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DATE: May 10, 2011

TO: Don Bussey, EPA/ERT Work Assignment Manager

THROUGH: Rick Leuser, SERAS Deputy Program Manager

FROM: Martin Ebel, SERAS Task Leader

SUBJECT: TRIP REPORT – GEOPHYSICAL INVESTIGATION OF THE MOJAVE RIVER PYROTECHNICS SITE, BARSTOW, CALIFORNIA, WORK ASSIGNMENT SERAS-127

INTRODUCTION

The United States Environmental Protection Agency (EPA) Region 9 requested the EPA - Environmental Response Team (ERT) to conduct a surface geophysical investigation of the Mojave River Pyrotechnics Site.

The Mojave River Pyrotechnics Site is located in Barstow, California, north of the Mojave River at 30433 Poplar Street. EPA Region 9 has determined that a source of perchlorate, which is contaminating local groundwater, is located at the property. The owner had stored the chemical on the site and drums were witnessed on the site. EPA Region 9 was concerned that drums were buried at the site.

METHODOLOGY

The geophysical investigation was conducted from March 21 through 24, 2011. A Geonics® EM31 MK2 (EM31) frequency-domain electromagnetic (FDEM) instrument, a Geonics® EM61 MK2 (EM61) time-domain electromagnetic (TDEM) instrument and a Sensors and Software® Smartcart Noggin with a 250 megahertz (MHz) antennae ground penetrating radar (GPR) system were used in the investigation.

The EM-61 is a time-domain metal detector that induces a magnetic field in the earth and measures the secondary magnetic field that is created. Measurements are made over different time gates to provide better discrimination of the materials based on the decay of their secondary magnetic field. The EM-61 generates an electromagnetic field that creates eddy currents in the vicinity of the field, which in turn, induces a secondary magnetic field. When the signal generating the electromagnetic field stops, the receiver begins measuring the secondary magnetic field at different time gates as the eddy currents decay. If metal is present, the decay is slower, producing a time-based signature. The measurement is a differential between the primary and secondary fields; hence, the mapped differential response is a unitless quantity.

The EM31 has a 12-foot long boom that separates the transmitter and receiver coils that set up an electromagnetic (EM) dipole. The transmitter coil transmits an EM field inducing eddy current loops in the ground, which in turn generates a secondary field that is measured by the receiver coil. The EM field measured by the receiver is comprised of both the field generated by the transmitter and the secondary field. The measured field is broken into two components by the instrument. The component that includes the primary field generated by the transmitter combined with the portion of the secondary field that has the same phase as the primary field is the in-phase component. The quadrature component is the portion of the measured field that is 90 degrees out of phase with the primary field. The in-phase component is sensitive to buried metal while the quadrature component is proportional to the terrain conductivity. The in-phase portion of the field may provide the locations of buried steel due to its sensitive to metal.

The GPR system transmits a high frequency electromagnetic wave into the earth and records reflections from subsurface discontinuities. The 250-MHz operating frequency of the Noggin is a mid-range frequency with a penetration and resolution appropriate for most environmental and engineering uses. Data are collected by moving the GPR unit over the ground, while the system transmits short pulses of electromagnetic waves and records the received reflections. The recorded reflections, commonly called traces, are plotted side-by-side as they are collected creating a profile of the subsurface.

Prior to collecting data with the EM61 and the EM31, standard equipment checks were run to ensure the equipment was operating correctly. The EM61 was taken to an area presumably free of buried metal and nulled. Using the digital readout, an area with low values was found and unit was nulled, which sets the four channels to zero. The EM31 was checked for zero of the both quadrature and in-phase components and the phase was also checked. To null the quadrature component (terrain conductivity), the transmitter coil was attached to the EM31 and the unit was turned on. The zero was not within the +/- 1 millisiemen per meter (mS/m) tolerance and adjusting the DC zero offset failed, so the backup unit was used. The backup unit was within the tolerance and the in-phase nulling, conducted by attaching both the receiver and transmitter then turning on the unit and setting the range set to 100, was within the tolerance of +/- 0.1 of a part per thousand from zero.

The phase of the instrument was checked by setting the mode switch to PHASE and noting the conductivity reading. After the rotating the Coarse control one step counterclockwise, the conductivity reading remained the same (+/- 0.2 mS/m), indicating the phase was correct. The Coarse control was rotated back to its original position.

OBSERVATIONS AND ACTIVITIES

The initial activity was to use the GPR to ensure boring locations were clear of subsurface utilities. The GPR was deployed over each boring location in several directs and the data were interpreted as they were collected. In cases where a potential obstruction existed, the information was conveyed directly to the individuals responsible for the soil borings.

The EM61 was used to investigate the area within the wooden fence and around the mobile home in the northwest portion of the property (Figure 1). Measurements were collected across grids using fiberglass measuring tapes to define the spacing, boundaries and orientation of the survey lines. Measurements were collected along transects that were three feet apart and overlapped for complete coverage of the investigation area. The spacing between data points along the transects was determined by the odometer on a wheel of the transmitter-receiver assembly. The odometer was set to trigger the transmitter every 0.64 feet. The survey lines were limited by the wooden fence and the home that was within the survey area.

The remainder of the site was investigated using the EM31. Data from the EM31 were merged with data from a Global Positioning System (GPS) receiver into a single data file. The data were collected once per second along transects that were 12 feet apart.

Once a survey was completed or at the end of a day, the data were downloaded to a portable computer, processed and interpreted on site. A contour map, showing the strength of the response to the electromagnetic pulse was created so that the location of each anomaly could be identified in the field.

RESULTS

The EM61 survey showed the approximate locations of buried irrigation lines (Figure 2). The anomalies associated with the irrigation lines match the above ground irrigation points and were too narrow to be associated with buried drums. Interference from the home and metal in its vicinity, such as the non-functioning vehicle, also caused large anomalies. These are also noted on Figure 2.

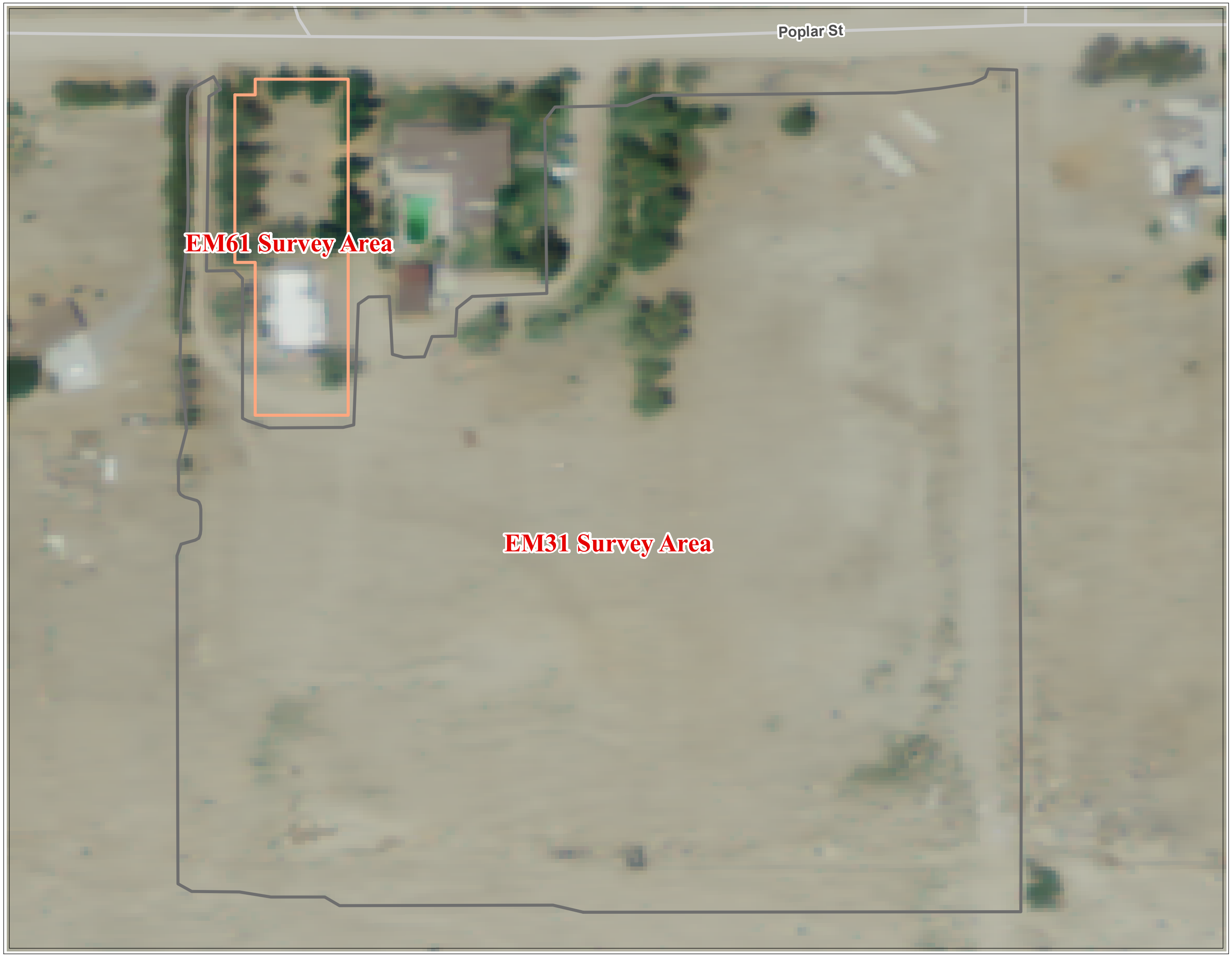
The in-phase portion of the EM31 survey was the component of primary concern due its sensitivity to metal (Figure 3). Most of the anomalies were related to metal found on the surface and were confirmed in the field. These included a garage, fence features, sheet metal and other scrap metal. The long anomaly along the eastern edge of the site is relatively low magnitude that corresponds to the road through the site and is not consistent the expected signal from buried drums. The remaining anomalies that could not be explained by metal at the surface, all but one was eliminated using the EM61 and GPR. The depth to the anomaly was estimated with the GPR and the areas was hand dug to the depth. The cause of the anomaly was not identified.

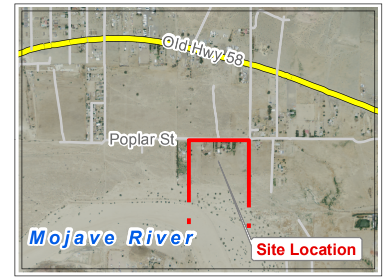
The quadrature data were also collected and results are displayed on Figure 4. Over most of the site, the terrain conductivity is low and relatively homogenous. The conductivity is higher, around the homes and along the site road on the eastern side of the site. Irrigation around the homes and compression of the soil along the road are the likely causes of the higher conductivity in these areas.

CONCLUSIONS

Three geophysical methods were employed at the Mohave River Pyrotechnics site to determine whether drums were buried at the site. Soil boring locations were also cleared. These methods included a time domain and a frequency domain electromagnetic survey, EM61 and EM31, respectively, and ground penetrating radar. The data were interpreted in near real time. Although anomalies were identified on the site, most could be correlated to surface metal, known irrigation lines, or were too small to be caused by drums. One anomaly was investigated by hand digging; however the cause of the anomaly was not identified. There were no indications of buried drums found at the site.

FIGURES
Mojave River Pyrotechnics Site
Trip Report
May 2001





Magnetic North

Legend

EM31 Survey Area

EM61 Survey Area

Map created using NAIP imagery data from California State Website,
site survey GPS data and sample result data.

Map Creation Date: 02 May 2011

Coordinate system: California State Plane V
FIPS: 0405
Datum: NAD83
Units: Feet

120 0 120 Feet

Data: g:\arcviewprojects\SERAS01\00-127
MXD file: G:\ArcInfoProjects\SERAS01\SER00127_MojaveRiverSite\127_TripR_SiteInvestigationAreas_f1

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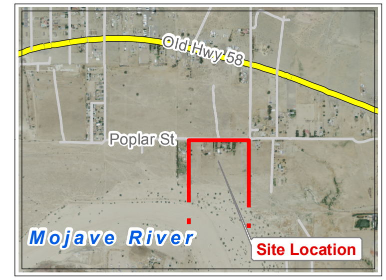
W.A.# 0-127

Figure 1
Site Investigation Areas
Mojave River Pyrotechnics Site
Barstow, California



N
W E
S
Magnetic North

Legend

Differential Response

790
630
500
400
320
250
200
160
130
100
79
63
50
40
32
25
20
10
4
0
-1000

Map created using NAIP imagery data from California State Website, site survey GPS data and sample result data.

120 0 120
Feet

Map Creation Date: 02 May 2011

Coordinate system: California State Plane V
FIPS: 0405
Datum: NAD83
Units: Feet

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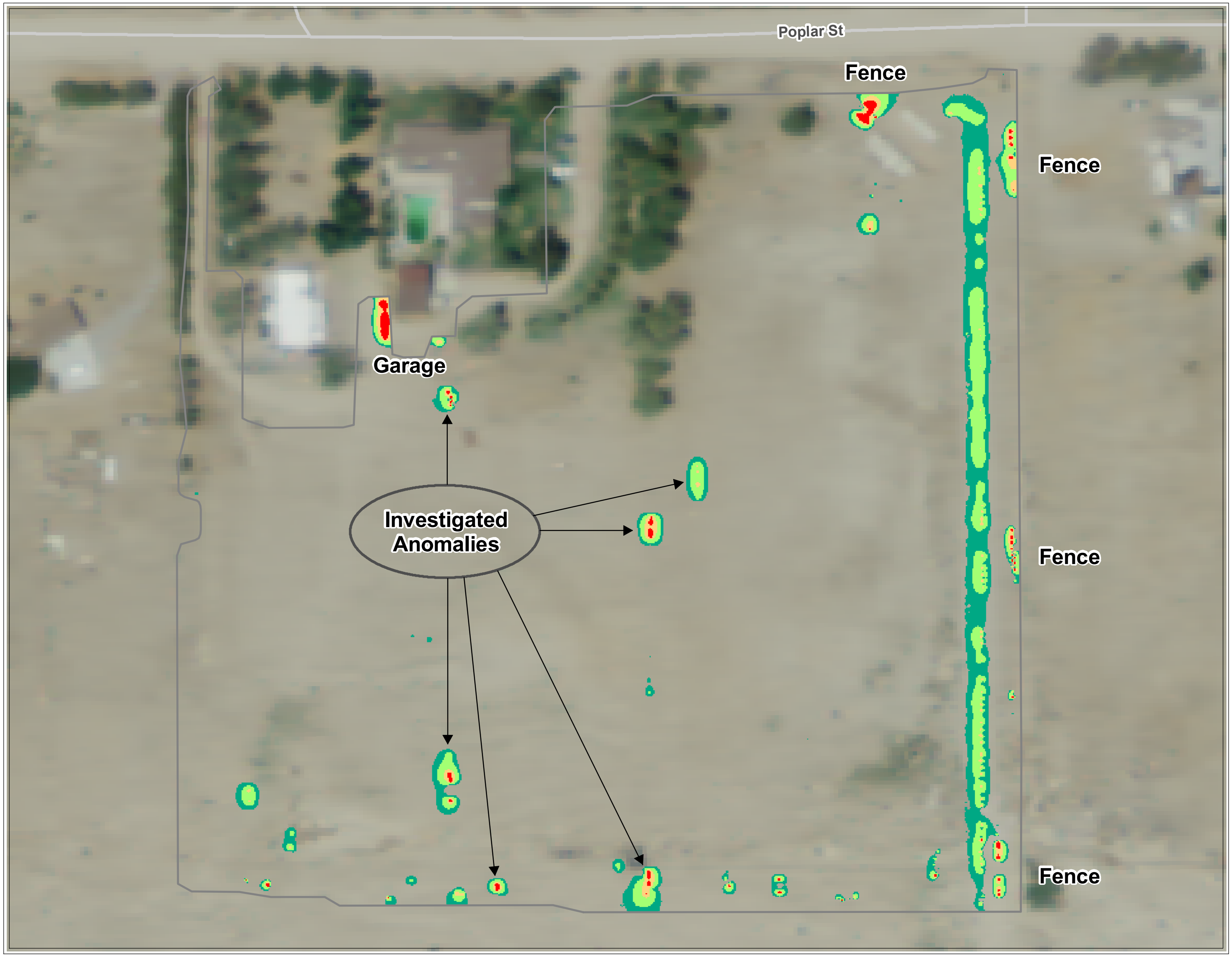
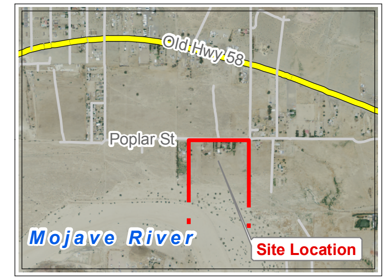
Figure 2
Time Domain Electromagnetic Survey
Mojave River Pyrotechnics Site
Barstow, California





N
W E
S
Magnetic North

Legend

EM31 Survey Area

In-Phase Contour

Parts per thousand

- (-22) - (-16)
- (-16) - (-12)
- (-12) - (-8)
- (-8) - (-6)
- (-6) - 0
- 0 - 6
- 6 - 8
- 8 - 12
- 12 - 16
- 16 - 22

Map created using NAIP imagery data from California State Website,
site survey GPS data and sample result data.

Map Creation Date: 02 May 2011

Coordinate system: California State Plane V
FIPS: 0405
Datum: NAD83
Units: Feet

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Feet

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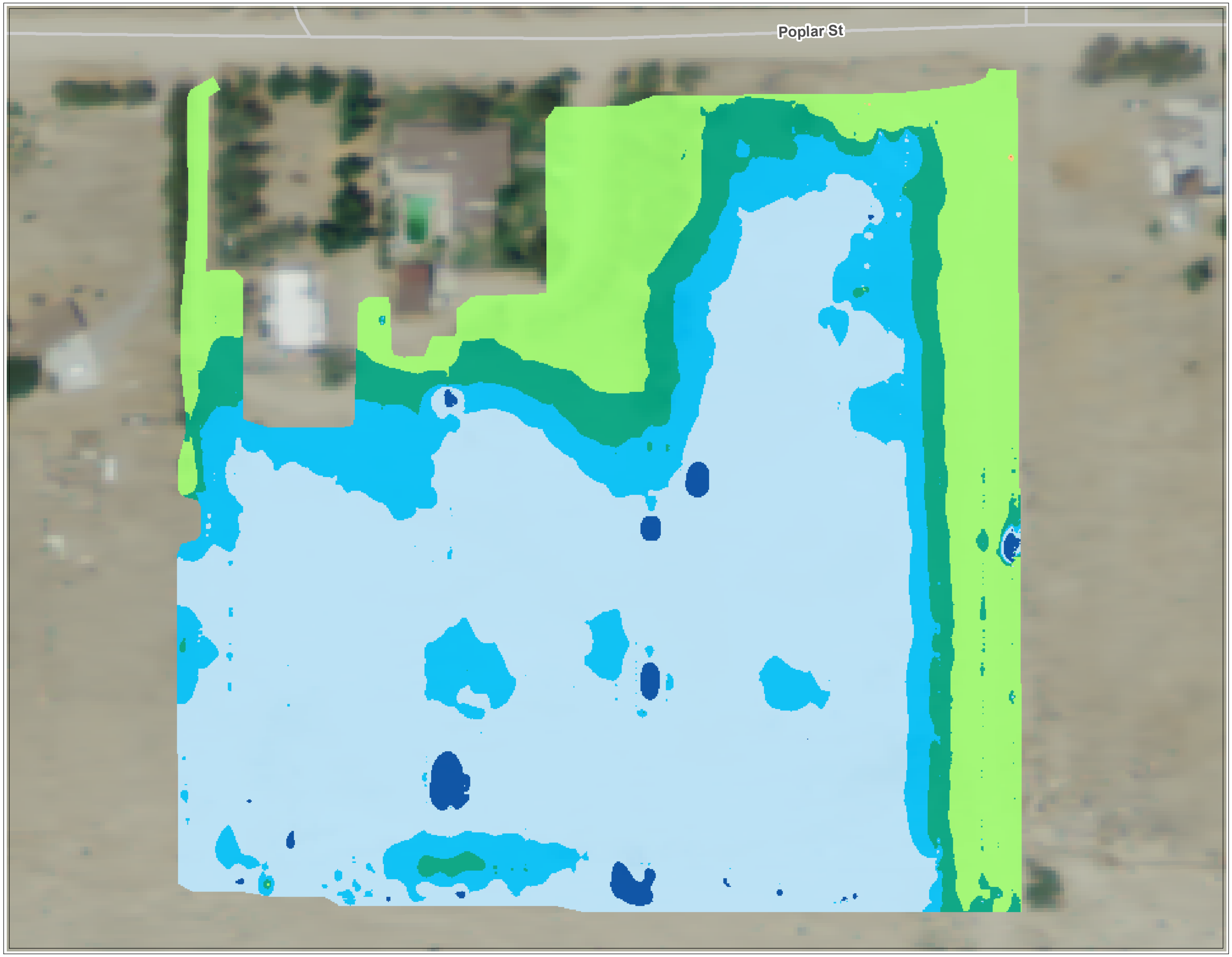
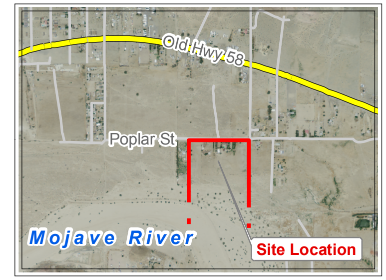
Figure 3
In-Phase Frequency Domain Survey
Mojave River Pyrotechnics Site
Barstow, California





N
W E
S
Magnetic North

Legend

Terrain Conductivity Contour

mS/m

- < 5
- 5- 12
- 12- 15
- 15 - 20
- 20 - 100
- 100 - 150
- > 150

Map created using NAIP imagery data from California State Website.
site survey GPS data and sample result data.

100 0 100
Feet

Map Creation Date: 02 May 2011

Coordinate system: California State Plane V
FIPS: 0405
Datum: NAD83
Units: Feet

Data: g:\arcviewprojects\SERAS01\00-127
MXD file: G:\ArcInfoProjects\SERAS01\SER00127_MojaveRiverSite\127_TripR_TerrainConductivity_f4

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Figure 4
Terrain Conductivity
Mojave River Pyrotechnics Site
Barstow, California