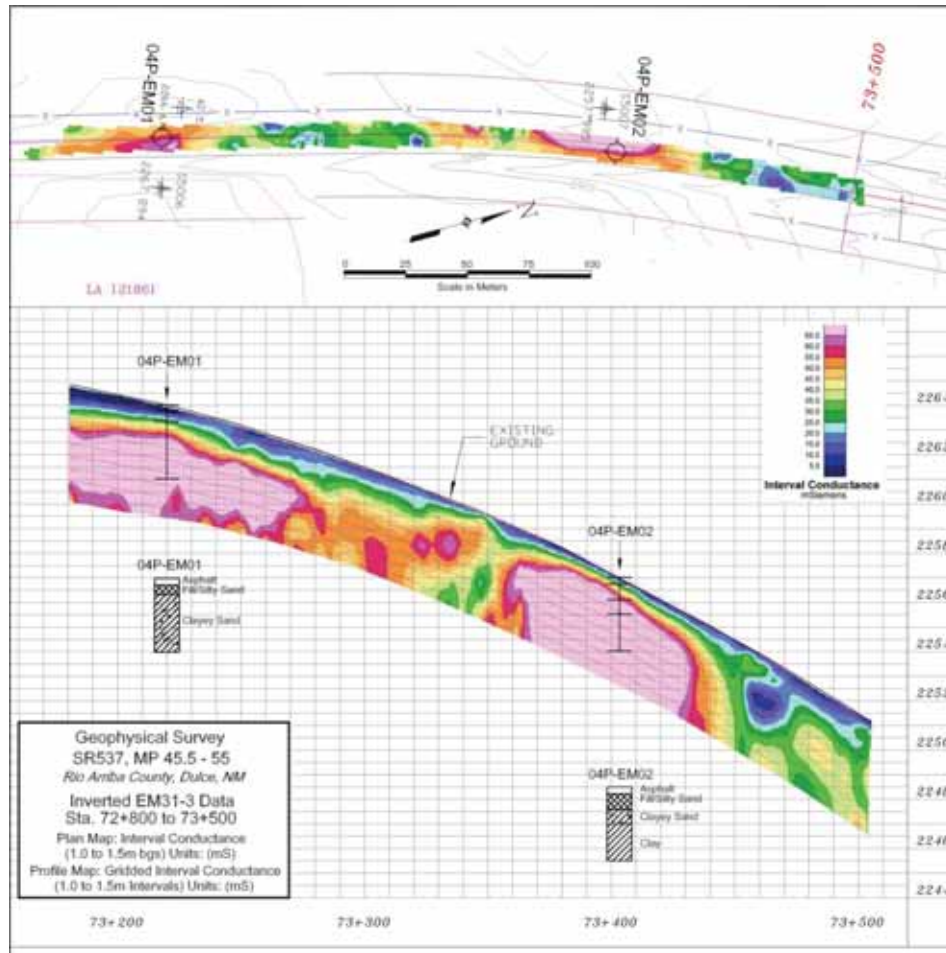


# CLAY SEAM MAPPING With Electromagnetic Induction

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U.S. Department  
of Transportation  
**Federal Highway  
Administration**

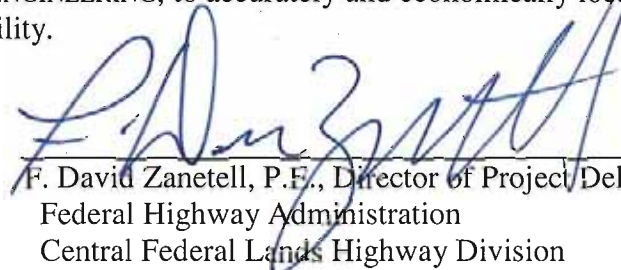


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Lakewood, CO 80228

## FOREWORD

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Oftentimes the FLH seeks outside services for studies where final reports or other documents are required. At many sites where road projects are planned by the FLH, unknown or undetected swelling-clay zones may be present. This report provides an engaged effort by the FLH and Blackhawk, a division of ZAPATA ENGINEERING, to accurately and economically locate clay rich zones that may affect highway stability.



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F. David Zanetell, P.E., Director of Project Delivery  
Federal Highway Administration  
Central Federal Lands Highway Division

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**Technical Report Documentation Page**

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16. Abstract The presence of swelling clay beneath roadway poses a significant problem to road rehabilitation design and construction. Roads constructed over areas of clay are generally subjected to potential differential settlement due to volume changes caused by swell/shrink and low shear strength of the clay resulting from high moisture content. If roadways with clay seams are not properly designed, a premature subgrade failure may occur and will also pose difficulties during construction resulting in higher construction costs.  This report summarizes multi-phase geophysical demonstrations using various electromagnetic induction (EMI) methods on SR537 near Dulce, New Mexico. The road has had extensive surface rehabilitation due to the presence of swelling clay-rich zones in the road base. Using electromagnetic geophysical methods with rapid acquisition procedures provided a means of detecting the location of potential swelling clay-rich zones. This information was used to guide the soil boring program, thus greatly reducing the risk of missing a clay-rich zone during the site characterization planning stage and thus preventing or minimizing cost-overruns during the reconstruction phase. The results from the three-phase investigation prompted a production survey along Natchez Trace Parkway, Mississippi. The combined results from Dulce and Natchez have shown that the EMI method can provide qualitative correlations for evaluating the roadbase materials. A comparison between individual Atterberg Limits of soils obtained from the soil lab analysis and the EMI data suggests that no direct correlation can be established. However, the correlation between the bulk conductivity and the Casagrande Plasticity Classification may be used as a quick evaluation tool for predicting Casagrande soil type along the entire length of the roadway surveyed.					
17. Key Words <b>CLAY, CLAY SEAMS, ELECTROMAGNETIC EMI, GEOPHYSICAL METHODS.</b>			18. Distribution Statement No restriction. This document is available to the public from the sponsoring agency at the website <a href="http://www.cflhd.gov">http://www.cflhd.gov</a> .		
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<b>SI* (MODERN METRIC) CONVERSION FACTORS</b>				
<b>APPROXIMATE CONVERSIONS TO SI UNITS</b>				
<b>Symbol</b>	<b>When You Know</b>	<b>Multiply By</b>	<b>To Find</b>	<b>Symbol</b>
<b>LENGTH</b>				
in	inches	25.4	millimeters	mm
ft	feet	0.305	meters	m
yd	yards	0.914	meters	m
mi	miles	1.61	kilometers	km
<b>AREA</b>				
in <sup>2</sup>	square inches	645.2	square millimeters	mm <sup>2</sup>
ft <sup>2</sup>	square feet	0.093	square meters	m <sup>2</sup>
yd <sup>2</sup>	square yard	0.836	square meters	m <sup>2</sup>
ac	acres	0.405	hectares	ha
mi <sup>2</sup>	square miles	2.59	square kilometers	km <sup>2</sup>
<b>VOLUME</b>				
fl oz	fluid ounces	29.57	milliliters	mL
gal	gallons	3.785	liters	L
ft <sup>3</sup>	cubic feet	0.028	cubic meters	m <sup>3</sup>
yd <sup>3</sup>	cubic yards	0.765	cubic meters	m <sup>3</sup>
NOTE: volumes greater than 1000 L shall be shown in m <sup>3</sup>				
<b>MASS</b>				
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2000 lb)	0.907	megagrams (or "metric ton")	Mg (or "t")
<b>TEMPERATURE (exact degrees)</b>				
°F	Fahrenheit	5 (F-32)/9 or (F-32)/1.8	Celsius	°C
<b>ILLUMINATION</b>				
fc	foot-candles	10.76	lux	lx
fl	foot-Lamberts	3.426	candela/m <sup>2</sup>	cd/m <sup>2</sup>
<b>FORCE and PRESSURE or STRESS</b>				
lbf	poundforce	4.45	newtons	N
lbf/in <sup>2</sup>	poundforce per square inch	6.89	kilopascals	kPa
<b>APPROXIMATE CONVERSIONS FROM SI UNITS</b>				
<b>Symbol</b>	<b>When You Know</b>	<b>Multiply By</b>	<b>To Find</b>	<b>Symbol</b>
<b>LENGTH</b>				
mm	millimeters	0.039	inches	in
m	meters	3.28	feet	ft
m	meters	1.09	yards	yd
km	kilometers	0.621	miles	mi
<b>AREA</b>				
mm <sup>2</sup>	square millimeters	0.0016	square inches	in <sup>2</sup>
m <sup>2</sup>	square meters	10.764	square feet	ft <sup>2</sup>
m <sup>2</sup>	square meters	1.195	square yards	yd <sup>2</sup>
ha	hectares	2.47	acres	ac
km <sup>2</sup>	square kilometers	0.386	square miles	mi <sup>2</sup>
<b>VOLUME</b>				
mL	milliliters	0.034	fluid ounces	fl oz
L	liters	0.264	gallons	gal
m <sup>3</sup>	cubic meters	35.314	cubic feet	ft <sup>3</sup>
m <sup>3</sup>	cubic meters	1.307	cubic yards	yd <sup>3</sup>
<b>MASS</b>				
g	grams	0.035	ounces	oz
kg	kilograms	2.202	pounds	lb
Mg (or "t")	megagrams (or "metric ton")	1.103	short tons (2000 lb)	T
<b>TEMPERATURE (exact degrees)</b>				
°C	Celsius	1.8C+32	Fahrenheit	°F
<b>ILLUMINATION</b>				
lx	lux	0.0929	foot-candles	fc
cd/m <sup>2</sup>	candela/m <sup>2</sup>	0.2919	foot-Lamberts	fl
<b>FORCE and PRESSURE or STRESS</b>				
N	newtons	0.225	poundforce	lbf
kPa	kilopascals	0.145	poundforce per square inch	lbf/in <sup>2</sup>

TABLE OF CONTENTS

	Page
<b>EXECUTIVE SUMMARY .....</b>	<b>1</b>
<b>REPORT ORGANIZATION.....</b>	<b>3</b>
<b>CHAPTER 1 – INTRODUCTION .....</b>	<b>5</b>
1.1 Problem Description .....	5
1.2 Objectives .....	5
1.3 Geophysical Program Overview.....	6
1.3.1 Summary of Phase I.....	6
1.3.2 Summary of Phase II.....	8
<b>CHAPTER 2 – GEOLOGICAL SETTINGS AND SITE CONDITIONS.....</b>	<b>9</b>
<b>CHAPTER 3 – GEOPHYSICAL METHODOLOGY AND INSTRUMENTATION .....</b>	<b>13</b>
<b>CHAPTER 4 – DATA ACQUISITION .....</b>	<b>15</b>
4.1 Data Acquisition Methods.....	15
4.2 Site Specific Considerations and Limitations.....	16
<b>CHAPTER 5 – DATA PROCESSING.....</b>	<b>19</b>
5.1 EMI Modeling .....	19
5.2 Ground Truth.....	21
<b>CHAPTER 6 – RESULTS.....</b>	<b>23</b>
6.1 Analysis of Geophysical Results .....	23
6.2 Correlation of Geophysical and Atterberg Limits of Soils Data .....	23
6.2.1 Grab Samples Collected Between 0.9 to 1.5 m (3 to 5 ft) .....	23
6.2.2 Grab Samples Collected at Depths Greater Than 1.5 m (5 ft).....	26
6.2.3 Interpretation of Geophysical and Atterberg Limits of Soils Results.....	26
6.3 Advantages of EMI Method .....	29
<b>CHAPTER 7 – CASE STUDY – NATCHEZ TRACE PARKWAY .....</b>	<b>31</b>
7.1 Introduction .....	31
7.2 Geophysical Methodology and Instrumentation.....	31
7.3 Data Acquisition .....	32
7.4 Data Processing .....	33
7.5 Ground Truth .....	33
7.6 Results .....	33
7.6.1 Analysis of Geophysical Results .....	33
7.6.2 Correlation of Geophysical and Atterberg Limits of Soils Properties Data .....	35
7.7 Conclusions .....	35
<b>CHAPTER 8 – CONCLUSIONS AND RECOMMENDATIONS .....</b>	<b>39</b>
8.1 Conclusions .....	39
8.2 Recommendations .....	41

8.3 Electromagnetic Induction Benefits .....42

**CERTIFICATION AND DISCLAIMER.....43**

**ACKNOWLEDGEMENTS .....45**

**REFERENCES.....47**

**APPENDIX A – PLAN AND PROFILE MAPS FROM DULCE, NEW MEXICO.....49**

**APPENDIX B – COMPARISON PLOTS OF THE LAB SOIL ANALYSIS DATA AND  
THE EMI GEOPHYSICAL DATA FROM THE 0.9 TO 1.5 m GRAB SAMPLE, DULCE,  
NEW MEXICO. ....69**

**APPENDIX C – COMPARISON PLOTS OF THE LAB SOIL ANALYSIS DATA AND  
THE EMI GEOPHYSICAL DATA FROM THE 1.5 TO 3 m GRAB SAMPLE, DULCE,  
NEW MEXICO. ....79**

**APPENDIX D – COMPARISON PLOTS OF THE LAB SOIL ANALYSIS DATA AND  
THE EMI GEOPHYSICAL DATA, NATCHEZ, MISSISSIPPI.....89**

LIST OF FIGURES

	Page
Figure 1. Map. Site Location Map.....	7
Figure 2. Map. Geological map of the Dulce survey area.....	9
Figure 3. Photo. Data collection in representative open area traveling north on SR537.....	10
Figure 4. Photo. Representative wooded area traveling north on SR537.....	11
Figure 5. Photo. EM31-3 mounted on low metal content trailer.....	13
Figure 6. Charts. Hypothetical Example of Derivation of Interval Conductance.....	20
Figure 7. Chart. Soil Conductivity vs. Casagrande Plasticity.....	28
Figure 8. Map. Natchez Trace Parkway Site Map.....	31
Figure 9. Photo. EM31-3 and ATV on Natchez Trace Parkway.....	32
Figure 10. Plan View Map. EM31-3 EMI Apparent Conductivity Map from Natchez, Mississippi.....	34
Figure 11. Plan and Profile Maps. Inverted EM31 –3 Data (Stat. 72+800 to 73+500).....	50
Figure 12. Plan and Profile Maps. Inverted EM31 –3 Data (Stat. 73+500 to 74+200).....	51
Figure 13. Plan and Profile Maps. Inverted EM31 –3 Data (Stat. 74+200 to 74+900).....	52
Figure 14. Plan and Profile Maps. Inverted EM31 –3 Data (Stat. 74+900 to 75+600).....	53
Figure 15. Plan and Profile Maps. Inverted EM31 –3 Data (Stat. 75+600 to 75+800).....	54
Figure 16. Plan and Profile Maps. Inverted EM31 –3 Data (Stat. 80+500 to 81+200).....	55
Figure 17. Plan and Profile Maps. Inverted EM31 –3 Data (Stat. 81+200 to 81+900).....	56
Figure 18. Plan and Profile Maps. Inverted EM31 –3 Data (Stat. 81+900 to 82+600).....	57
Figure 19. Plan and Profile Maps. Inverted EM31 –3 Data (Stat. 82+600 to 83+300).....	58
Figure 20. Plan and Profile Maps. Inverted EM31 –3 Data (Stat. 83+300 to 84+000).....	59
Figure 21. Plan and Profile Maps. Inverted EM31 –3 Data (Stat. 84+000 to 84+700).....	60
Figure 22. Plan and Profile Maps. Inverted EM31 –3 Data (Stat. 84+700 to 85+400).....	61
Figure 23. Plan and Profile Maps. Inverted EM31 –3 Data (Stat. 85+400 to 86+100).....	62
Figure 24. Plan and Profile Maps. Inverted EM31 –3 Data (Stat. 86+100 to 86+800).....	63
Figure 25. Plan and Profile Maps. Inverted EM31 –3 Data (Stat. 86+800 to 87+500).....	64
Figure 26. Plan and Profile Maps. Inverted EM31 –3 Data (Stat. 87+500 to 88+200).....	65
Figure 27. Plan and Profile Maps. Inverted EM31 –3 Data (Stat. 88+200 to 88+900).....	66

Figure 28. Plan and Profile Maps. Inverted EM31 –3 Data (Stat. 88+900 to 89+200). .....67

Figure 29. Graph. Dulce. 1-1.5 m Interval Conductance vs. Fines Percentage. ....70

Figure 30. Graph. Dulce. 1-1.5 m Interval Conductance vs. Liquid Limit.....70

Figure 31. Graph. Dulce. 1-1.5 m Interval Conductance vs. Plastic Limit.....71

Figure 32. Graph. Dulce. 1-1.5 m Interval Conductance vs. Plasticity Index. ....71

Figure 33. Graph. Dulce. 1-1.5 m Interval Conductance vs. Moisture Content. ....72

Figure 34. Graph. Dulce. 1-1.5 m Interval Conductance vs. Liquidity Index. ....72

Figure 35. Graph. Dulce. 2 m Coil Bulk Conductivity vs. Fines Percentage. ....73

Figure 36. Graph. Dulce. 2 m Coil Bulk Conductivity vs. Liquid Limit.....73

Figure 37. Graph. Dulce. 2 m Coil Bulk Conductivity vs. Plastic Limit.....74

Figure 38. Graph. Dulce. 2 m Coil Bulk Conductivity vs. Plasticity Index. ....74

Figure 39. Graph. Dulce. 2 m Coil Bulk Conductivity vs. Moisture Content. ....75

Figure 40. Graph. Dulce. 2 m Coil Bulk Conductivity vs. Liquidity Index. ....75

Figure 41. Graph. Dulce. 4 m Coil Bulk Conductivity vs. Fines Percentage. ....76

Figure 42. Graph. Dulce. 4 m Coil Bulk Conductivity vs. Liquid Limit.....76

Figure 43. Graph. Dulce. 4 m Coil Bulk Conductivity vs. Plastic Limit.....77

Figure 44. Graph. Dulce. 4 m Coil Bulk Conductivity vs. Plasticity Index. ....77

Figure 45. Graph. Dulce. 4 m Coil Bulk Conductivity vs. Moisture Content. ....78

Figure 46. Graph. Dulce. 4 m Coil Bulk Conductivity vs. Liquidity Index. ....78

Figure 47. Graph. Dulce. 1-1.5 m Interval Conductance vs. Fines Percentage. ....80

Figure 48. Graph. Dulce. 1-1.5 m Interval Conductance vs. Liquid Limit.....80

Figure 49. Graph. Dulce. 1-1.5 m Interval Conductance vs. Plastic Limit.....81

Figure 50. Graph. Dulce. 1-1.5 m Interval Conductance vs. Plasticity Index. ....81

Figure 51. Graph. Dulce. 1-1.5 m Interval Conductance vs. Moisture Content. ....82

Figure 52. Graph. Dulce. 1-1.5 m Interval Conductance vs. Liquidity Index. ....82

Figure 53. Graph. Dulce. 2 m Coil Bulk Conductivity vs. Fines Percentage. ....83

Figure 54. Graph. Dulce. 2 m Coil Bulk Conductivity vs. Liquid Limit.....83

Figure 55. Graph. Dulce. 2 m Coil Bulk Conductivity vs. Plastic Limit.....84

Figure 56. Graph. Dulce. 2 m Coil Bulk Conductivity vs. Plasticity Index. ....84

Figure 57. Graph. Dulce. 2 m Coil Bulk Conductivity vs. Moisture Content. ....85



Figure 58. Graph. Dulce. 2 m Coil Bulk Conductivity vs. Liquidity Index. ....85

Figure 59. Graph. Dulce. 4 m Coil Bulk Conductivity vs. Fines Percentage. ....86

Figure 60. Graph. Dulce. 4 m Coil Bulk Conductivity vs. Liquid Limit. ....86

Figure 61. Graph. Dulce. 4 m Coil Bulk Conductivity vs. Plastic Limit. ....87

Figure 62. Graph. Dulce. 4 m Coil Bulk Conductivity vs. Plasticity Index. ....87

Figure 63. Graph. Dulce. 4 m Coil Bulk Conductivity vs. Moisture Content. ....88

Figure 64. Graph. Dulce. 4 m Coil Bulk Conductivity vs. Liquidity Index. ....88

Figure 65. Graph. Natchez. 2 m Coil Bulk Conductivity vs. Liquid Limit. ....90

Figure 66. Graph. Natchez. 2 m Coil Bulk Conductivity vs. Plastic Limit. ....90

Figure 67. Graph. Natchez. 2 m Coil Bulk Conductivity vs. Plasticity Index. ....91

Figure 68. Graph. Natchez. 2 m Coil Bulk Conductivity vs. Moisture Content. ....91

Figure 69. Graph. Natchez. 2 m Coil Bulk Conductivity vs. Liquidity Index. ....92

Figure 70. Graph. Natchez. 4 m Coil Bulk Conductivity vs. Liquid Limit. ....92

Figure 71. Graph. Natchez. 4 m Coil Bulk Conductivity vs. Plastic Limit. ....93

Figure 72. Graph. Natchez. 4 m Coil Bulk Conductivity vs. Plasticity Index. ....93

Figure 73. Graph. Natchez. 4 m Coil Bulk Conductivity vs. Moisture Content. ....94

Figure 74. Graph. Natchez. 4 m Coil Bulk Conductivity vs. Liquidity Index. ....94

**LIST OF TABLES**

	Page
Table 1. Base Station Coordinates.....	15
Table 2. EM31-3 Instrument Height and Orientation.....	16
Table 3. Definitions of Atterberg Limits of Soils Properties.....	21
Table 4. Dulce Borehole Locations. ....	22
Table 5. Bulk Conductivity and Interval Conductance Values at Dulce Borehole .....	24
Table 6. Atterberg Limits of Soils Properties of Dulce Borehole Grab Samples (0.9 to 1.5 m). .25	25
Table 7. Atterberg Limits of Soils Properties of Dulce Borehole Grab Samples (1.5 to 3.0 m). .27	27
Table 8. Comparison of Soil Boring vs. EMI Surveying.....	29
Table 9. EMI Properties at Borehole Locations in Natchez, Mississippi. ....	36
Table 10. Atterberg Limits of Soil Properties from Boreholes in Natchez, Mississippi. ....	37
Table 11. Statistical Analysis of the Atterberg Limits of Soils Results from Natchez, Mississippi. ....	38
Table 12. Correlation of Coefficients Summary.....	41

**LIST OF ACRONYMS**

<b>ATV</b>	All-Terrain Vehicle
<b>bgs</b>	below ground surface
<b>BIA</b>	Bureau of Indian Affairs
<b>CPC</b>	Casagrande Plasticity Classification
<b>DGPS</b>	Differential Global Positioning System
<b>EMI</b>	Electromagnetic Induction
<b>GPS</b>	Global Positioning System
<b>Hz</b>	Hertz
<b>LI</b>	Liquidity Index
<b>LL</b>	Liquid Limit
<b>MC</b>	Moisture Content
<b>MP</b>	Mile Post
<b>mS</b>	milliSiemens
<b>P&amp;P</b>	Plan and Profile
<b>PI</b>	Plasticity Index
<b>PL</b>	Plastic Limit
<b>RTK</b>	Real-Time Kinematic
<b>Rx</b>	Receiver
<b>TSCI</b>	Trimble Survey Controller
<b>Tx</b>	Transmitter
<b>WGS</b>	World Geodetic System
<b>USCS</b>	Unified Soil Classification System

