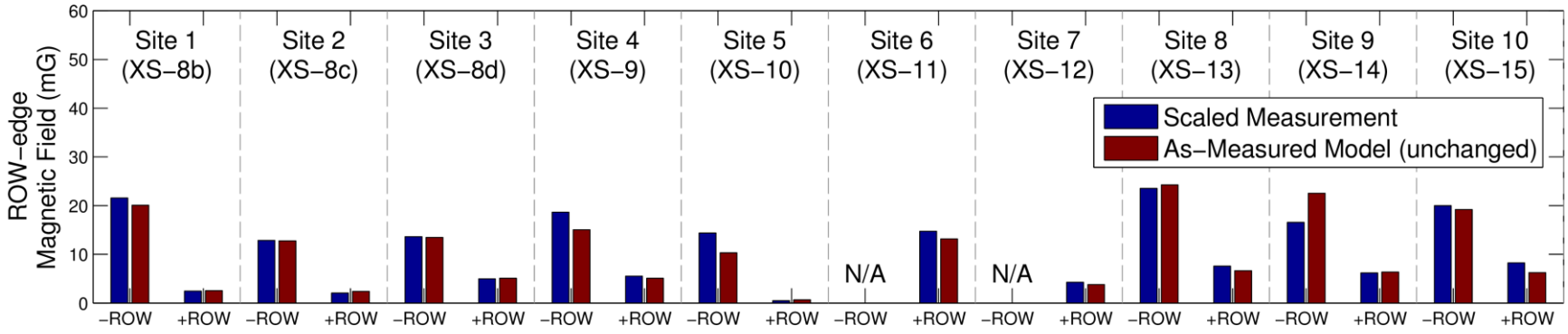

Figure 4s. Comparison of scaled measurement values and modeled magnetic field levels at the ROW edges. The As-Measured Model is unchanged from the original Exponent Report

Electric field measurements were unaffected by the calibration and so are not included here.

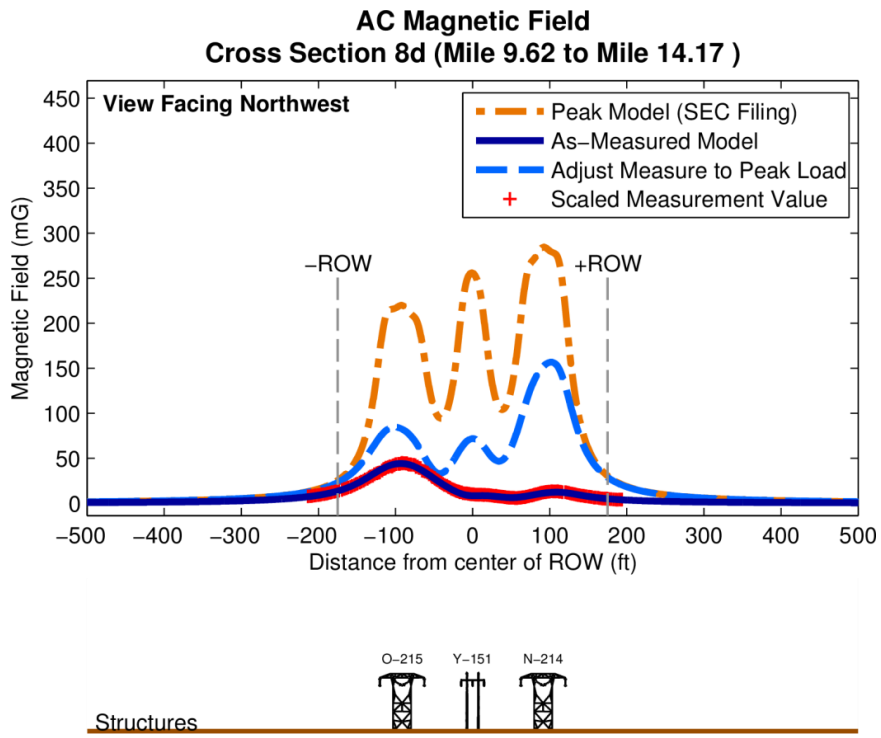

Figure 5s. Comparison of scaled measurement values at Site 3 (XS-8d) with calculations from the As-Measured Model, the As-Measured – Adjusted to Peak Model and the calculations (at annual-peak loading) provided in the Application. The three models are unchanged from the original Exponent Report

Electric field measurements were unaffected by the calibration and so are not included here.

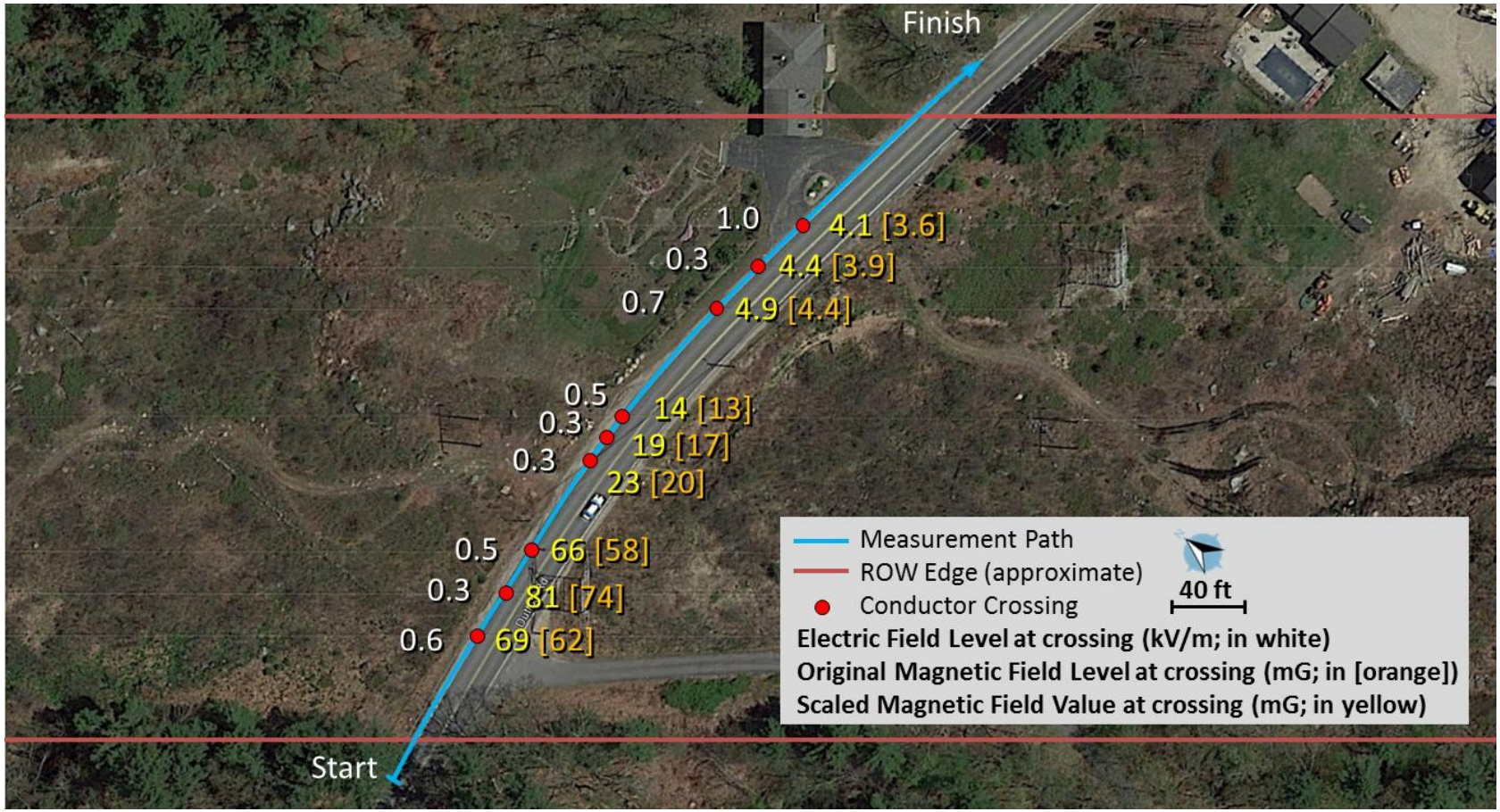

Figure 6s. PUC Road Crossing 1: Dutton Road in Pelham.

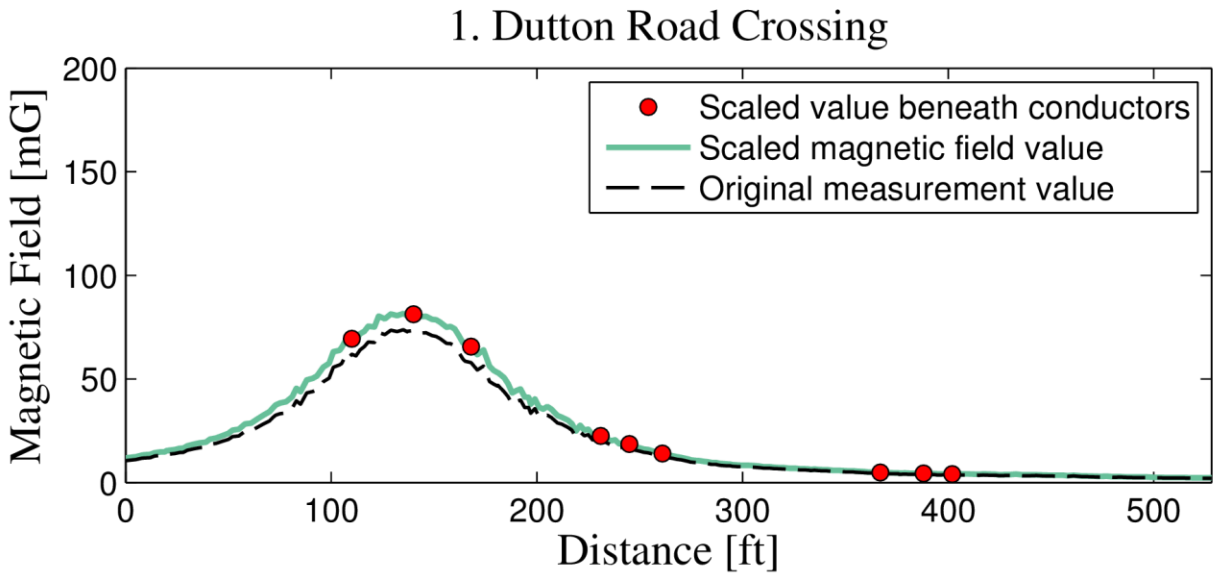

Figure 7s. Detailed Magnetic field measurement results recorded at PUC Road Crossing 1: Dutton Road in Pelham. Both the original measurement values and scaled measurement values are shown.

Electric field measurements were unaffected by the calibration and so are not included here.

Revised Summary Table of Measured and Calculated Magnetic Field Levels

Table A-1s. Original magnetic field values extracted from Appendix A, Table A-1 of the Exponent Report and scaled values assuming meter was out-of-calibration

Section Number	Condition	Distance from Centerline of ROW				
		- ROW Edge -100 ft	**-ROW Edge**	**Max on ROW**	**+ROW Edge**	**+ROW Edge +100 ft**
8b	Pre-Project (average line height and load)	1.4	6.2	52	5.5	1.3
	Pre-Project (minimum line height and peak load)	4.7	21	297	26	5.5
	Scaled Magnetic Field Values Originally-Measured Field (1/12/2017)	n/a	**[22]** (19)	**[124]** (111)	**[2.5]** (2.1)	n/a
	Modeled Field (for measured line height and load on 1/12/2017)	4.3	20	118	2.4	1.2
	Modeled Field (for line height and load adjusted to peak conditions)	4.7	21	238	24	5.4
8c	Pre-Project (average line height and load)	1.4	6.2	71	5.5	1.4
	Pre-Project (minimum line height and peak load)	4.8	21	311	26	5.5
	Scaled Magnetic Field Values Originally-Measured Field (1/16/2017)	n/a	**[13]** (11)	**[56]** (51)	**[2.0]** (1.8)	n/a
	Modeled Field (for measured line height and load on 1/16/2017)	3.0	13	55	2.4	1.0
	Modeled Field (for line height and load adjusted to peak conditions)	4.6	20	165	22	5.2
8d	Pre-Project (average line height and load)	1.9	7.3	60	6.6	1.8
	Pre-Project (minimum line height and peak load)	6.5	25	285	30	7.3
	Scaled Magnetic Field Values Originally-Measured Field (1/13/2017)	n/a	**[14]** (12)	**[45]** (40)	**[5.0]** (4.4)	n/a
	Modeled Field (for measured line height and load on 1/13/2017)	3.5	14	44	5.0	1.7
	Modeled Field (for line height and load adjusted to peak conditions)	6.4	23	157	29	7.2
9	Pre-Project (average line height and load)	1.6	6.5	34	5.7	1.4
	Pre-Project (minimum line height and peak load)	5.3	23	292	28	6.1
	Scaled Magnetic Field Values Originally-Measured Field (1/13/2017)	n/a	**[19]** (16)	**[72]** (64)	**[5.5]** (4.7)	n/a
	Modeled Field (for measured line height and load on 1/13/2017)	3.6	15	67	5.1	1.7
	Modeled Field (for line height and load adjusted to peak conditions)	5.1	21	198	26	6.0
10	Pre-Project (average line height and load)	0.7	5.3	151	6.0	2.4
	Pre-Project (minimum line height and peak load)	4.2	20	261	5.6	1.9
	Scaled Magnetic Field Values Originally-Measured Field (1/25/2017)	n/a	**[14]** (12)	**[50]** (45)	**[0.5]** (0.4)	n/a
	Modeled Field (for measured line height and load on 1/25/2017)	2.4	10	43	0.6	0.3
	Modeled Field (for line height and load adjusted to peak conditions)	4.0	18	194	5.8	2.0

Section Number	Condition	Distance from Centerline of ROW				
		- ROW Edge -100 ft	**-ROW Edge**	**Max on ROW**	**+ROW Edge**	**+ROW Edge +100 ft**
11	Pre-Project (average line height and load)	7.6	28	139	10	2.1
	Pre-Project (minimum line height and peak load)	11	44	234	30	3.0
	Scaled Magnetic Field Values Originally-Measured Field (1/27/2017)	n/a	n/a	**[60]** (54)	**[15]** (13)	n/a
	Modeled Field (for measured line height and load on 1/27/2017)	5.5	20	66	13	2.9
	Modeled Field (for line height and load adjusted to peak conditions)	11	43	186	32	5.7
12	Pre-Project (average line height and load)	3.5	7.6	140	3.3	1.1
	Pre-Project (minimum line height and peak load)	5.1	11	233	7.3	1.7
	Scaled Magnetic Field Values Originally-Measured Field (1/20/2017)	n/a	n/a	**[123]** (108)	**[4.3]** (3.8)	n/a
	Modeled Field (for measured line height and load on 1/20/2017)	1.6	4.1	108	2.8	0.6
	Modeled Field (for line height and load adjusted to peak conditions)	5.1	11	240	7.5	1.7
13	Pre-Project (average line height and load)	7.6	29	140	11	0.8
	Pre-Project (minimum line height and peak load)	11	44	234	20	1.7
	Scaled Magnetic Field Values Originally-Measured Field (1/19/2017)	n/a	**[24]** (20)	**[123]** (110)	**[7.6]** (6.5)	n/a
	Modeled Field (for measured line height and load on 1/19/2017)	5.5	25	127	6.5	0.6
	Modeled Field (for line height and load adjusted to peak conditions)	11	45	224	18	1.7
14	Pre-Project (average line height and load)	7.7	29	140	3.1	1.3
	Pre-Project (minimum line height and peak load)	11	44	234	8.7	1.6
	Scaled Magnetic Field Values Originally-Measured Field (1/20/2017)	n/a	**[17]** (14)	**[64]** (57)	**[6.2]** (5.5)	n/a
	Modeled Field (for measured line height and load on 1/20/2017)	4.4	18	66	2.5	0.5
	Modeled Field (for line height and load adjusted to peak conditions)	11	39	134	7.7	1.7
15	Pre-Project (average line height and load)	7.6	29	140	7.5	0.9
	Pre-Project (minimum line height and peak load)	11	44	234	15	1.6
	Scaled Magnetic Field Values Originally-Measured Field (1/19/2017)	n/a	**[20]** (17)	**[88]** (79)	**[8.2]** (7.2)	n/a
	Modeled Field (for measured line height and load on 1/19/2017)	4.0	19	88	4.5	0.9
	Modeled Field (for line height and load adjusted to peak conditions)	12	45	167	10	1.4

Table A-2. Electric-field levels (NO CHANGES FROM ORIGINAL)

Revised Graphical Profiles including Scaled Magnetic Field Measurements and Original Calculated Magnetic Field Levels at Cross Section Sites

Site 1

Measurements at Site 1 (cross section XS-8b) were performed on January 12, 2017. A graphical summary of results are presented below.

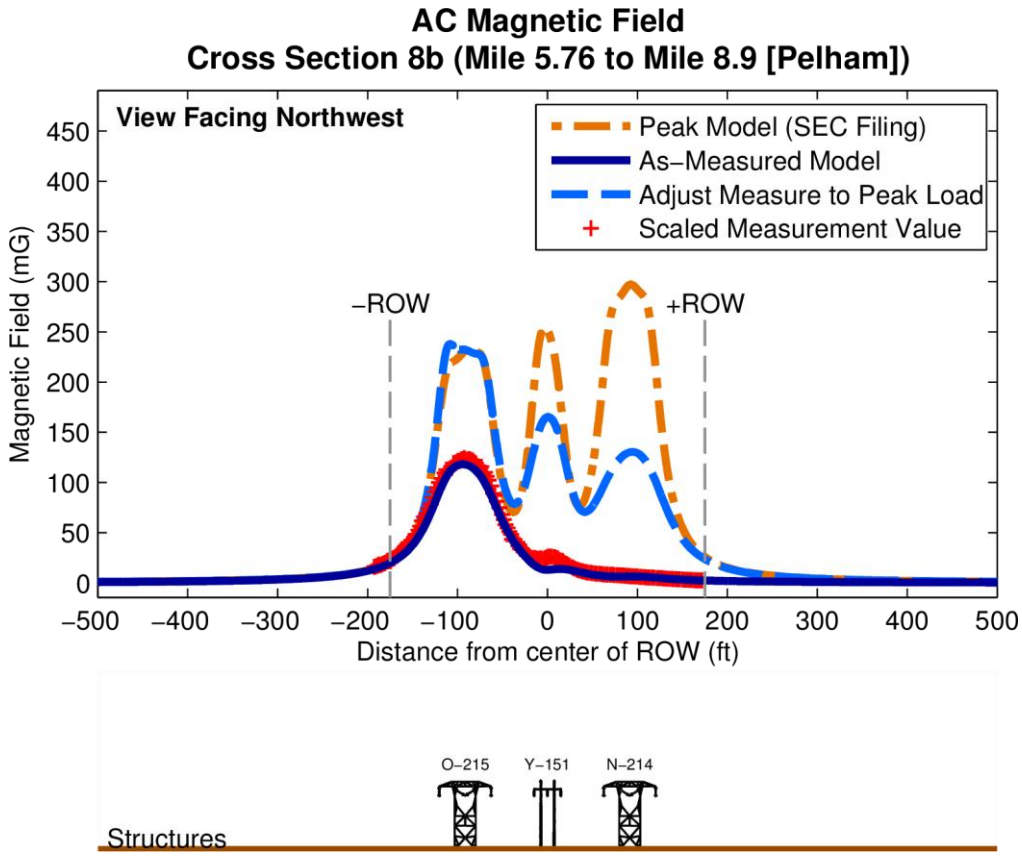

Figure B-1s. Scaled measurement values and modeled magnetic-field levels at Site 1 in XS-8b. The three models are unchanged from the original Exponent Report.

Electric field measurements were unaffected by the calibration and so are not included here.

Site 2

Measurements at Site 2 (cross section XS-8c) were performed on January 16, 2017. A graphical summary of results are presented below.

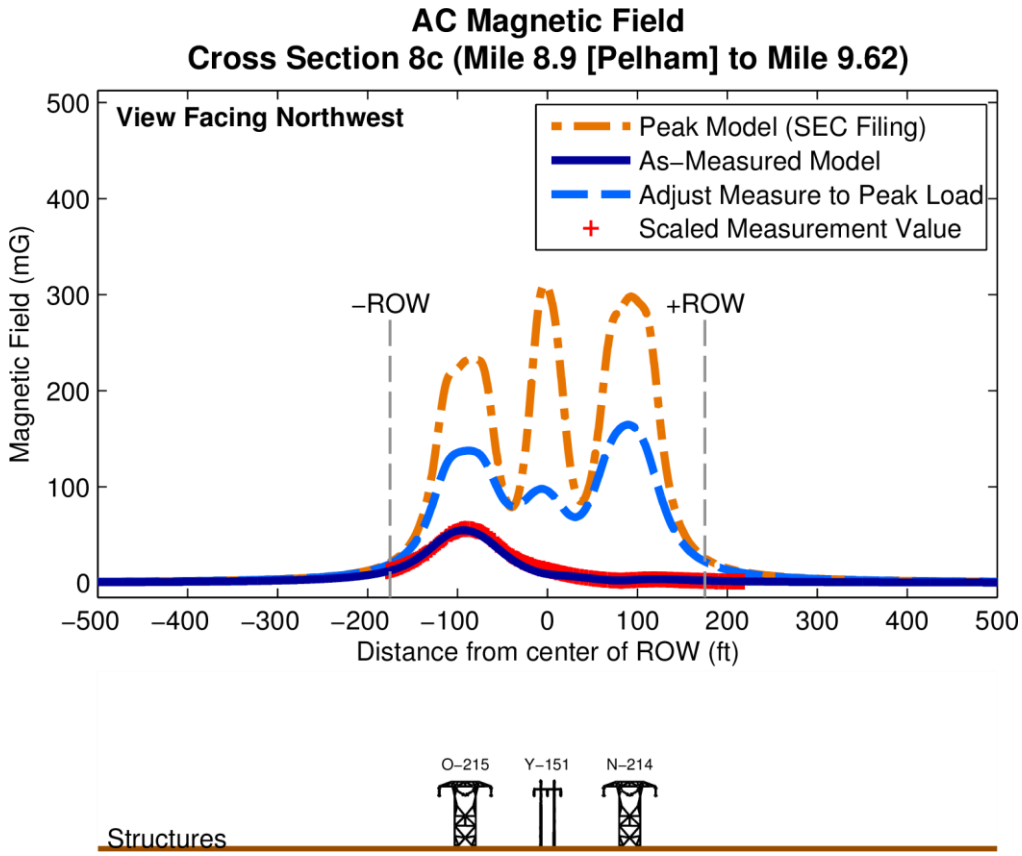

Figure B-3s. Scaled measurement values and modeled magnetic-field levels at Site 2 in XS-8c. The three models are unchanged from the original Exponent Report.

Electric field measurements were unaffected by the calibration and so are not included here.

Site 3

Measurements at Site 3 (cross section XS-8d) were performed on January 13, 2017. A graphical summary of results are presented below.

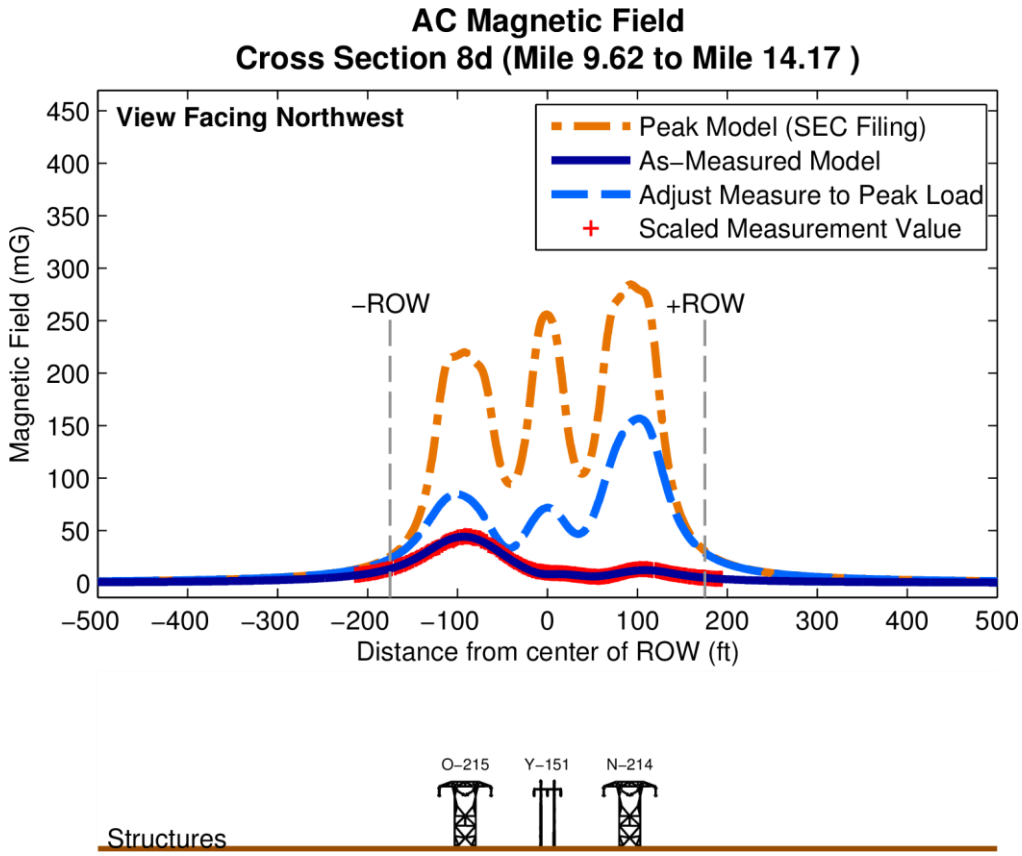

Figure B-5s. Scaled measurement values and modeled magnetic-field levels at Site 3 in XS-8d. The three models are unchanged from the original Exponent Report.

Electric field measurements were unaffected by the calibration and so are not included here.

Site 4

Measurements at Site 4 (cross section XS-9) were performed on January 13, 2017. A graphical summary of results are presented below.

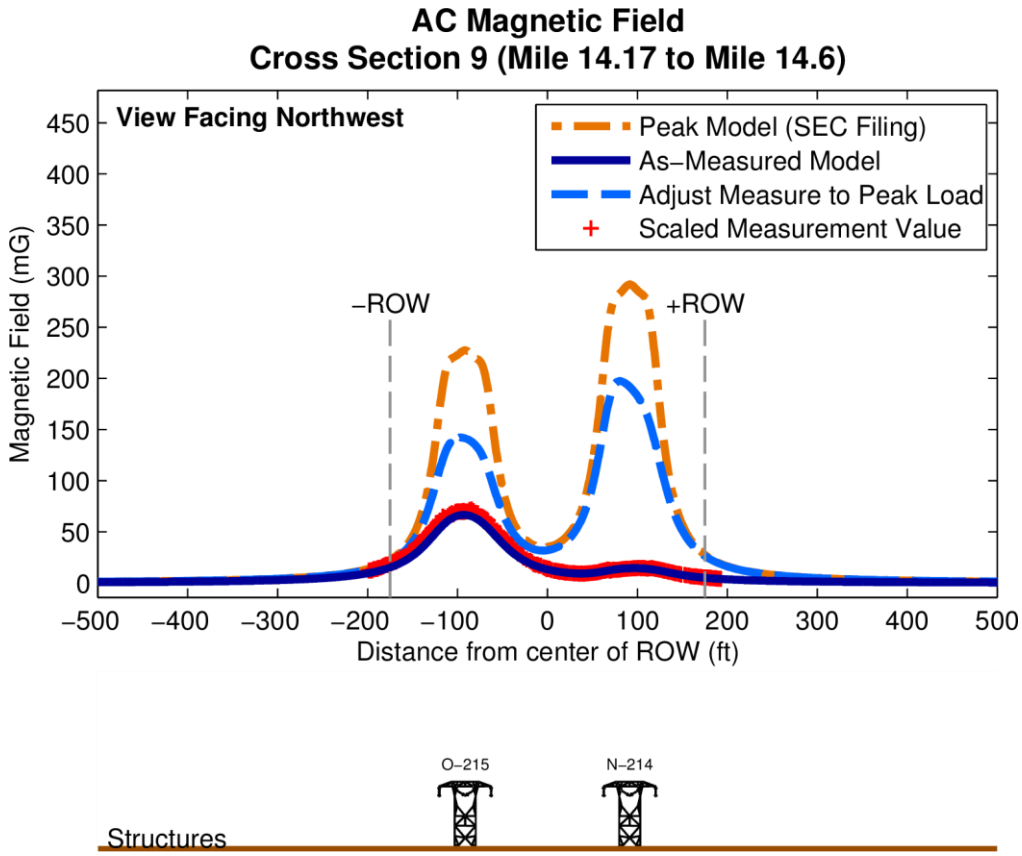

Figure B-7s. Scaled measurement values and modeled magnetic-field levels at Site 4 in XS-9. The three models are unchanged from the original Exponent Report.

Electric field measurements were unaffected by the calibration and so are not included here.

Site 5

Measurements at Site 5 (cross section XS-10) were performed on January 25, 2017. A graphical summary of results are presented below.

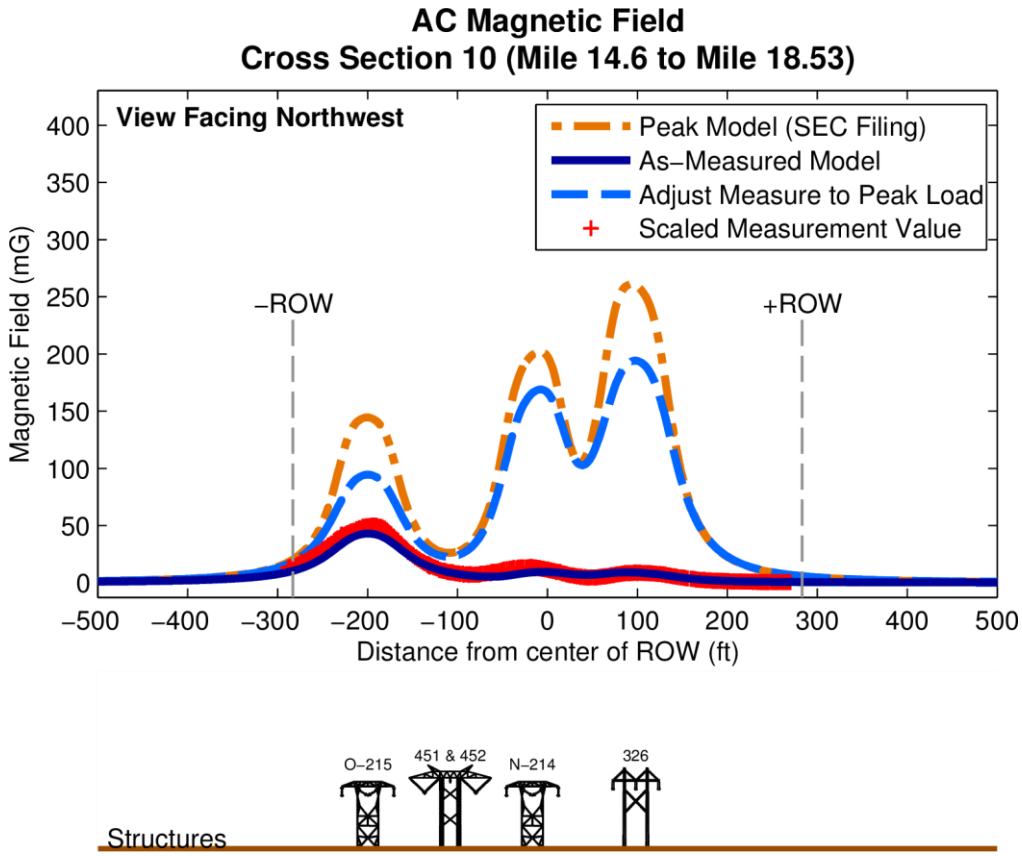

Figure B-9s. Scaled measurement values and modeled magnetic-field levels at Site 5 in XS-10. The three models are unchanged from the original Exponent Report.

Electric field measurements were unaffected by the calibration and so are not included here.

Site 6

Measurements at Site 6 (cross section XS-11) were performed on January 27, 2017. A graphical summary of results are presented below.

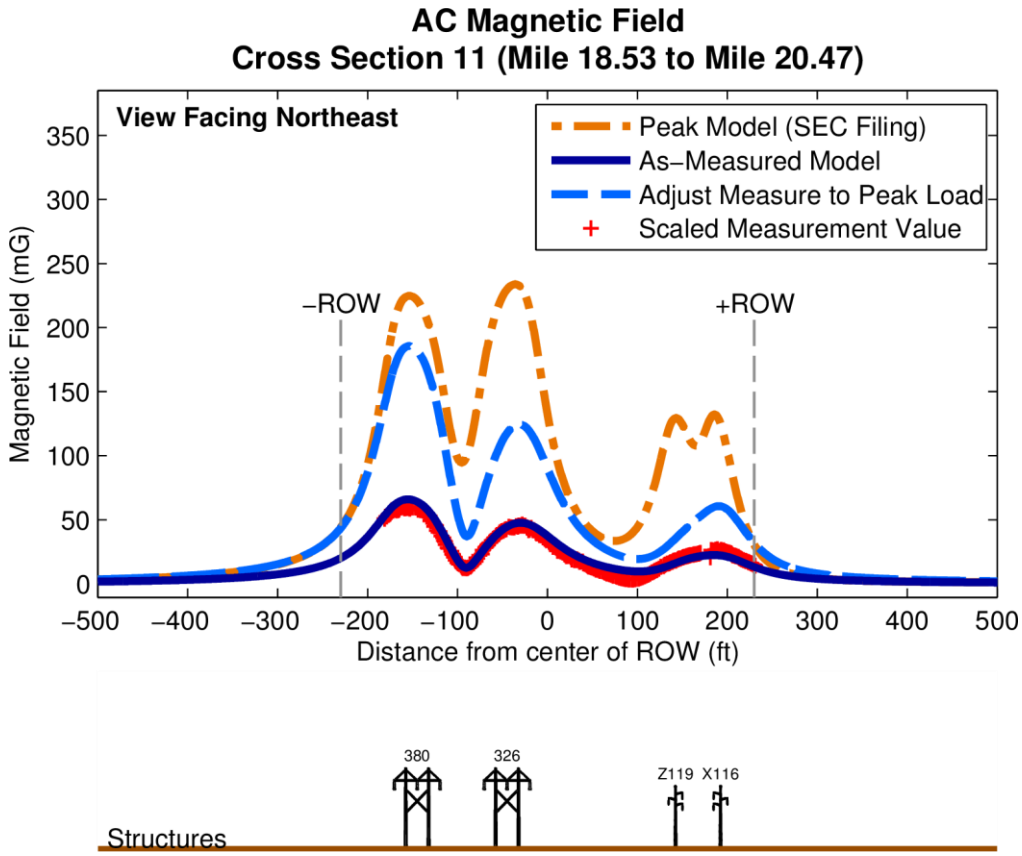

Figure B-11s. Scaled measurement values and modeled magnetic-field levels at Site 6 in XS-11. The three models are unchanged from the original Exponent Report.

Electric field measurements were unaffected by the calibration and so are not included here.

Site 7

Measurements at Site 7 (cross section XS-12) were performed on January 20, 2017. A graphical summary of results are presented below.

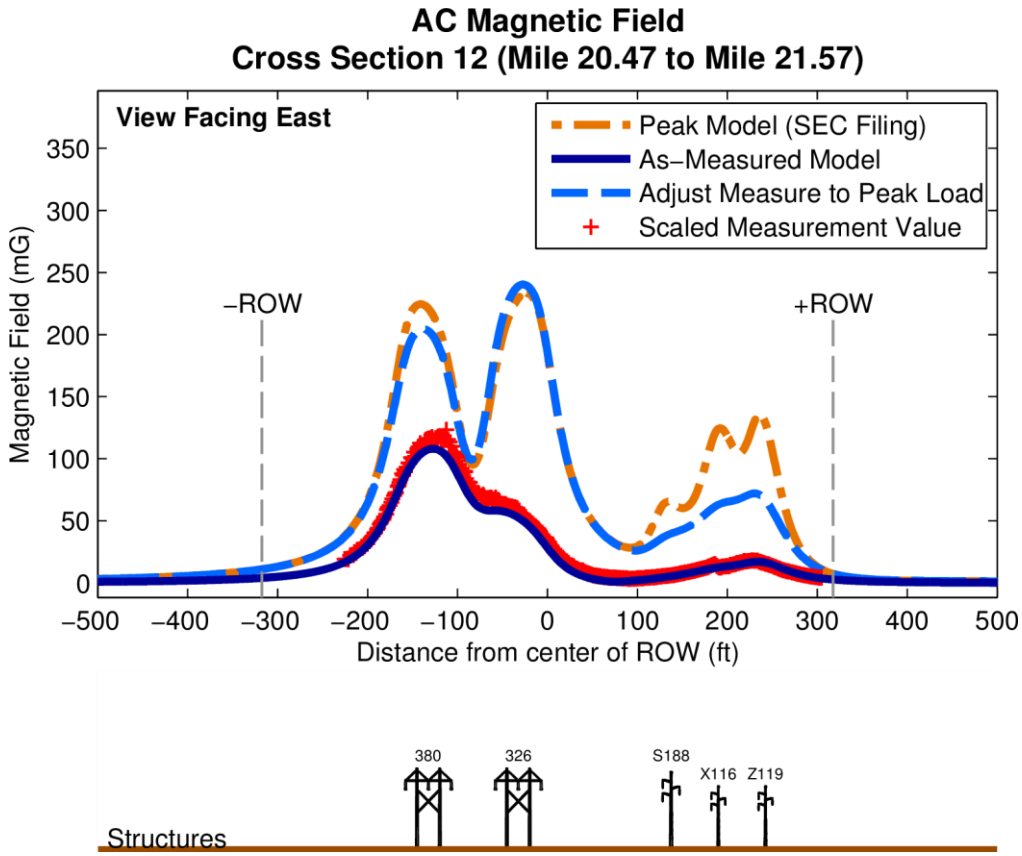

Figure B-13s. Scaled measurement values and modeled magnetic-field levels at Site 7 in XS-12. The three models are unchanged from the original Exponent Report.

Electric field measurements were unaffected by the calibration and so are not included here.

Site 8

Measurements at Site 8 (cross section XS-13) were performed on January 19, 2017. A graphical summary of results are presented below.

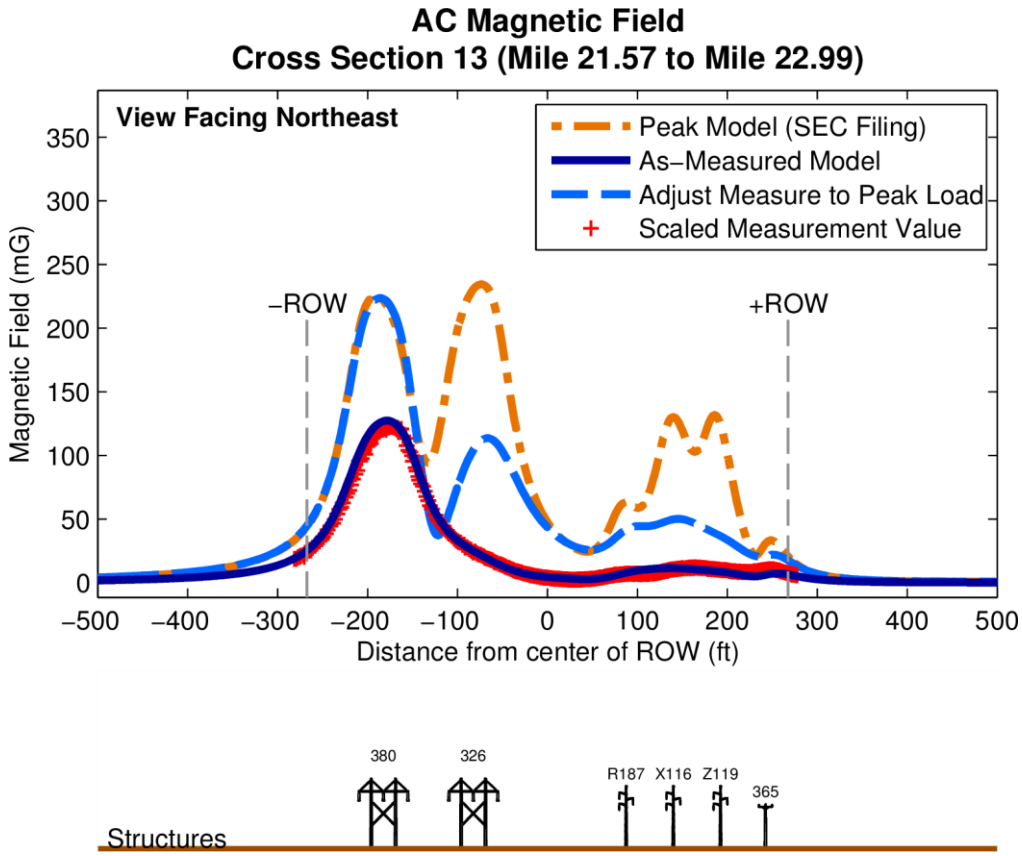

Figure B-15s. Scaled measurement values and modeled magnetic-field levels at Site 8 in XS-13. The three models are unchanged from the original Exponent Report.

Electric field measurements were unaffected by the calibration and so are not included here.

Site 9

Measurements at Site 9 (cross section 14) were performed on January 20, 2017. A graphical summary of results are presented below.

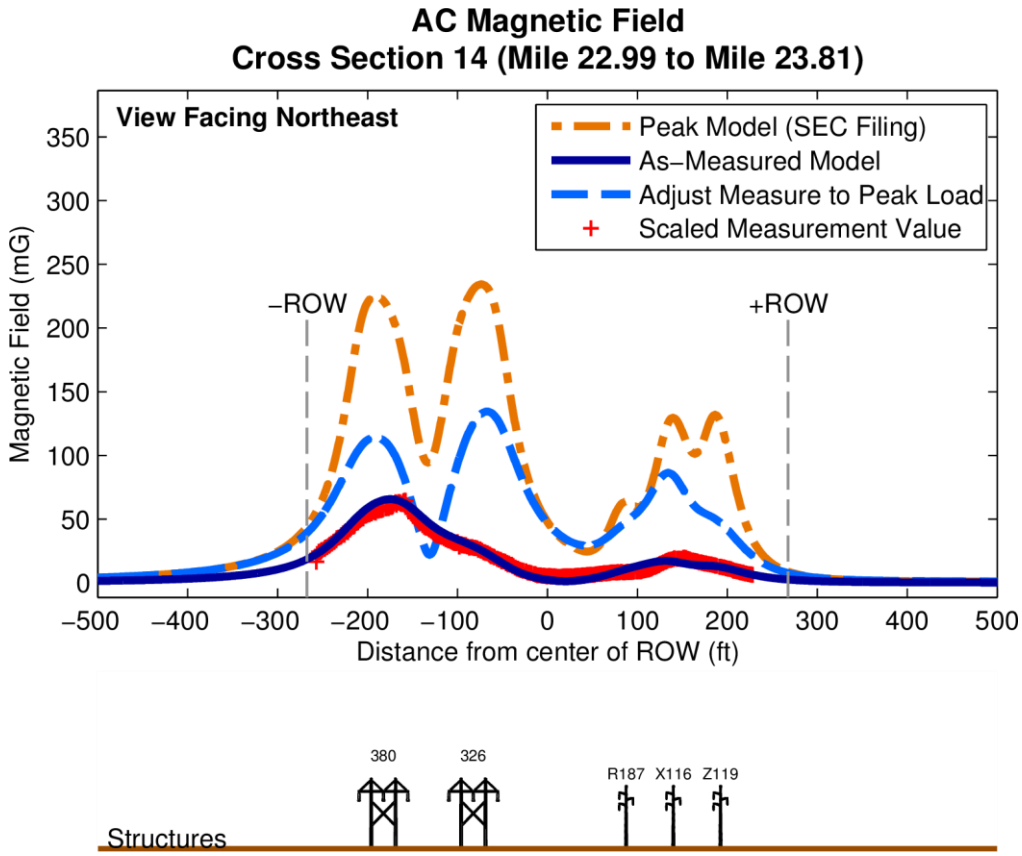

Figure B-17s. Scaled measurement values and modeled magnetic-field levels at Site 9 in XS-14. The three models are unchanged from the original Exponent Report.

Electric field measurements were unaffected by the calibration and so are not included here.

Site 10

Measurements at Site 10 (cross section XS-15) were performed on January 19, 2017. A graphical summary of results are presented below.

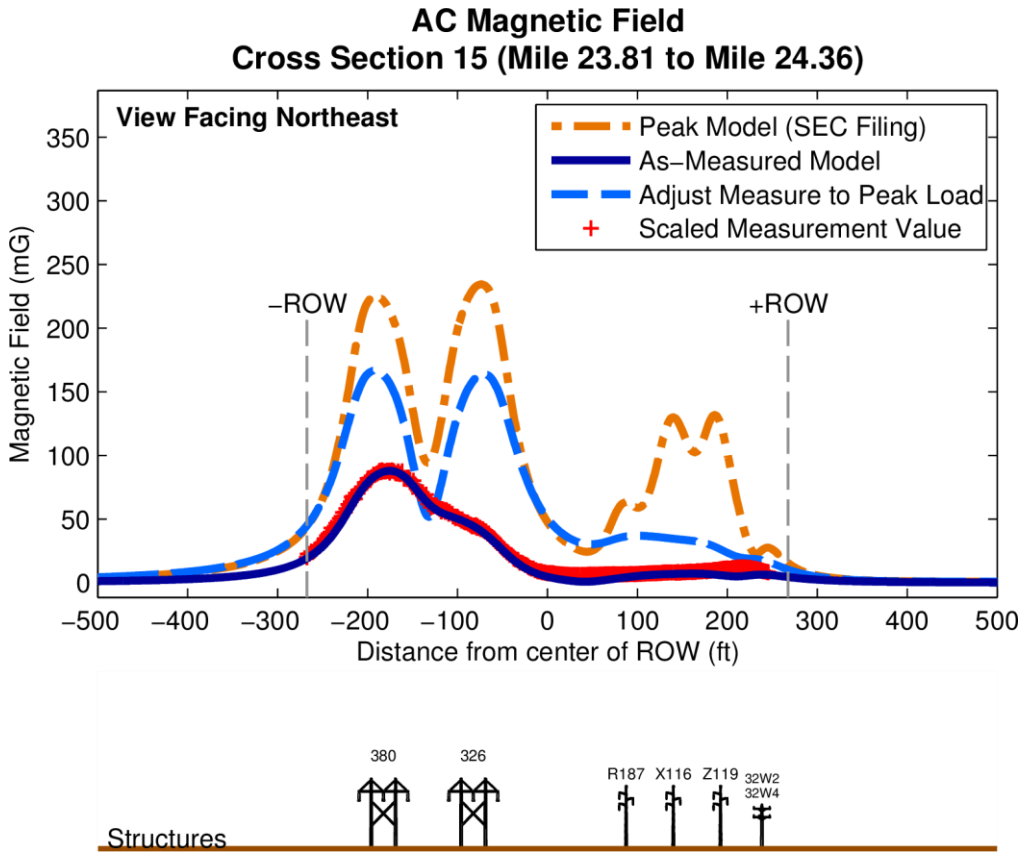

Figure B-19s. Scaled measurement values and modeled magnetic-field levels at Site 10 in XS-15. The three models are unchanged from the original Exponent Report.

Electric field measurements were unaffected by the calibration and so are not included here.

Scaled Magnetic Field Values from of Road Crossing Measurement Sites

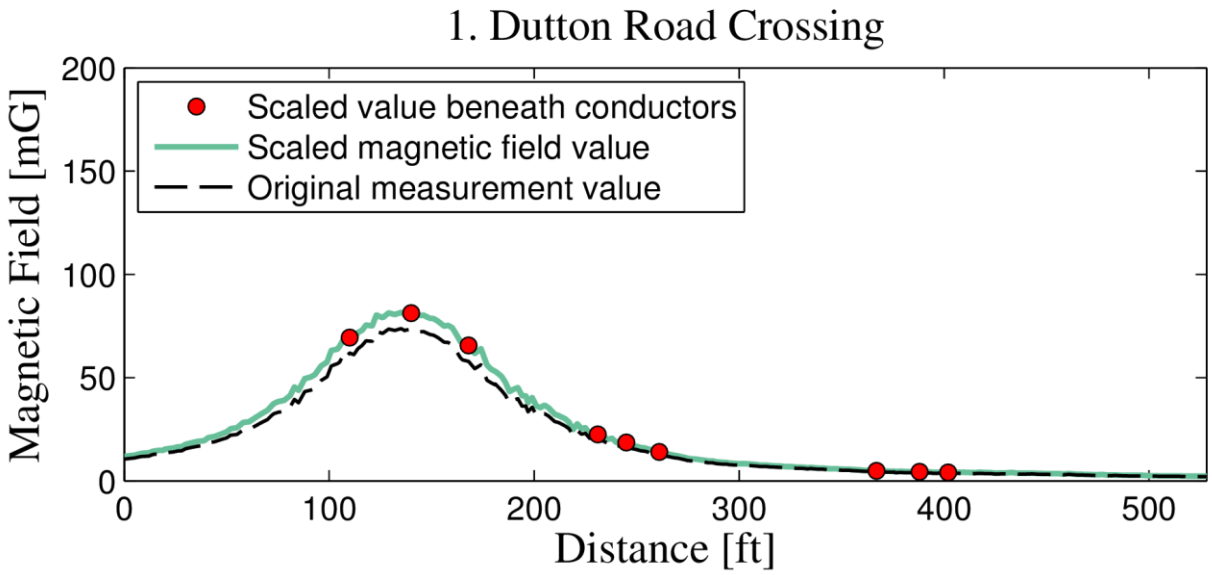

Figure E-7s. Detailed EMF measurements performed at PUC Site 1 (Dutton Road in XS-8b) . Both the original measurement values and scaled measurement values are shown.

Electric field measurements were unaffected by the calibration and so are not included here.

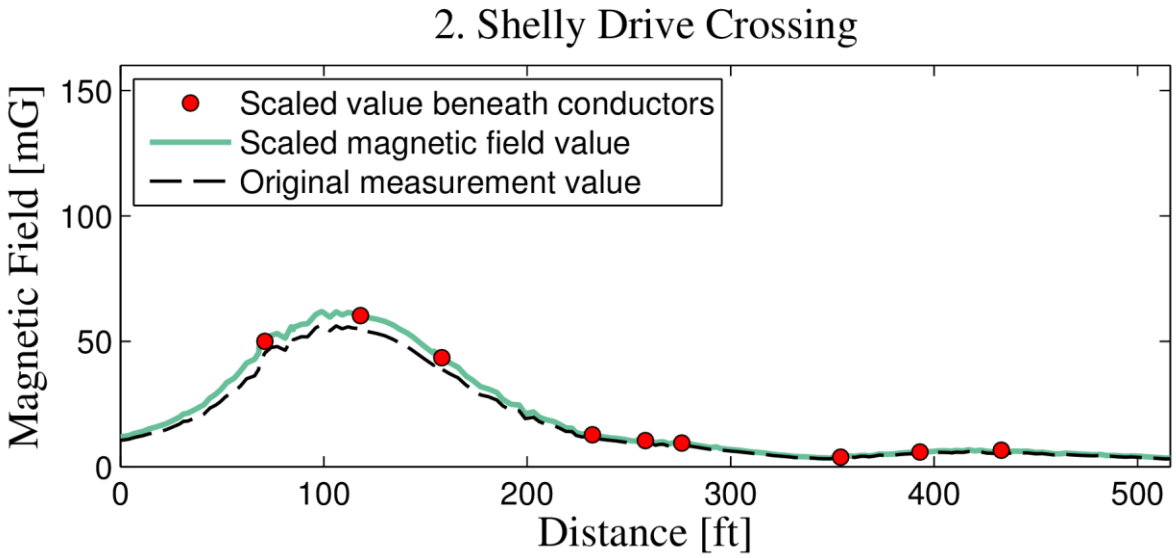

Figure E-8s. Detailed EMF measurements performed at PUC Site 2 (Shelly Drive in XS-8d). Both the original measurement values and scaled measurement values are shown.

Electric field measurements were unaffected by the calibration and so are not included here.

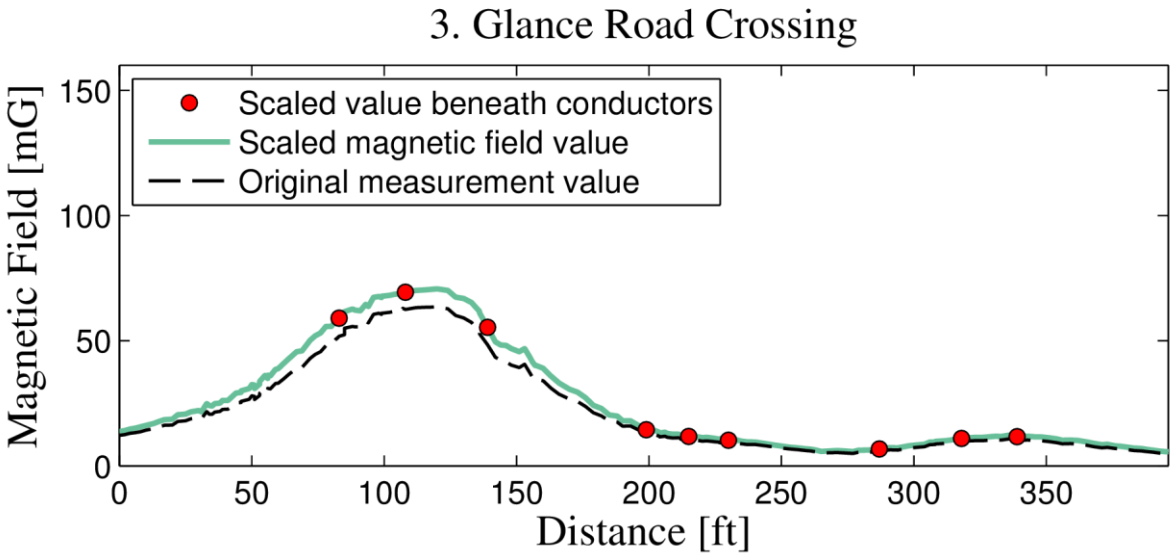

Figure E-9s. Detailed EMF measurements performed at PUC Site 3 (Glance Road in XS-8d). Both the original measurement values and scaled measurement values are shown.

Electric field measurements were unaffected by the calibration and so are not included here.

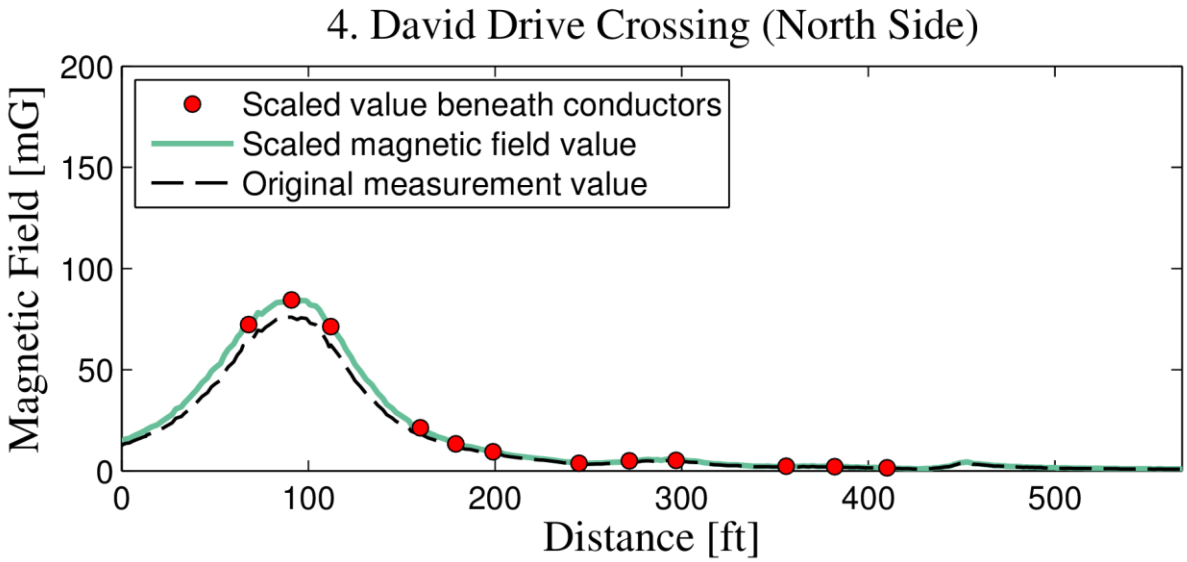

Figure E-10s. Detailed EMF measurements performed at PUC Site 4 (David Drive in XS-10). Both the original measurement values and scaled measurement values are shown.

Electric field measurements were unaffected by the calibration and so are not included here.

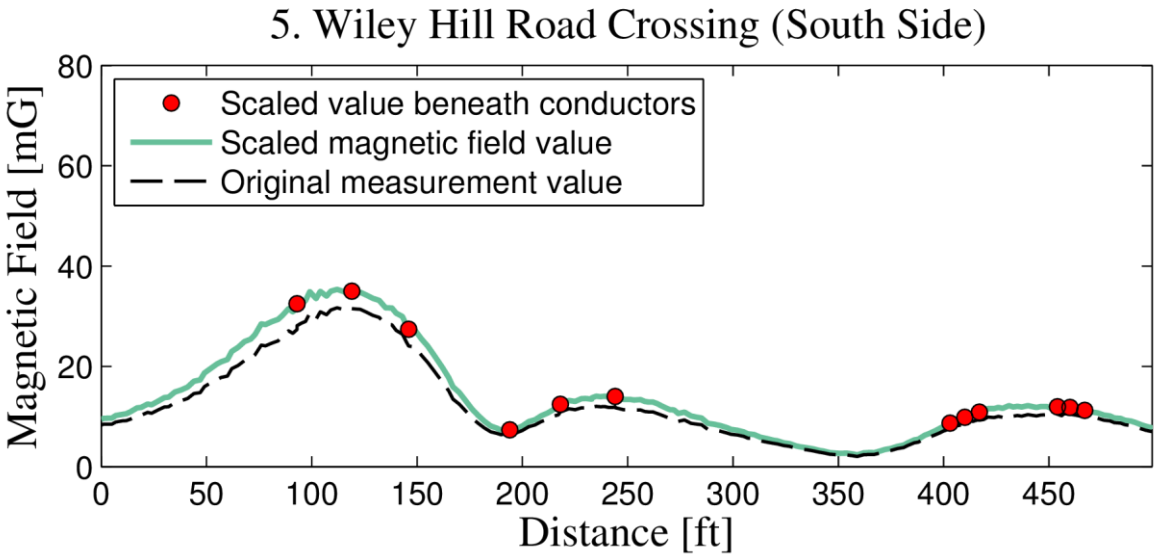

Figure E-11s. Detailed EMF measurements performed at PUC Site 5 (Wiley Hill Road in XS-11). Both the original measurement values and scaled measurement values are shown.

Electric field measurements were unaffected by the calibration and so are not included here.

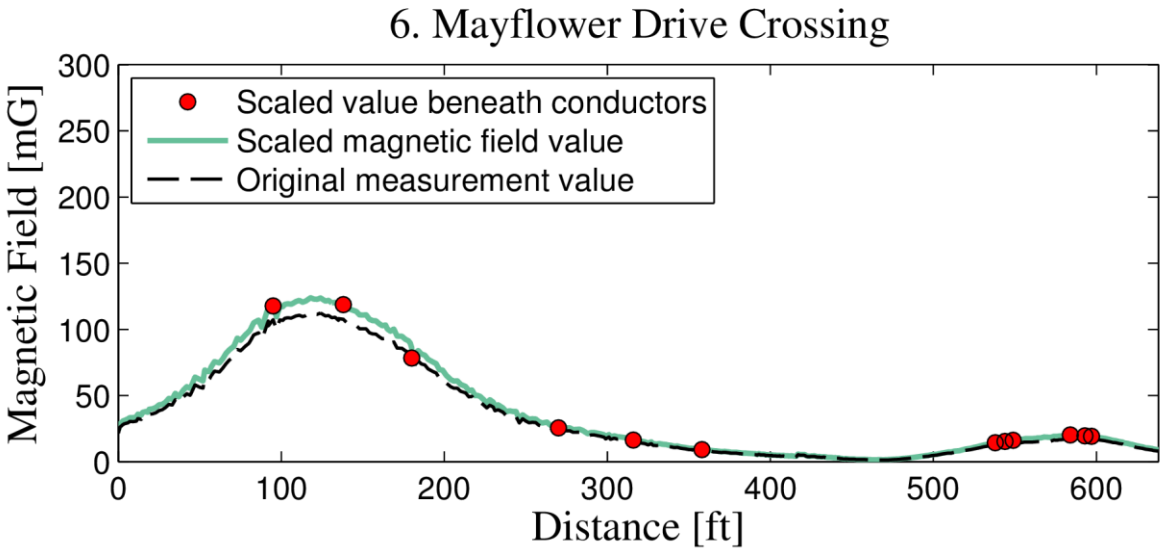

Figure E-12s. Detailed EMF measurements performed at PUC Site 6 (Mayflower Drive in XS-11). Both the original measurement values and scaled measurement values are shown.

Electric field measurements were unaffected by the calibration and so are not included here.