CLAY SEAM MAPPING
With Electromagnetic Induction

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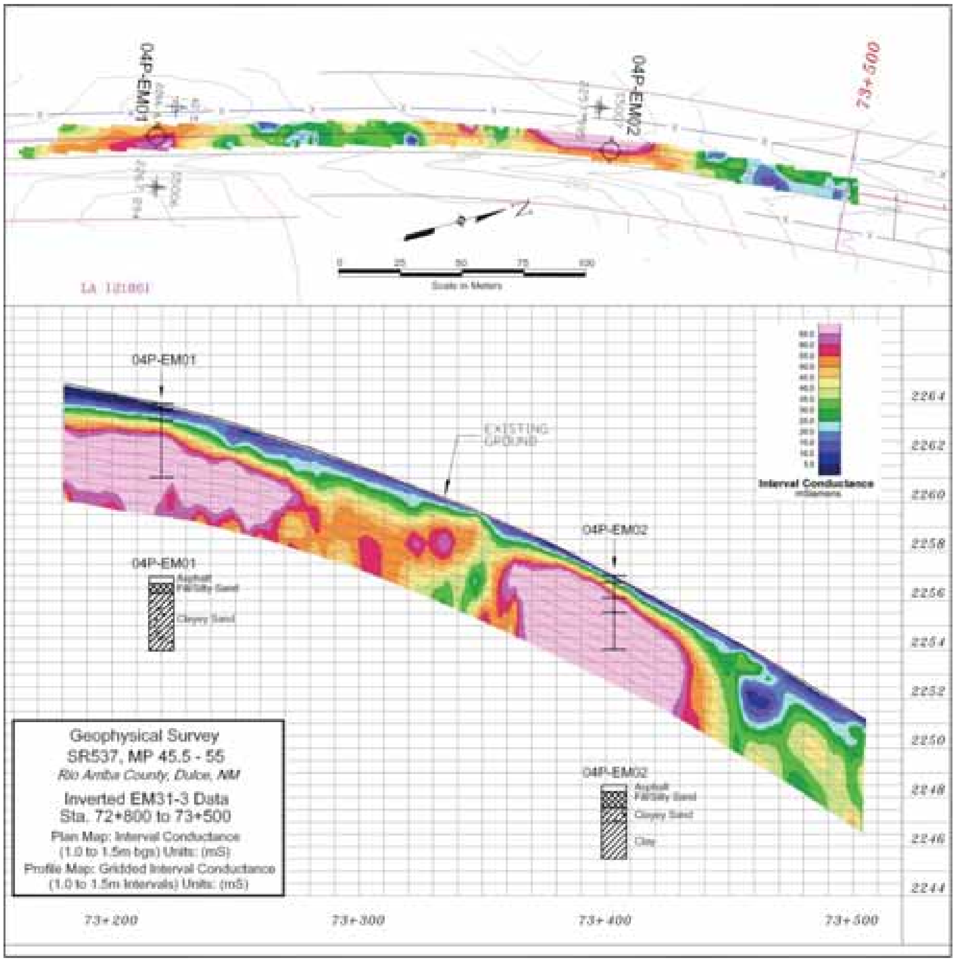

U.S. Department of Transportation
Federal Highway Administration

Federal Lands Highway
Commitment to Excellence

Central Federal Lands Highway Division
12300 West Dakota Avenue
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.

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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15. Supplementary Notes

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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 **CLAY, CLAY SEAMS, ELECTROMAGNETIC EMI, GEOPHYSICAL METHODS.**	18. Distribution Statement No restriction. This document is available to the public from the sponsoring agency at the website http://www.cflhd.gov.

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SI* (MODERN METRIC) CONVERSION FACTORS

APPROXIMATE CONVERSIONS TO SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
in	inches	25.4	millimeters	mm
ft	feet	0.305	meters	m
yd	yards	0.914	meters	m
mi	miles	1.61	kilometers	km
		AREA		
in^2	square inches	645.2	square millimeters	mm^2
ft^2	square feet	0.093	square meters	m^2
yd^2	square yard	0.836	square meters	m^2
ac	acres	0.405	hectares	ha
mi^2	square miles	2.59	square kilometers	km^2
		VOLUME		
fl oz	fluid ounces	29.57	milliliters	mL
gal	gallons	3.785	liters	L
ft^3	cubic feet	0.028	cubic meters	m^3
yd^3	cubic yards	0.765	cubic meters	m^3
		NOTE: volumes greater than 1000 L shall be shown in m^3		
		MASS		
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")
		TEMPERATURE (exact degrees)		
°F	Fahrenheit	5 (F-32)/9 or (F-32)/1.8	Celsius	°C
		ILLUMINATION		
fc	foot-candles	10.76	lux	lx
fl	foot-Lamberts	3.426	candela/m^2	cd/m^2
		FORCE and PRESSURE or STRESS		
lbf	poundforce	4.45	newtons	N
lbf/in^2	poundforce per square inch	6.89	kilopascals	kPa

APPROXIMATE CONVERSIONS FROM SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
mm	millimeters	0.039	inches	in
m	meters	3.28	feet	ft
m	meters	1.09	yards	yd
km	kilometers	0.621	miles	mi
		AREA		
mm^2	square millimeters	0.0016	square inches	in^2
m^2	square meters	10.764	square feet	ft^2
m^2	square meters	1.195	square yards	yd^2
ha	hectares	2.47	acres	ac
km^2	square kilometers	0.386	square miles	mi^2
		VOLUME		
mL	milliliters	0.034	fluid ounces	fl oz
L	liters	0.264	gallons	gal
m^3	cubic meters	35.314	cubic feet	ft^3
m^3	cubic meters	1.307	cubic yards	yd^3
		MASS		
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
		TEMPERATURE (exact degrees)		
°C	Celsius	1.8C+32	Fahrenheit	°F
		ILLUMINATION		
lx	lux	0.0929	foot-candles	fc
cd/m^2	candela/m^2	0.2919	foot-Lamberts	fl
		FORCE and PRESSURE or STRESS		
N	newtons	0.225	poundforce	lbf
kPa	kilopascals	0.145	poundforce per square inch	lbf/in^2

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LIST OF ACRONYMS

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