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February 2014

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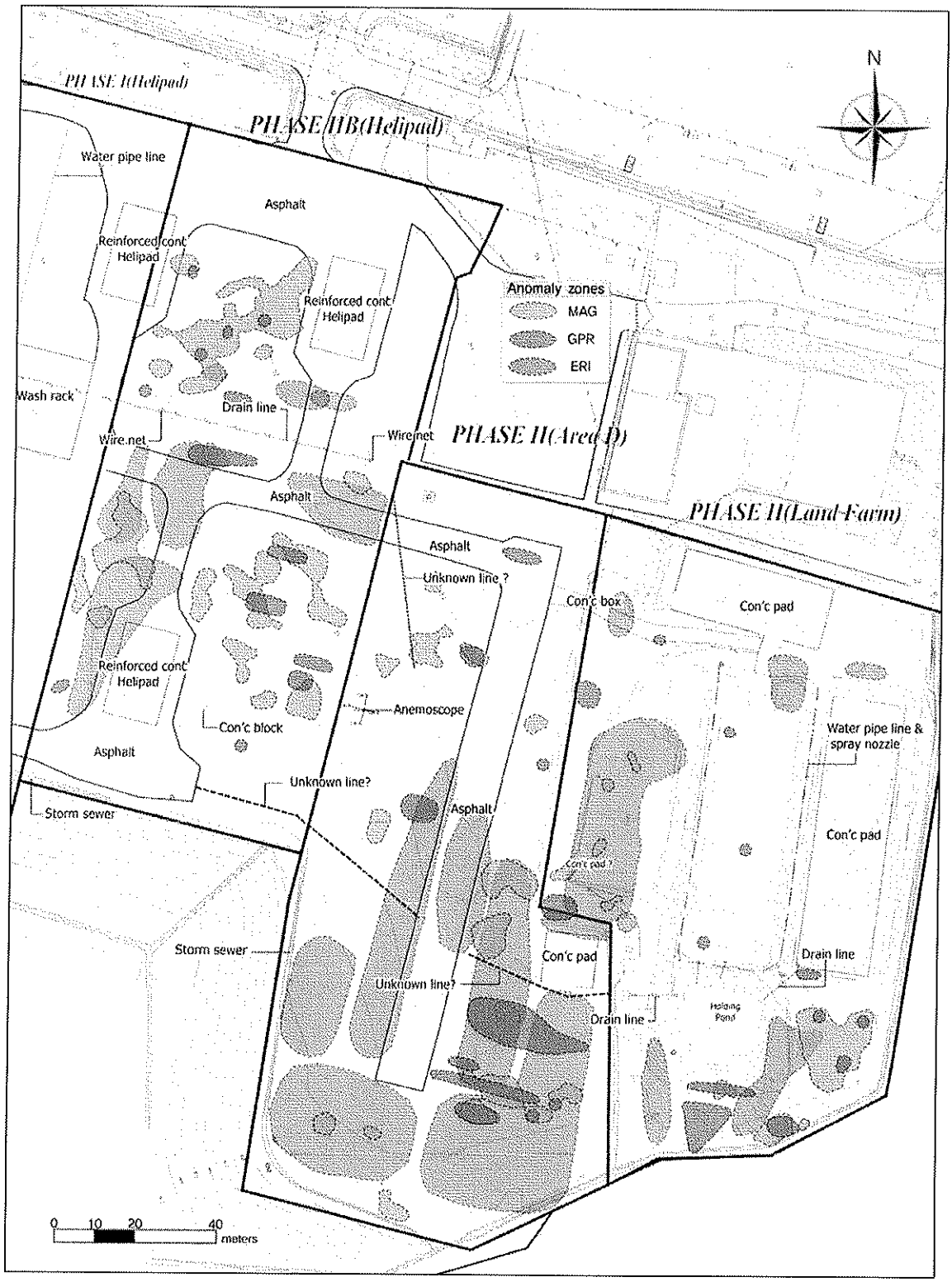
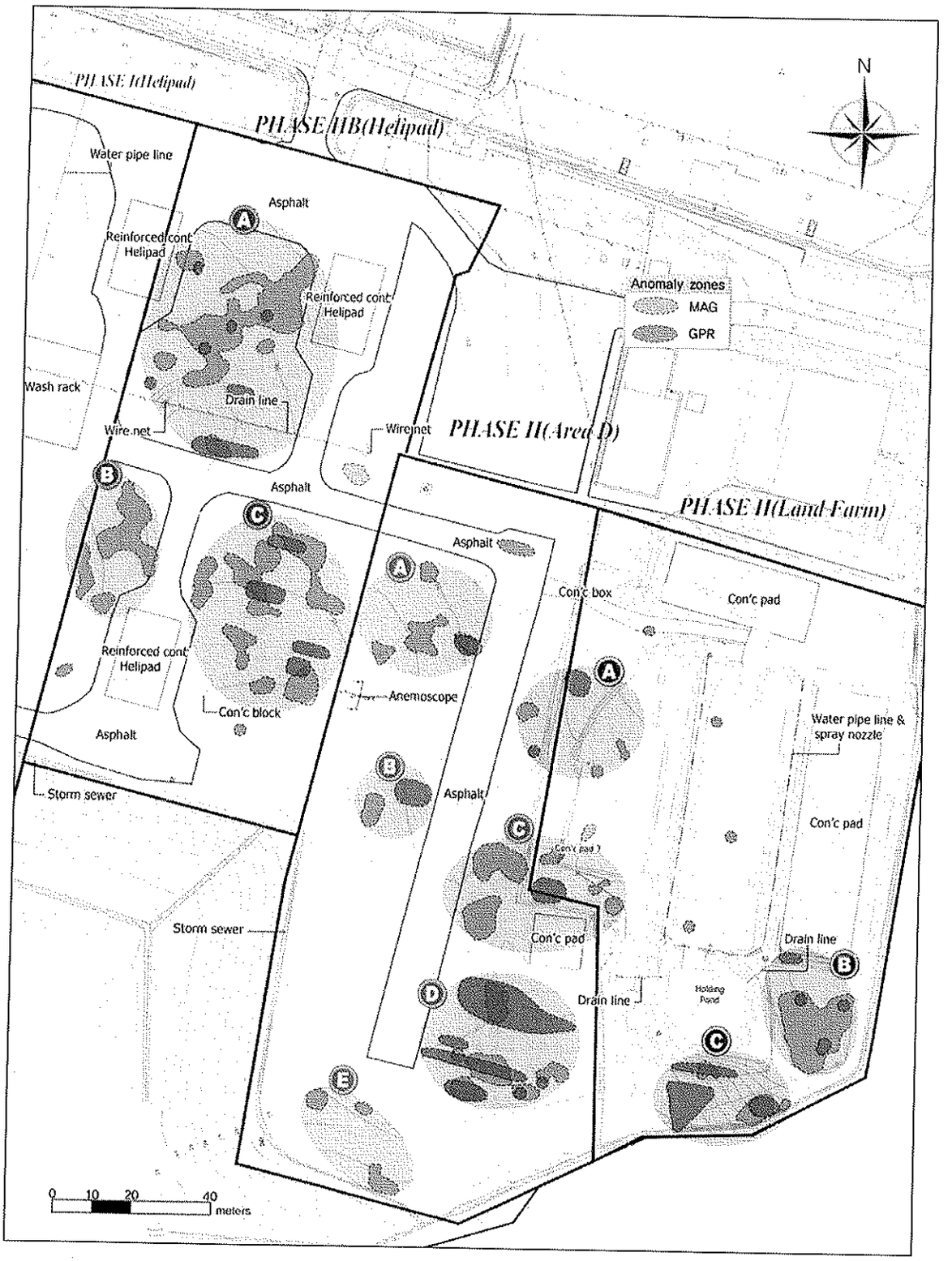
Figure 4-4. Combined Magnetic Gradiometry, GPR and ERI Results



3901

Figure 4-5. Final Interpretation of Subsurface Anomaly Zones



2902

APPENDIX A
GEOPHYSICAL SURVEY INSTRUMENT SPECIFICATIONS

Bartington Instrument Ltd model Grad601 gradiometer
MALÅ GeoScience model ProEx™ Professional Explorer GPR
ABEM Instrument AB model Terrameter LS

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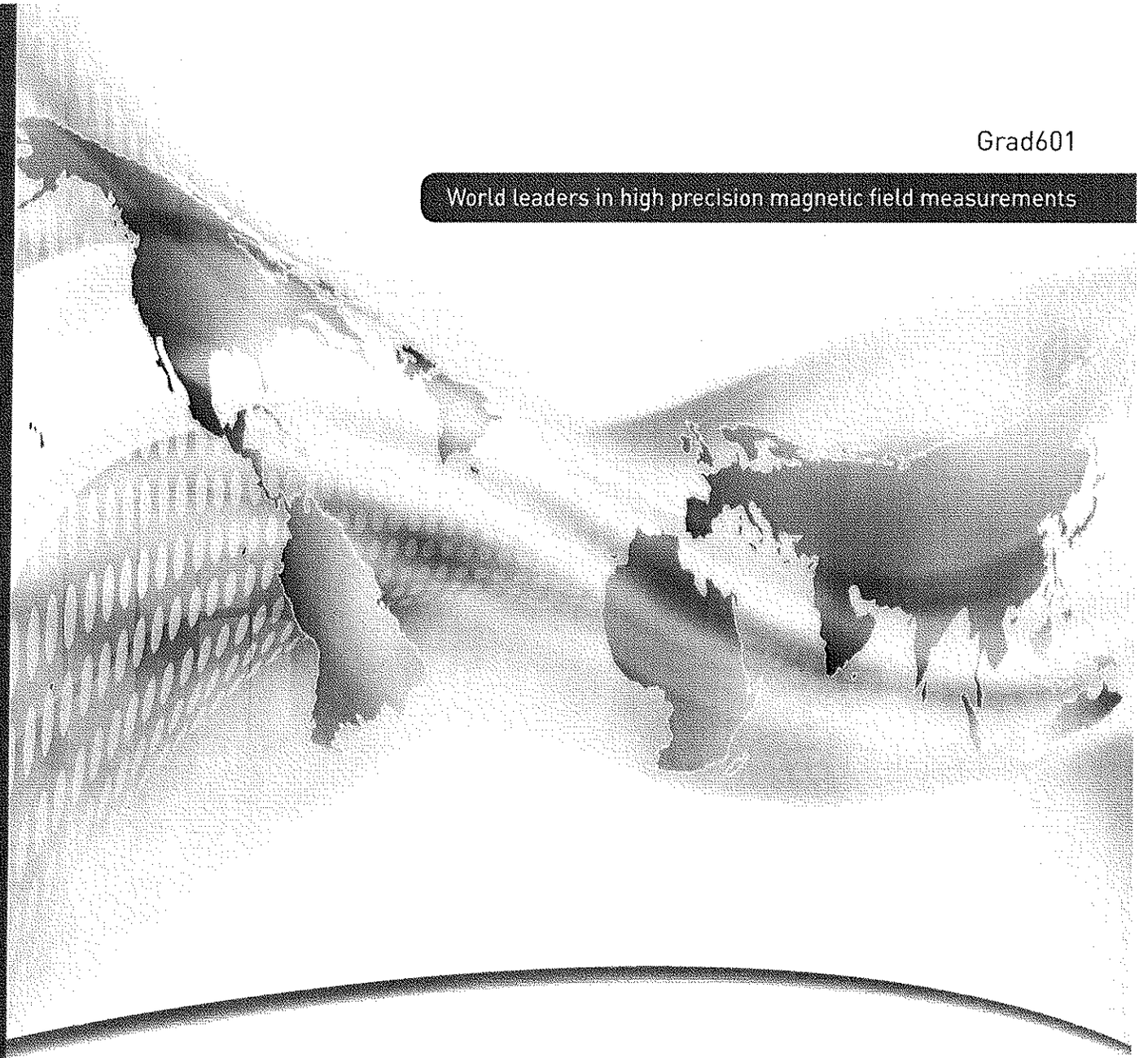
World leaders in high precision magnetic field measurements

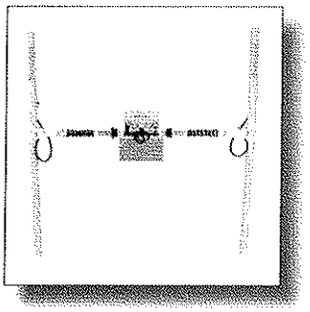


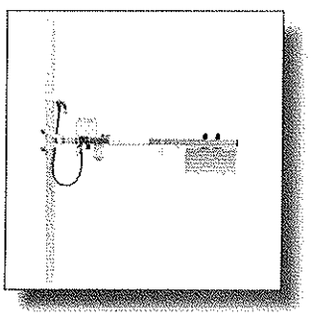
Grad601

Magnetic Gradiometer System

2905

Bartington® Instruments





Grad601

Magnetic Gradiometer System

The Grad601 is a vertical component fluxgate gradiometer comprising a data logger, battery cassette and either one or two Grad-01-1000L cylindrical sensors mounted on a rigid carrying bar. Each sensor contains two fluxgate magnetometers with one metre vertical separation. The system provides an enhanced depth response compared to a gradiometer with 0.5 metre separation, along with exceptional stability. Calibration of the gradiometer is by simple push-button control, eliminating the uncertainties usually associated with mechanically adjusted instruments.

- The Grad601-1 single sensor version is ideal for the location of pipes, cables, drums and archaeological features.
- The Grad601-2 two sensor version allows geophysical surveys to be completed in about half the time.

Both versions provide linear ranges of 100nT with a resolution of 0.01nT (effective resolution 0.03nT) and 1000nT with a resolution of 0.1nT. A large non-volatile flash memory and fast downloading of data enhance survey efficiency.

The exceptional temperature stability of the sensors ensures minimal drift during surveys and reduces the need for adjustment. All adjustments are accomplished using a single push-button and audible cueing. Overall system delay is minimal, ensuring negligible data skew. Powerline rejection can be keypad selected for 50Hz or 60Hz, giving >1000:1 reduction.

The instrument operates in either survey or scanning mode. In survey mode, data is logged using continuous or single-shot measurements, while covering the site in parallel or zigzag paths. In scanning mode, the instrument operates as a search tool with an adjustable audio alarm, without logging data. Either mode can be used to locate archaeological features, pipes, cables, waste drums and unexploded ordnance. Survey data are saved in grids of 10, 20, 30 or 40 metre squares.

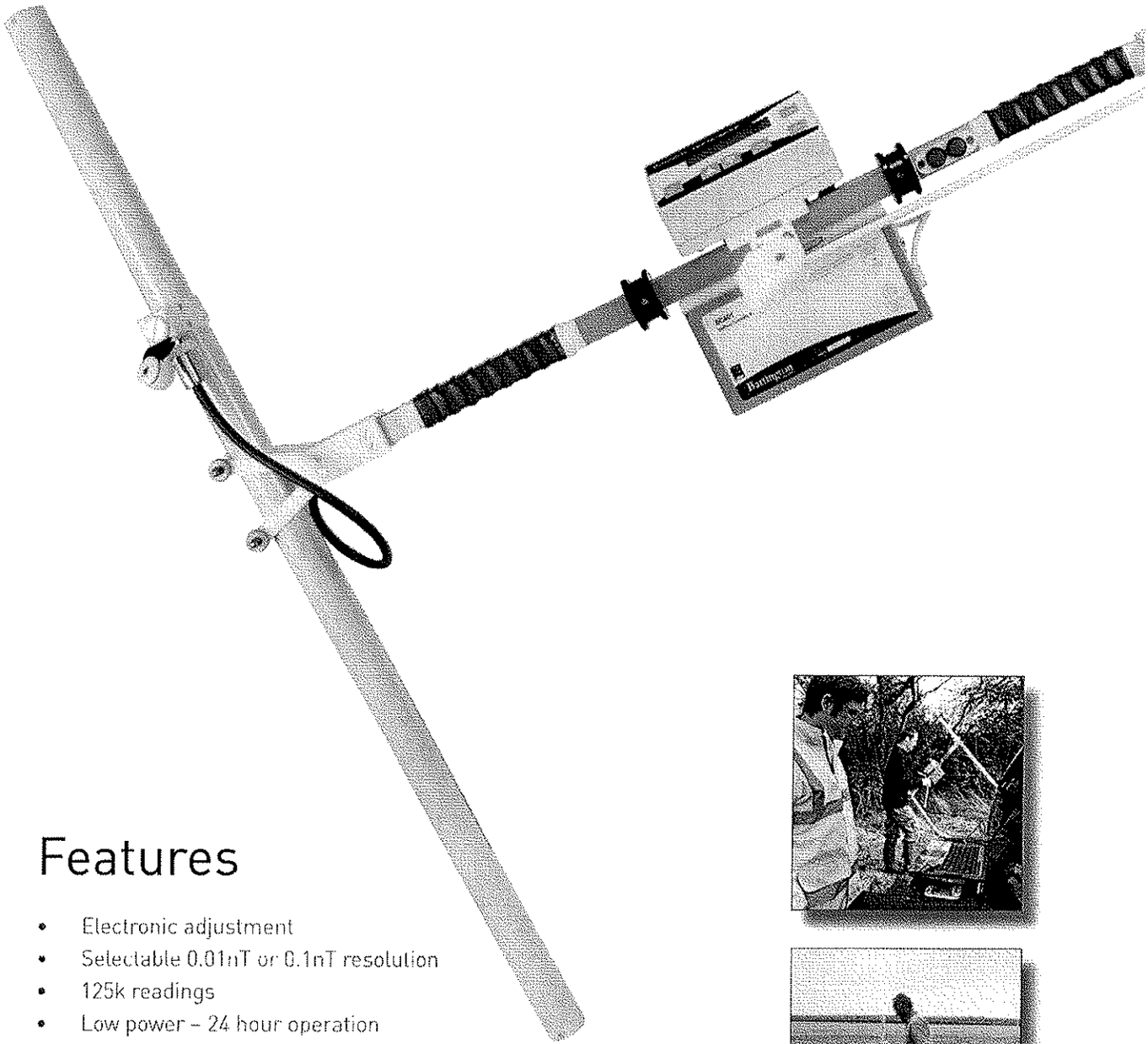
The non-volatile 256kB flash memory is sufficient, for example, to log 30 grids of 30 x 30 metres with a one metre line separation and a resolution of four readings per metre. Software is provided for downloading data from the data logger to a PC via a RS232 serial or USB interface, and it can save data in any of three formats for subsequent data processing. Downloading a full memory takes less than seven minutes.

The intelligent data logger measures the gradient using a high sample rate with automatic averaging to smooth the data for each reading. Sample rate can be adjusted to suit the operator's pace.

GPS

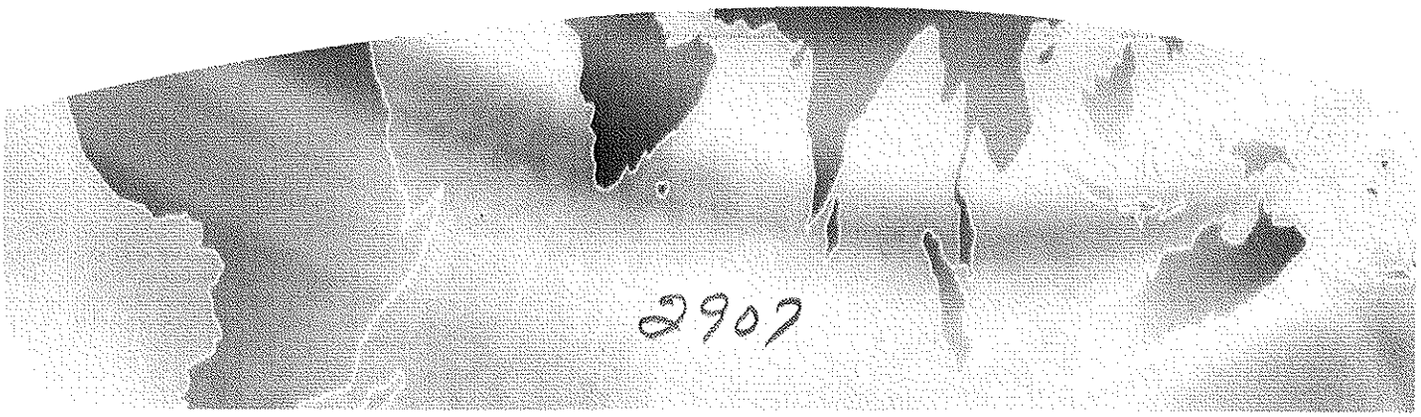
A version of the logger with an NMEA data output, suitable for use with GPS devices, can be supplied. Contact us for details.

2906



Features

- Electronic adjustment
- Selectable 0.01nT or 0.1nT resolution
- 125k readings
- Low power – 24 hour operation
- Survey and Scan modes
- 1 to 4 lines/m
- 1 to 8 readings/m along each line (4 max on 40m grids)
- Fast download – 6.5 minutes max



Accessories

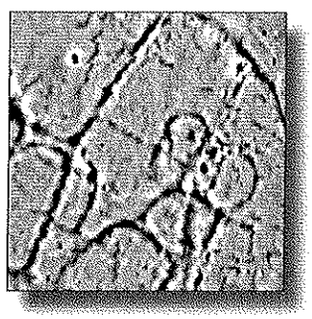
Each gradiometer system is supplied in a universal rugged carrying case, with cut-outs for either a single or dual system, together with the following accessories:

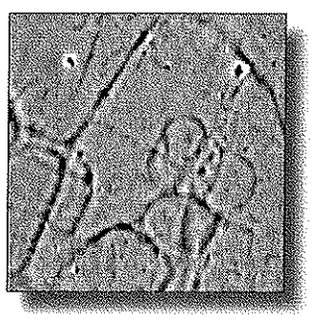
- Carrying harness with spare rings (Grad601-2 only)
- Mains adaptor: 110V-240V/47-63Hz, charging current 1.25A maximum
- In-car charger: regulated 12V-24V DC-DC, 2A current rating, short circuit protected, automatic thermal and overload cut-off
- 9-pin serial cable and USB adaptor
- Downloading software on CD
- Grad601 Operation Manual on CD

The Grad601-2 carrying harness provided for the dual gradiometer system relieves the operator's arms of the weight of the gradiometer, while enhancing the operator's ability to use the instrument. A water-filled bag in the back of the harness counter balances the gradiometer.

The harness can be adjusted to fit the operator and enables the gradiometer to be positioned at the required carrying height. The dual gradiometer bar sits in quick release swivel mounts on the abdominal spacer bar to assist in keeping the sensor vertical. The spacer is attached to the harness by shock absorbing rubber rings.

Grad601 (1m vertical sensor spacing)





Same site surveyed using a gradiometer with 0.5 m vertical sensor spacing

Software

Most users will find that processing and interpretation of survey results is greatly simplified if graphical mapping software is used. The typical graphical image plots shown here indicate how detected features can be clearly identified.

ArcheoSurveyor by DW Consulting
This is a fully featured and powerful graphical imaging application specifically designed for archaeological geophysics. ArcheoSurveyor can read data directly from the Grad601 Gradiometer (and other commonly used survey instruments) via the serial/USB connection. The user can then apply a wide variety of data filters and algorithms (e.g. clip, destripe, destagger, etc.) to enhance the clarity of any magnetic anomalies.

ArcheoSurveyorLite is a 'lite' version of this graphical mapping software, providing the user with the majority of functions needed to process instrument data. There is a simple upgrade path to the full version when further features become necessary.

ArcheoSurveyor and ArcheoSurveyorLite can be purchased from Bartington Instruments or DW Consulting.

Grad601 Download Utility
This utility is supplied free of charge and allows survey data to be downloaded to a Windows® PC. Several file formats (including 'xyz', 'z data' and 'spreadsheet mode') are available, and are compatible with most common mapping software packages (e.g. Surfer, Geoplot).

These plots illustrate how the 1m vertical spacing of the sensors on the Grad601 provides an increased depth of response compared to a 0.5m spacing gradiometer.

2908

Specifications

Environmental Specification	
Rating	IP65
Operating temperature	-20°C to +70°C

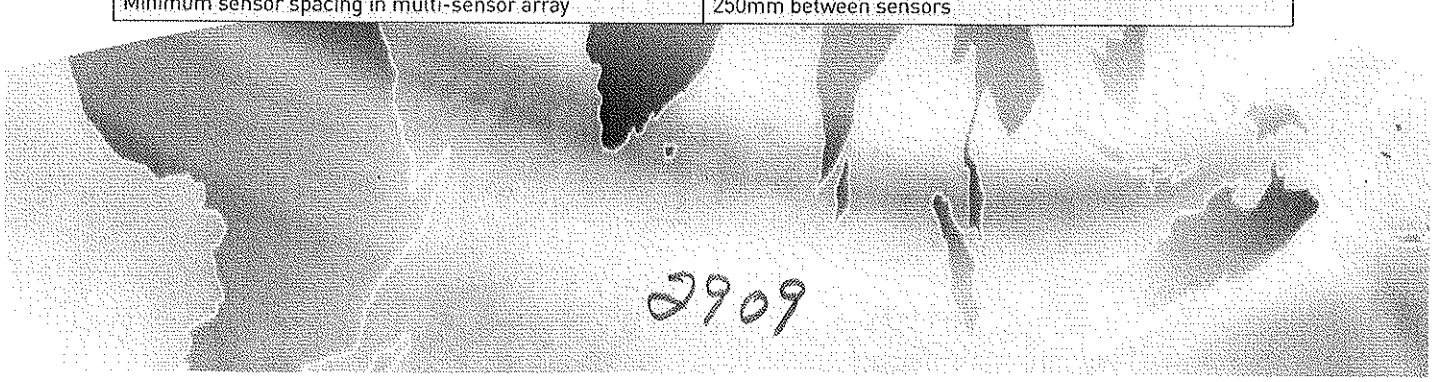
Mechanical Specification	
	Weight
Grad601-1 Single Gradiometer	2.9kg
Grad601-2 Dual Gradiometer	4.3kg
Harness with abdominal spacer and balance weight	1.6kg
Carrying case for either system (dimensions 1250 x 280 x 260mm)	9.85kg (empty) 15.75kg (full)

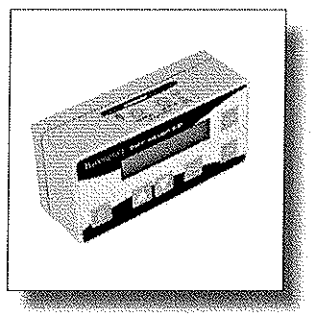
Optional alternative arrangements	
With some additional parts, the Grad601 can be used as either a dual sensor system (for best survey speed) or single sensor system (for confined spaces)	
Conversion:	Additional parts required:
Grad601-2 dual to Grad601-1 single system	Grad601-1 support beam including BC601 battery cassette extension cable
Grad601-1 single to Grad601-2 dual system	Grad601-2 support beam, Grad-01-1000L Sensor

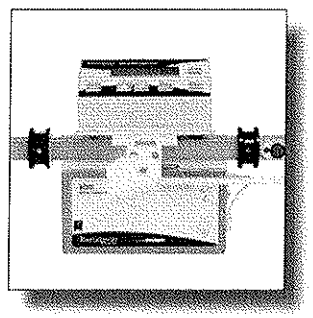
Grad-01-1000L Sensor

The Grad-01-1000L is a high stability fluxgate gradient sensor with a 1m separation between the sensing elements and an effective sensitivity of 0.03nT/m. The exceptional temperature stability of this sensor ensures minimal drift during surveys and reduces the need for adjustment to a minimum. Each sensor contains electronics and non-volatile memory for calibration data storage and can be operated independently, over long cables, if required.

Specification - Grad-01-1000L Fluxgate Gradiometer Sensor	
Sensor element spacing	1m
Gradient range	±100nT/m or ± 1000nT/m full-scale
Bandwidth	DC to 14Hz with -40dB 50Hz/60Hz rejection
Sensitivity	0.03nT/m (max effective)
Accuracy	±2%
Maximum ambient field	±100μT
Drift	<1nT in 24 hours
Dimensions	38mm diameter x 1050mm in length
Weight	0.83kg
Connector	12-way Tajimi R04-R12M
Power supply current	60mA
Minimum sensor spacing in multi-sensor array	250mm between sensors







DL601 Data Logger

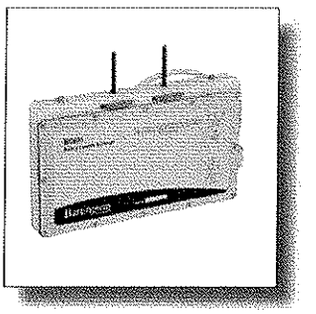
The data logger has a simple six-key control panel for menu-selected operation and liquid crystal display (LCD). External push-buttons are provided for optional use during survey operations.

Specification - DL601 Data Logger	
Sensors	1 or 2 Grad-01-1000L Gradiometers
Gradient ranges	±100nT and ±1000nT
Resolution	0.01nT on ±100nT range* 0.1nT on ±1000nT range
Attenuation	-20dB 50Hz/60Hz rejection
Control delay	27ms
Controls	ON/OFF switch, keypad and external switch
Display	2 rows x 20 characters LCD
Display update rate	Operation dependent
Gradiometer adjustment	Automatic via keypad
Data logging memory	125k data points non-volatile
Data output	RS232 interface USB converter supplied NMEA output version available **
Audio output	Variable rate bleeper
Dimensions (H x W x D)	160 x 80 x 60mm
Weight	0.49kg
Connectors: Grad-01-1000L RS232 output battery external switch	 Two 12-way Tajimi R04-R12F 9-way D type 1-way 62GB type 3-way series 712 subminiature
Power supply requirements	9-18V DC, 45mA (max)

* Effective resolution with Grad-01-1000L Sensor is 0.03nT/m.

** NMEA output for GPS logging, contact Bartington Instruments for details.

BC601 Battery Cassette



This Lithium Ion type of battery is housed in a sealed cassette which also contains the automatically terminating charging circuitry. The battery is charged by the mains adaptor supplied, or any isolated 9-18V DC supply (at 1.2A minimum) in 6 to 8 hours. One charge will operate the system for up to 24 hours with two gradiometer sensors, or 36 hours with one gradiometer. A push-button charge indicator is provided.

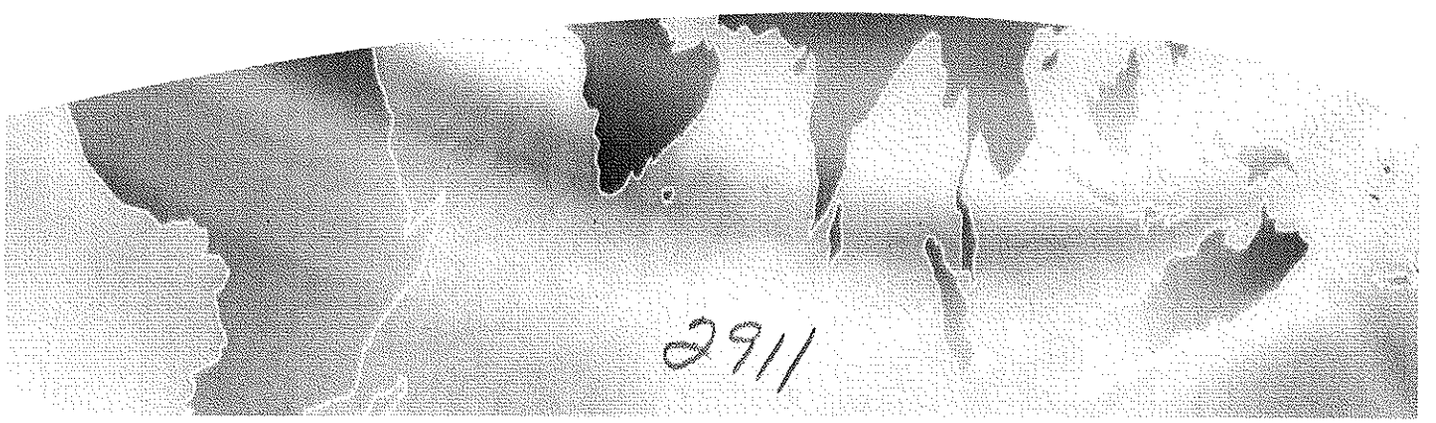
Specification - BC601 Battery Cassette	
Battery	12V 4Ah Lithium Ion
Battery charging	6 to 8 hours with mains adaptor supplied (automatic termination)
Indicators	Red LED lit when charging, off when complete
Fuse	2A 20mm anti-surge internal
Dimensions (H x W x D)	120 x 210 x 25mm
Weight	0.91kg including battery
Connectors: charger input output	 2.1mm socket 2-way 62GB type on 250mm cable

Grad601 Carrying Bar

The appropriate carrying bar is supplied for each configuration. The gradiometers are attached at the ends of the carrying bar by quick release clamps.

The data logger and battery cassette are normally left attached to the carrying bar. All cables are routed through the carrying bar.

Green and red push-buttons are provided on the carrying bar as alternatives to the keypad ENTER and ESC keys, for synchronising the data collection, interruption during surveys and for setting up. The auxiliary push-button sub-assembly, which is easily replaced, is conveniently located near the operator's hand, and reduces excessive wear of the most frequently used keys.



DS1800/14

For further reading, please refer to a paper entitled 'A high-stability fluxgate magnetic gradiometer for shallow geophysical survey applications' by G. Bartington and C.E. Chapman. Published online 4 November 2003 and available at the Wiley Online Library: www.onlinelibrary.wiley.com

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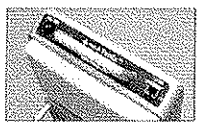
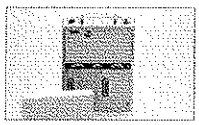
MALÅ

Geophysical ProEx

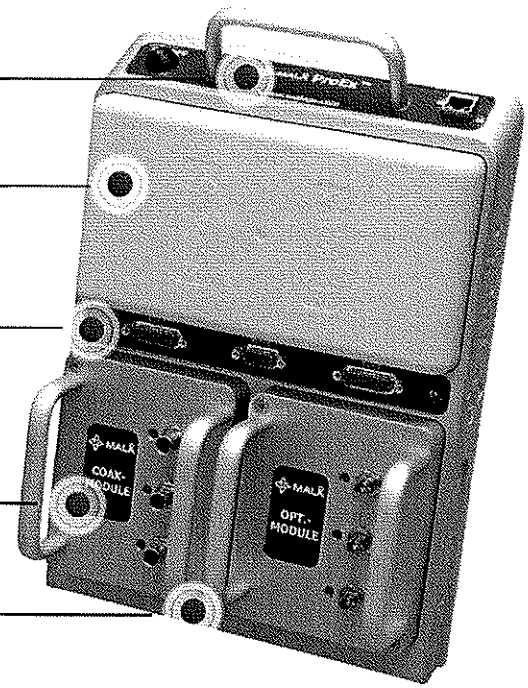

Ethernet communications 100Mbit/s


Battery or external 12V power supply


Antenna modules


Expansion unit

1. Field rugged Control Unit – IP65
2. 12V Li-Ion battery
3. Auxiliary connectors / ports
4. Antenna modules
5. Connectors for Expansion Unit



MALÅ Professional Explorer (ProEx™)

The most versatile GPR unit on the market

The MALÅ Professional Explorer (ProEx™) System is a modular, full-range Ground Penetrating Radar (GPR) system designed to meet the needs of the advanced professional user. At the heart of this system is the MALÅ ProEx Control Unit. Designed on a completely new technical platform, the MALÅ ProEx is the most versatile control unit in the MALÅ Geoscience range and replaces the World famous RAMAC/GPR CUII as the new high-end full range system.

GPR offers a practical, reliable and most importantly non-destructive solution for subsurface geophysical and geotechnical investigations.

The MALÅ ProEx Control Unit is fully compatible with broad range of antennas from MALÅ Geoscience and offers a flexible and versatile approach to detecting subsurface targets and geological layers accurately, efficiently and in real-time.

MALÅ Geoscience's modular design approach offers you a flexible and affordable choice to system configuration. You need only to invest in what you need today; however, as your needs change, so can your MALÅ GPR system.

2913

MALÅ

Geophysical ProEx

Main Applications

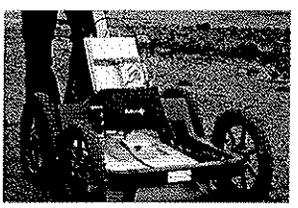
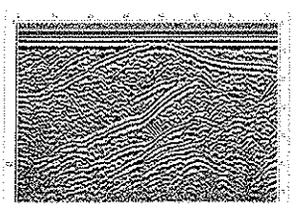
Whatever your application is, the MALÅ ProEx can assist in providing solutions to your subsurface investigation needs in areas such as:

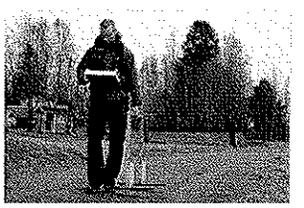
- Archeology & Forensics
- Borehole
- Concrete NDT & Civil Engineering
- Environmental
- Geological/Mining
- Ice & Snow Measurements
- Research
- Road & Transportation
- Utility Detection & Mapping
- And more!

Specific Features

MALÅ Geoscience is renowned for its innovative designs and the tradition continues with this third-generation digital control unit. The MALÅ ProEx boasts a list of practical features rolled into one rugged design suitable for advanced and professional users.

- Modular Design
- Dual hardware channel (4 data channels)
- Multi-channel: max. 8 antennas (16 data channels) as optional
- Supports all antennas from MALÅ Geoscience
- Supports array configurations
- Ethernet communication
- Pulse Repetition Frequency (PRF): 100 KHz (upgradeable)
- 100 KHz PRF per hardware channel



System Configuration

The MALÅ ProEx is a modular digital radar control unit with multi-channel functionality. The unit is designed for two hardware channels (4 data channels) and by adding antenna modules this allows connection of two separate antennas for simultaneous data collection whilst also providing a third "virtual antenna". As an option, the available MALÅ ProEx Expansion Unit can be added to expanded the system to eight hardware channels (16 data channels) and operate up to eight individual antennas.

A choice of three antenna modules (optical, high frequency and coax) allows the user to connect any MALÅ antenna in various configurations, for single, dual or multi-antenna operation. Thus enabling a wide range of advanced measurements to be carried out.

Technical Specification

Power supply: Li-Ion 12V battery
Operating time: 5 h nominal, depending on configuration
Operating temp: -20° to +50°C / 0° to 120 °F
Environmental: IP65
Dimensions: 32.5 x 22.2 x 4.2 cm
Weight: 1.9 kg
Antennas: The MALÅ ProEx is fully compatible with the entire range of MALÅ Geoscience antennas, the MALÅ XV Monitor data acquisition platform and the MALÅ GroundVision 2[1] acquisition software.

[1] Requires a notebook PC

See our webpage for latest information

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Terrameter LS

- Imaging system measuring Resistivity, IP and SP.
- High reliability, safety and robustness under harsh field conditions.
- Easy to use with multi-lingual graphical user interface on sunlight readable colour LCD.
- On-site capabilities for data QA, system diagnostics and fault tolerance.
- Superior quality in data acquisition with powerful transmitter and high dynamic range multi-channel receiver.
- Open communication platform for data exchange, Internet and remote diagnostics (TCP/IP, USB).

ABEM

2915

Technical Specifications: **Terrameter LS**

Receiver

No. of Channels	4 – 12 input (+ 2 for Tx monitoring)
Isolation	All channels are Galvanically isolated
Input Voltage Range	+ / - 600 V
Input Impedance	200 MOhm, 20 MOhm and 300 kOhm
Precision	0.1 %
Accuracy	0.2 %
Resolution	3 nV at 1 sec integration
Linearity	0.005 %
Range	Operator selected range of measurement + /- 5 V, 20 MOhm + / - 5 V 200 MOhm + / - 600 V 300 kOhm
Flat Frequency Response	better than 1 % up to 300 Hz

Measuring

Resistivity	YES, Full waveform recorded
SP	YES, Full waveform recorded
IP	YES, Full waveform recorded
Dynamic Averaging	24 bit A/D conversion
Data Sampling Rate	30 kHz
Cycle time	from 0.1sec to 30 sec User selectable
IP Windows	Arbitrary windows flexibility configured to powerline frequencies

Transmitter

Output power	250 W
Current transmission	True Current Transmitter
Output Current Accuracy	better than 0.4 %
Maximum Output Current	2500 mA
Maximum Output Voltage	+ / - 600 V 1200 V peak to peak
Instant Polarity Changer	YES
Accuracy	0.4 %
Precision	0.1 %
Self Diagnostics	Temperature, Power dissipation Monitoring
Safety	Emergency Interrupter easily accessible

Tx Monitor

Voltage	+/- 600 V
Current	+/- 2500 mA
Full wave from monitored	
Accuracy	0.2 %
Precision	0.1 %

General

Casing	Rugged Aluminum case meets IEC IP 66
Computer	Embedded ARM 9, 200 MHz
GPS	20 channels SirFstarIII chip
Display	8,4" Active TFT LCD, full colour, Daylight visible
I / O ports	2 x KPT 32 p for imaging, AUX 2 x USB, RJ45 for LAN
Service point	Accessible through Internet Multifuncion connector
Memory Capacity	More than 1 500 000 readings
Power	Internal NiMH 12 V power pack or Optional External 12 VDC battery
Dimensions (W x L x H)	39 x 21 x 32 cm
Weight	12 kg

Software & Communication

Terrameter LS is controlled using the incorporated Firmware. It has a Graphical User Interface that is easy to follow in all its aspects. Clear and instructive graphics assists the user in the operation of the instrument.

For enhanced Data Quality Control in the field it is possible to display the measured Multi-Electrode Resistivity Imaging data in near real time as a pseudo section. Thanks to access points as USB and RJ 45 (for LAN) transfer of data to other computers is extremely simple.

For full inversion of data external software is required. Most common today is RES2DINVor RES3DINV. This program supports data formats provided with the help of the Terrameter LS software.

Multi-Electrode Survey Systems for 2D & 3D for Resistivity, IP & SP Imaging & Monitoring

Switching matrix	Internal 10 X 64
Roll-a-Long	YES full coverage, both 2 & 3D
All 84 take-outs	in a Standard cable array are active for roll-a-long
Array types Default	Multiple Gradient, Dipole-Dipole, Pole-Dipole, Wenner etc.
Take-outs internal	64 inline + 3 remote electrodes
Expandable	through Multiconnector up to 16320 electrodes. Unlimited number via Interconnect cable.

The switch matrix is divided into four blocks for effective use of all receiver channels available.

Electrode Test	YES, Focus One and Pair

SAS LOG 300 logging unit (optional)

Measures both long and short Normal configuration. A lateral configuration is also included. A fluid resistivity cell, a temperature sensor and a water level indicator make it a complete electrical logging device. Refer to the separate leaflet for more details.

FIELD EQUIPMENT IMAGING

Consult your local ABEM distributor for full details of the various configurations available for you. A hint G30-2D = 30 m depth & 2D software.

Terrameter LS Imaging G30-2D	**33 3002 01**
Terrameter LS Imaging G70-2D	**33 3002 02**
Terrameter LS Imaging G140-2D	**33 3002 03**
Terrameter LS Imaging G200-2D	**33 3002 04**
Terrameter LS Imaging G275-2D	**33 3002 05**
Terrameter LS Imaging G30-3D	**33 3002 06**
Terrameter LS Imaging G70-3D	**33 3002 07**
Terrameter LS Imaging G140-3D	**33 3002 08**
Terrameter LS Imaging G200-3D	**33 3002 09**
Terrameter LS Imaging G275-3D	**33 3002 10**

With reservations for changes; our products undergo continuous development

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Your Distributor

APPENDIX B
GPR 2-DIMENSIONAL SECTIONS AND ERI VERTICAL CROSS SECTIONS

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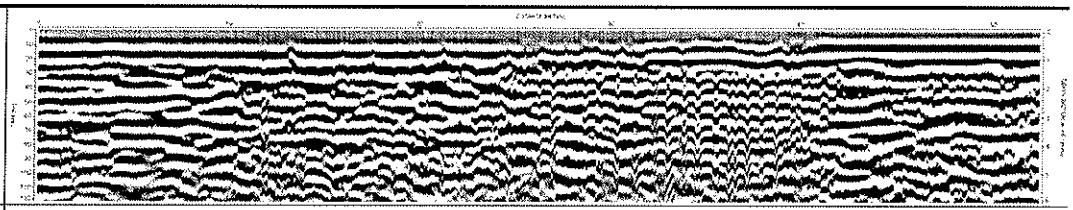
100 MHz GPR 2D Radargrams for Phase II Area D Site

1



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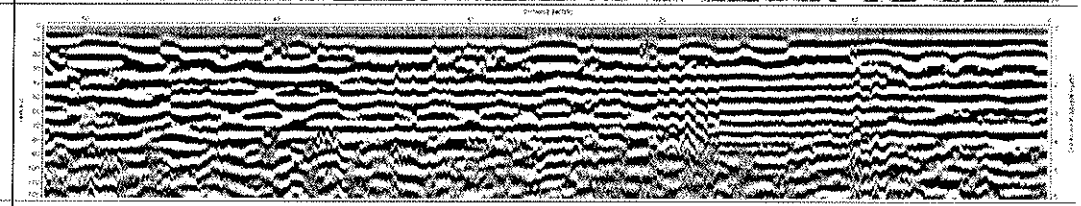

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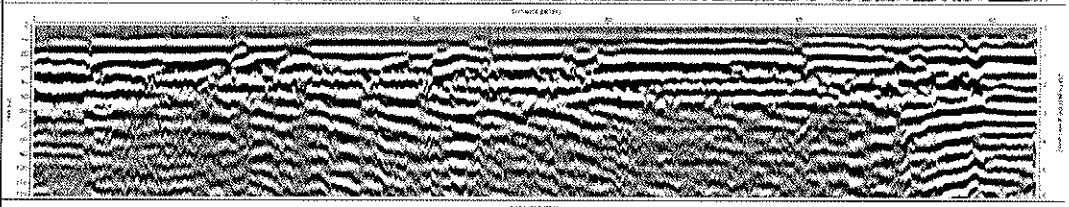

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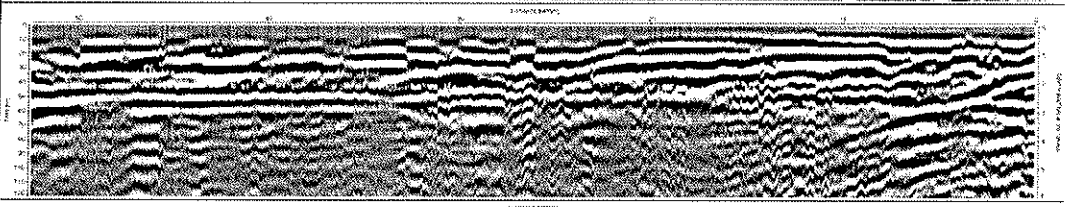

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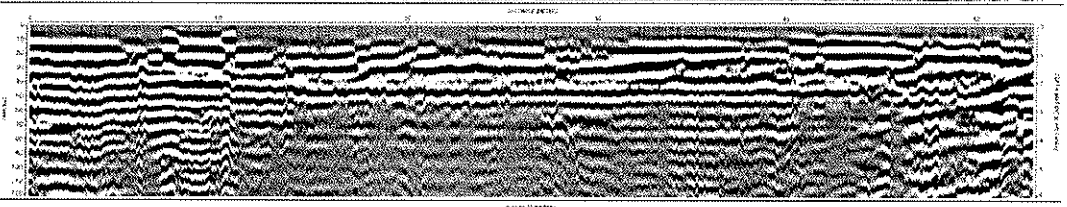

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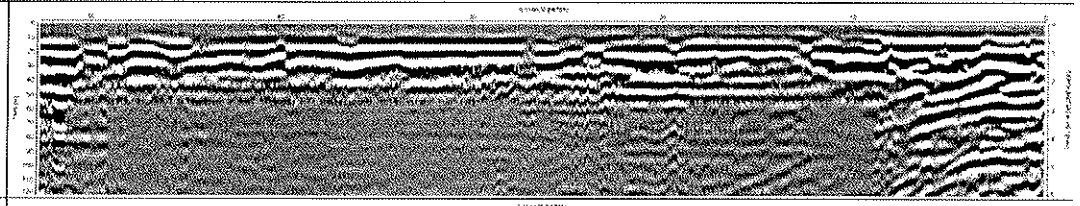

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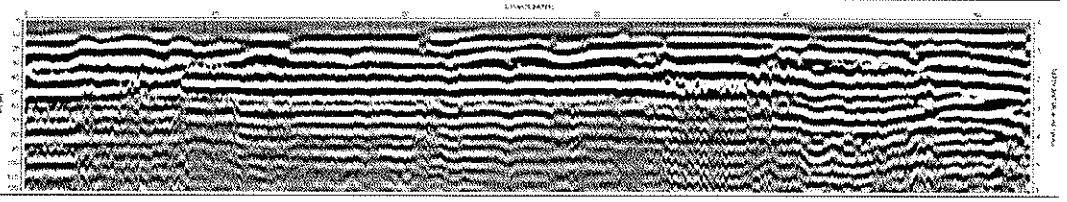
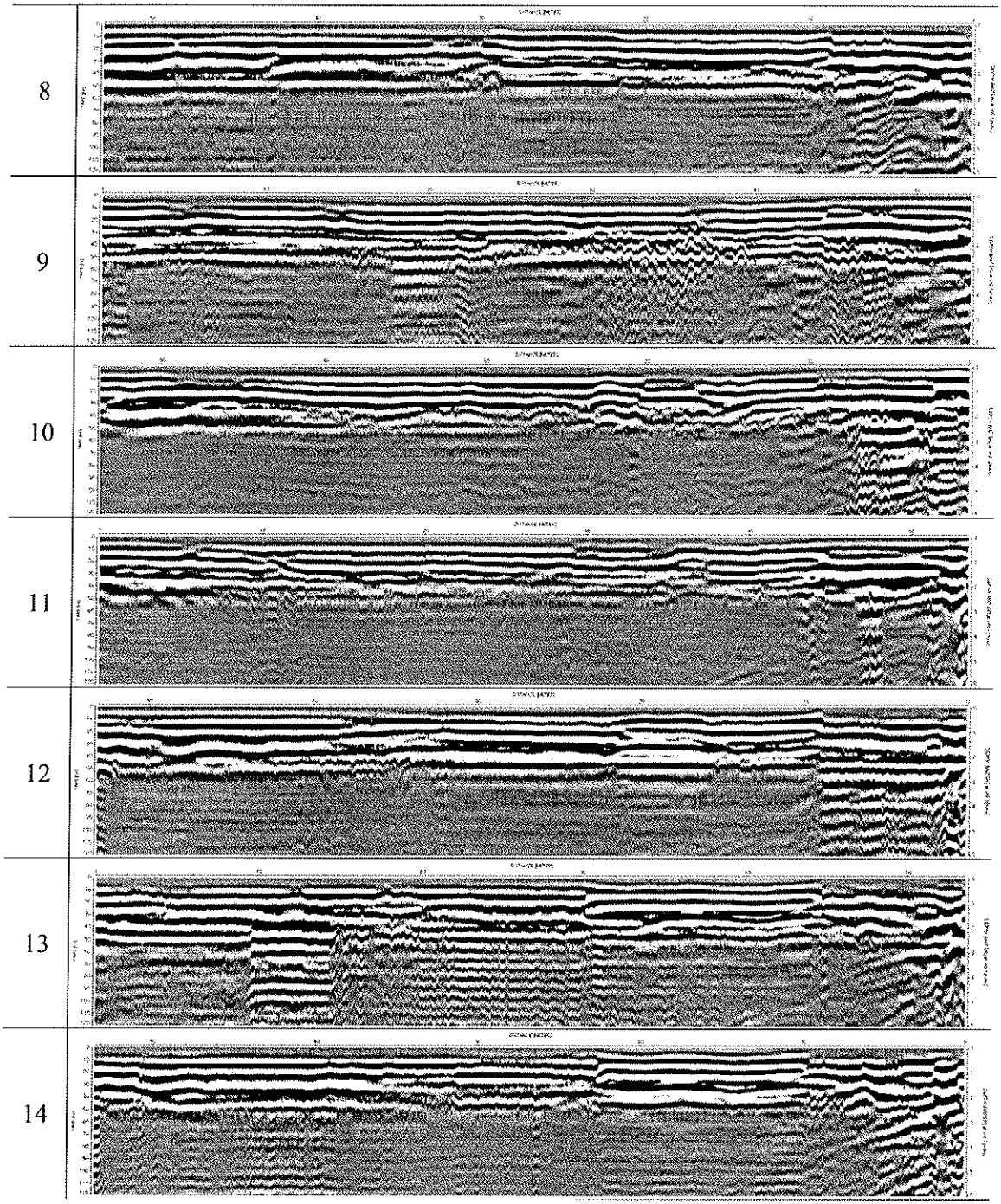


100 MHz GPR 2D Radargrams for Phase II Area D Site



100 MHz GPR 2D Radargrams for Phase II Area D Site

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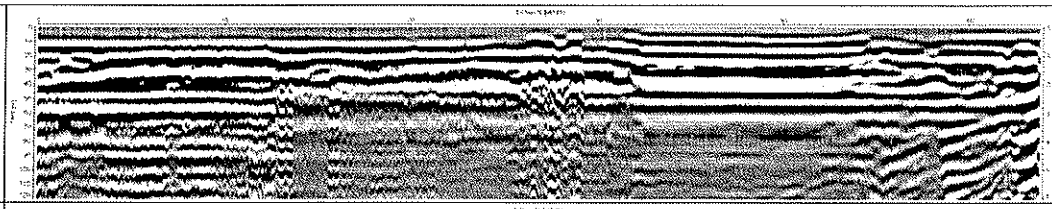

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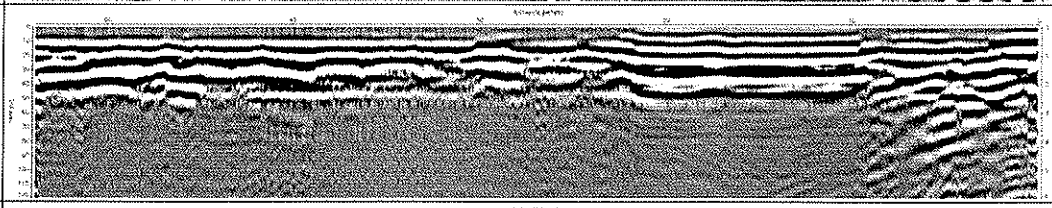

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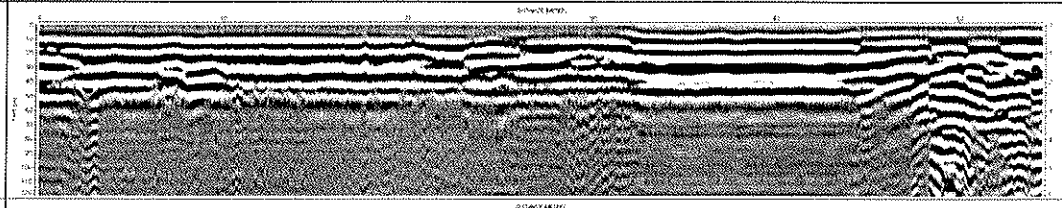

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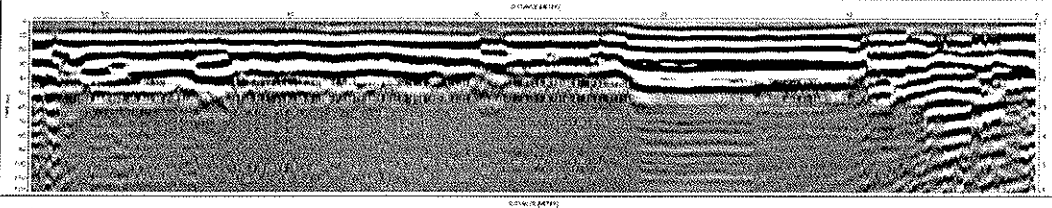

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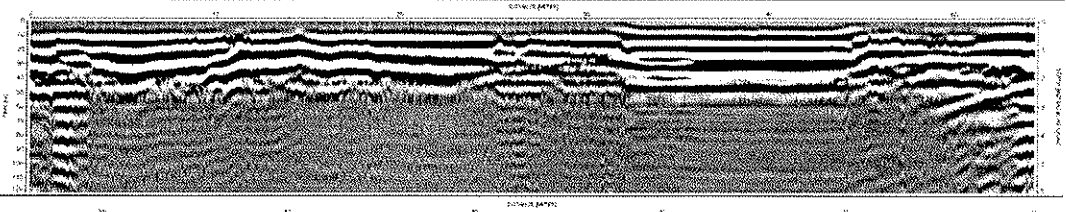

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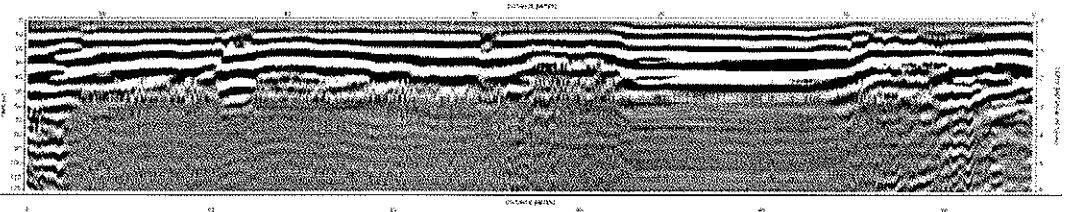

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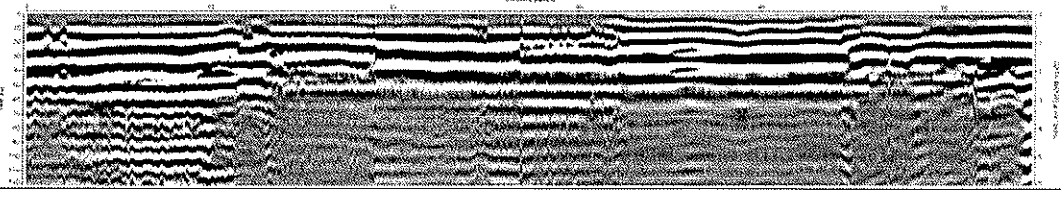

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100 MHz GPR 2D Radargrams for Phase II Area D Site

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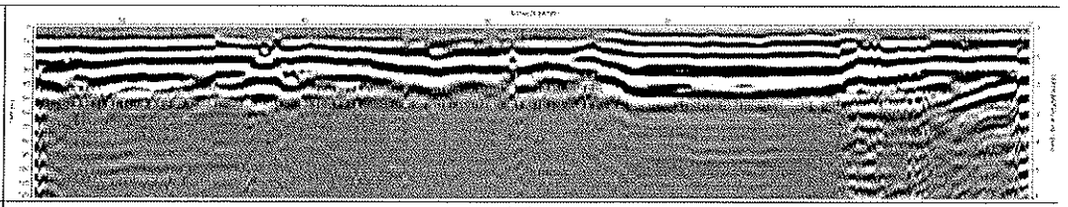

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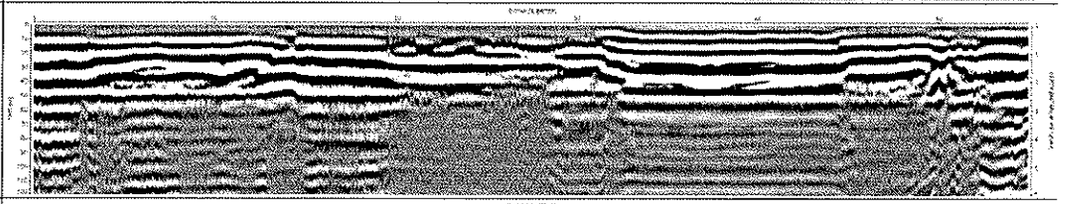

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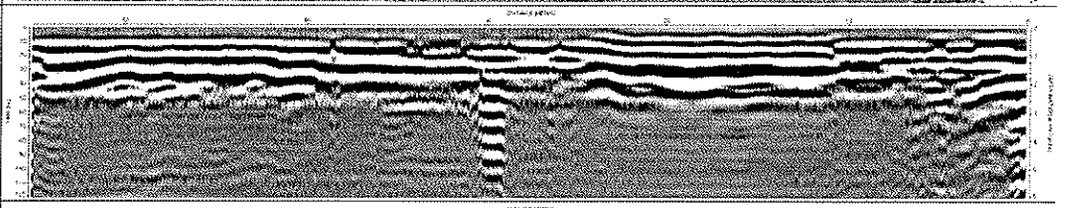

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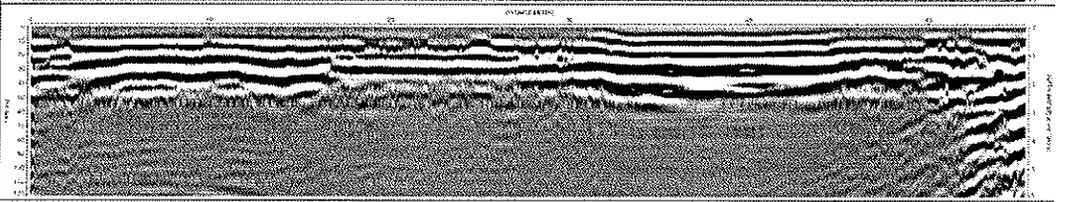

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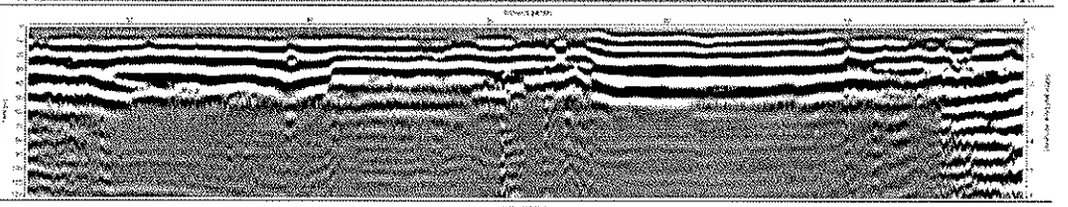

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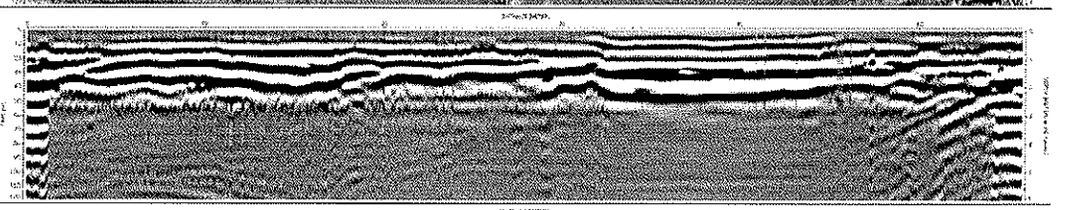

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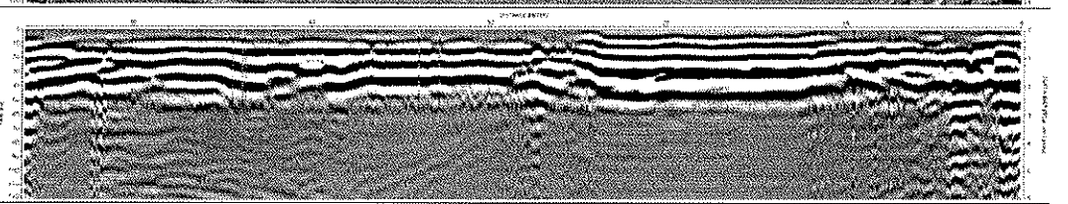
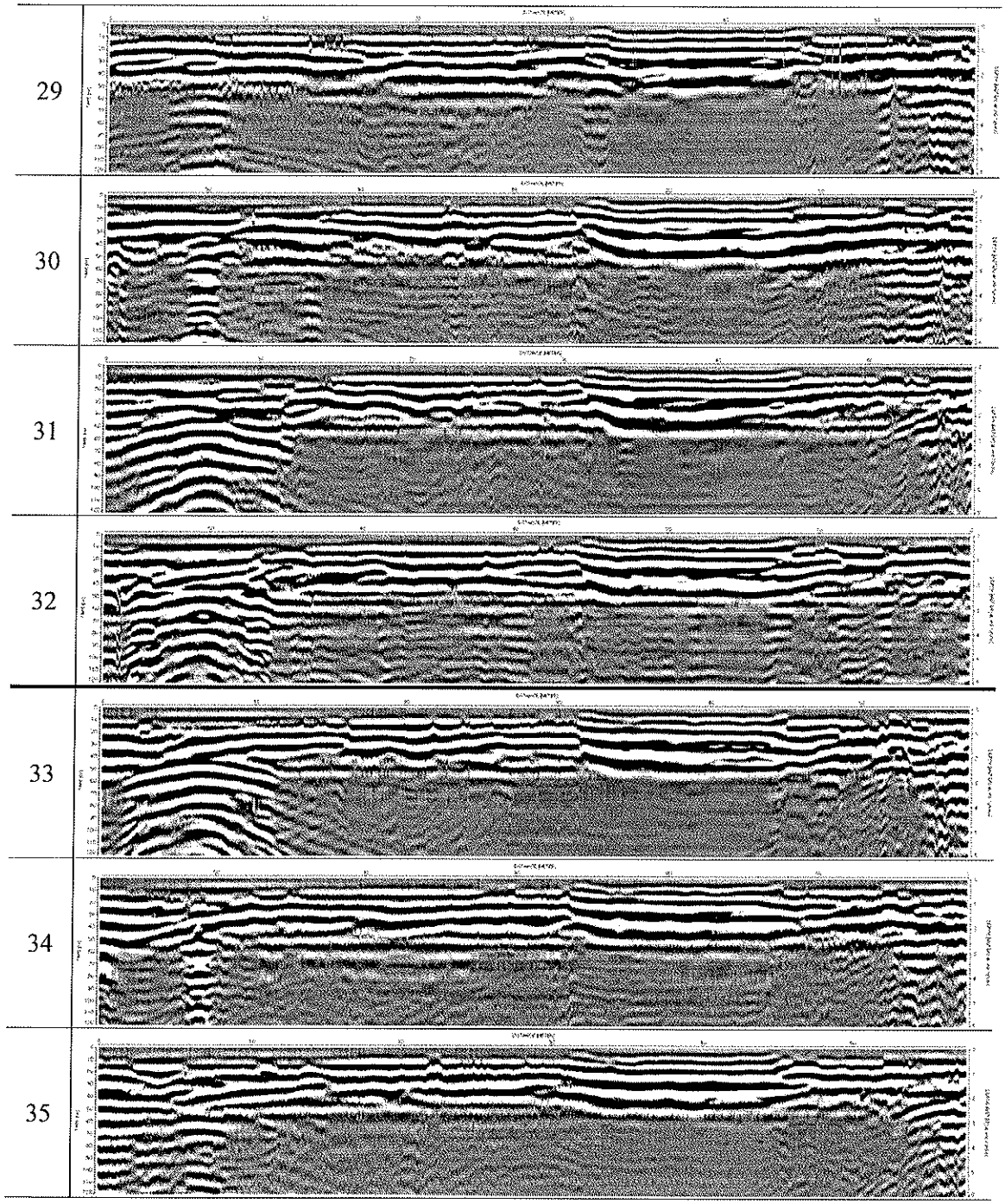
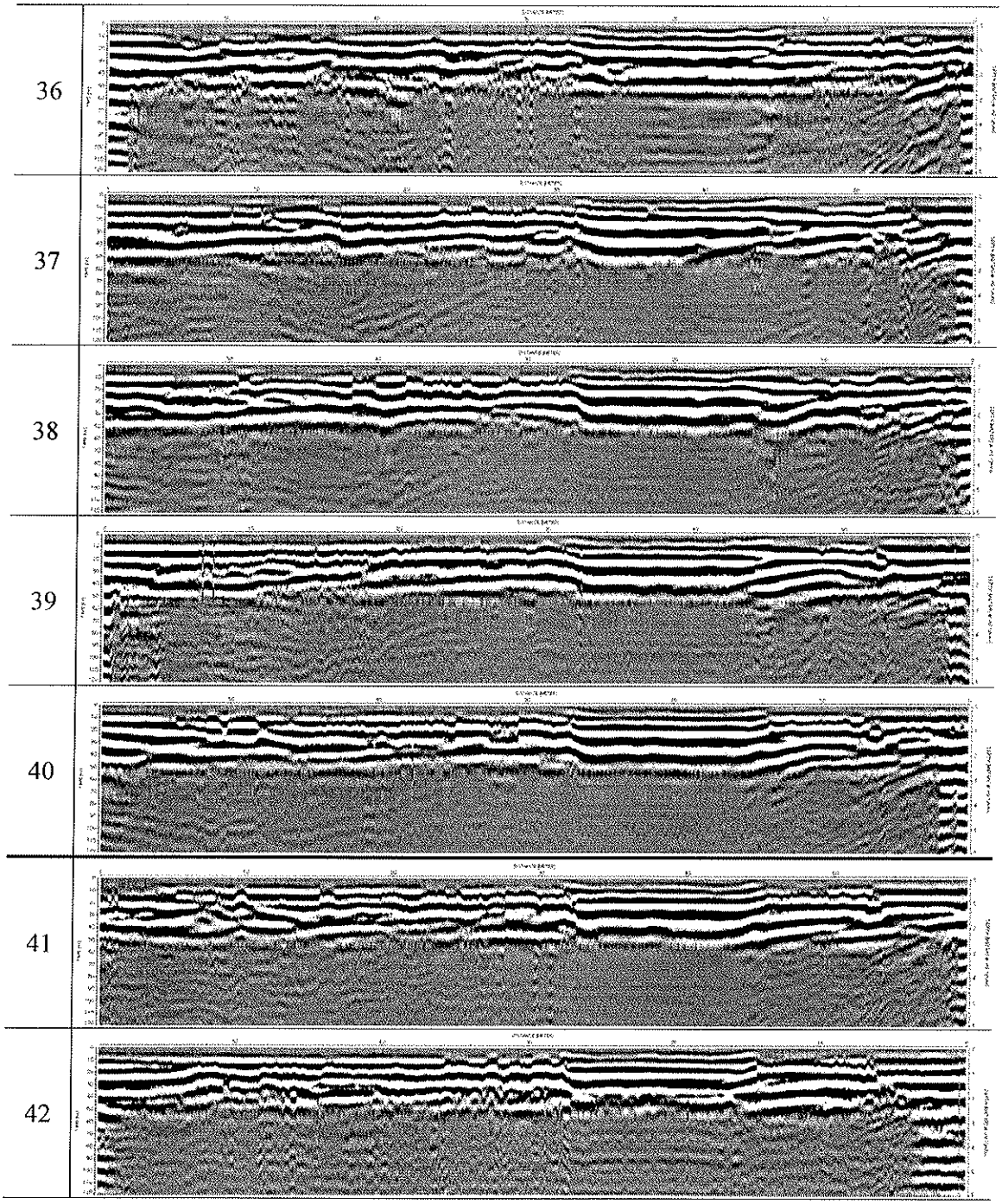


100 MHz GPR 2D Radargrams for Phase II Area D Site



100 MHz GPR 2D Radargrams for Phase II Area D Site



100 MHz GPR 2D Radargrams for Phase II Area D Site

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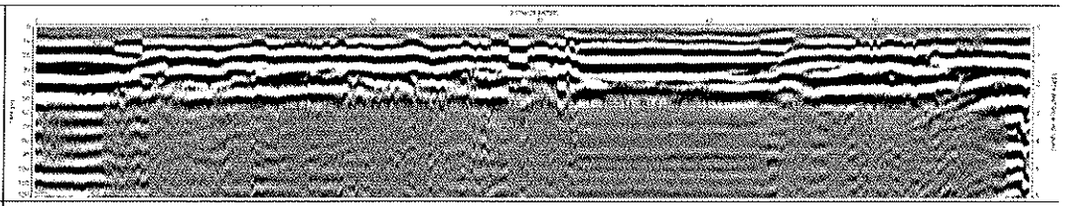

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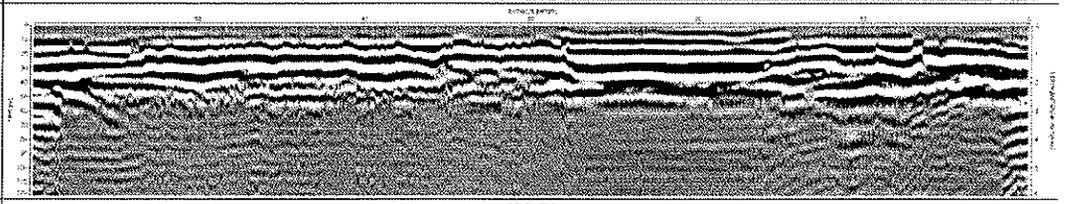

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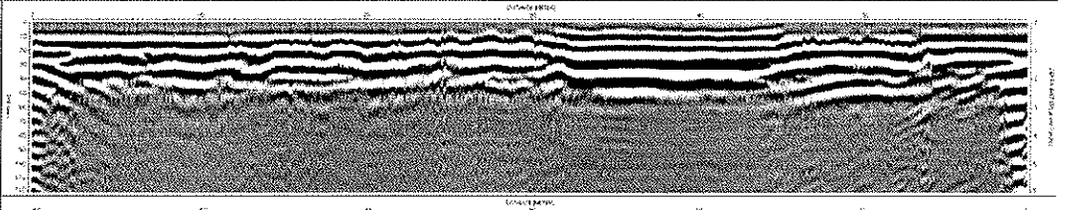

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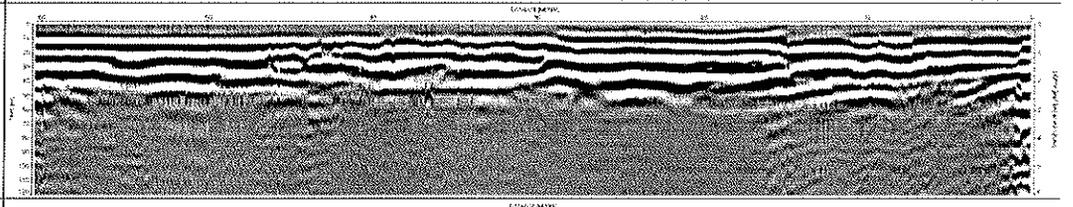

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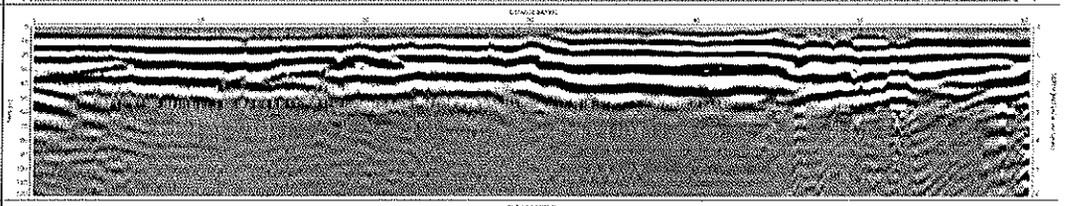

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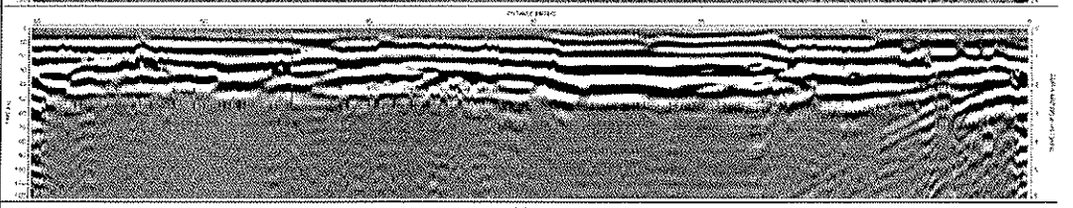

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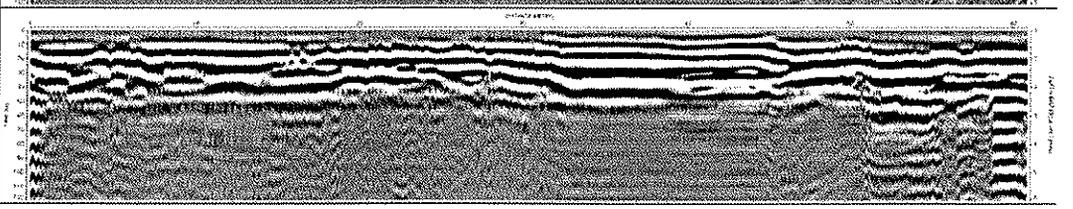
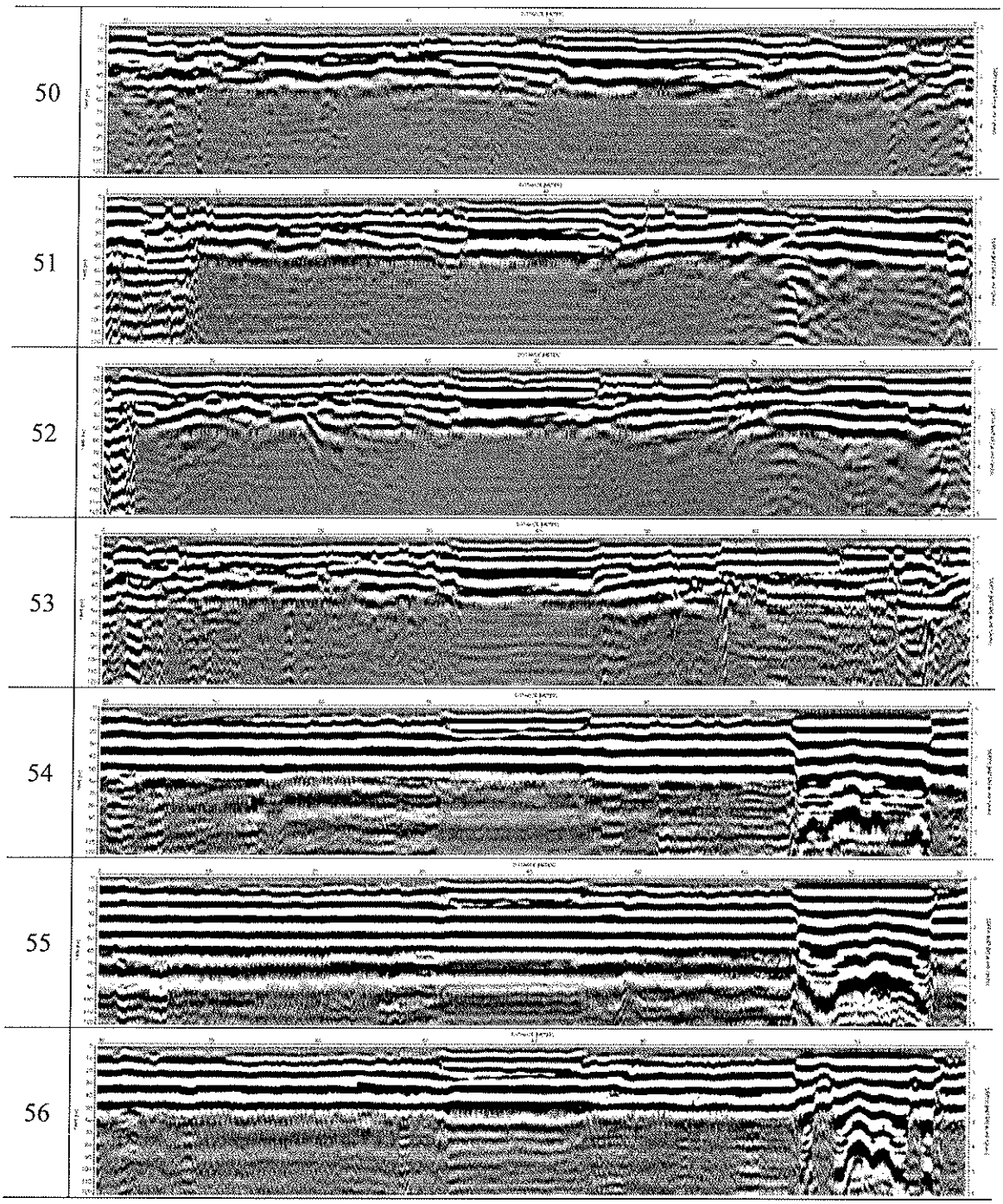


100 MHz GPR 2D Radargrams for Phase II Area D Site



100 MHz GPR 2D Radargrams for Phase II Area D Site

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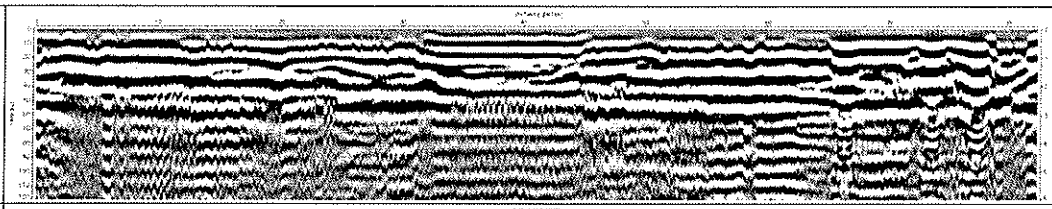

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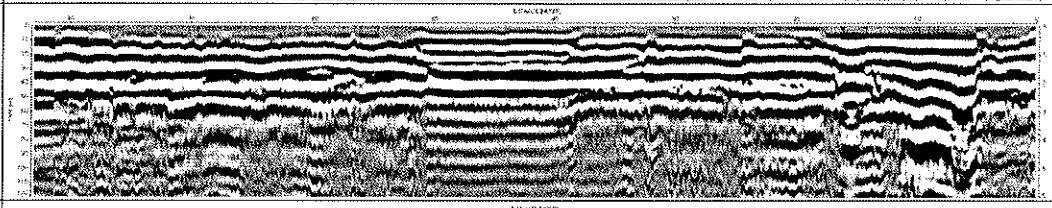

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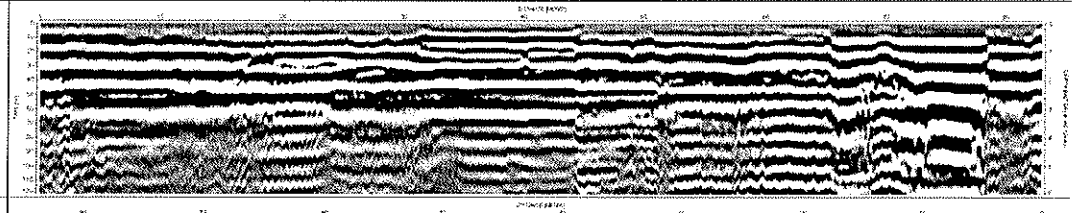

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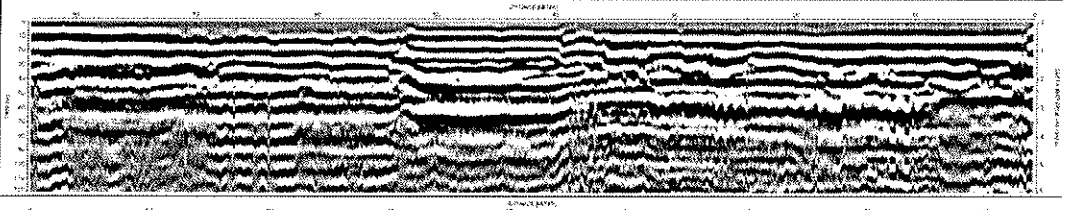

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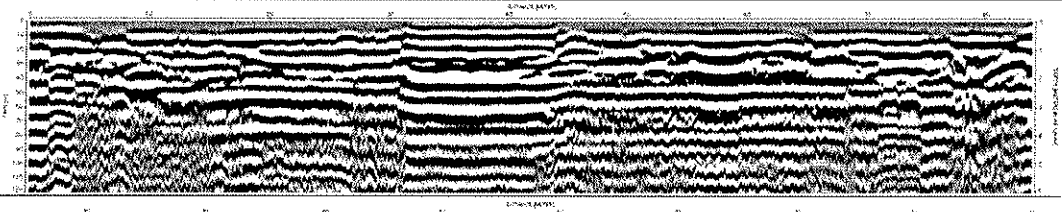

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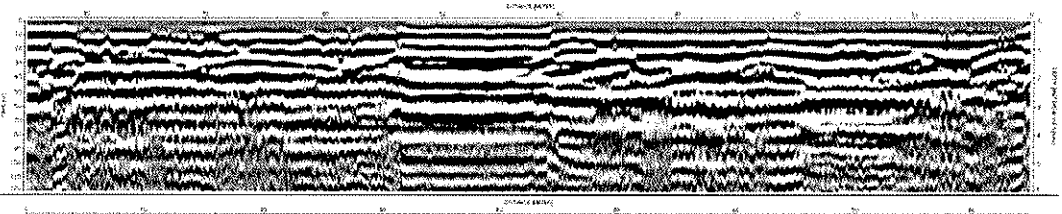

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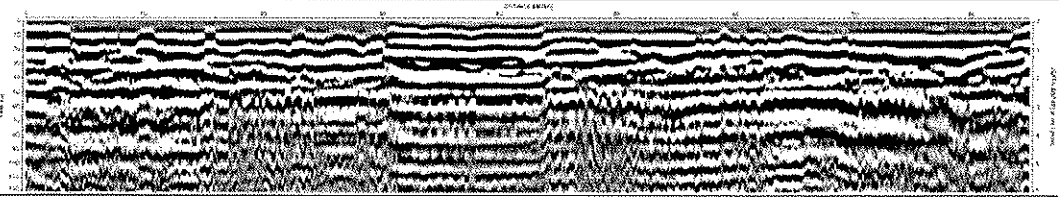

100 MHz GPR 2D Radargrams for Phase II Area D Site

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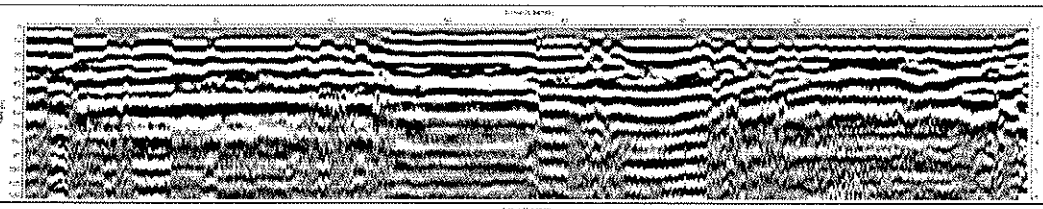

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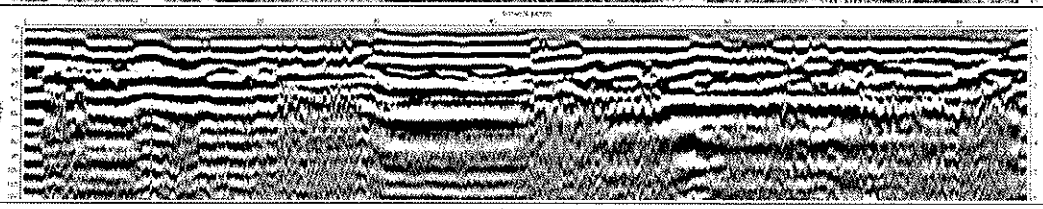

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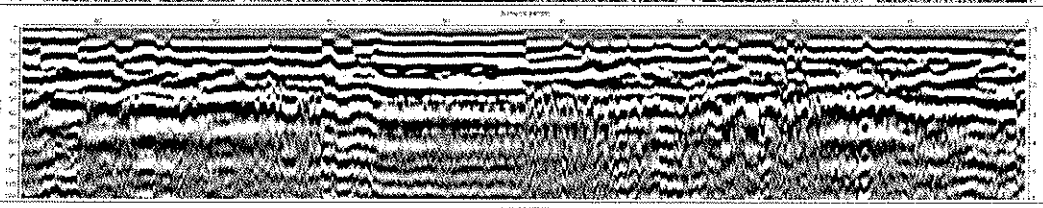

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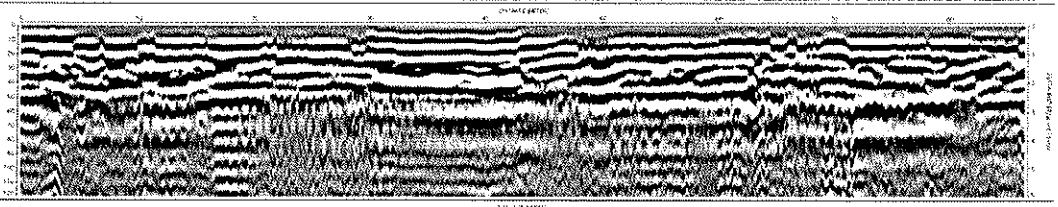

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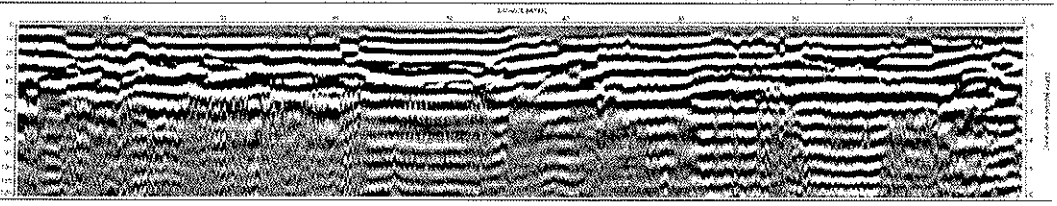

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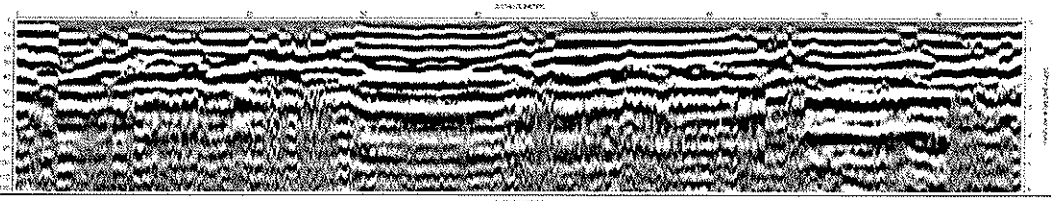

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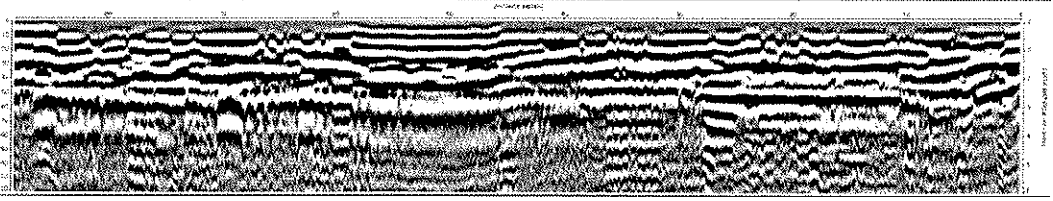

100 MHz GPR 2D Radargrams for Phase II Area D Site

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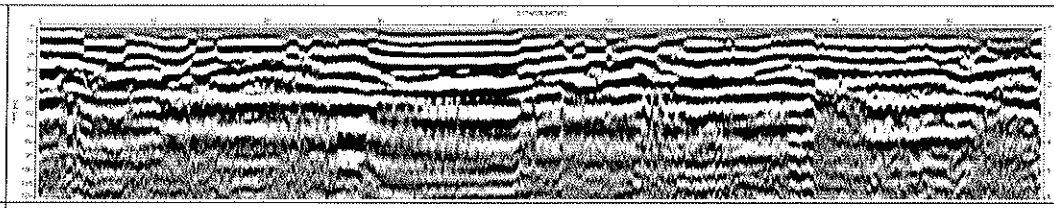

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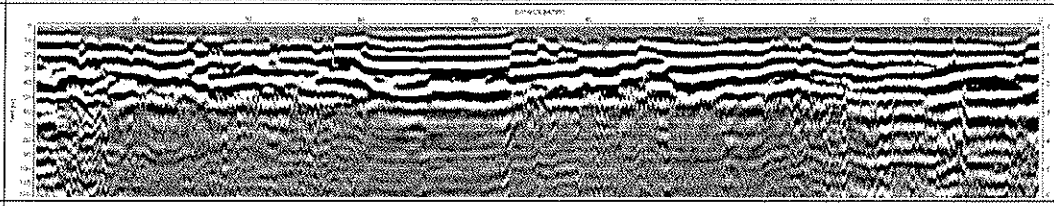

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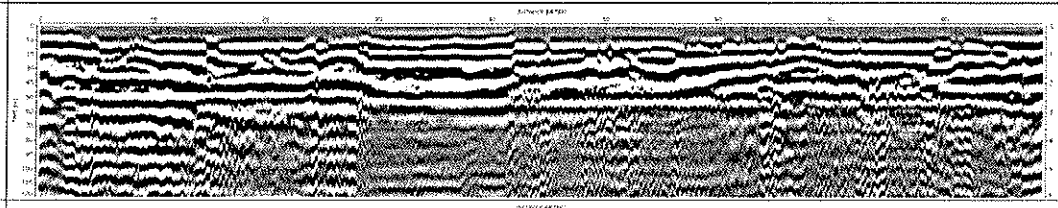

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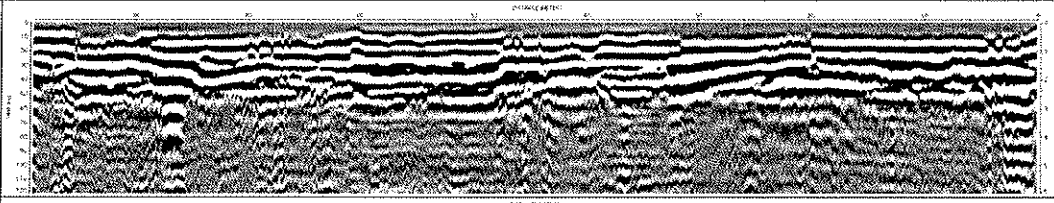

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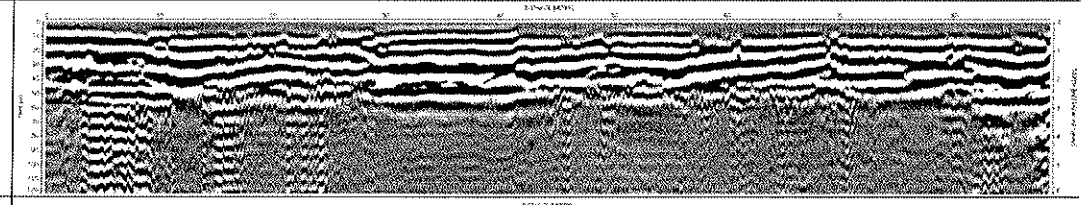

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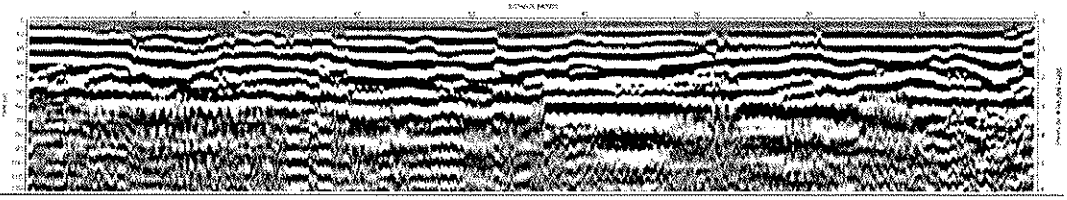

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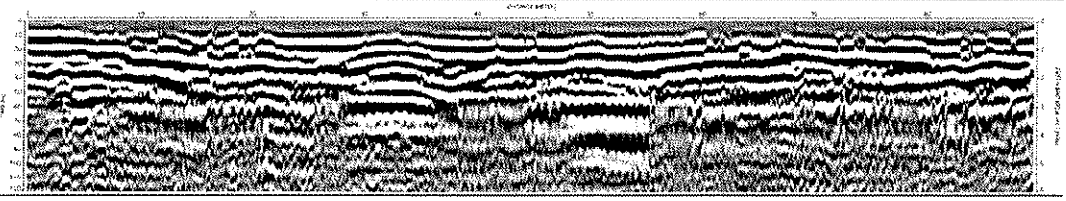

100 MHz GPR 2D Radargrams for Phase II Area D Site

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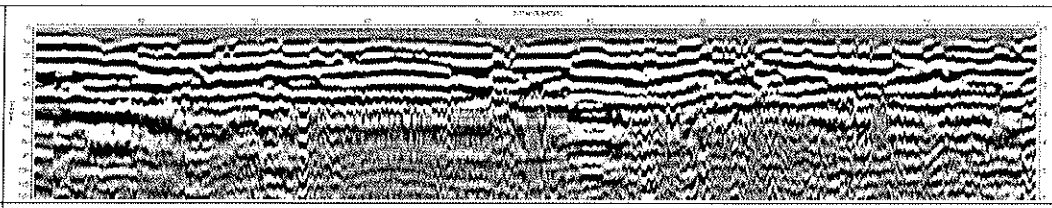

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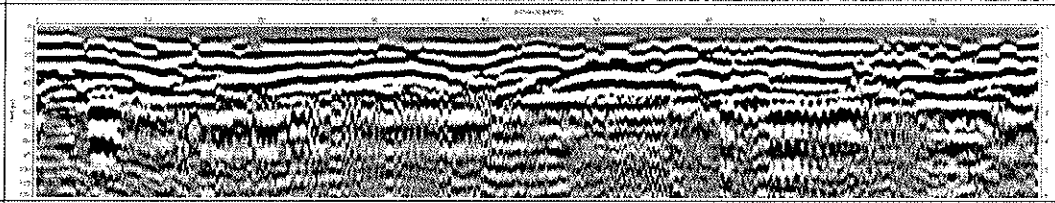

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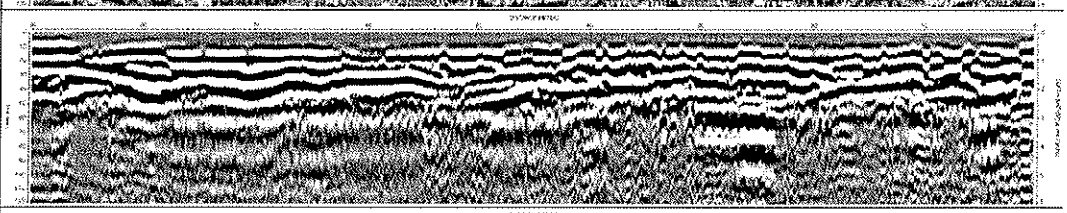

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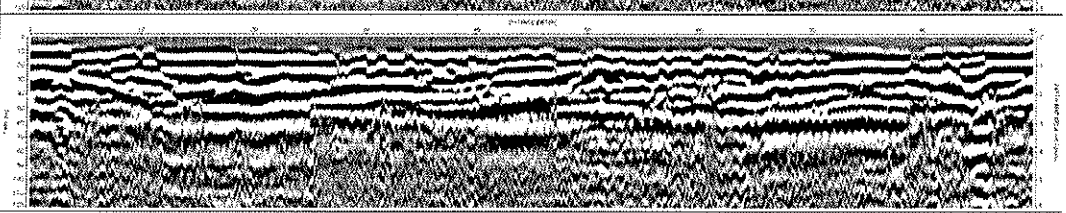

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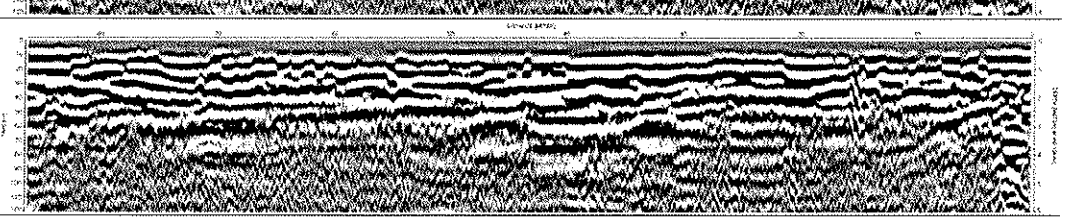

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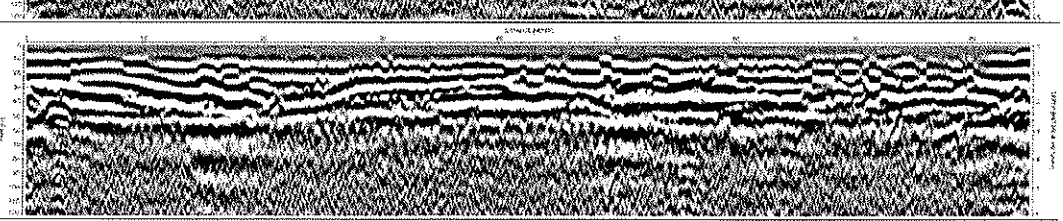

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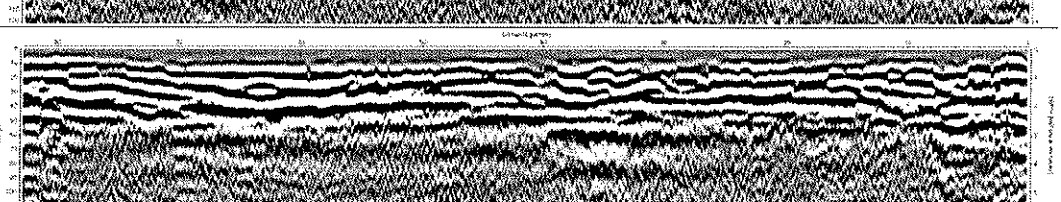
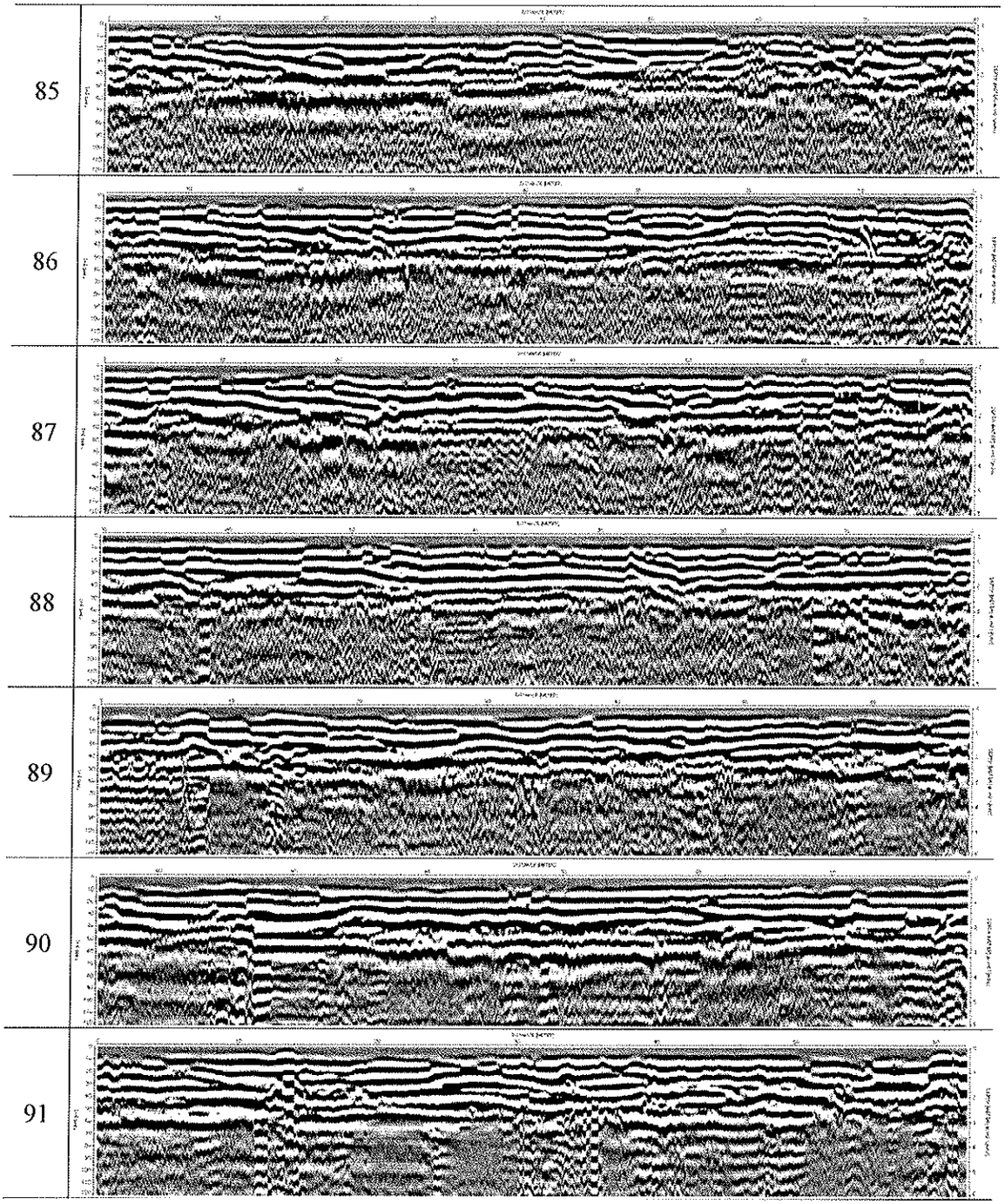
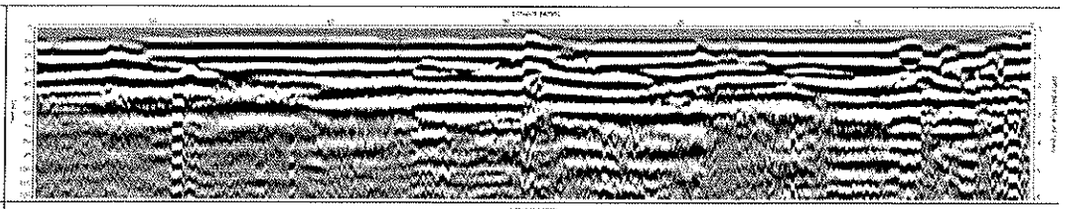


100 MHz GPR 2D Radargrams for Phase II Area D Site



100 MHz GPR 2D Radargrams for Phase II Area D Site

92



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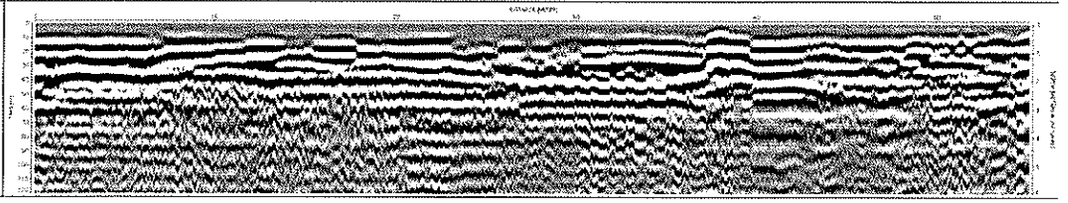
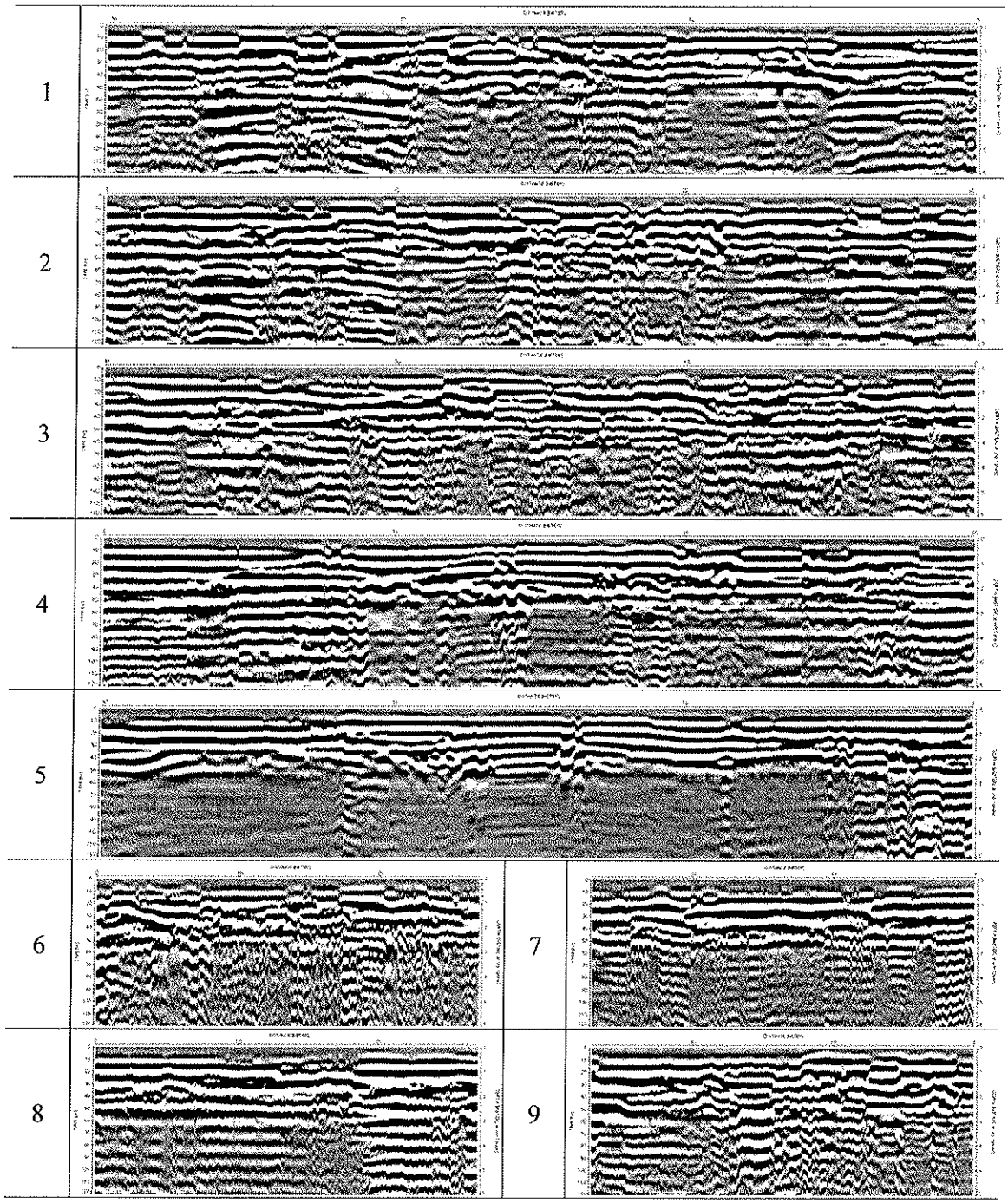
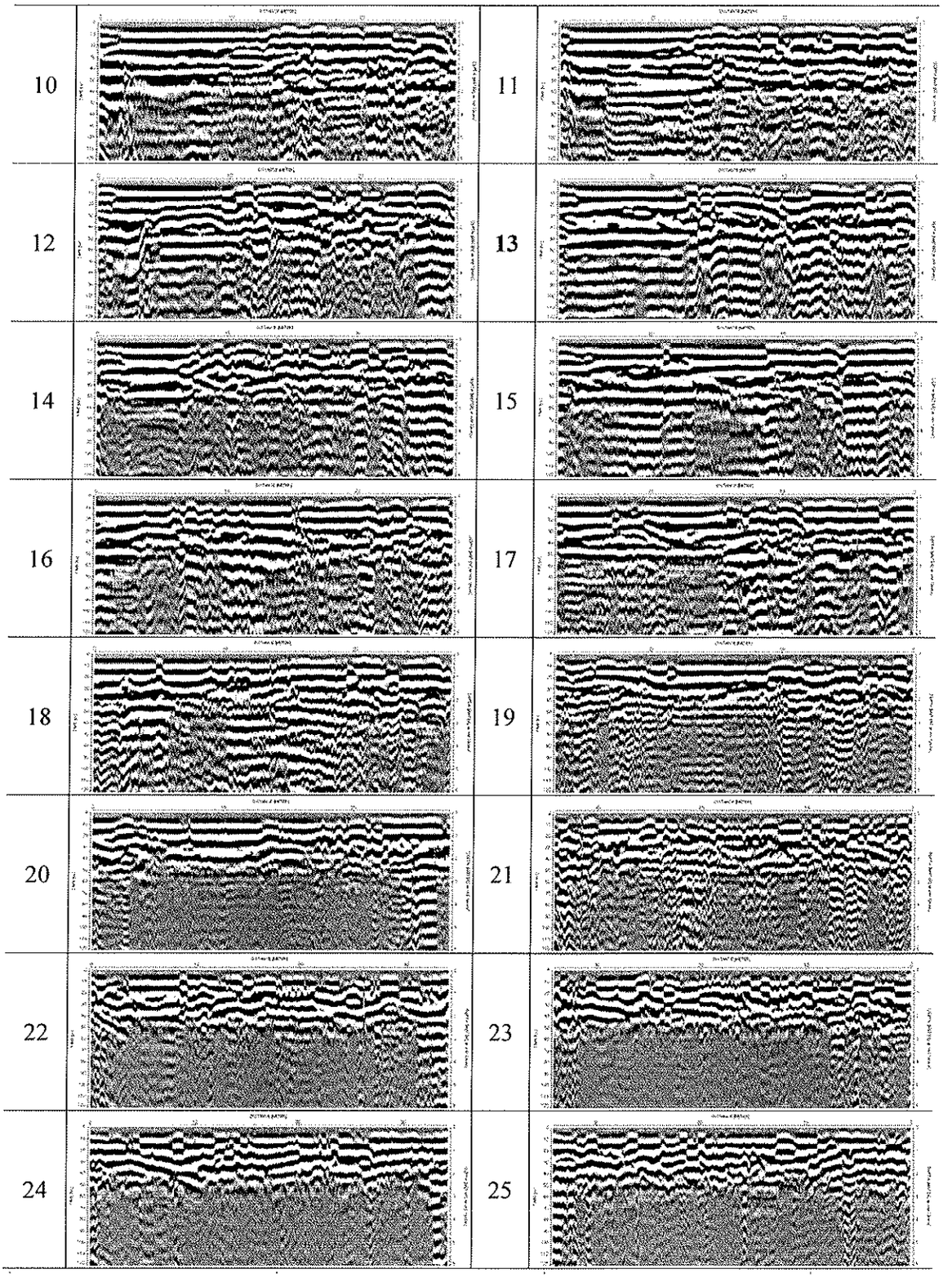


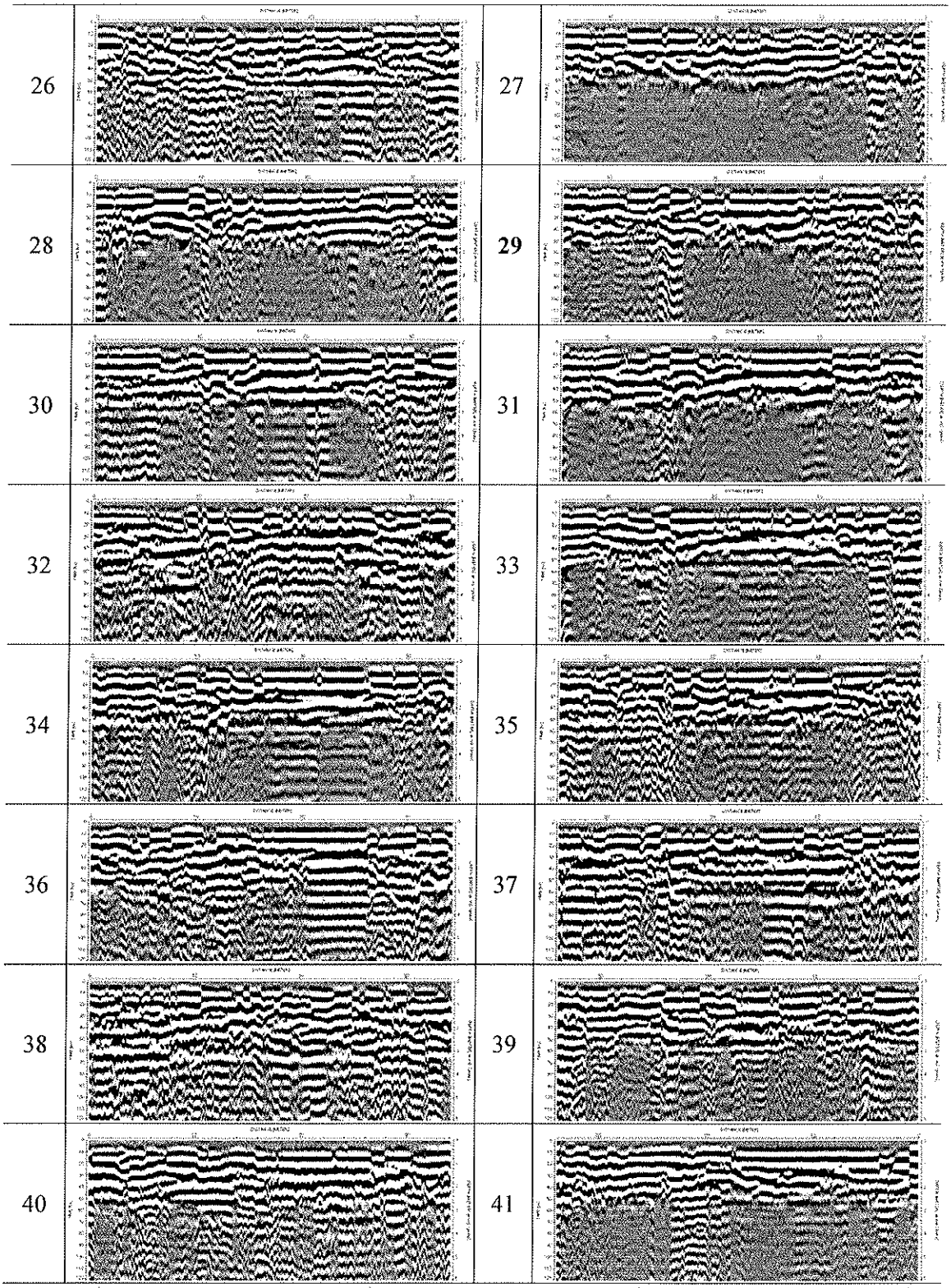
100 MHz GPR 2D Radargrams for Phase II Landfarm Site



100 MHz GPR 2D Radargrams for Phase II Landfarm Site



100 MHz GPR 2D Radargrams for Phase II Landfarm Site



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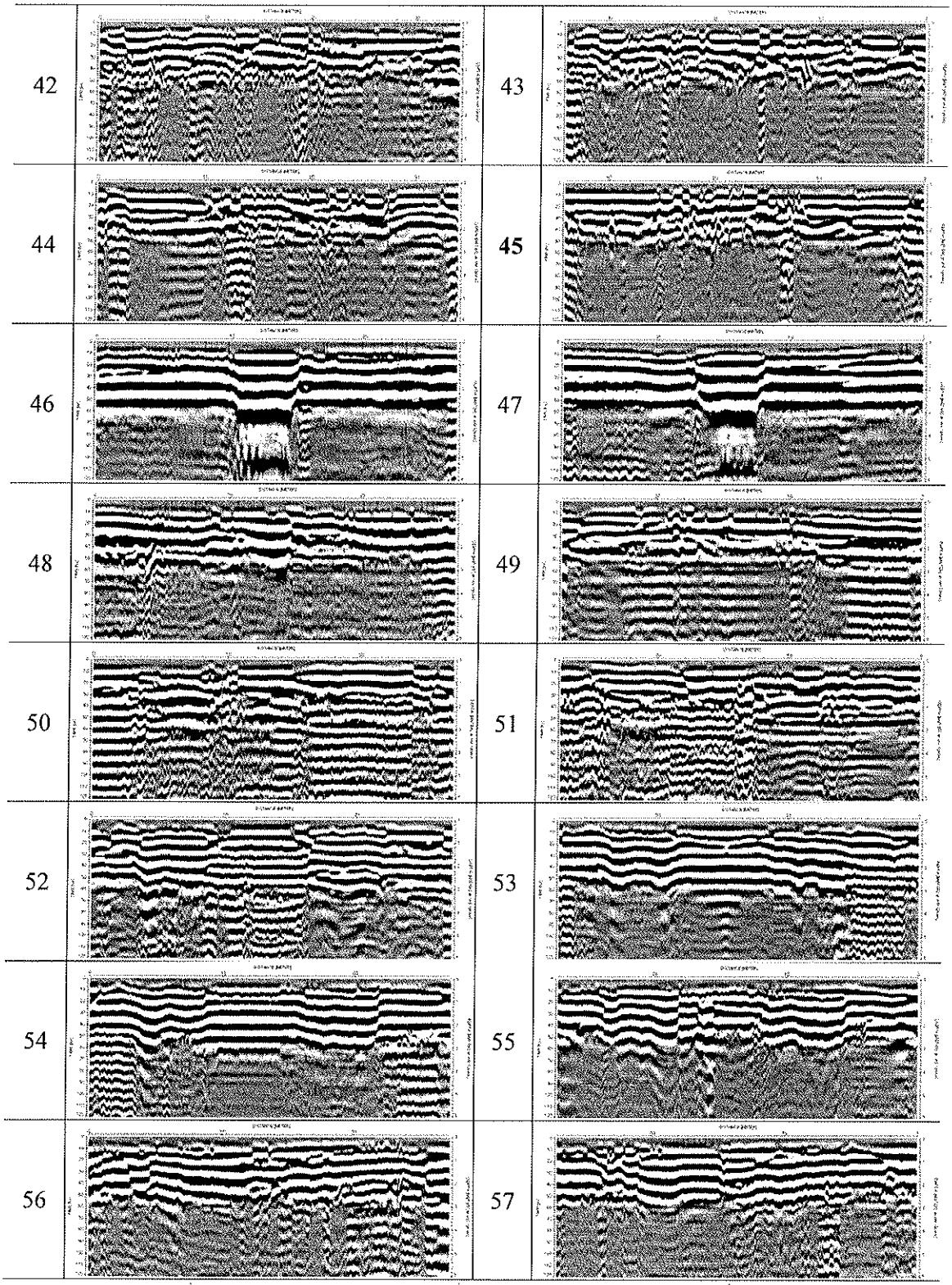
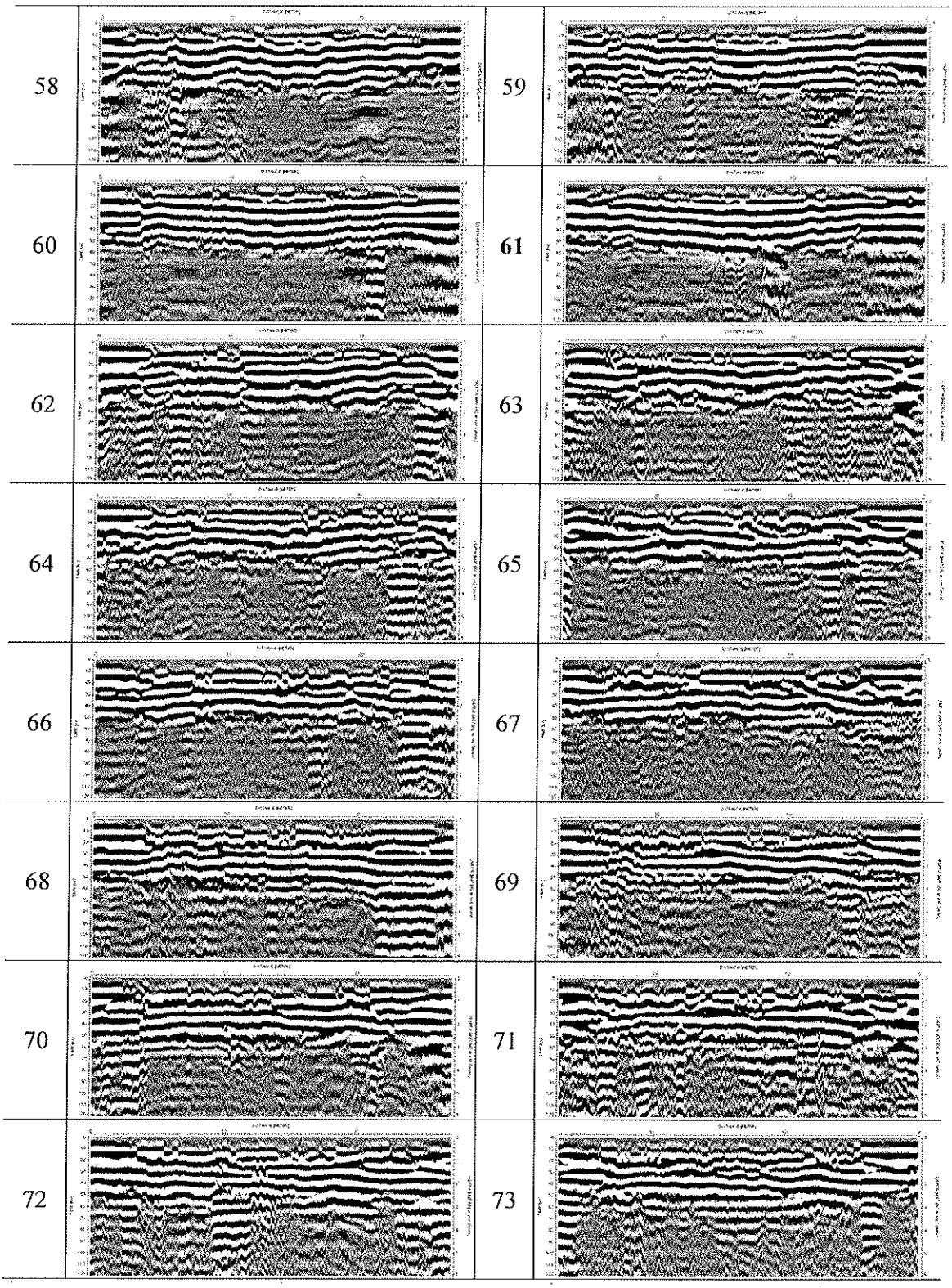
100 MHz GPR 2D Radargrams for Phase II Landfarm Site



100 MHz GPR 2D Radargrams for Phase II Landfarm Site



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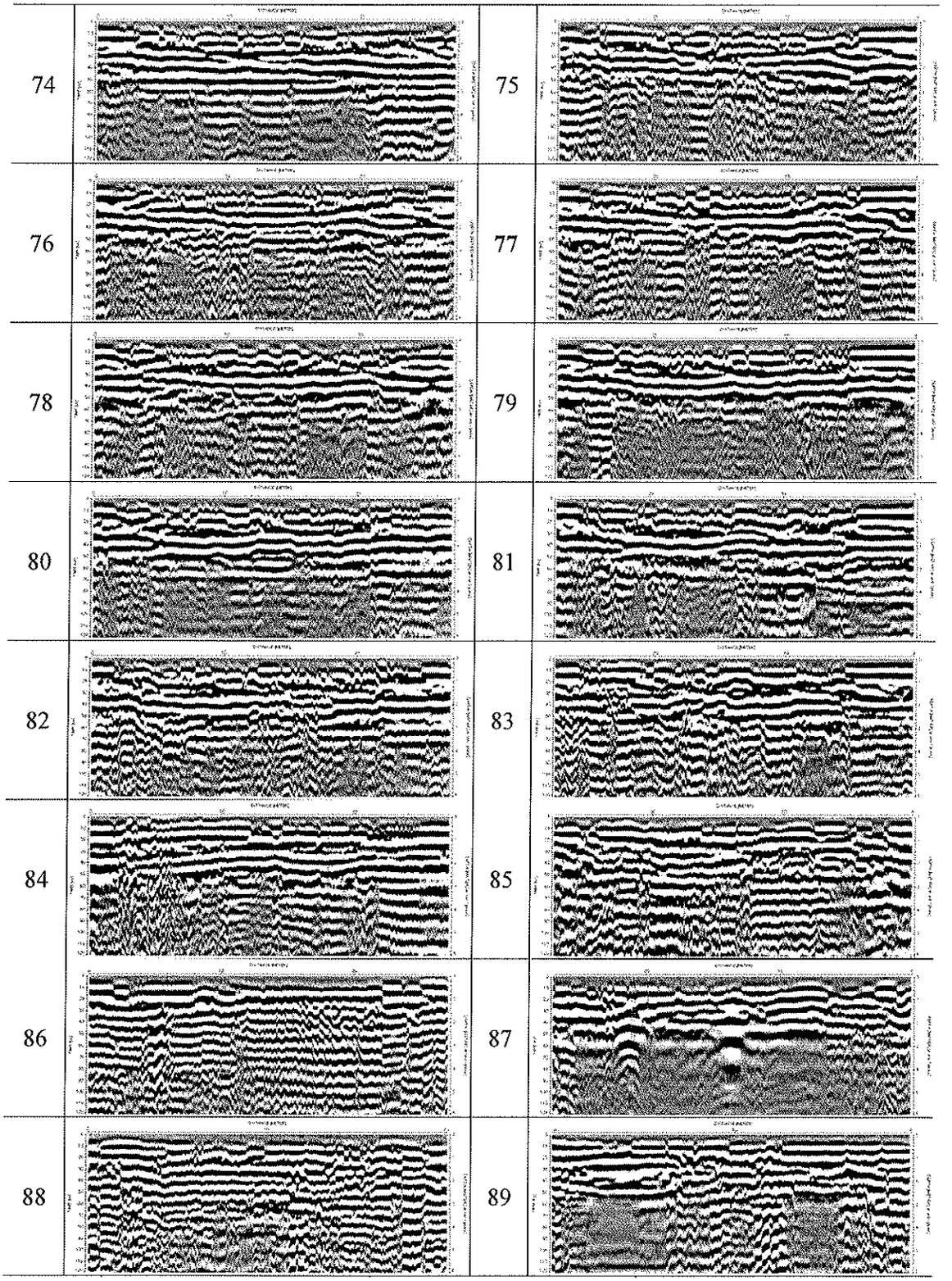
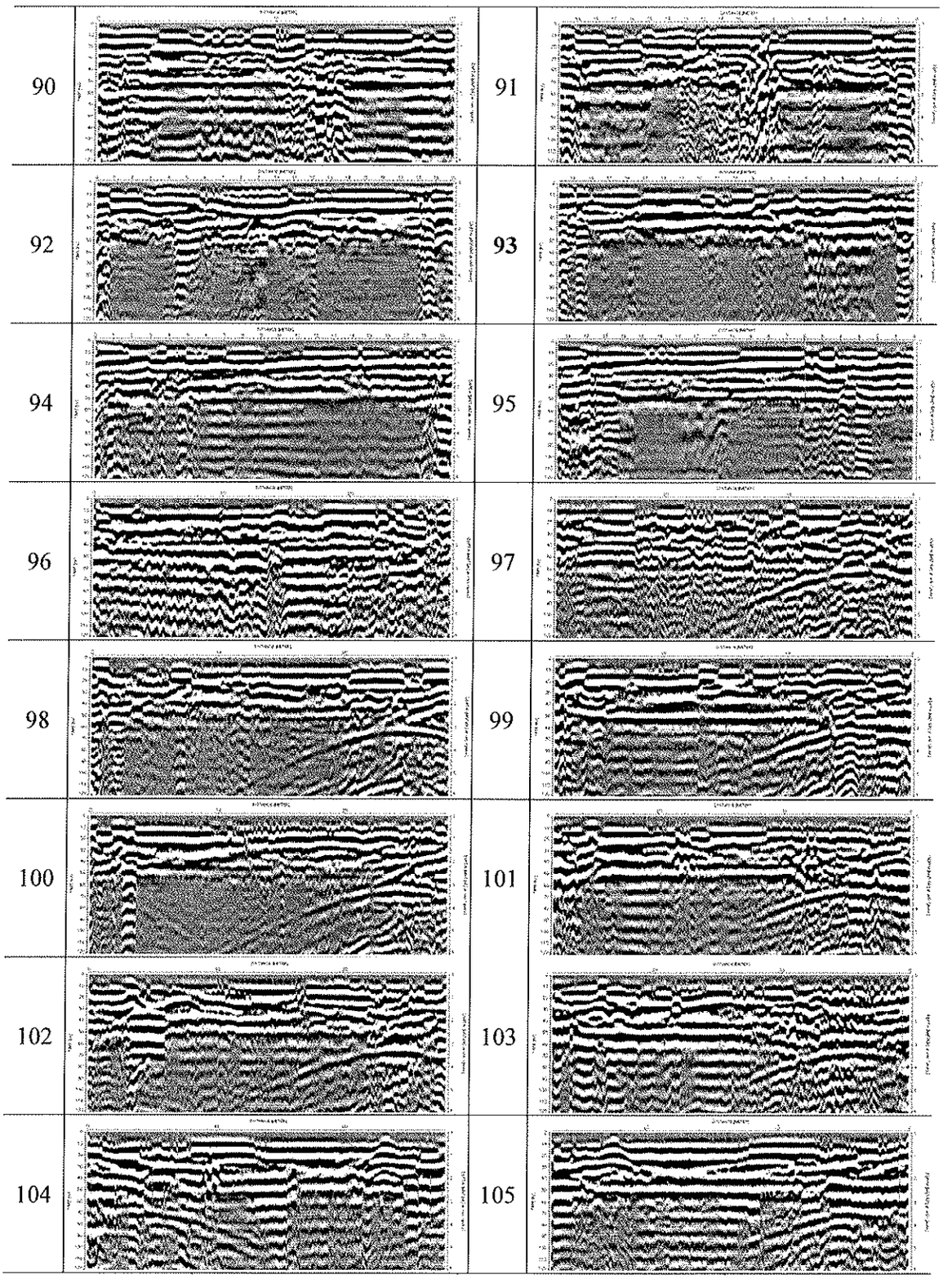
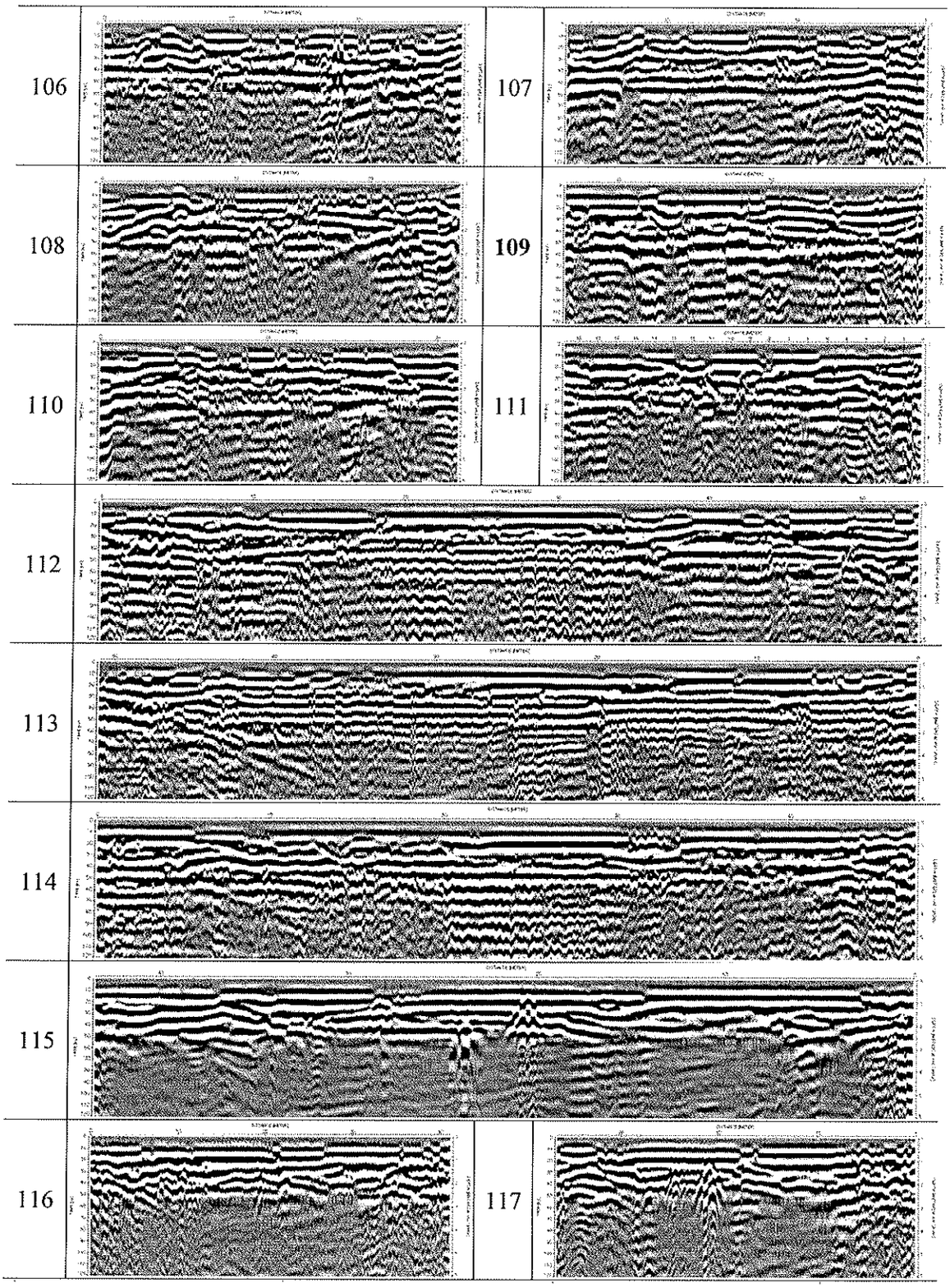
100 MHz GPR 2D Radargrams for Phase II Landfarm Site



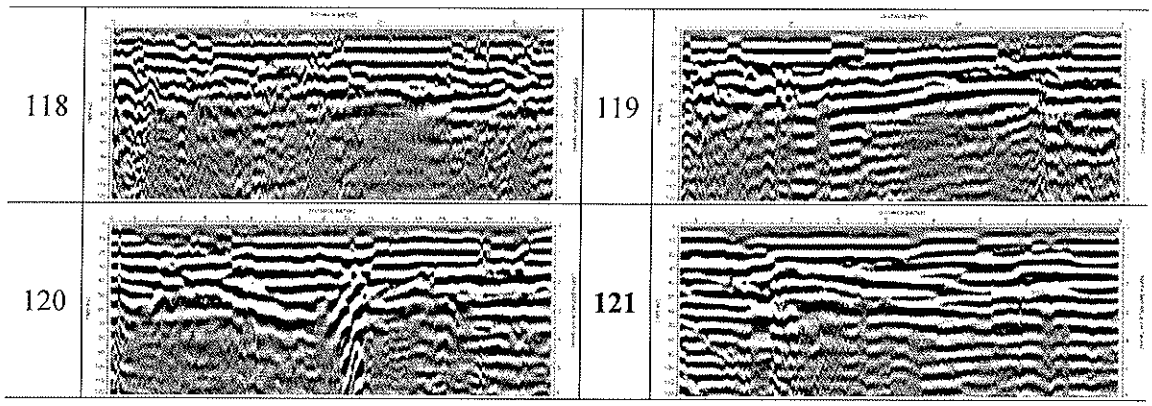
100 MHz GPR 2D Radargrams for Phase II Landfarm Site



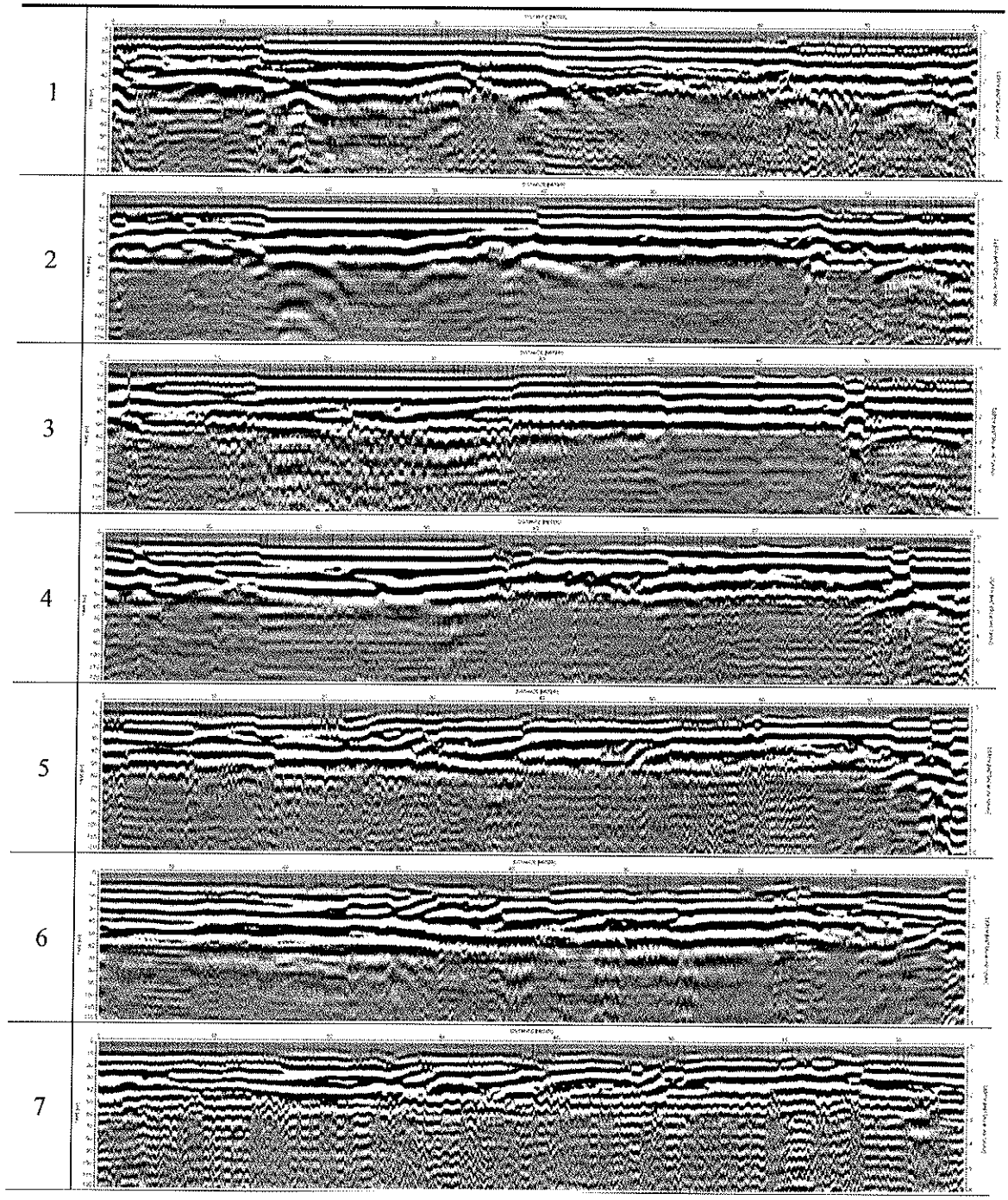
100 MHz GPR 2D Radargrams for Phase II Landfarm Site



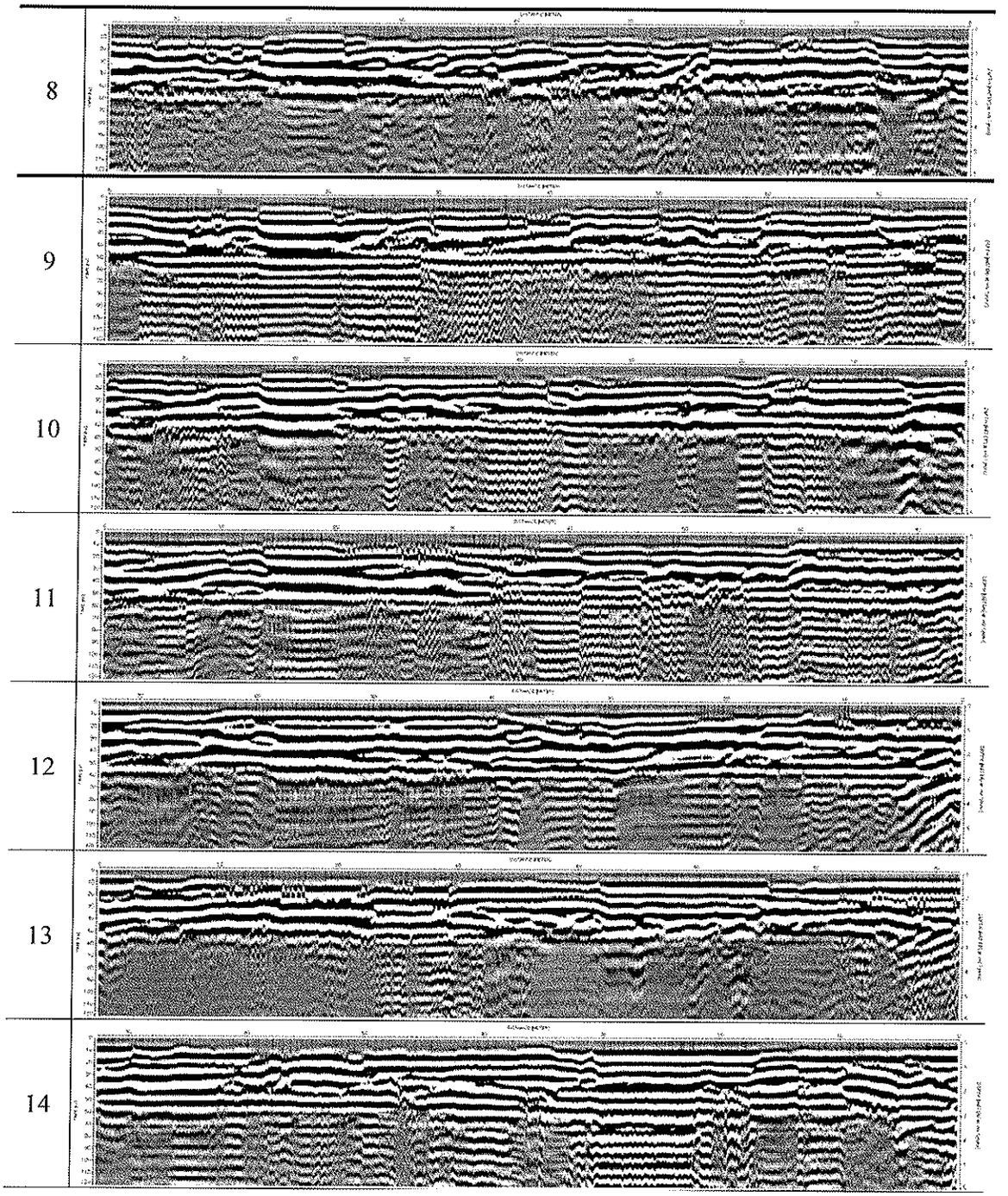
100 MHz GPR 2D Radargrams for Phase II Landfarm Site



100 MHz GPR 2D Radargrams for Phase IIB Helipad Site



100 MHz GPR 2D Radargrams for Phase IIB Helipad Site



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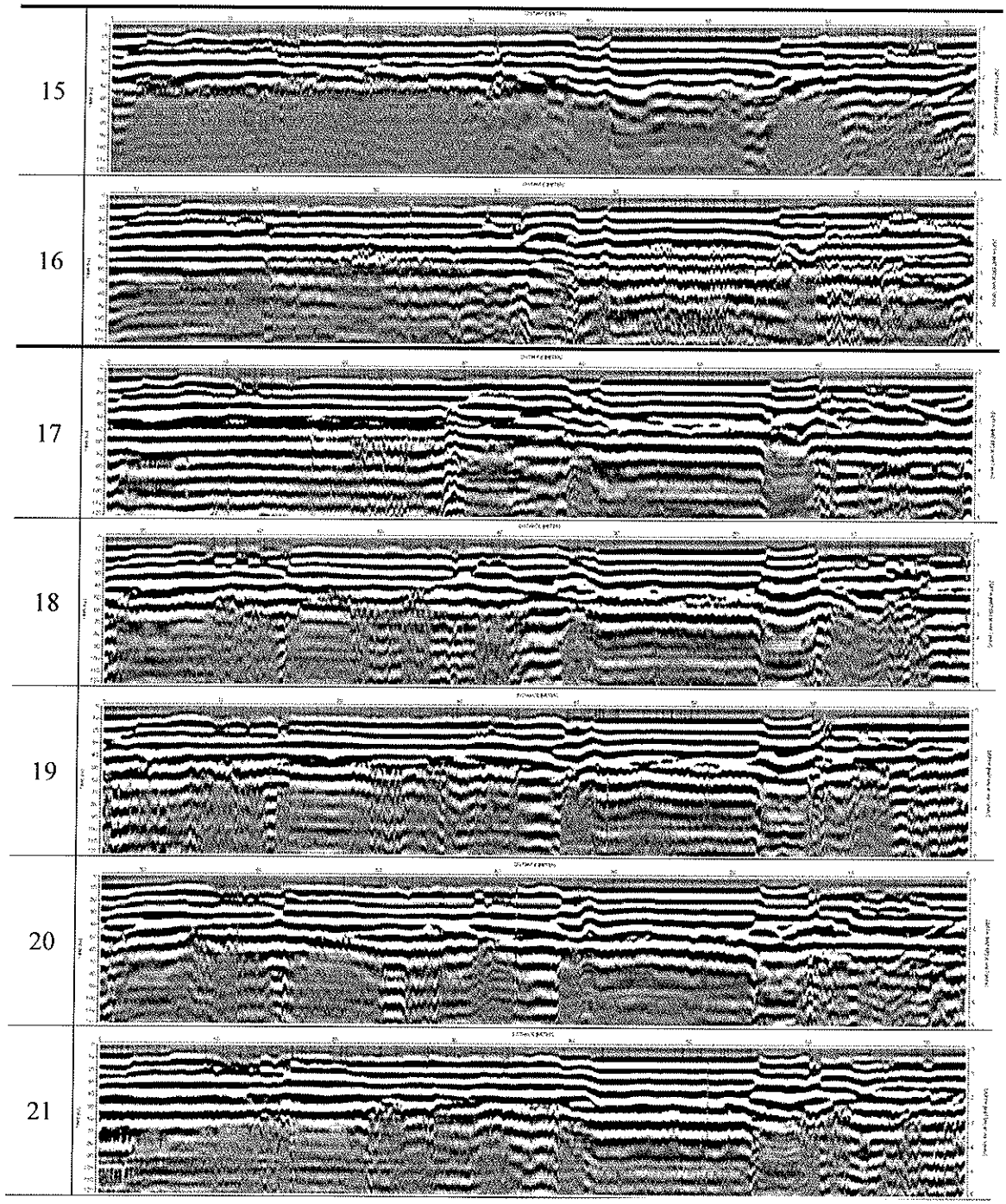
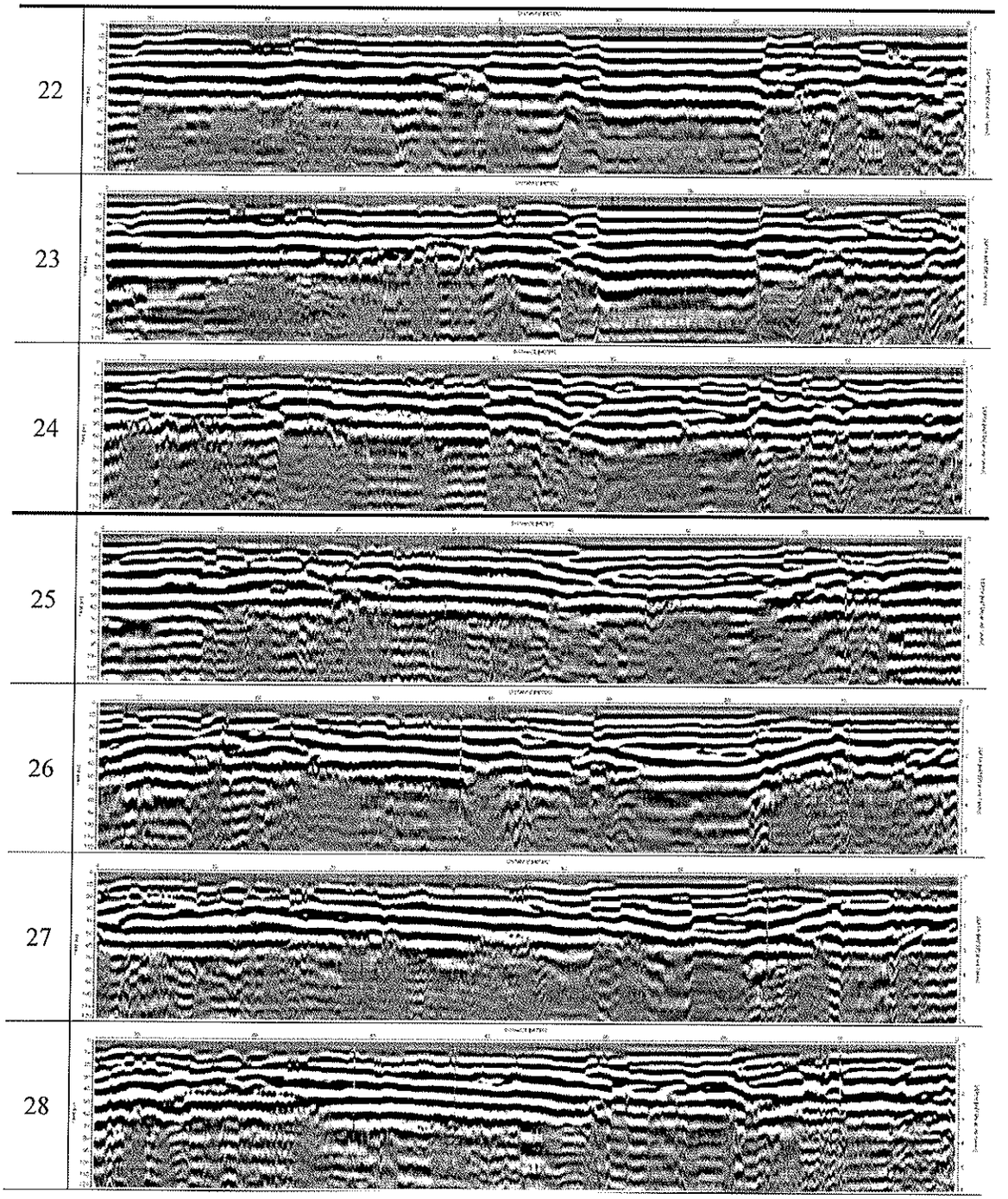
100 MHz GPR 2D Radargrams for Phase IIB Helipad Site



100 MHz GPR 2D Radargrams for Phase IIB Helipad Site



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100 MHz GPR 2D Radargrams for Phase IIB Helipad Site

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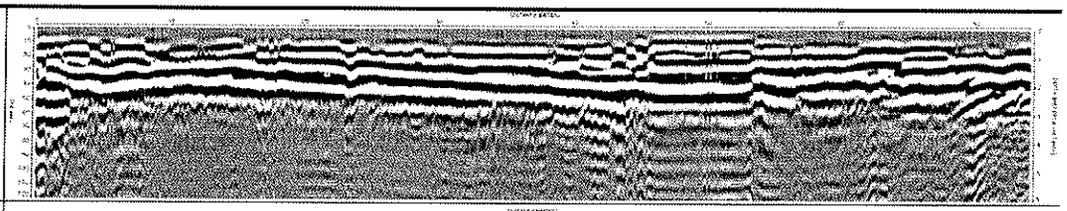

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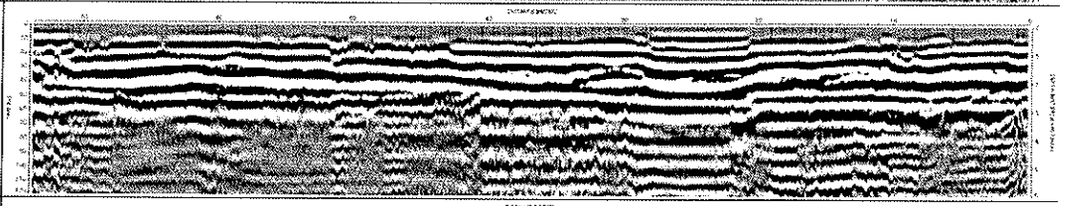

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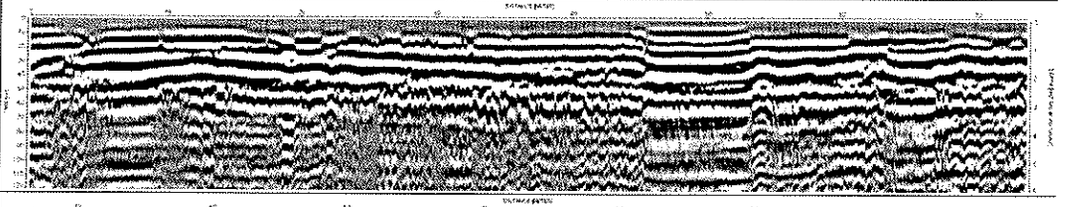

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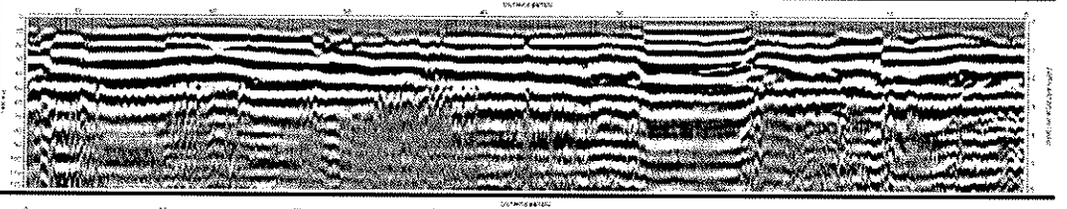

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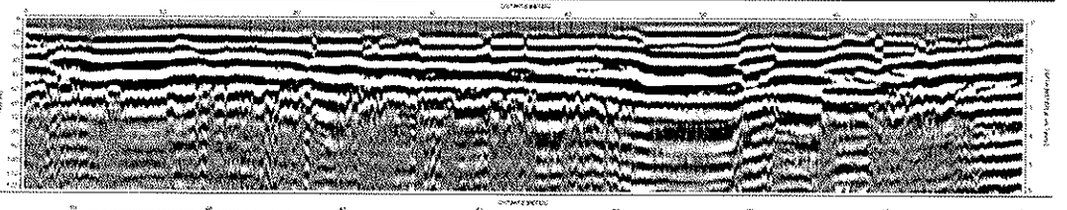

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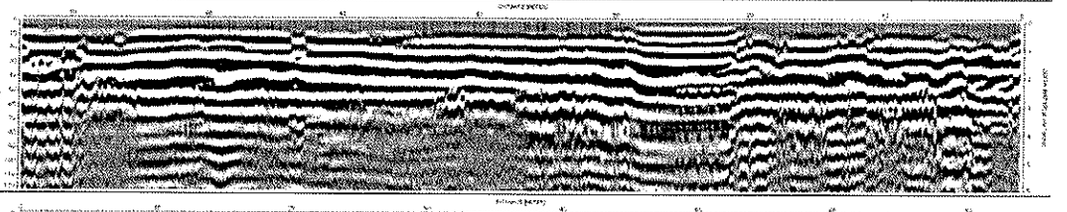

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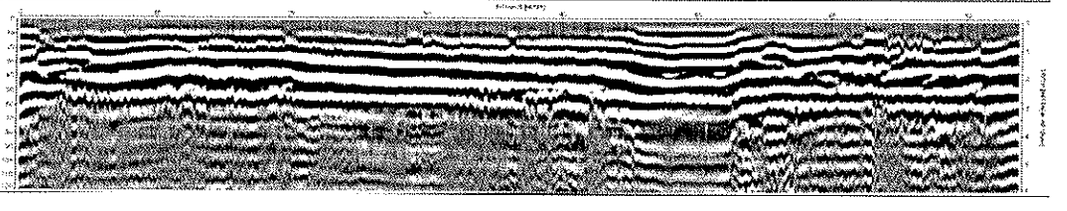
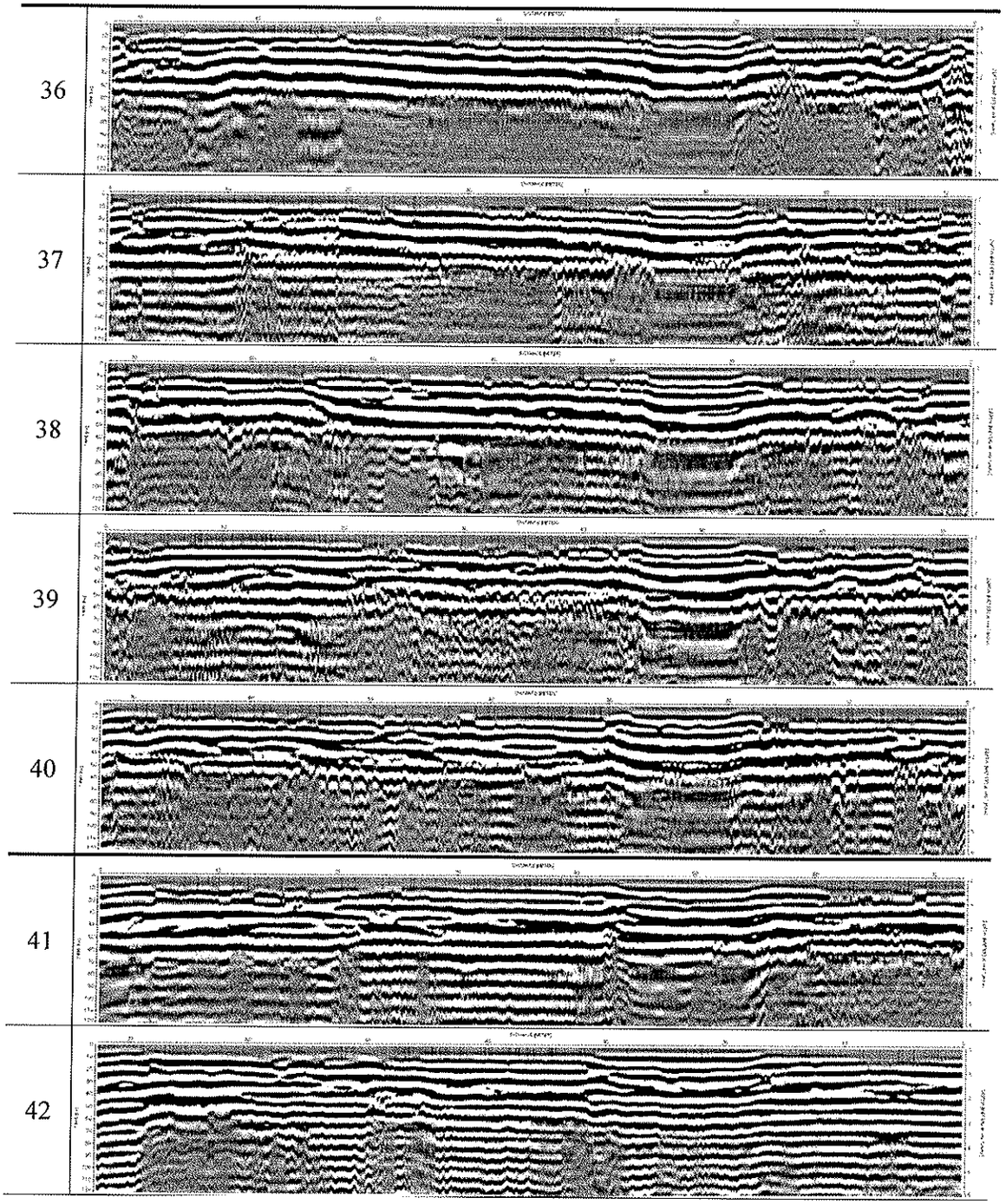


100 MHz GPR 2D Radargrams for Phase IIB Helipad Site



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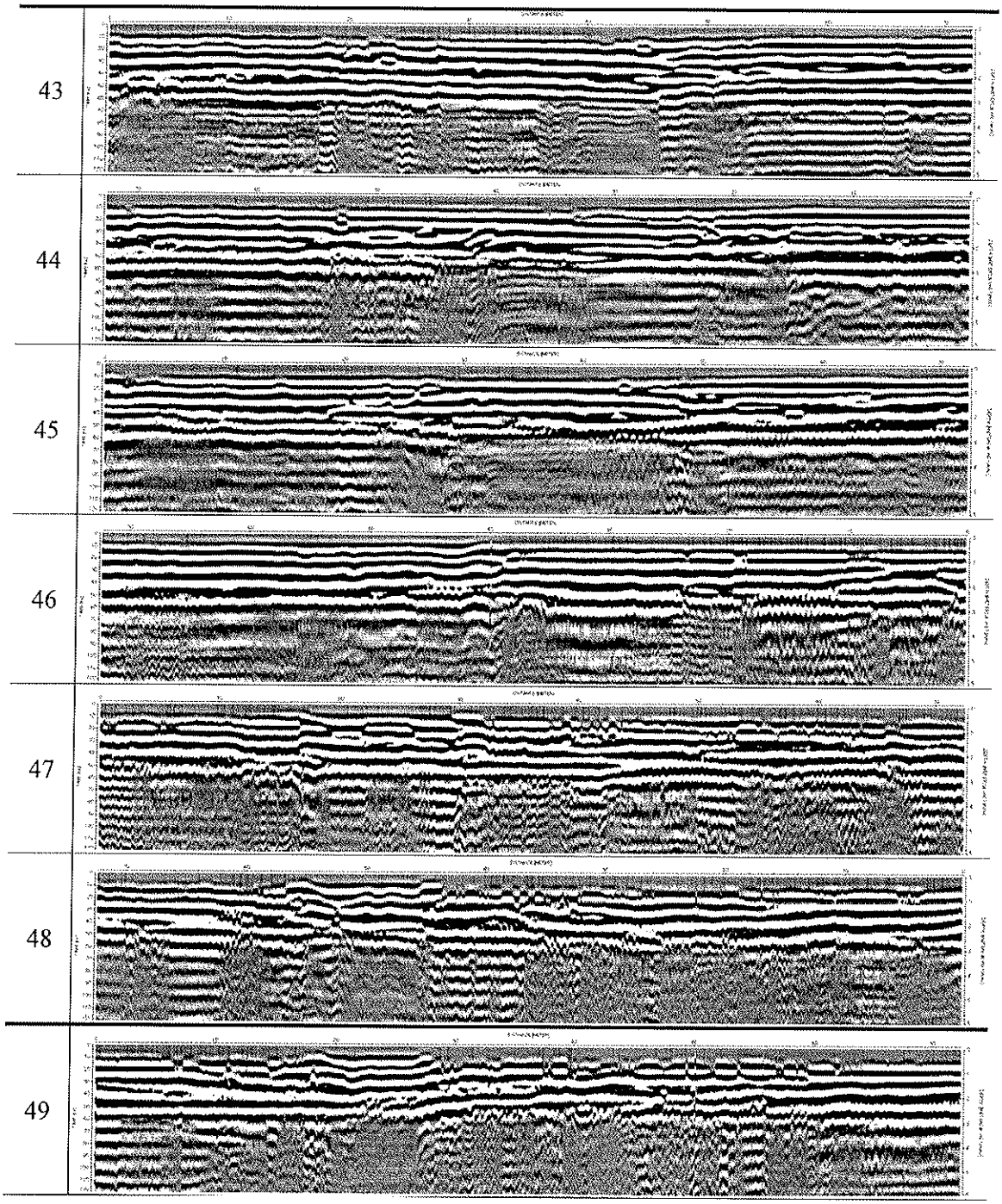
100 MHz GPR 2D Radargrams for Phase IIB Helipad Site



100 MHz GPR 2D Radargrams for Phase IIB Helipad Site

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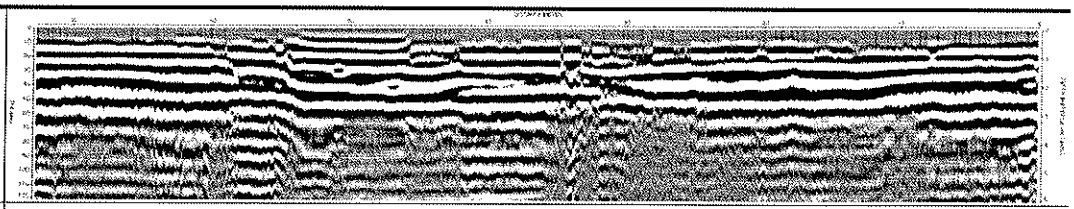

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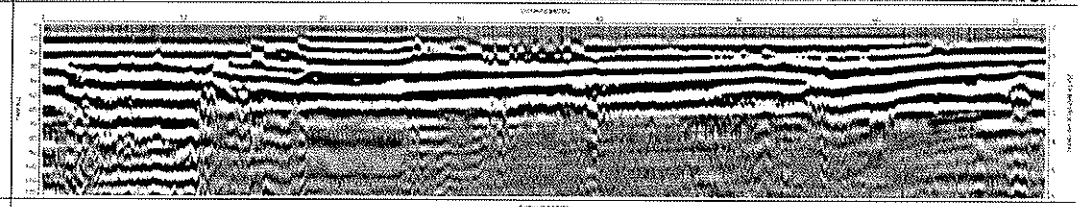

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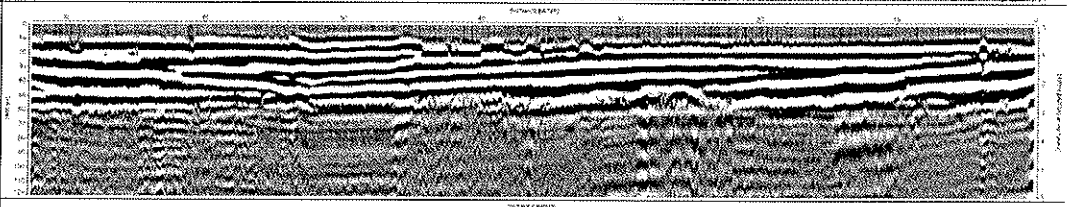

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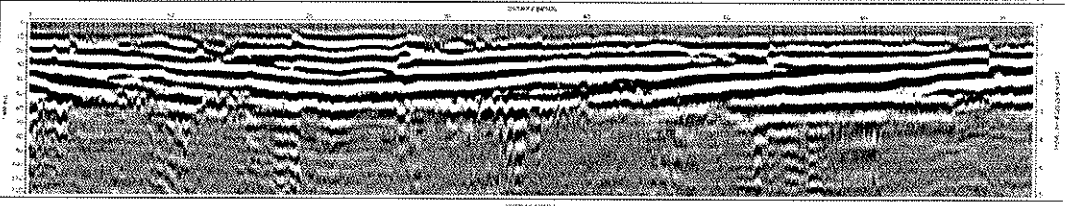

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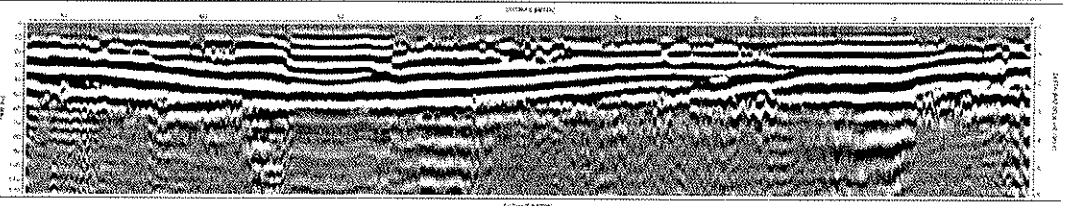

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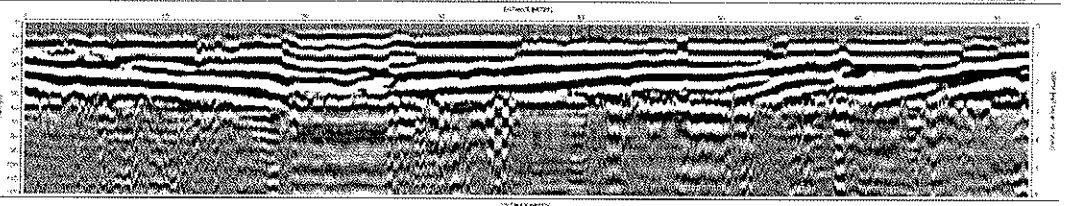

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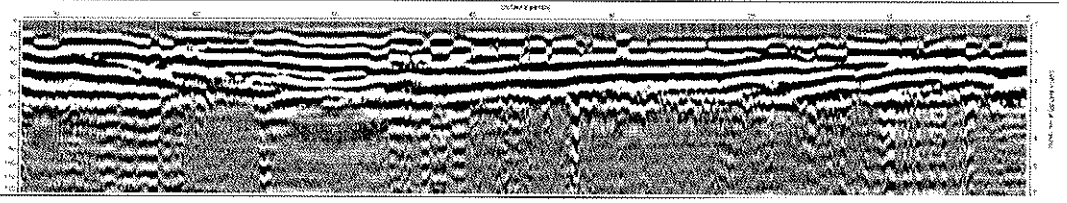
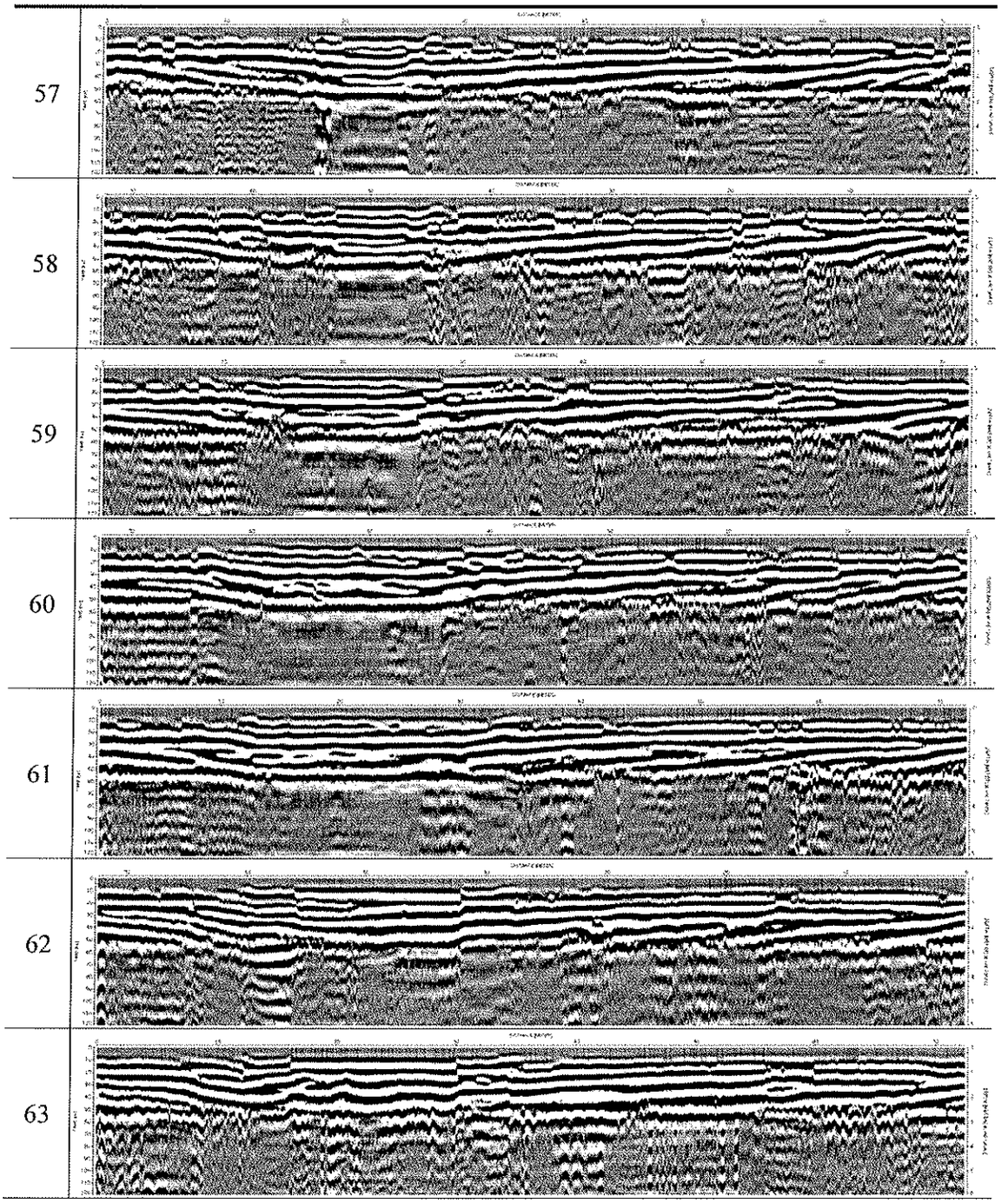


100 MHz GPR 2D Radargrams for Phase IIB Helipad Site



100 MHz GPR 2D Radargrams for Phase IIB Helipad Site

64

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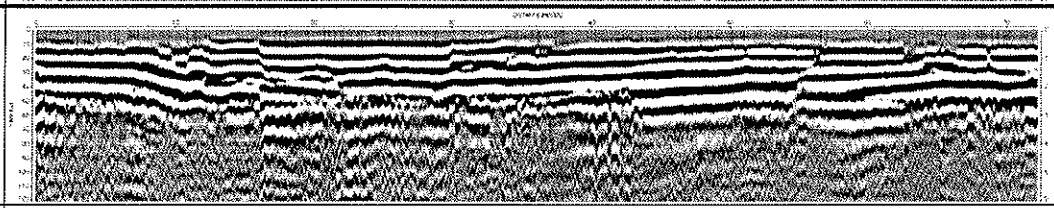

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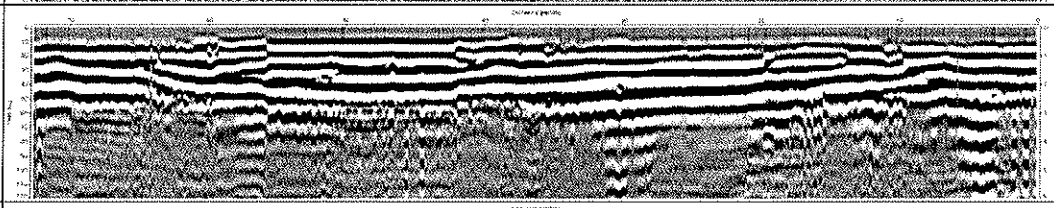

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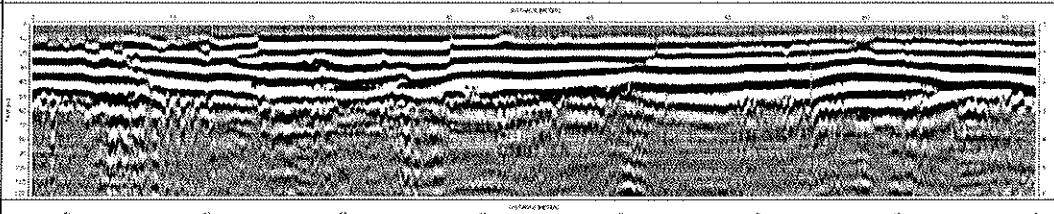

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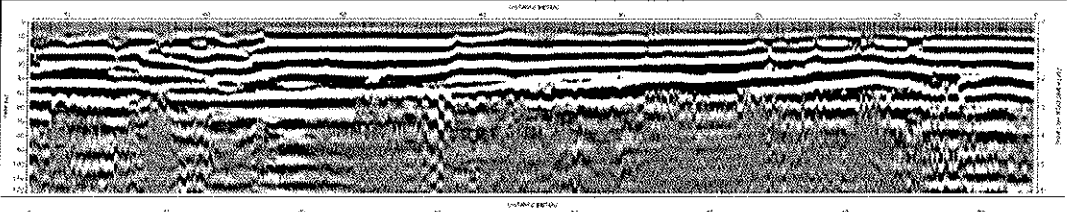

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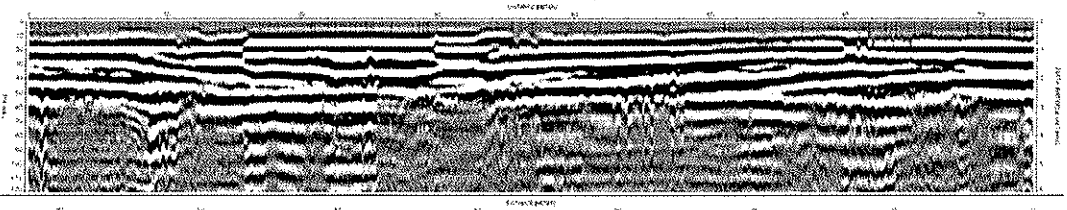

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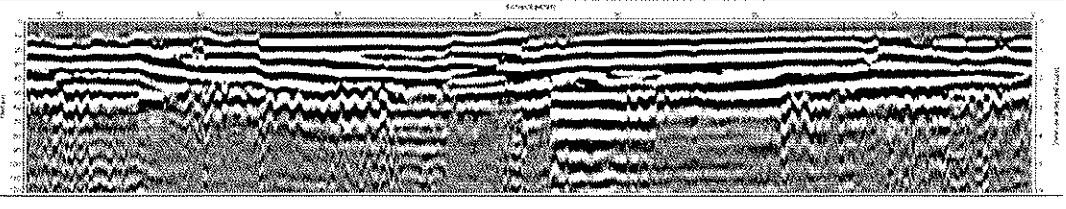

100 MHz GPR 2D Radargrams for Phase IIB Helipad Site

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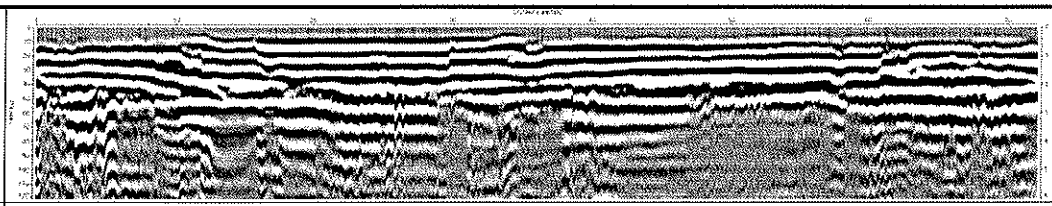

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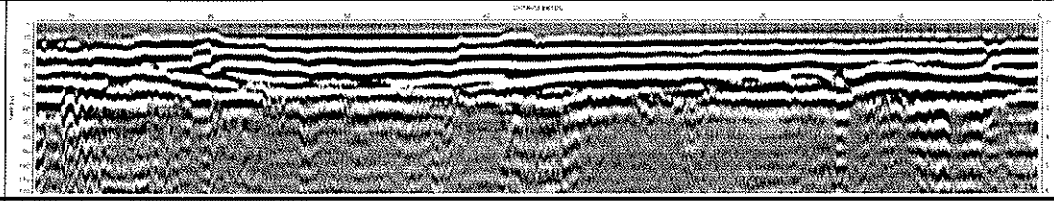

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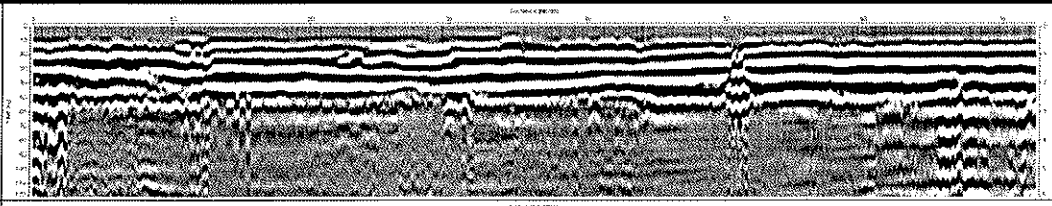

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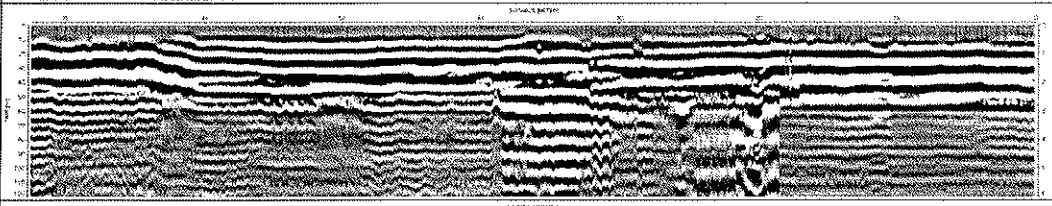

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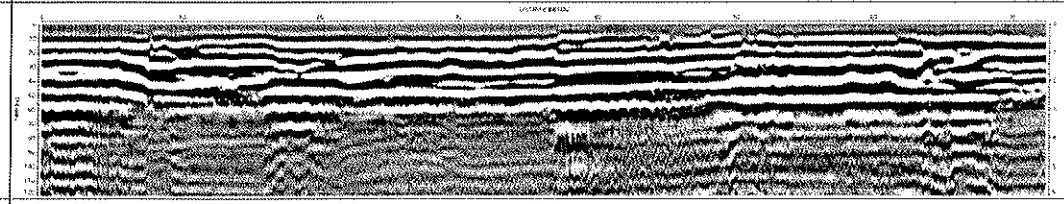

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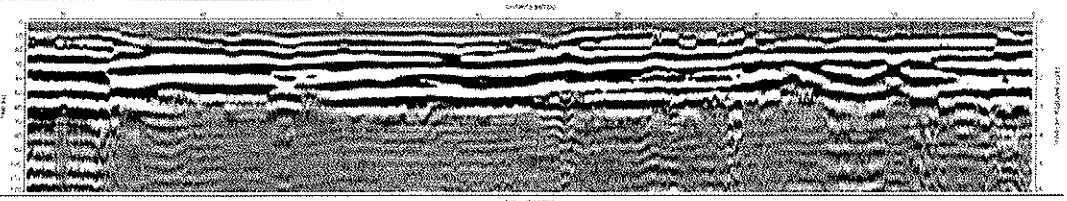

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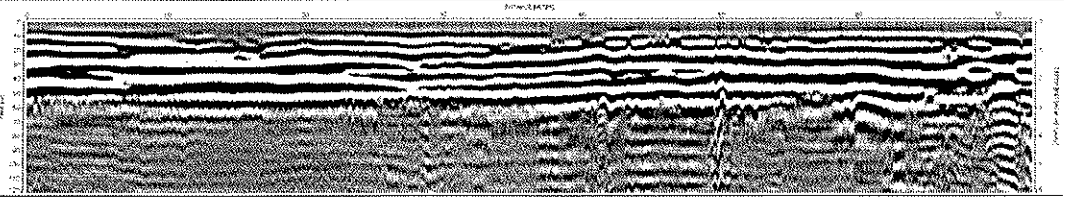

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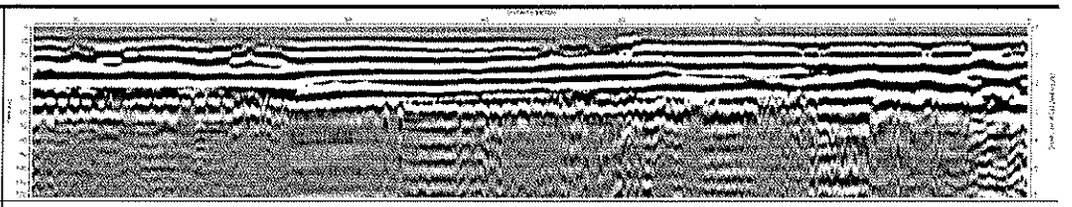
100 MHz GPR 2D Radargrams for Phase IIB Helipad Site

78



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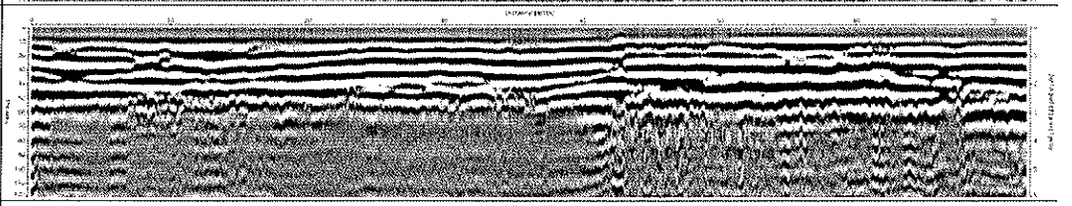

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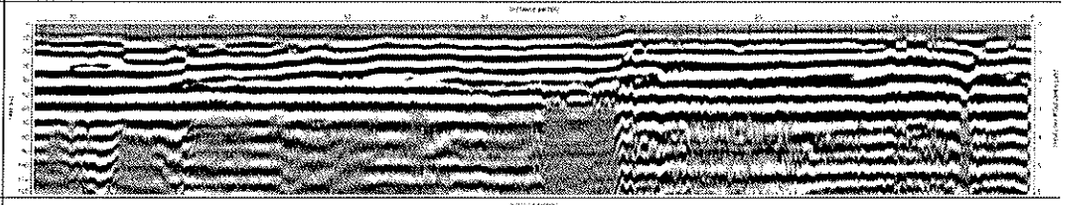

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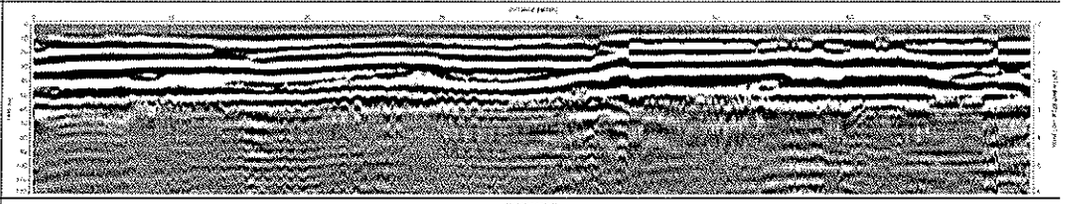

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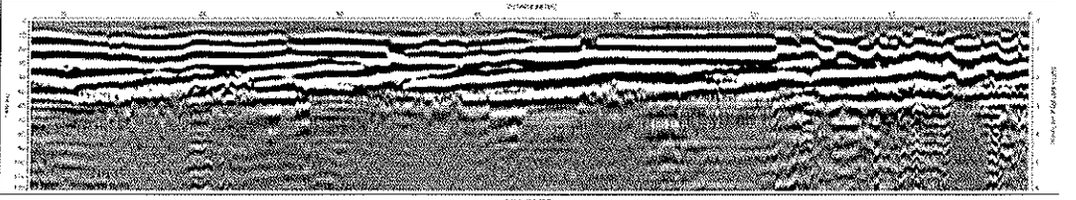

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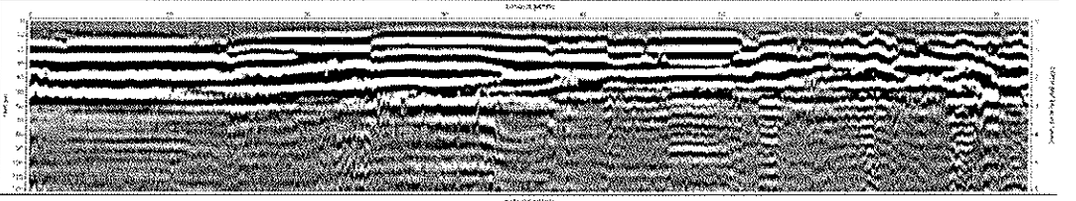

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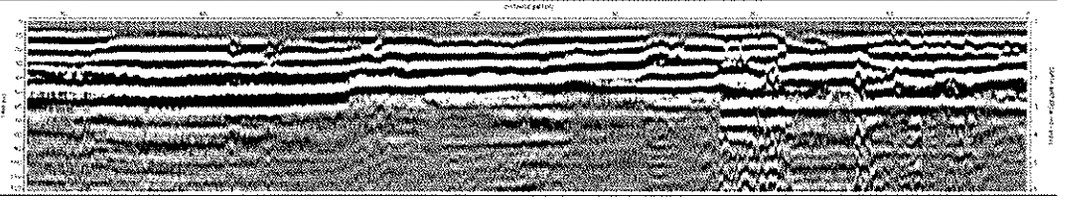
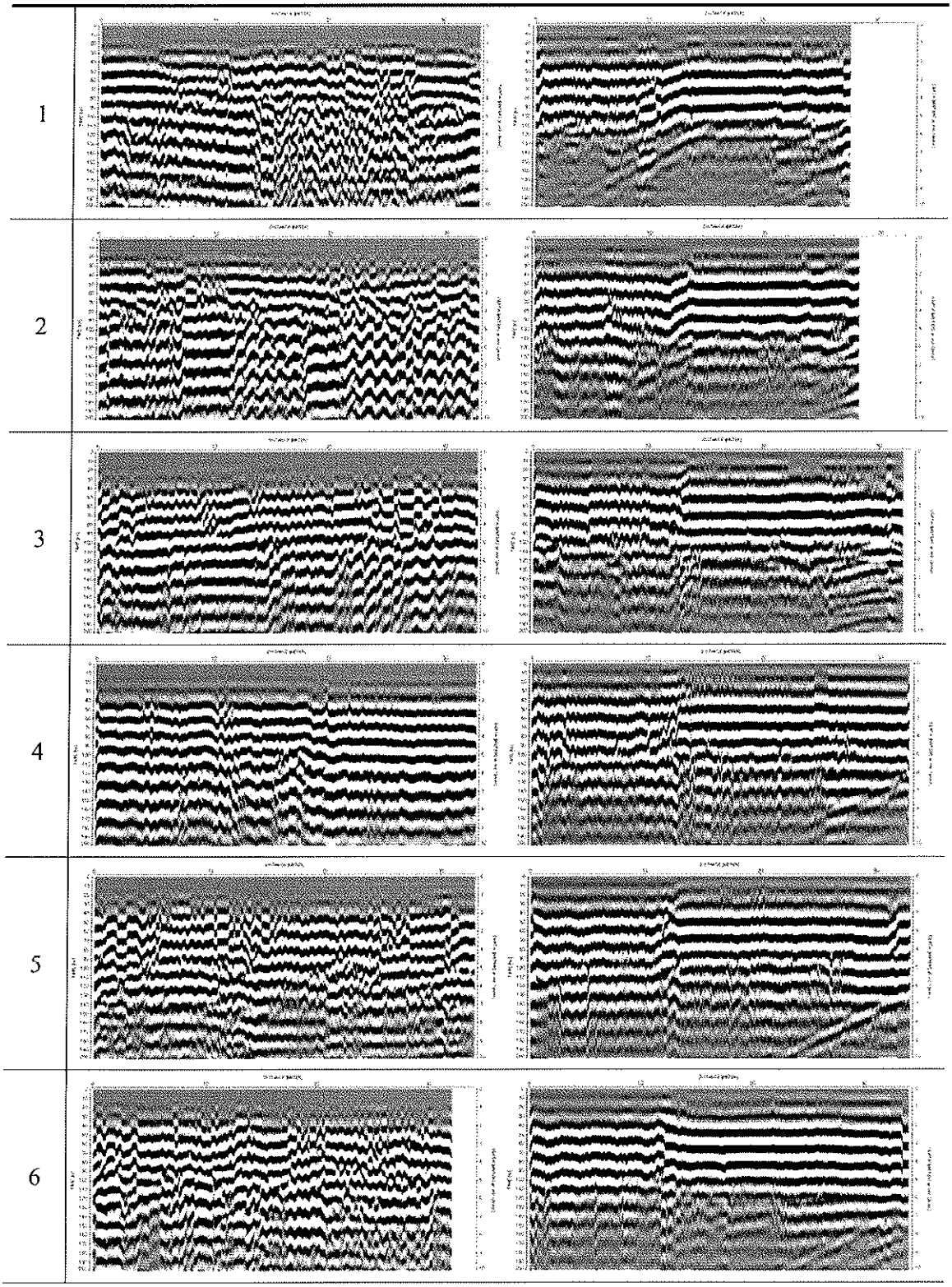


50 MHz GPR 2D Radargrams for Phase II Area D Site



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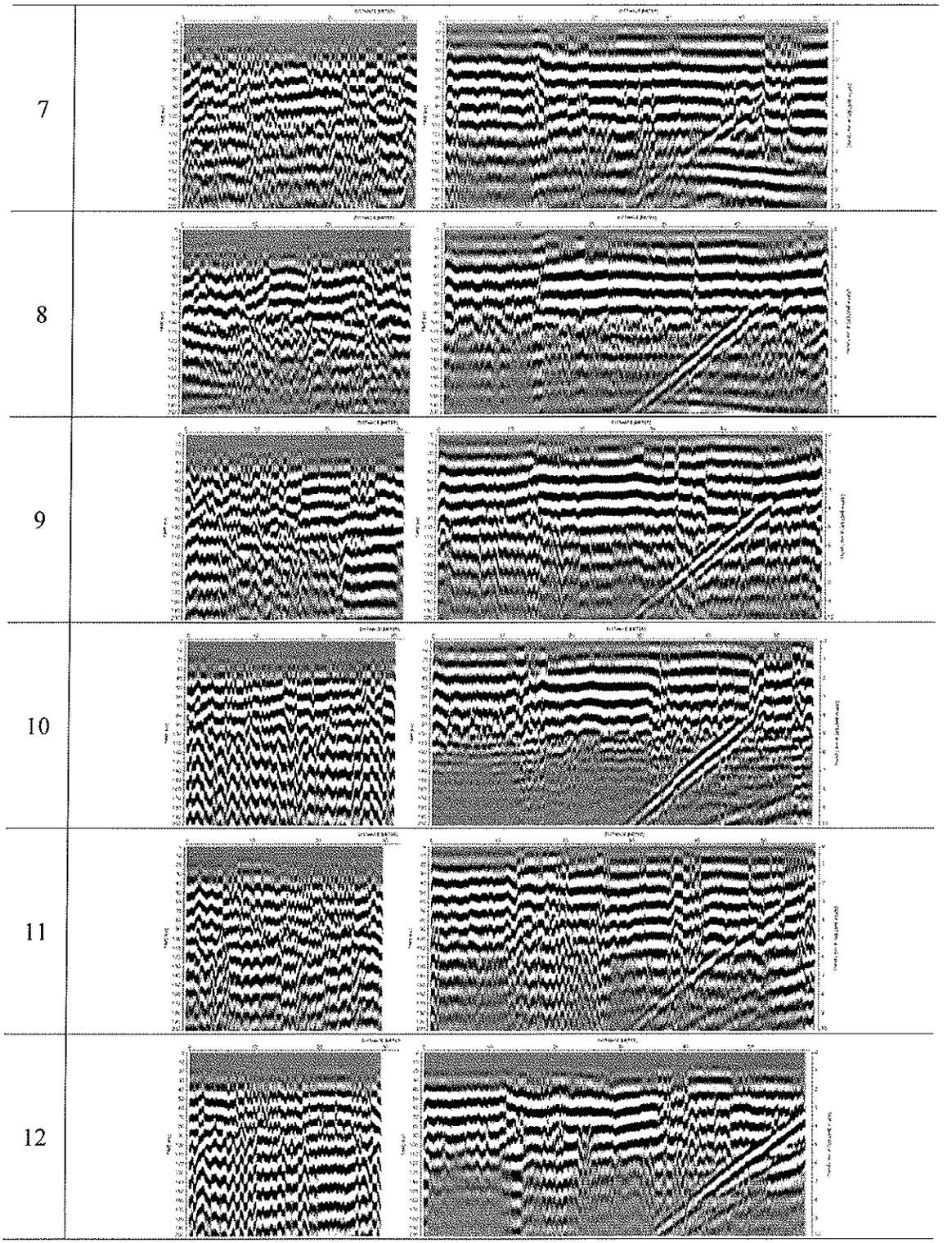
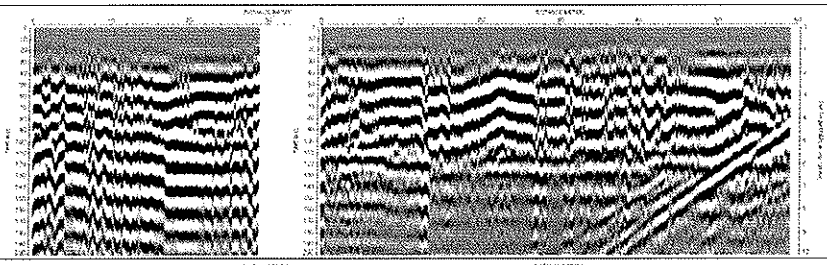
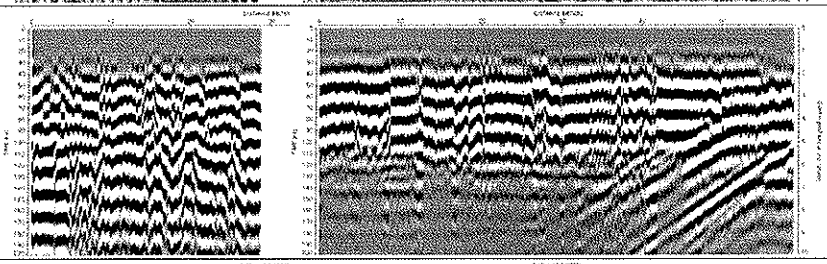
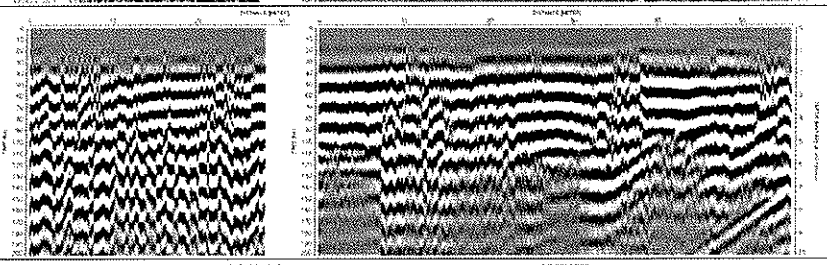
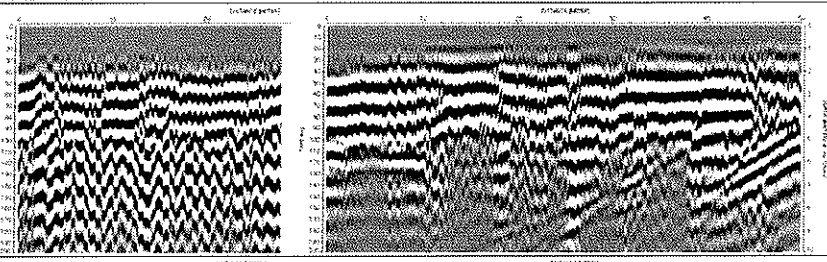
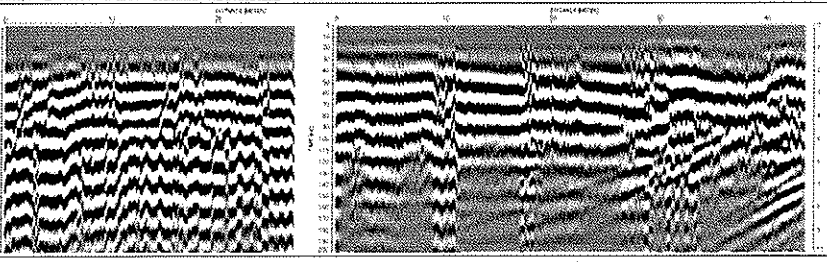
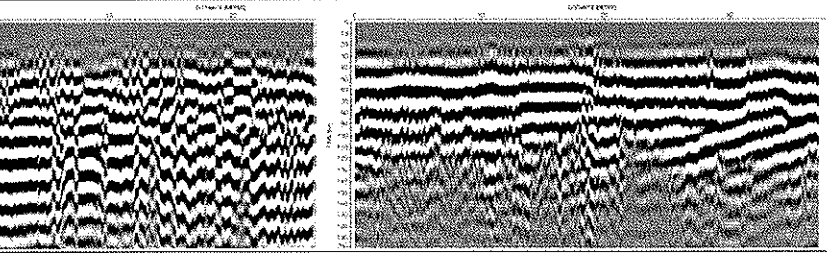
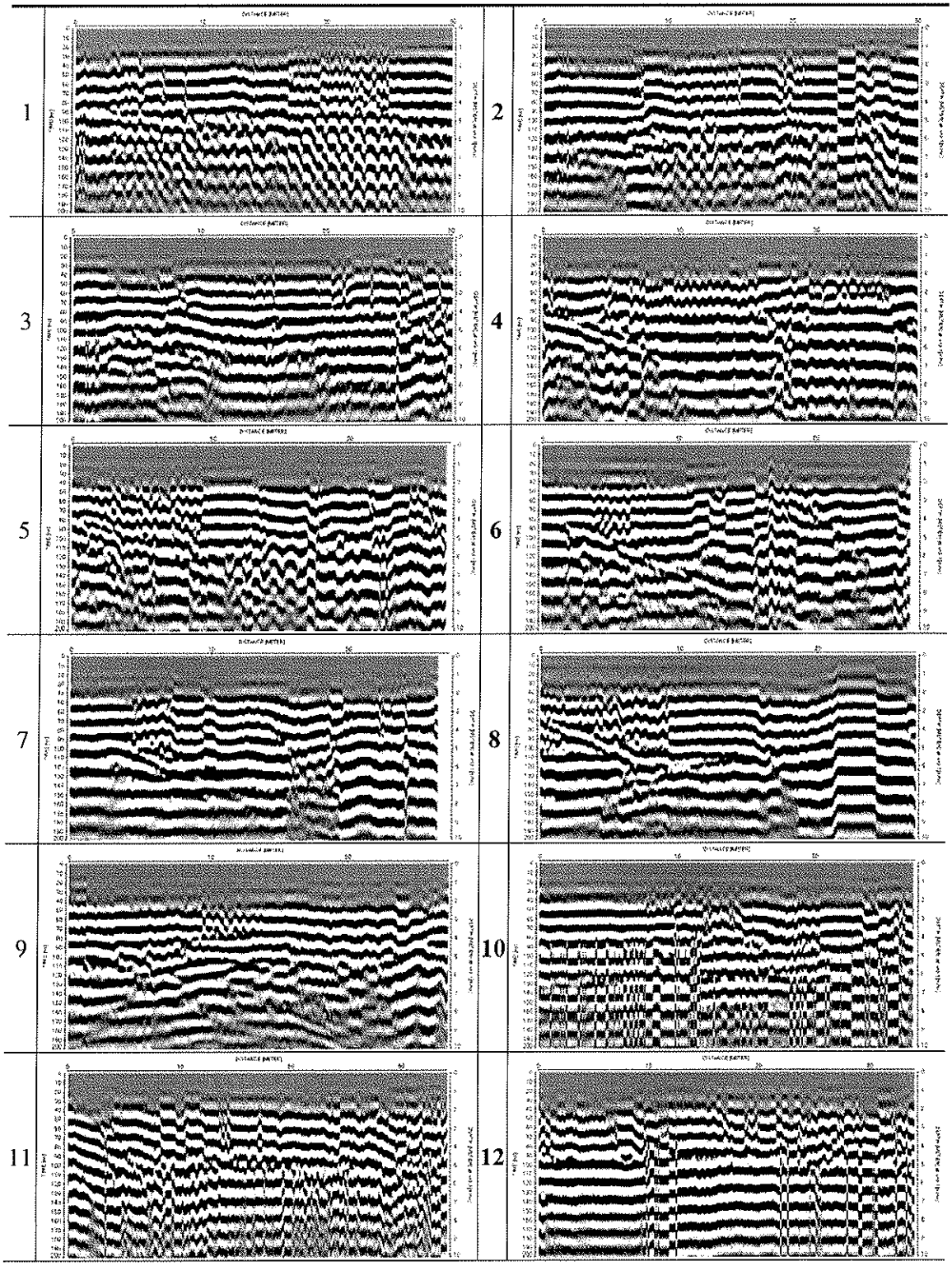
50 MHz GPR 2D Radargrams for Phase II Area D Site



50 MHz GPR 2D Radargrams for Phase II Area D Site

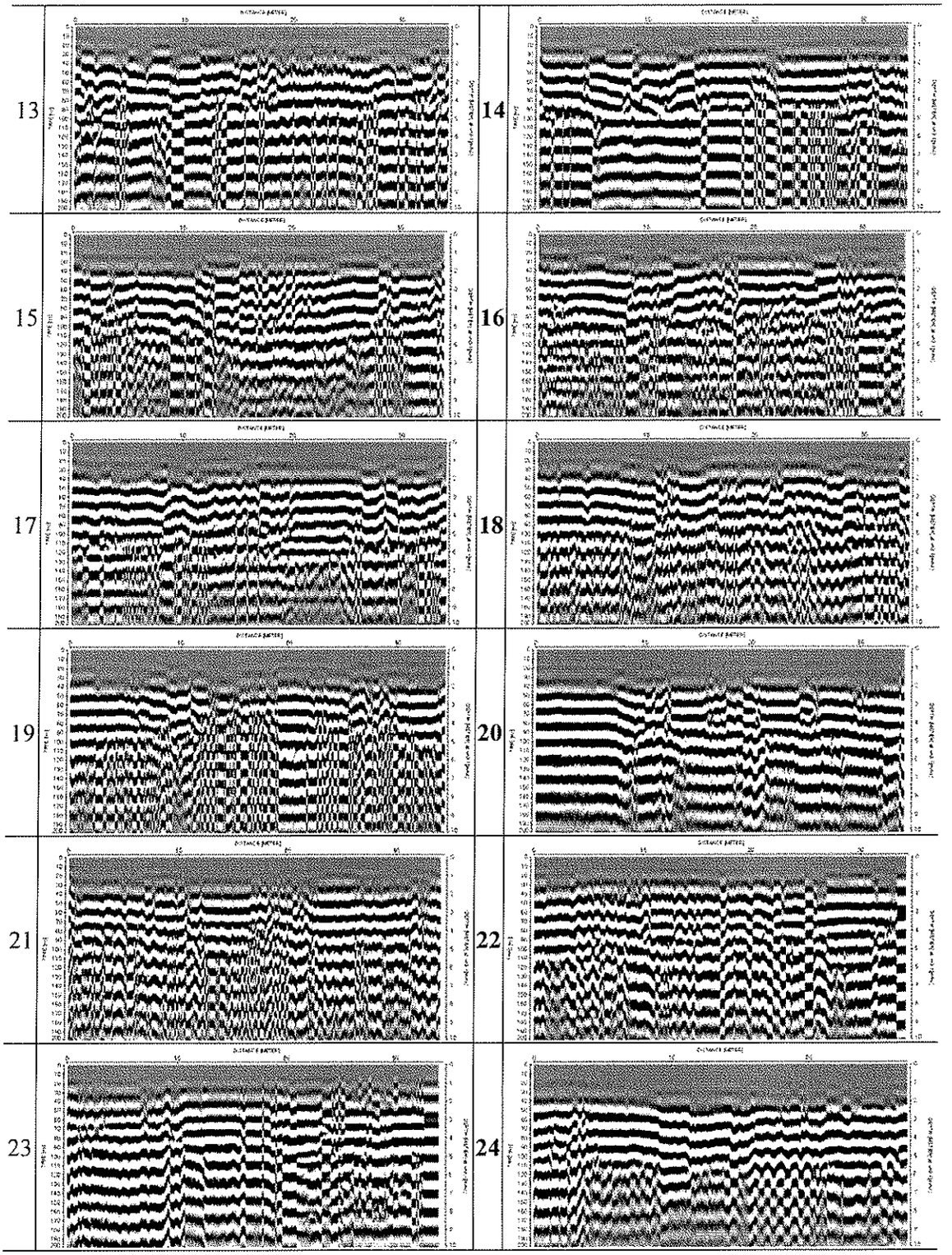
13	
14	
15	
16	
17	
18	

50 MHz GPR 2D Radargrams for Phase II Landfarm Site



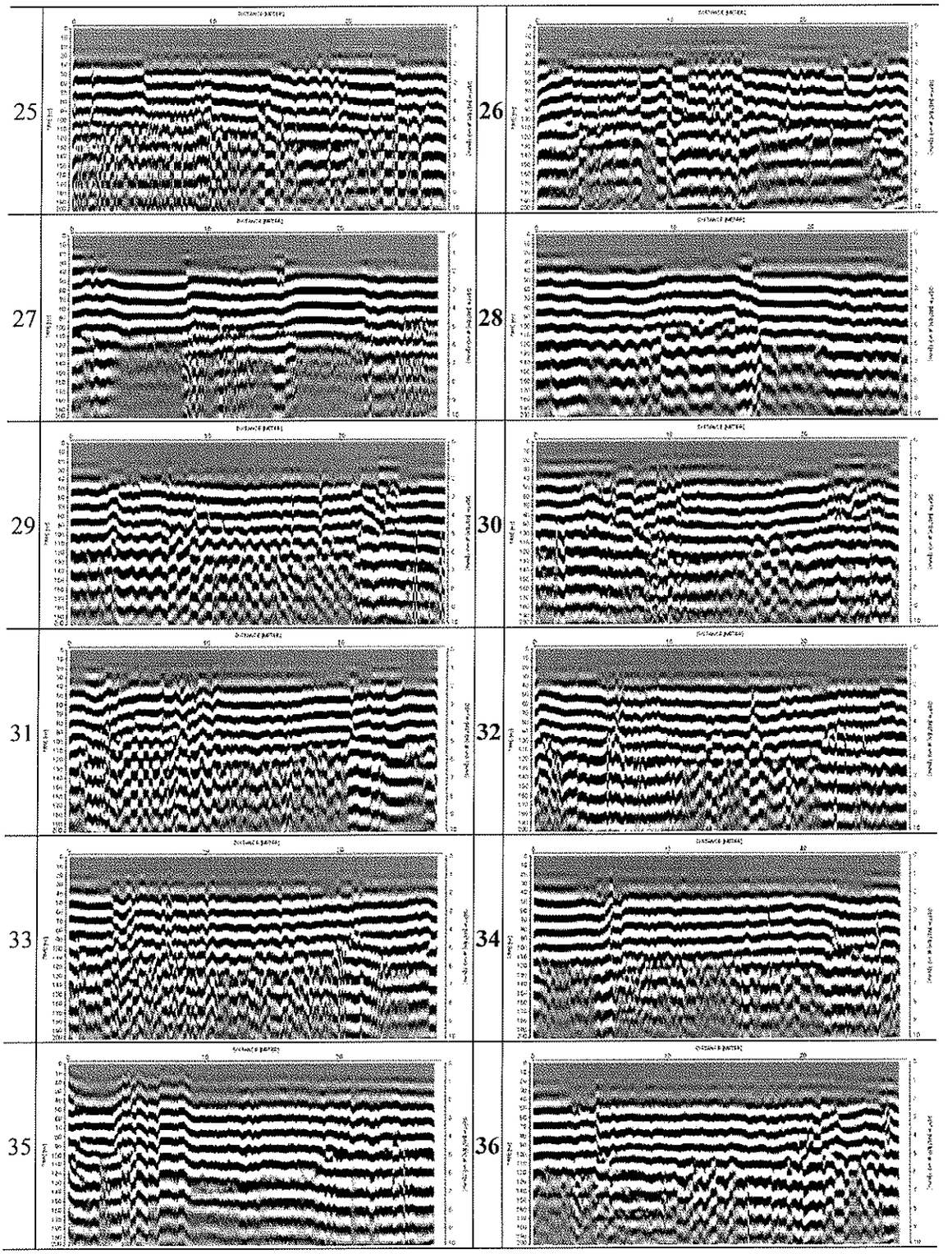
2957

50 MHz GPR 2D Radargrams for Phase II Landfarm Site



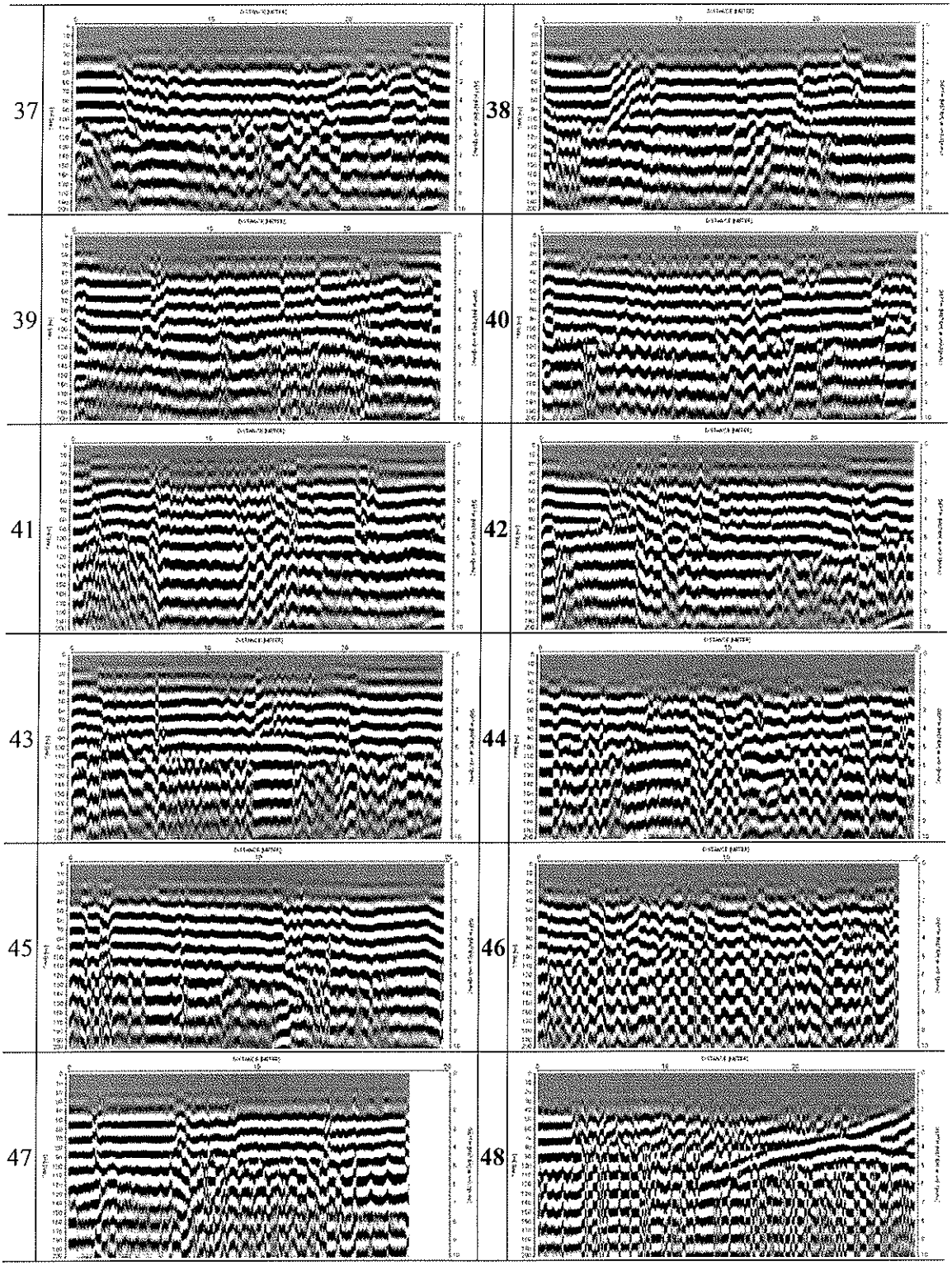
2958

50 MHz GPR 2D Radargrams for Phase II Landfarm Site



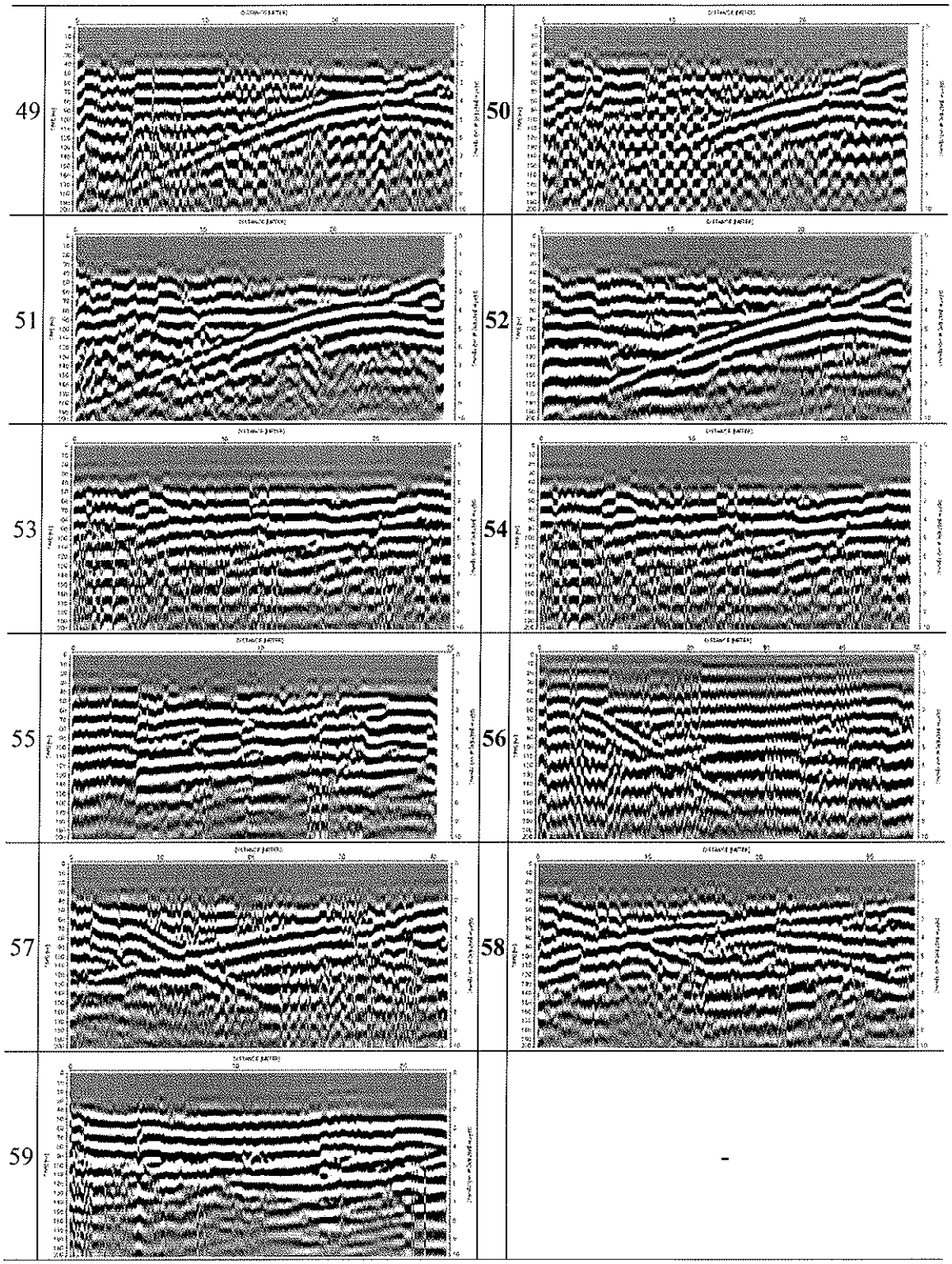
2959

50 MHz GPR 2D Radargrams for Phase II Landfarm Site

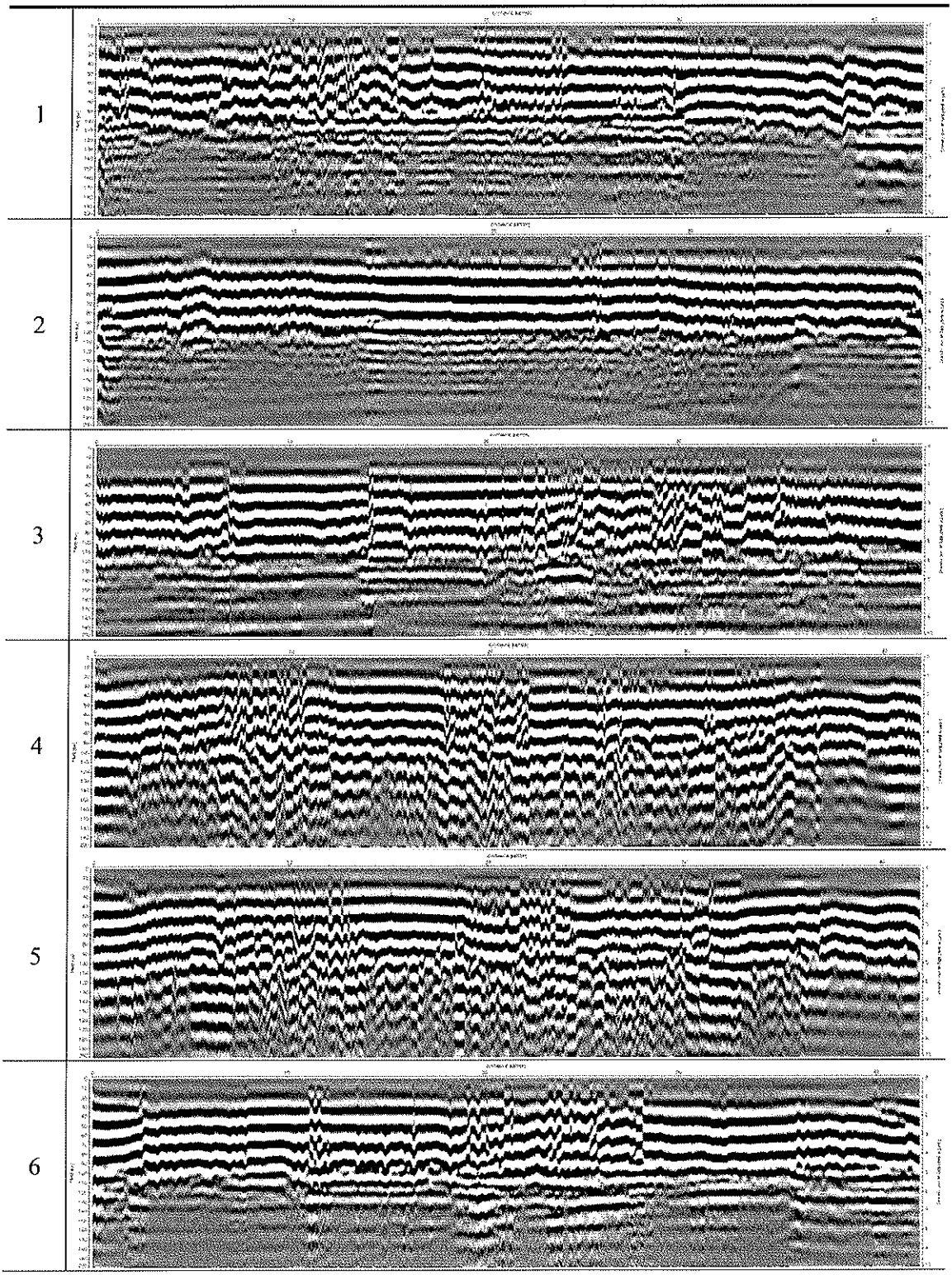


2960

50 MHz GPR 2D Radargrams for Phase II Landfarm Site

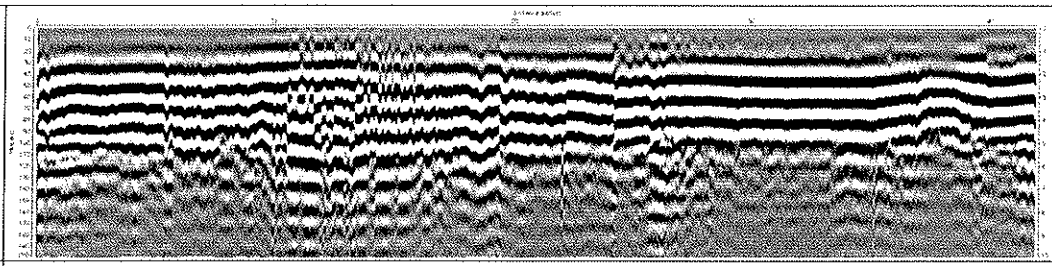


50 MHz GPR 2D Radargrams for Phase IIB Helipad Site



50 MHz GPR 2D Radargrams for Phase IIB Helipad Site

7



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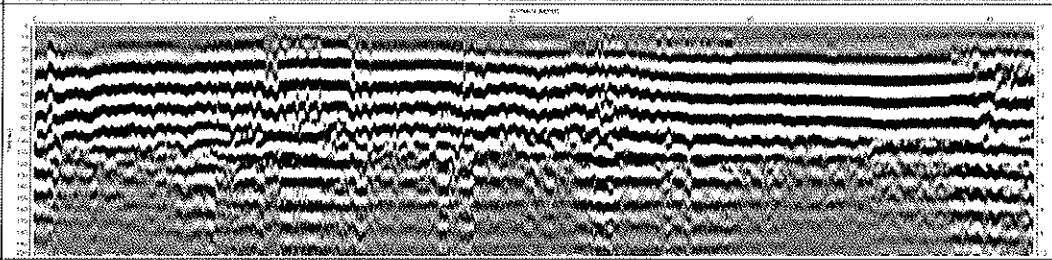

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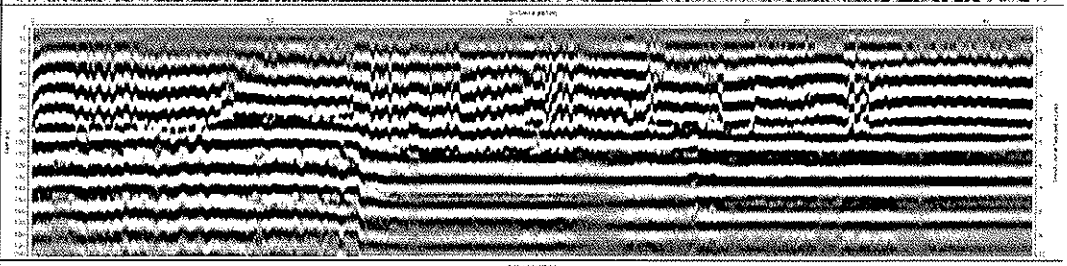

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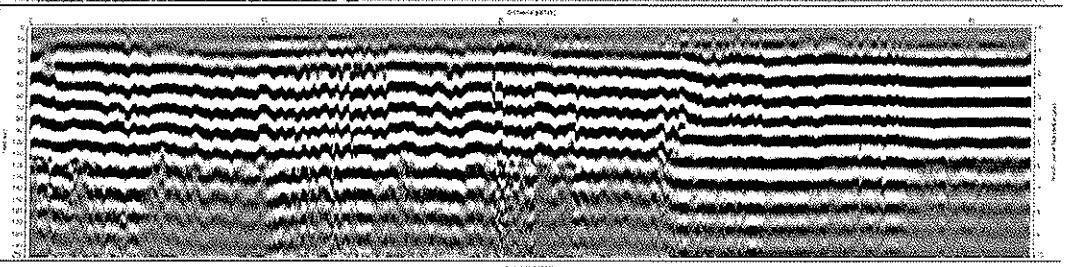

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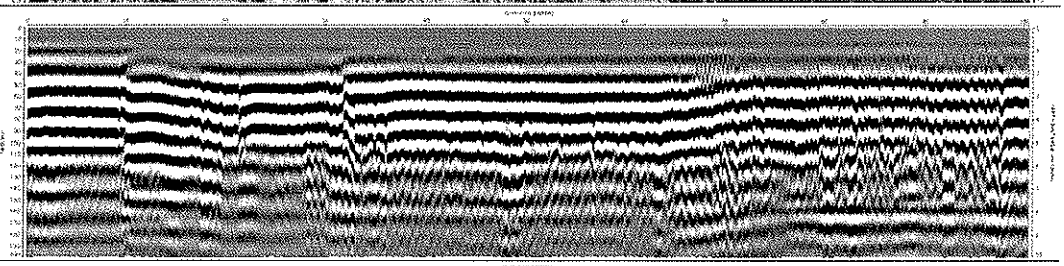

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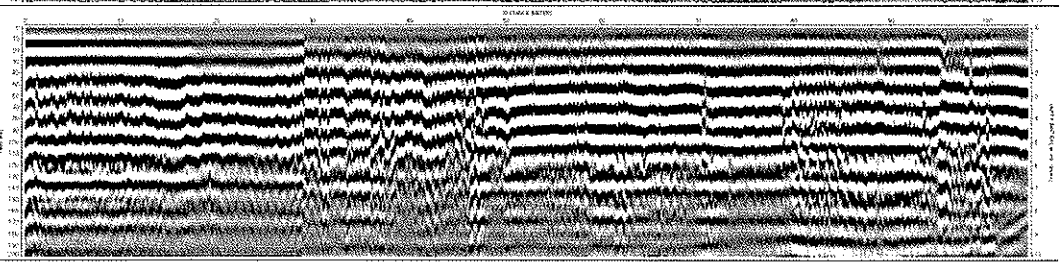
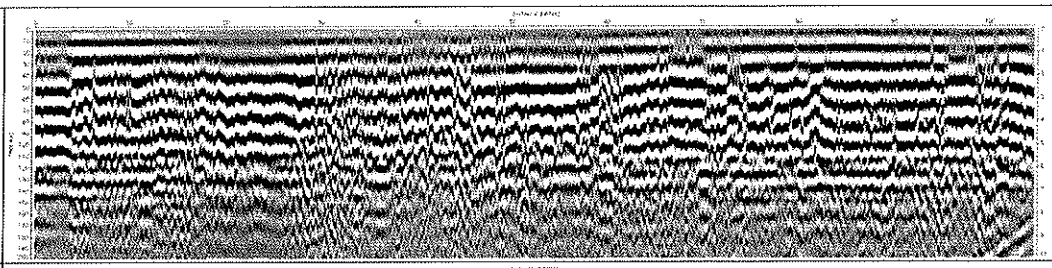


50 MHz GPR 2D Radargrams for Phase IIB Helipad Site

13



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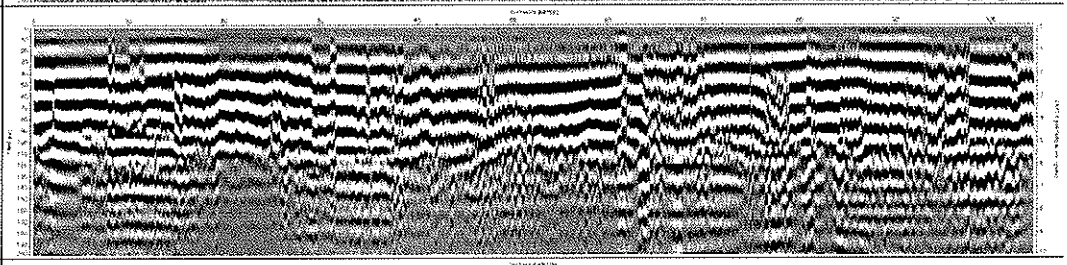

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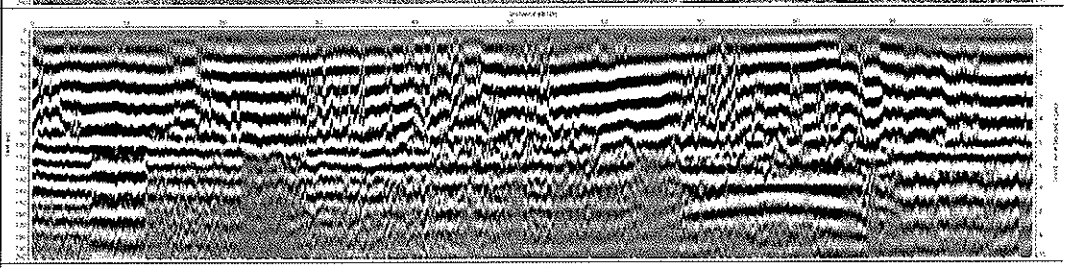

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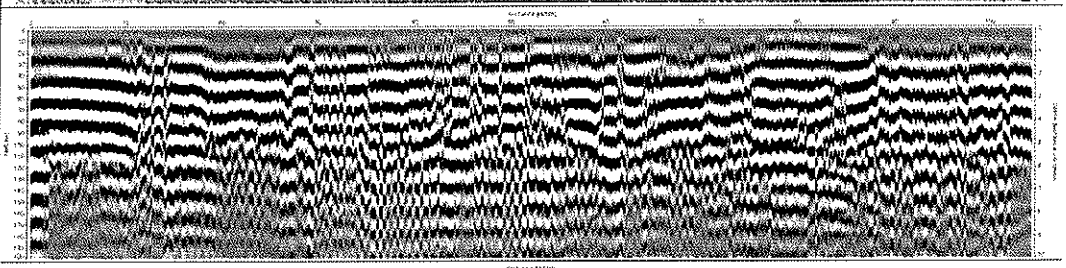

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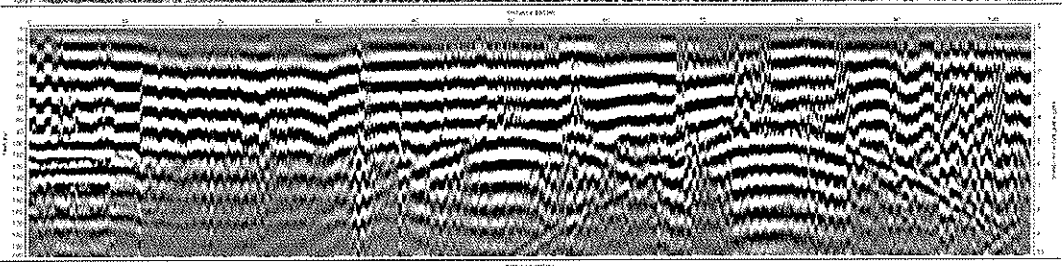

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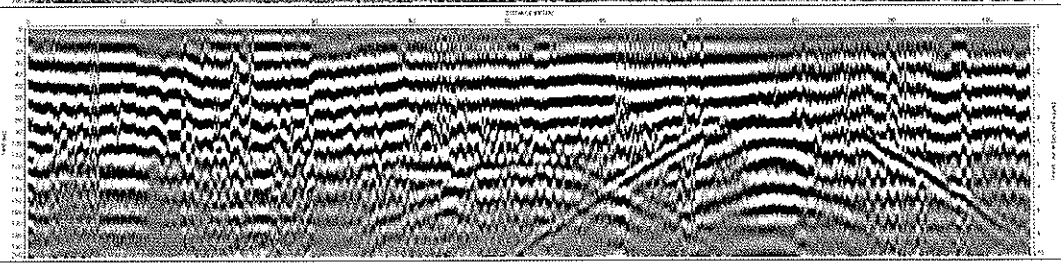
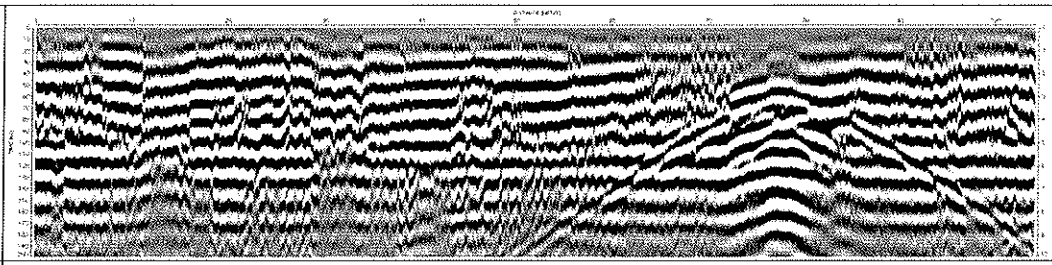


50 MHz GPR 2D Radargrams for Phase IIB Helipad Site

19



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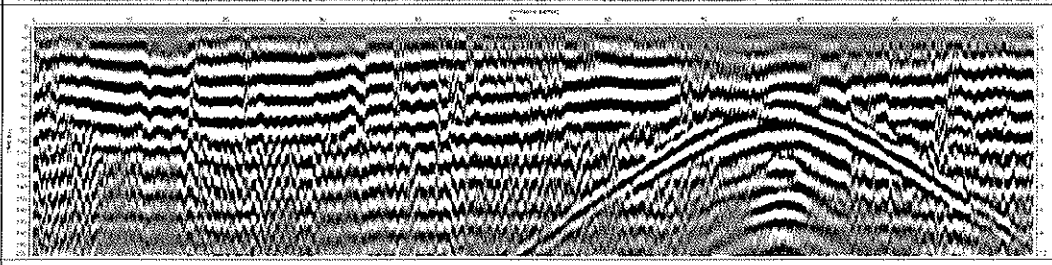

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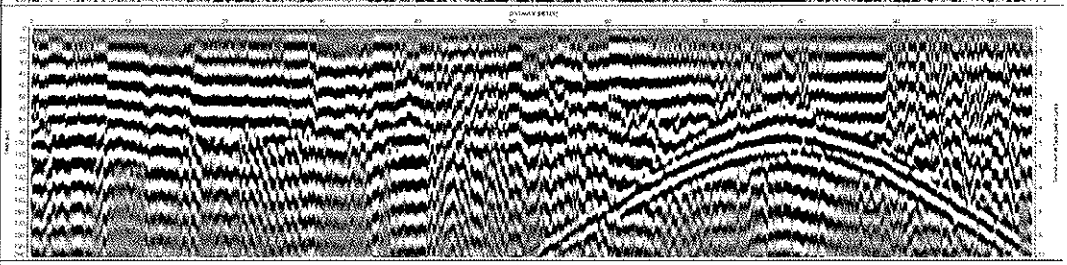

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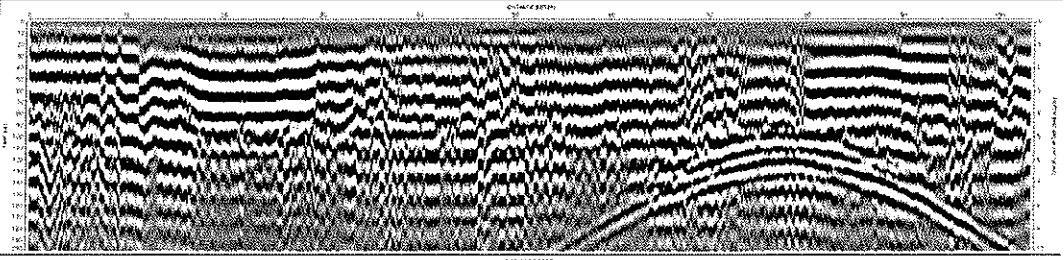

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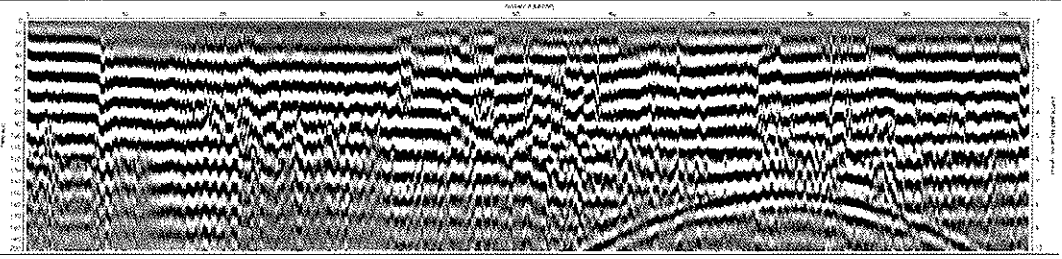
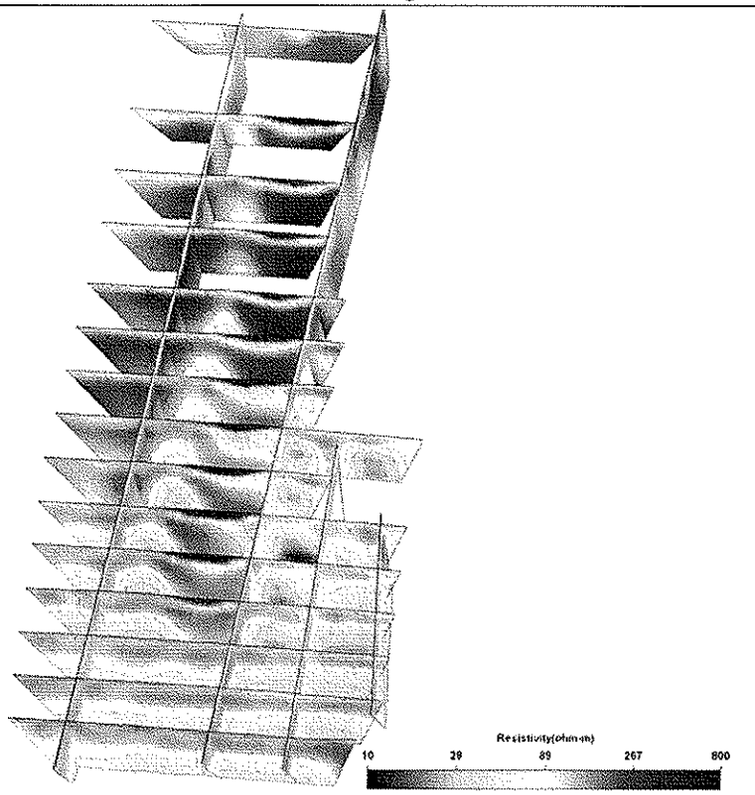
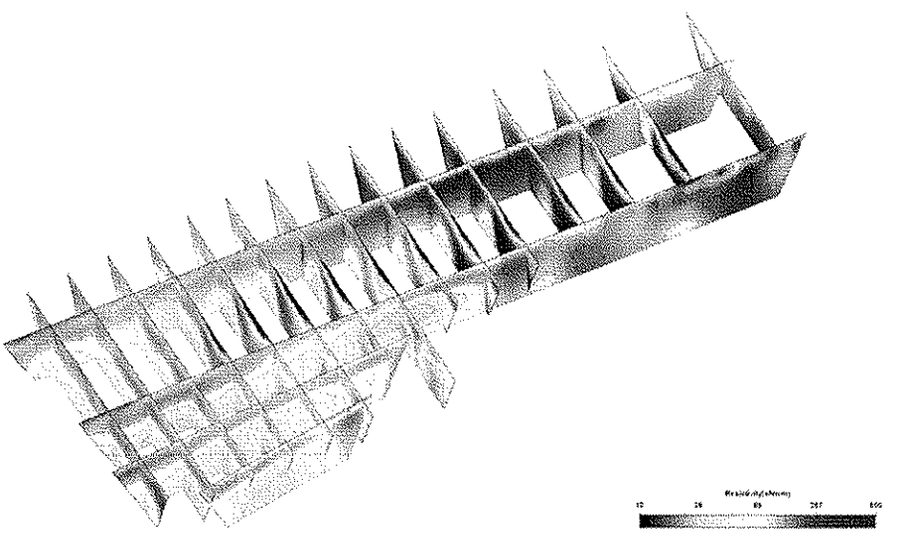


ERI Vertical Cross Sections for Phase II Area D Site

Fence Diagram

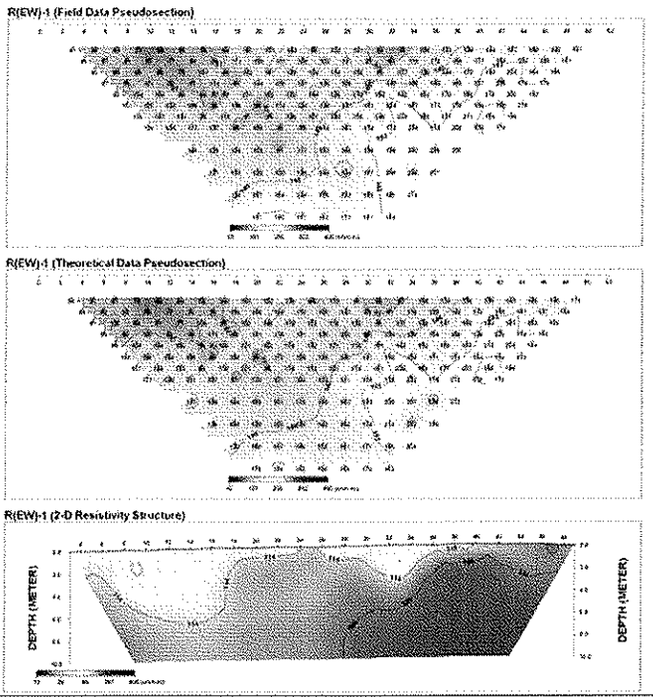




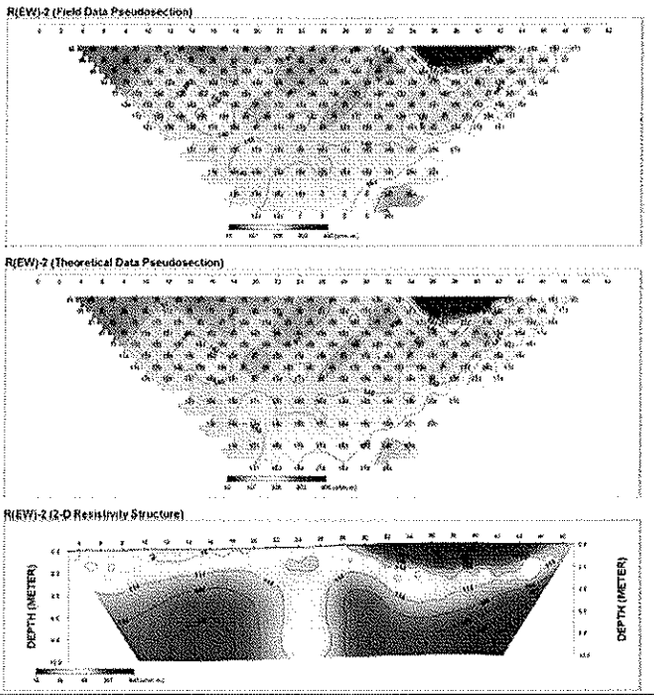
3965

ERI Vertical Cross Sections for Phase II Area D Site

R(EW)-1



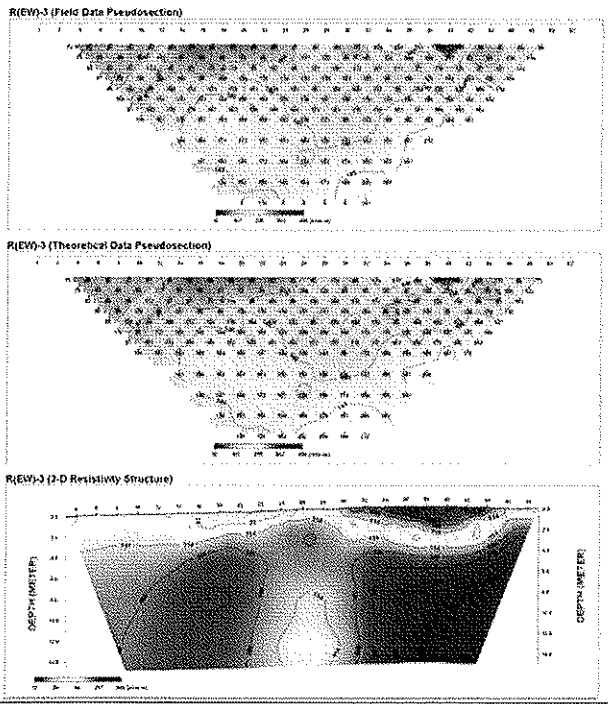
R(EW)-2



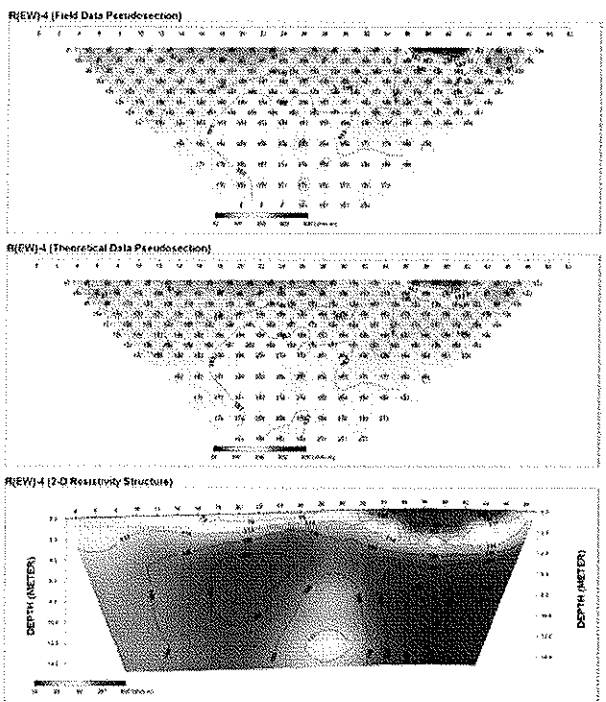
2767

ERI Vertical Cross Sections for Phase II Area D Site

R(EW)-3

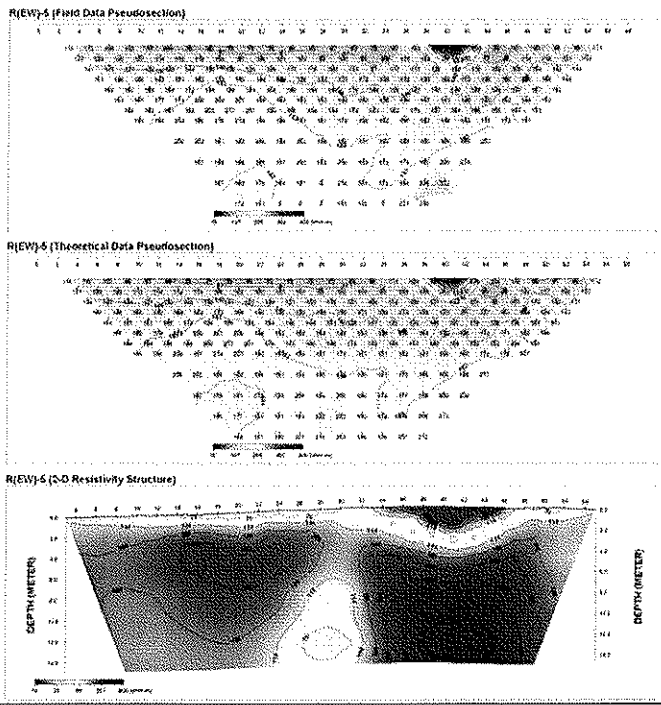


R(EW)-4

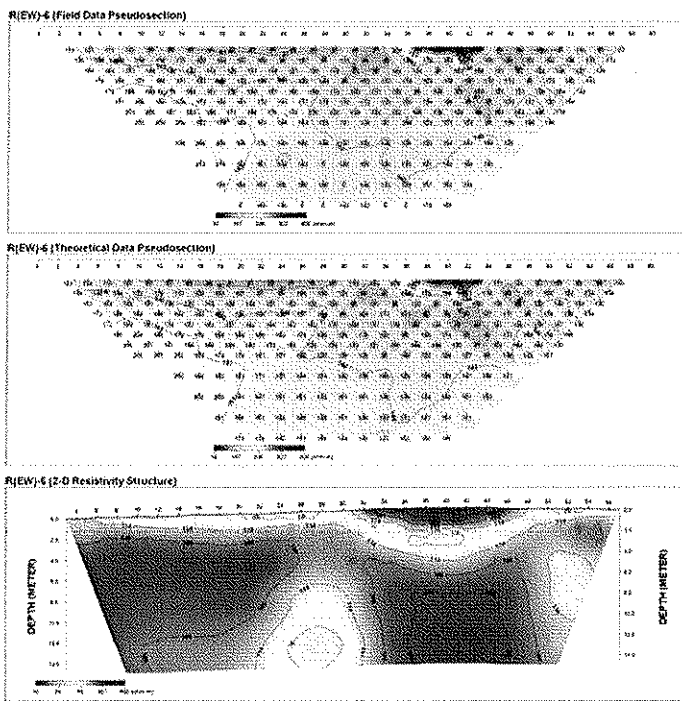


ERI Vertical Cross Sections for Phase II Area D Site

R(EW)-5

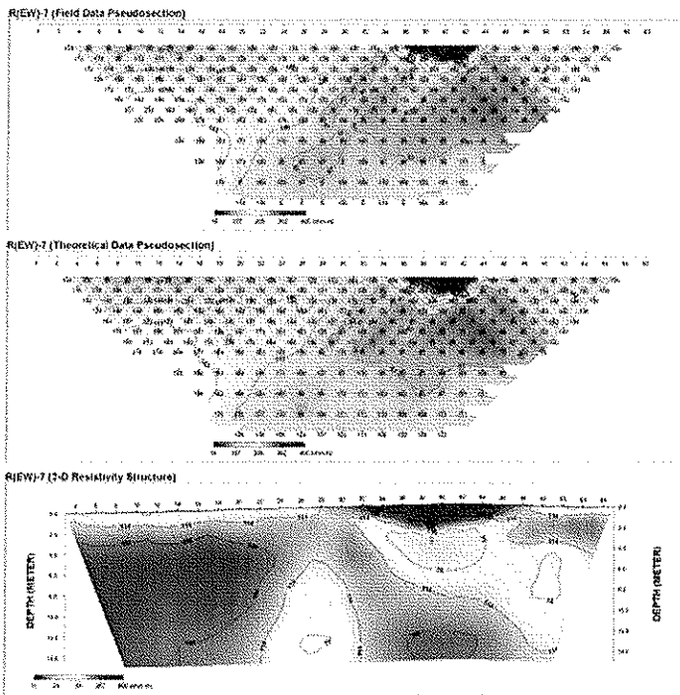


R(EW)-6

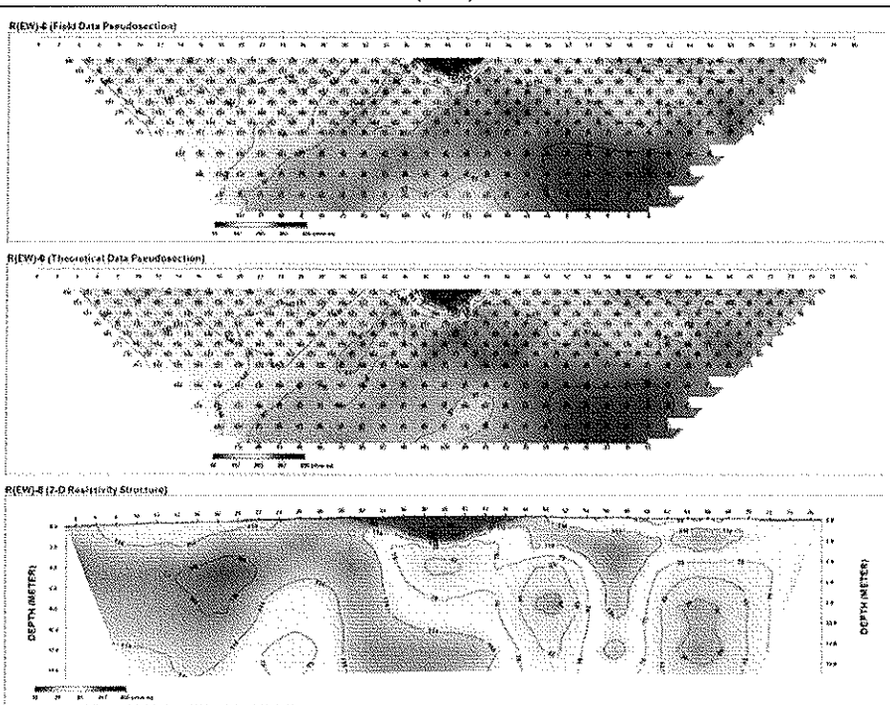


ERI Vertical Cross Sections for Phase II Area D Site

R(EW)-7

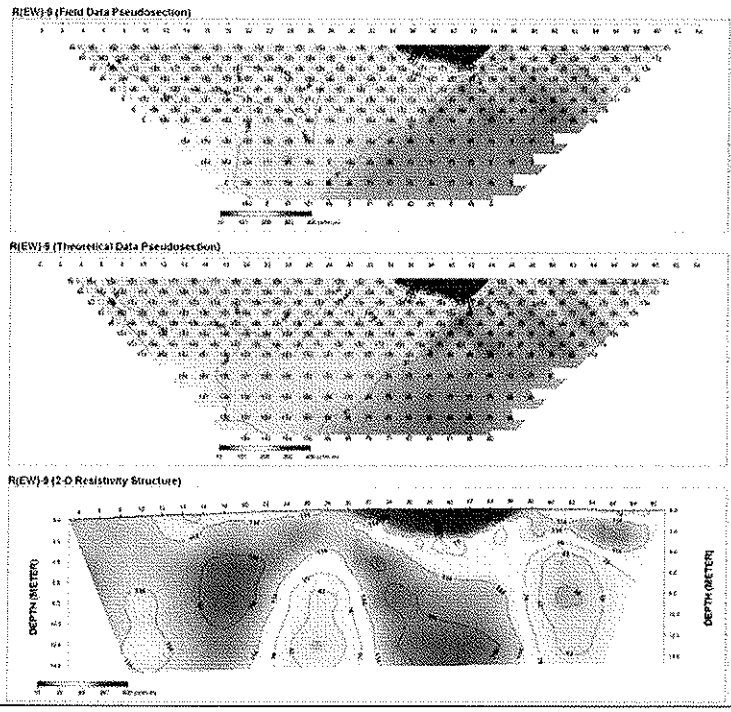


R(EW)-8

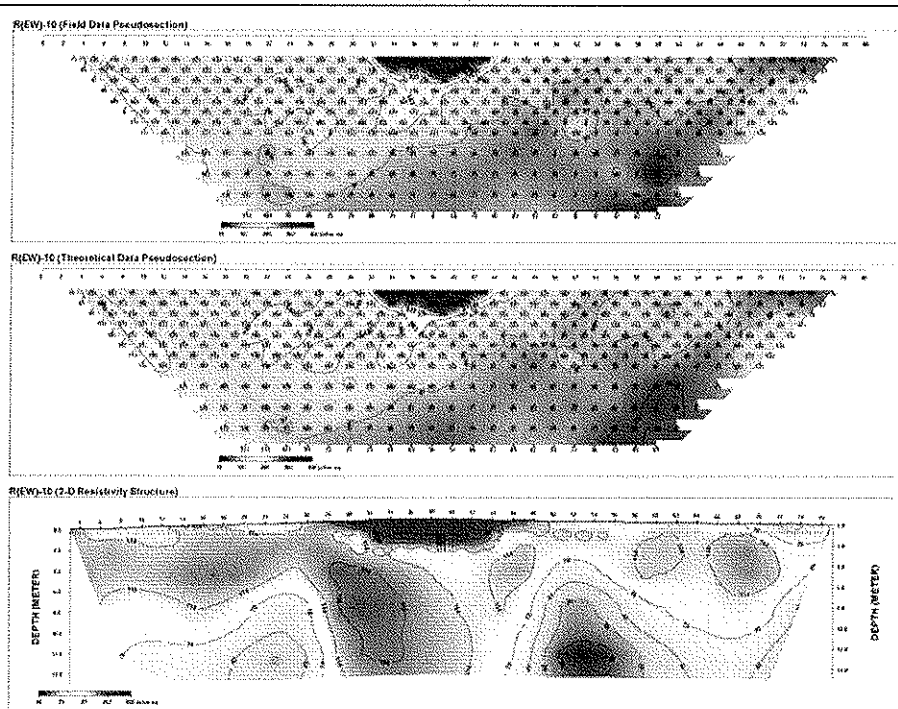


ERI Vertical Cross Sections for Phase II Area D Site

R(EW)-9

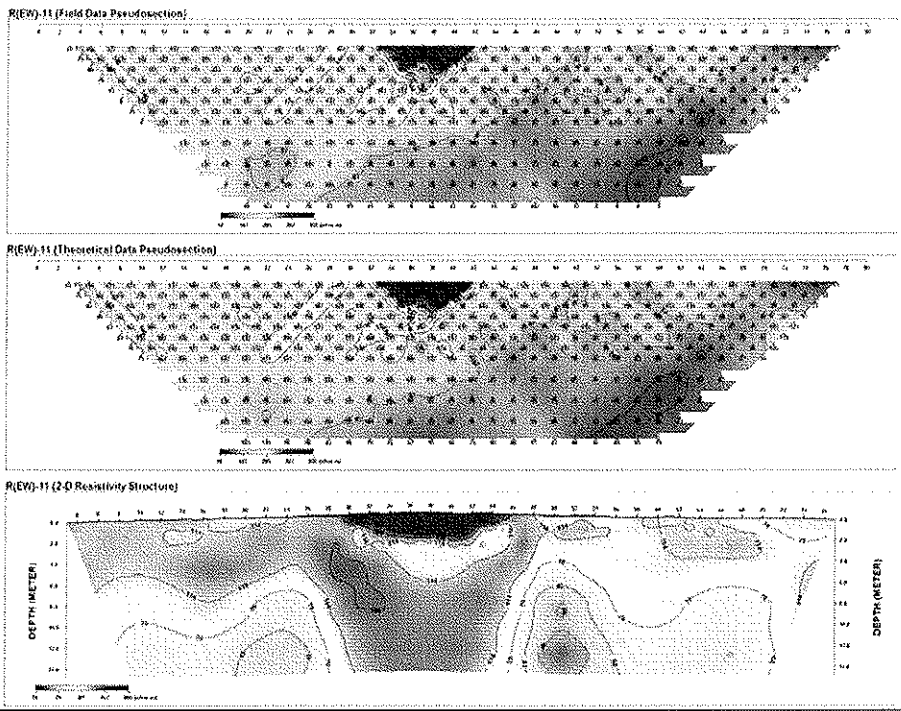


R(EW)-10

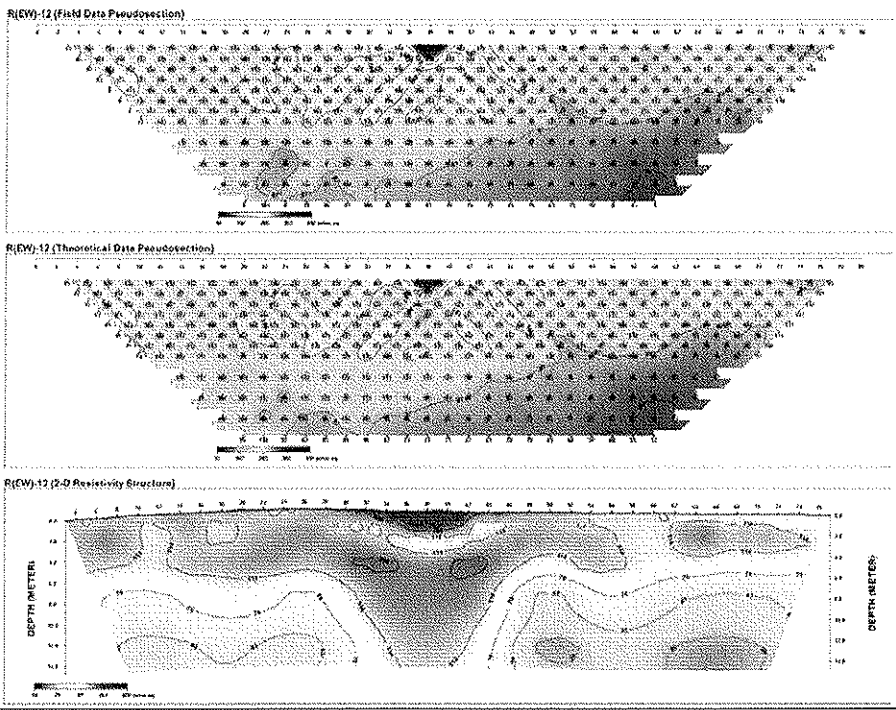


ERI Vertical Cross Sections for Phase II Area D Site

R(EW)-11



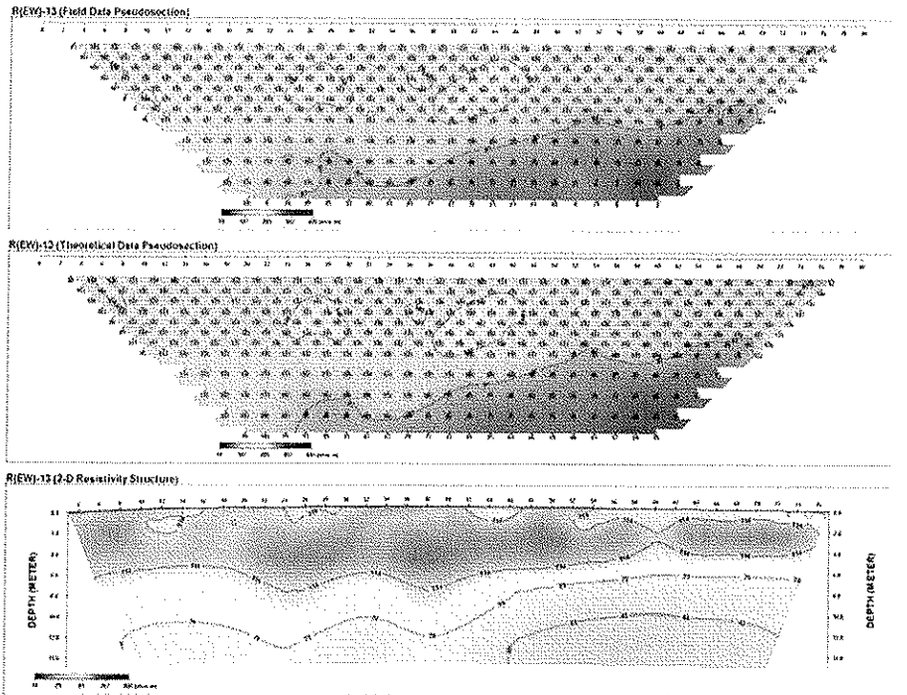
R(EW)-12



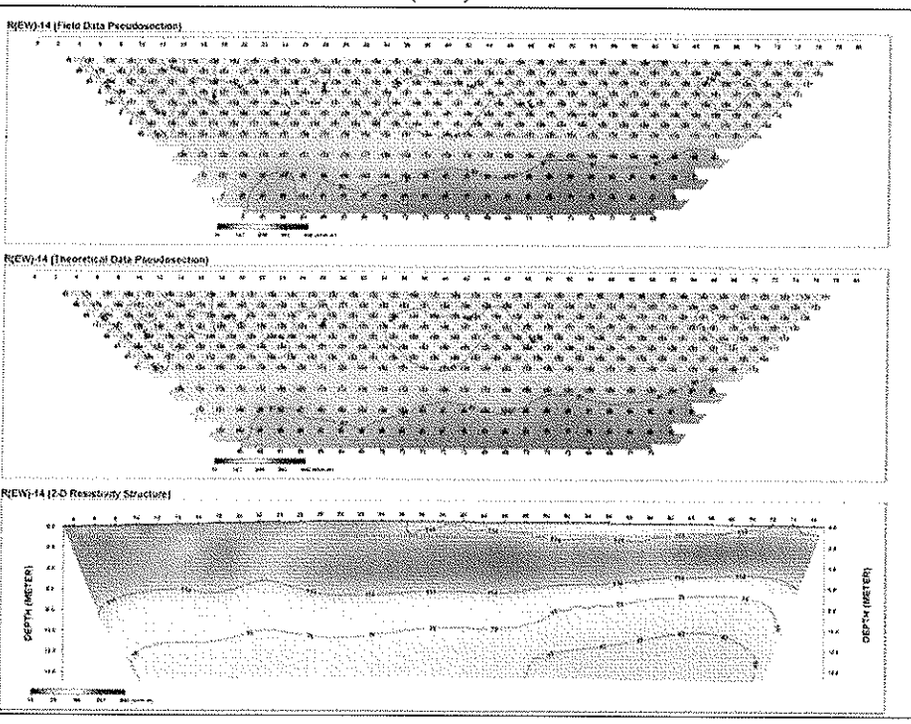
3972

ERI Vertical Cross Sections for Phase II Area D Site

R(EW)-13

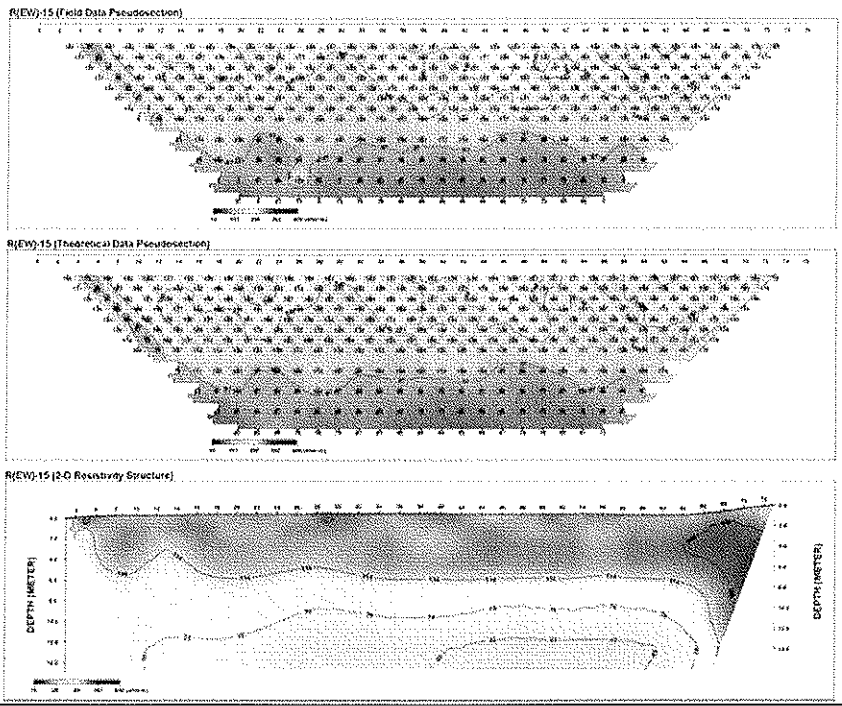


R(EW)-14

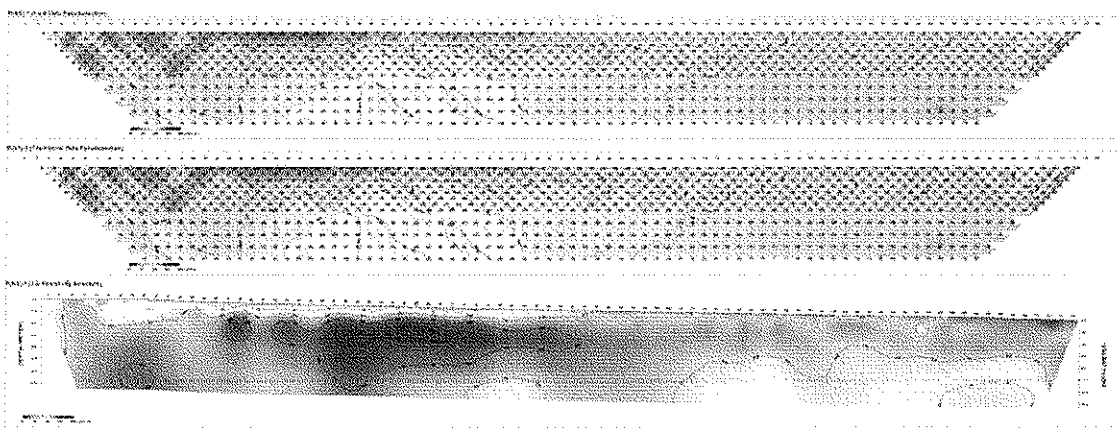


ERI Vertical Cross Sections for Phase II Area D Site

R(EW)-15



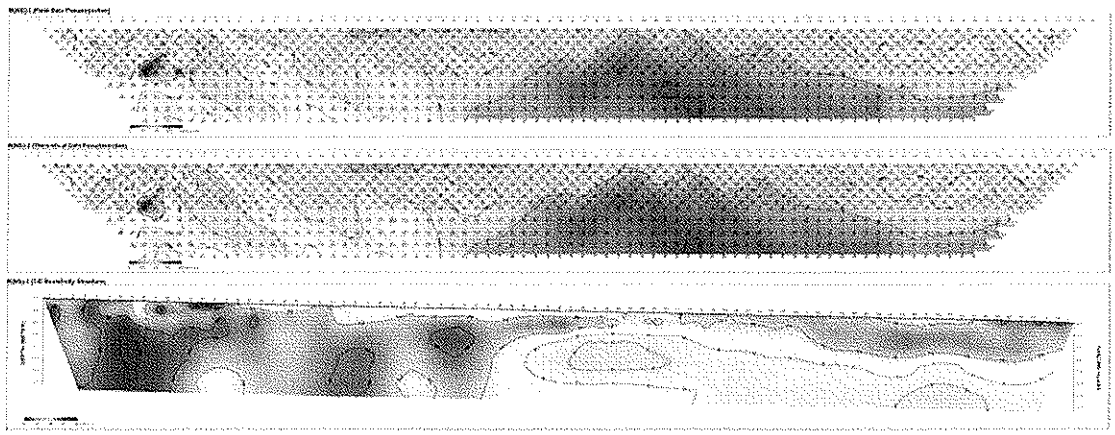
R(NS)-1



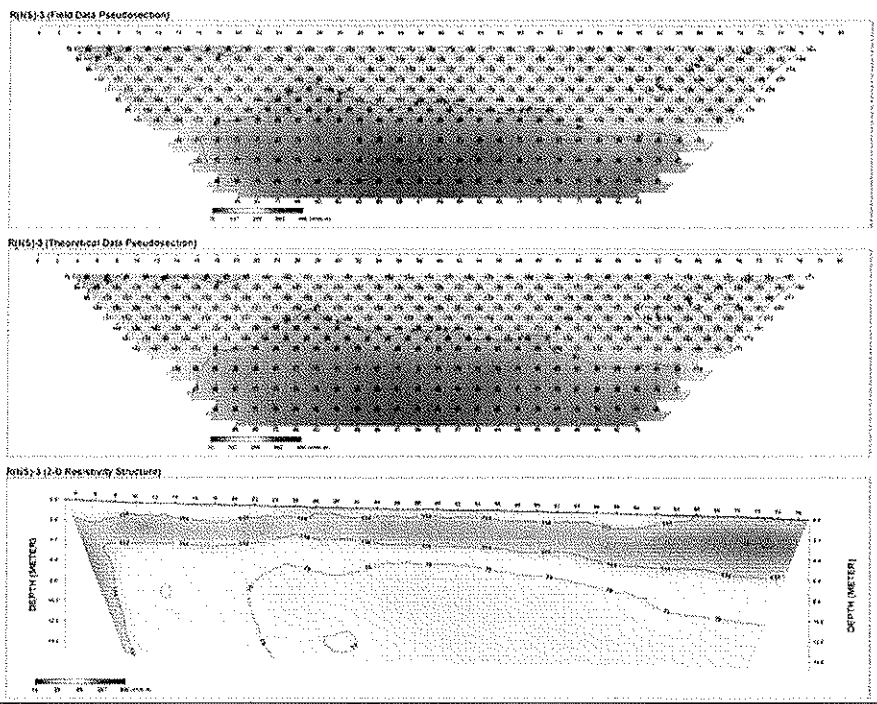
2974

ERI Vertical Cross Sections for Phase II Area D Site

R(NS)-2

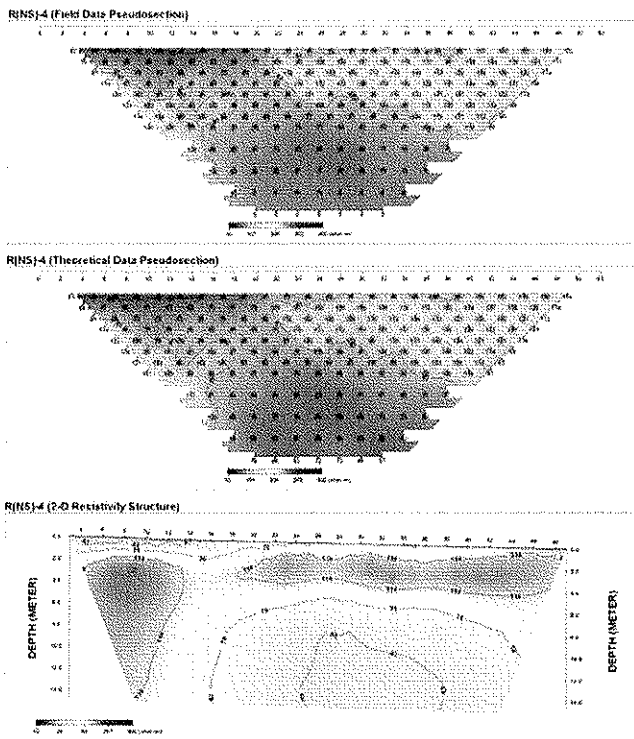


R(NS)-3



ERI Vertical Cross Sections for Phase II Area D Site

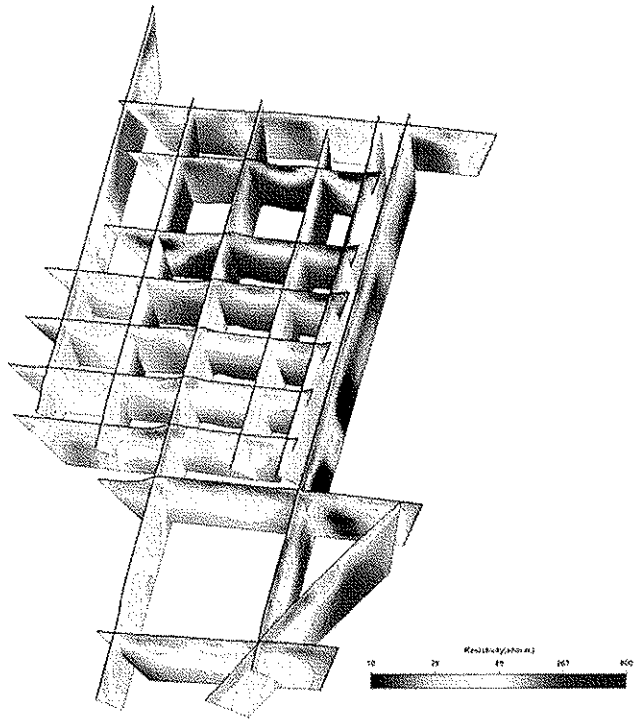
R(NS)-4

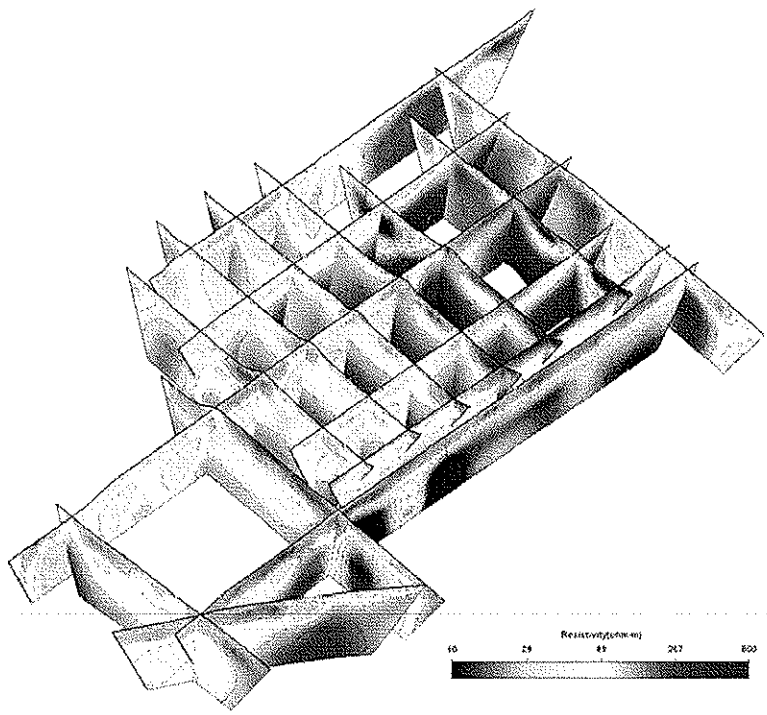


3926

ERI Vertical Cross Sections for Phase II Landfarm Site

Fence Diagram

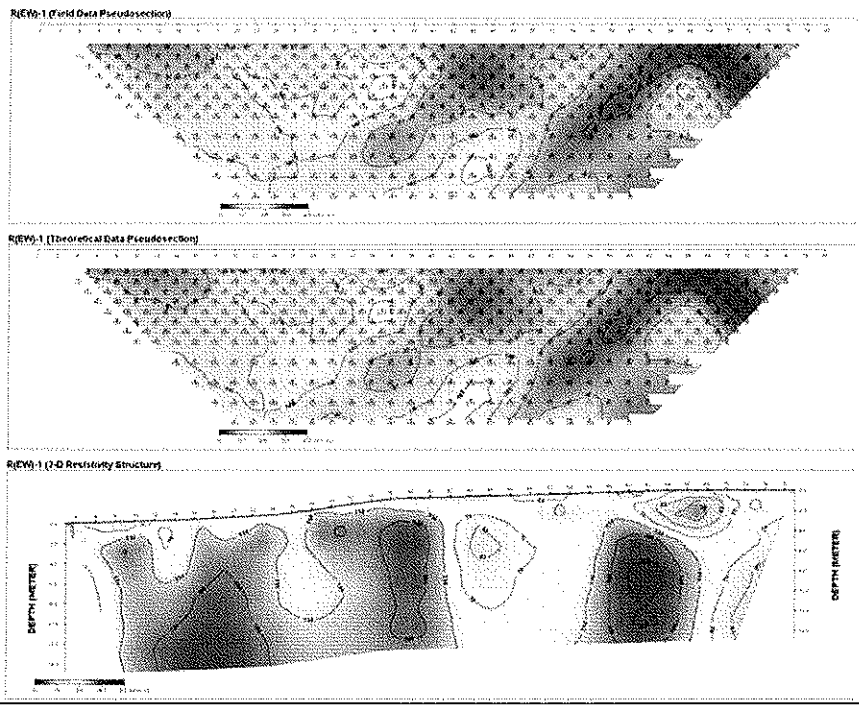




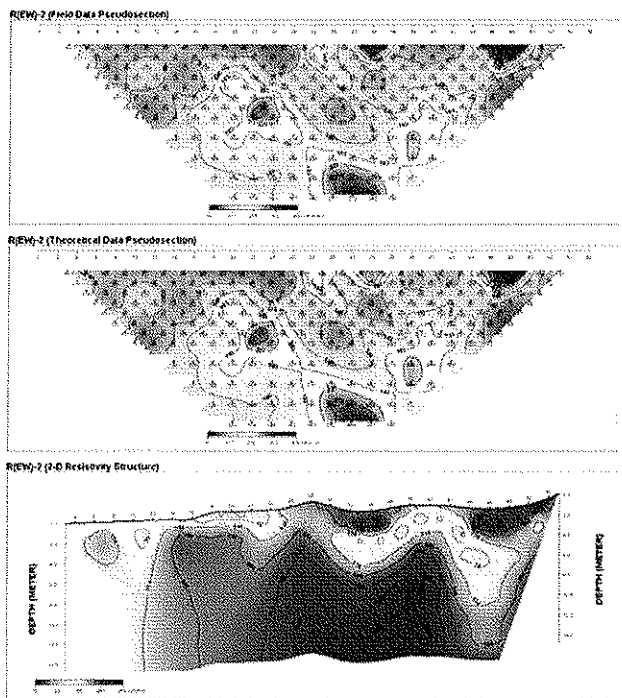
3977

ERI Vertical Cross Sections for Phase II Landfarm Site

R(EW)-1



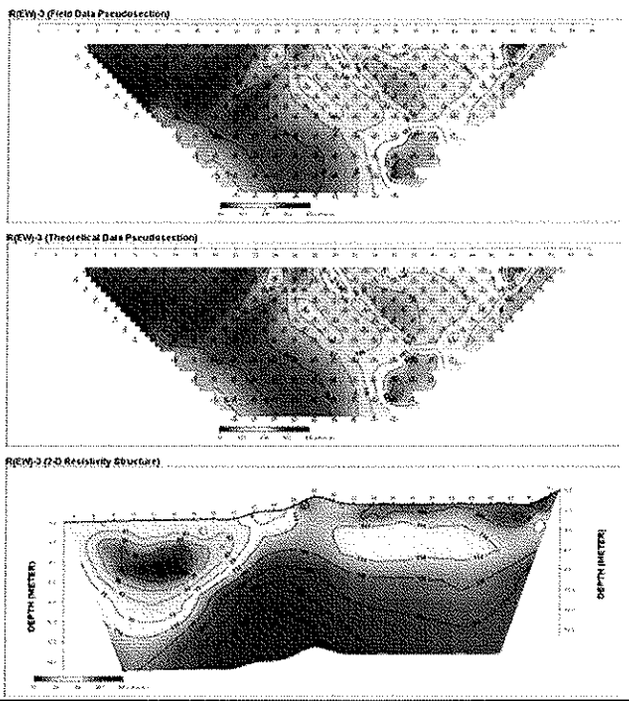
R(EW)-2



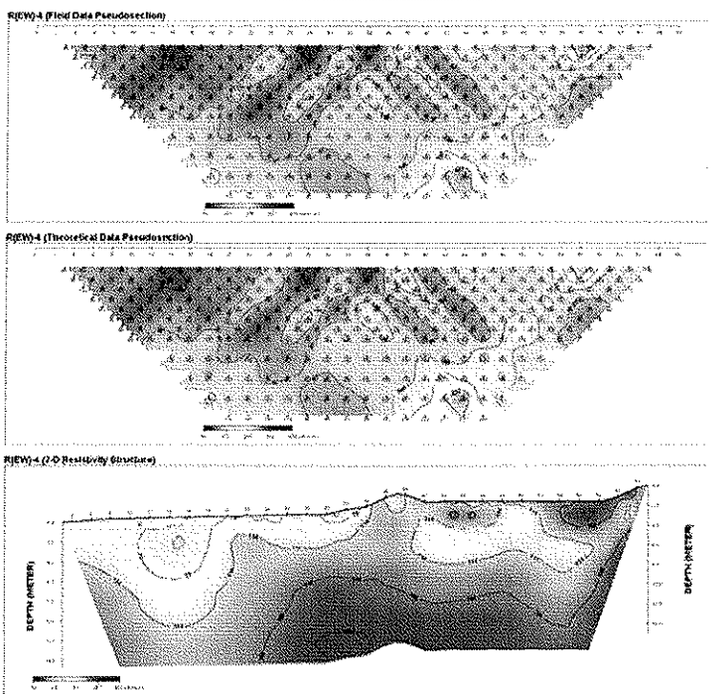
3978

ERI Vertical Cross Sections for Phase II Landfarm Site

R(EW)-3



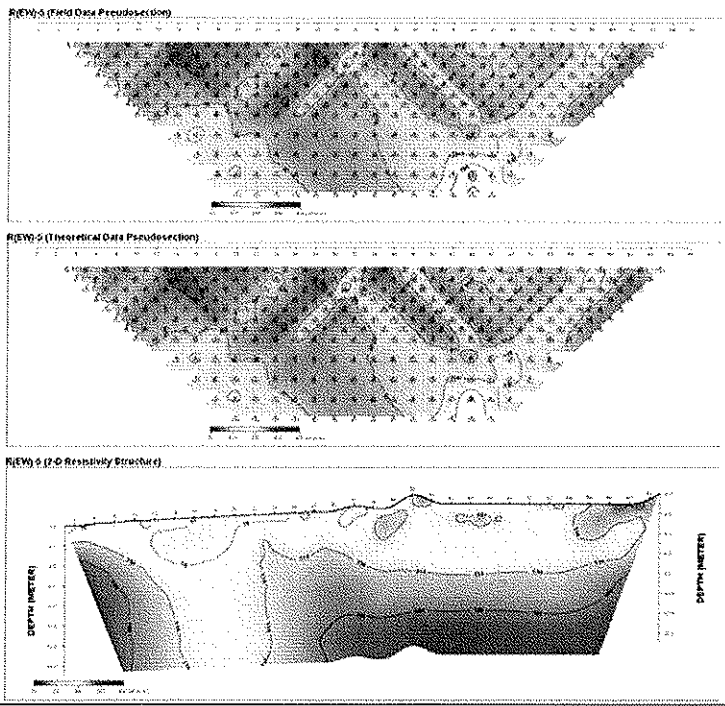
R(EW)-4



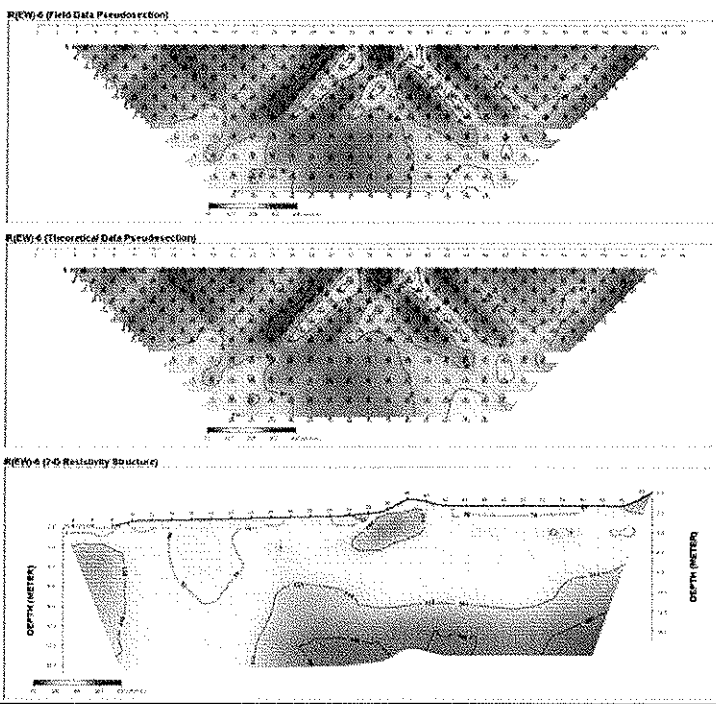
3979

ERI Vertical Cross Sections for Phase II Landfarm Site

R(EW)-5



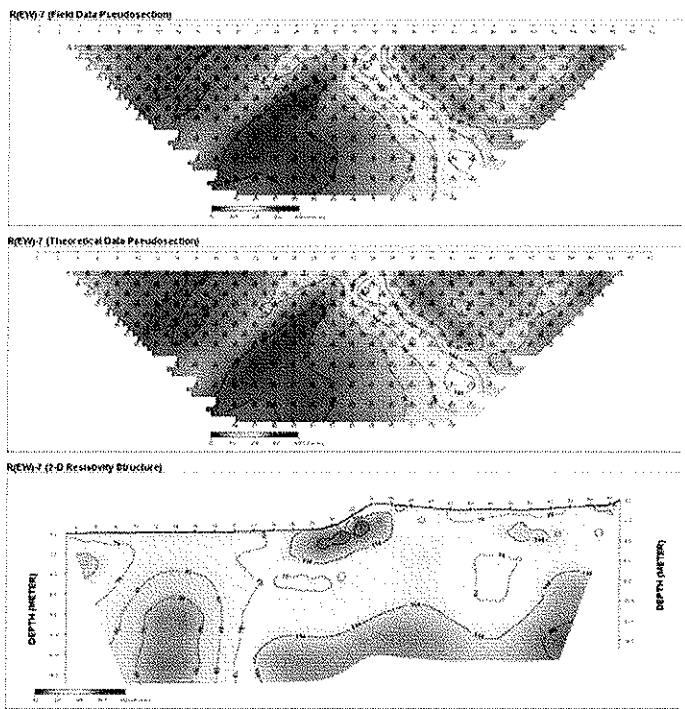
R(EW)-6



2980

ERI Vertical Cross Sections for Phase II Landfarm Site

R(EW)-7



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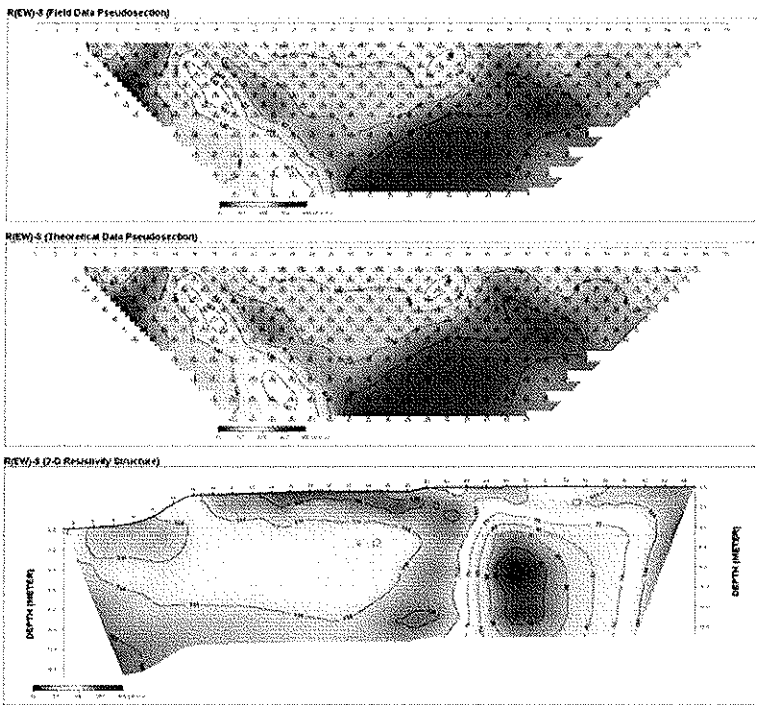

ERI Vertical Cross Sections for Phase II Landfarm Site

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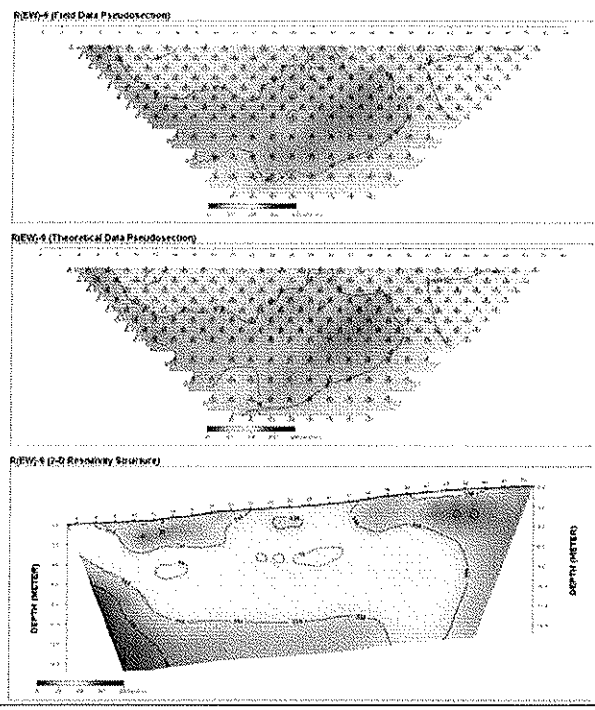

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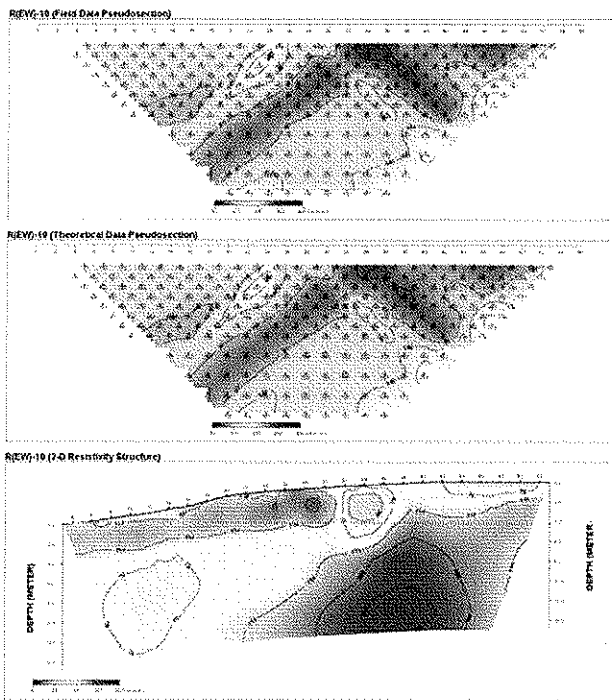

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ERI Vertical Cross Sections for Phase II Landfarm Site

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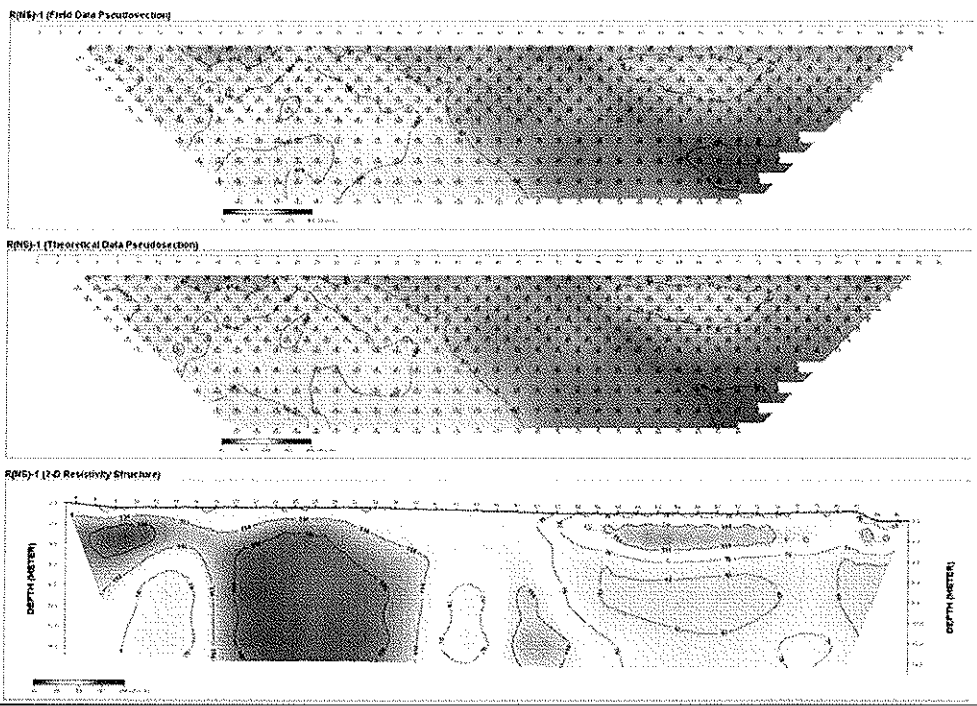

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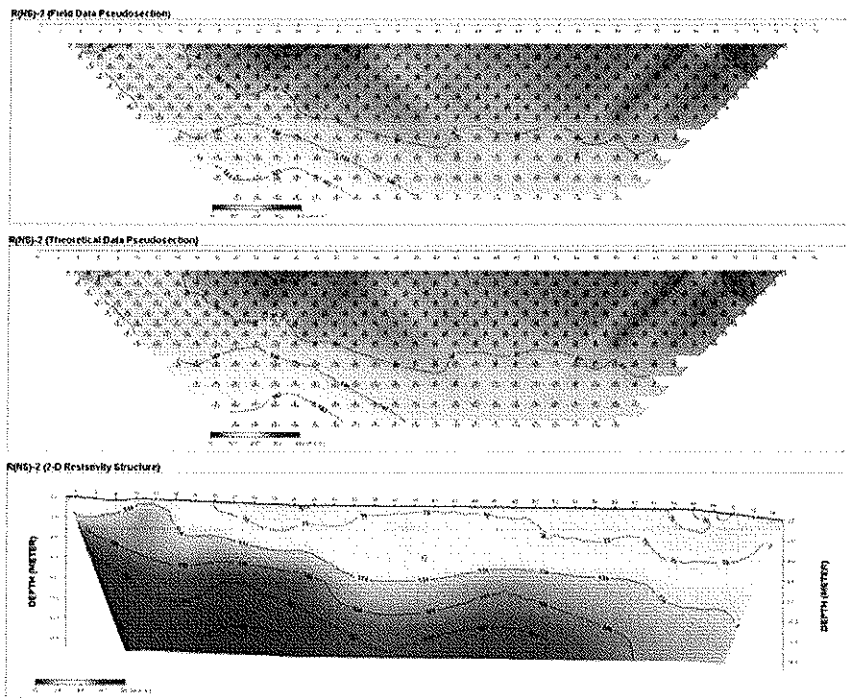

ERI Vertical Cross Sections for Phase II Landfarm Site

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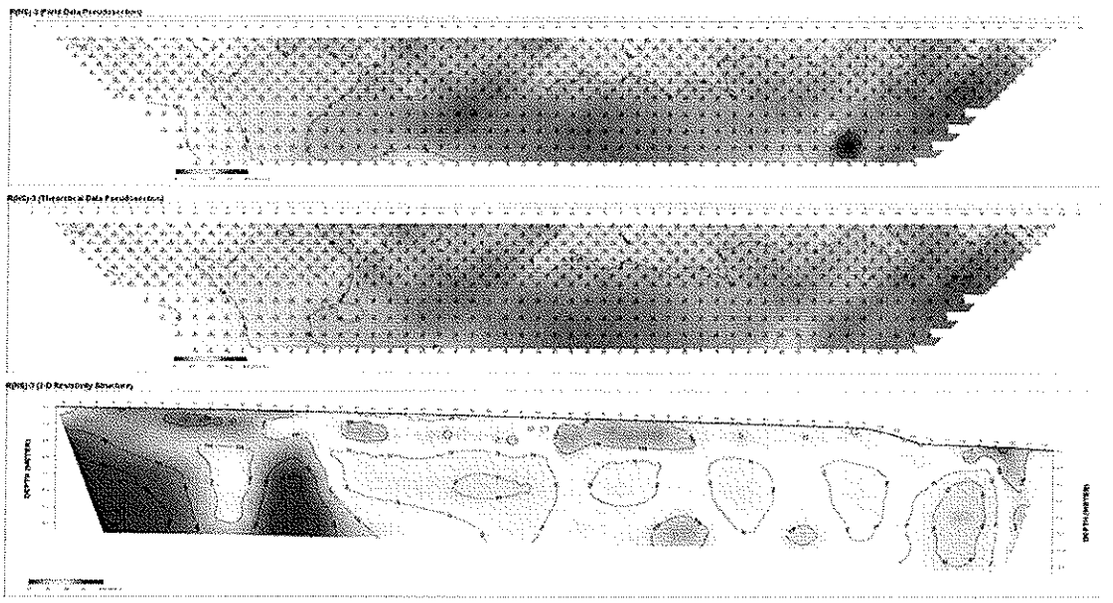

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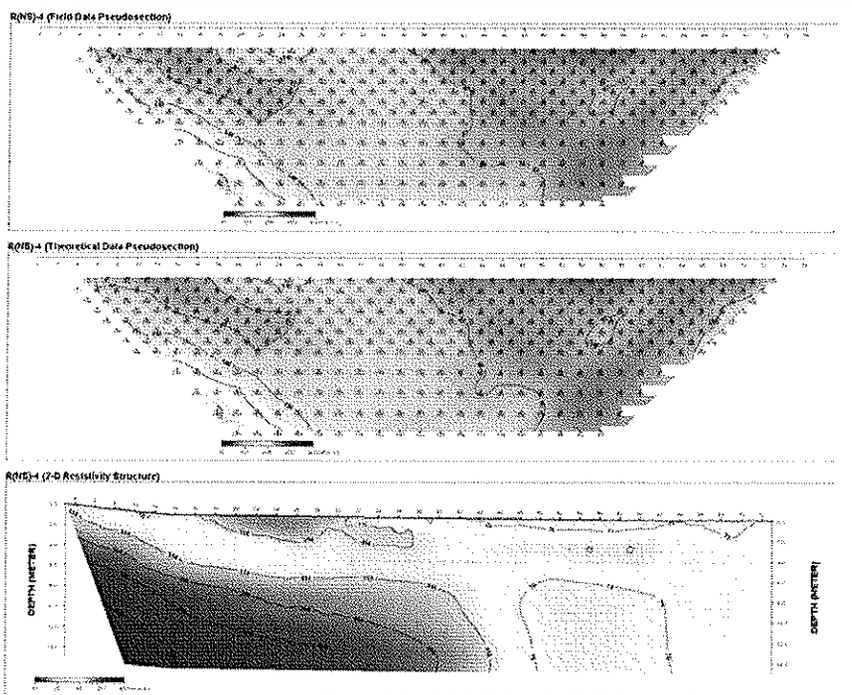

ERI Vertical Cross Sections for Phase II Landfarm Site

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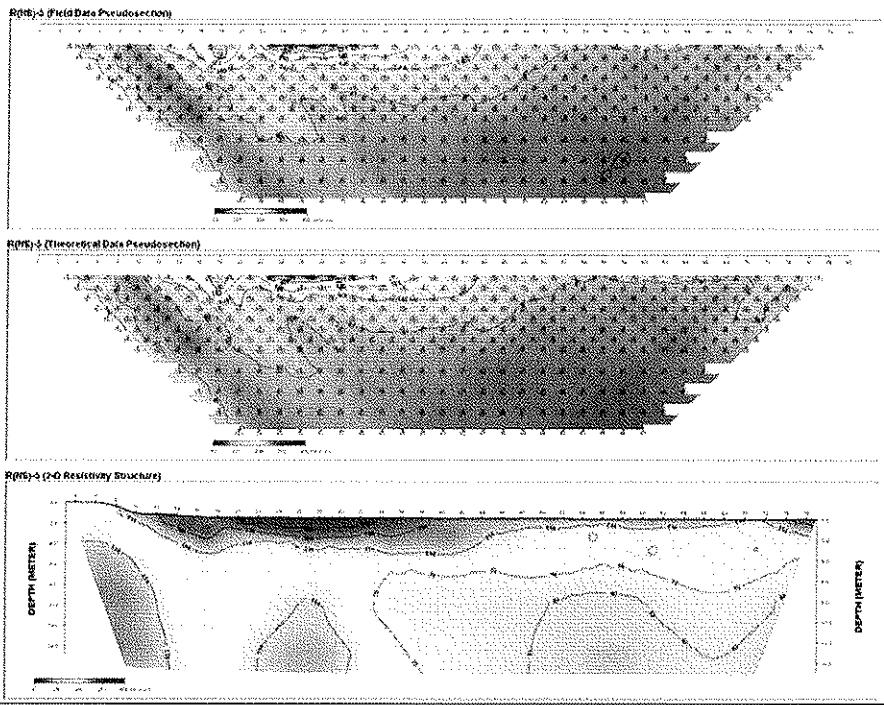

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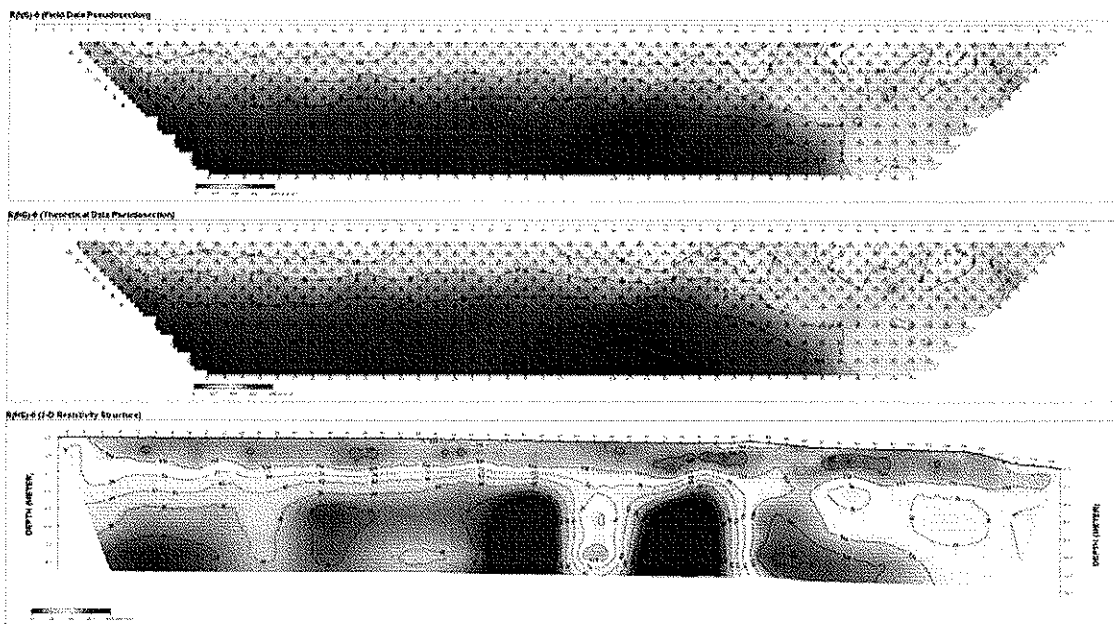
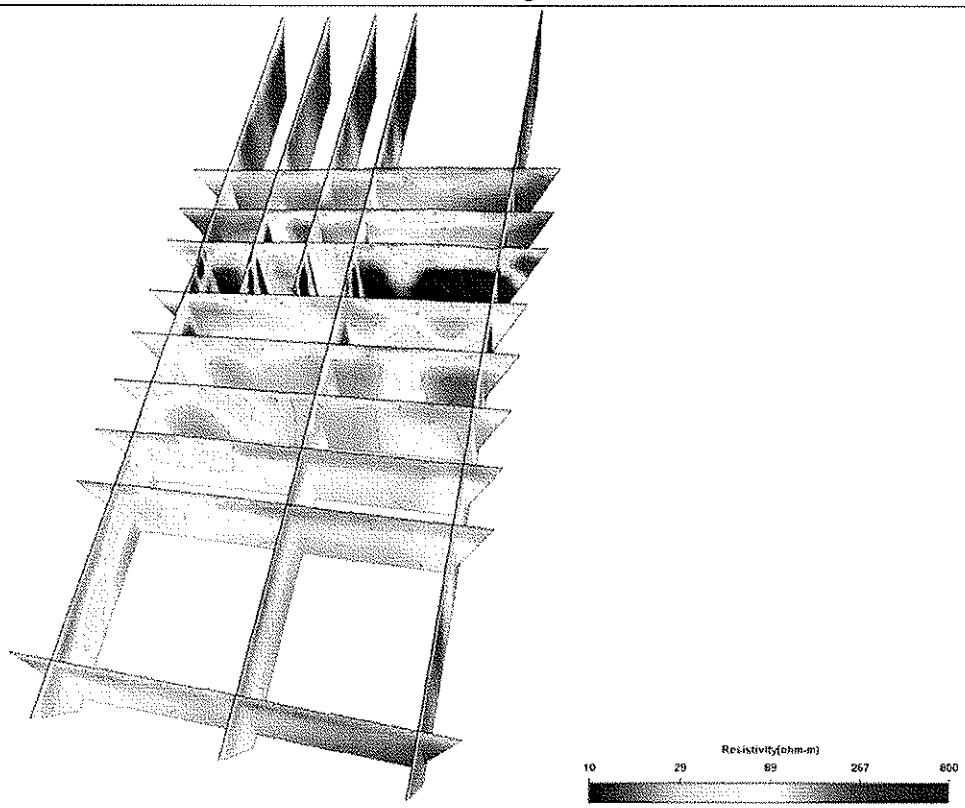
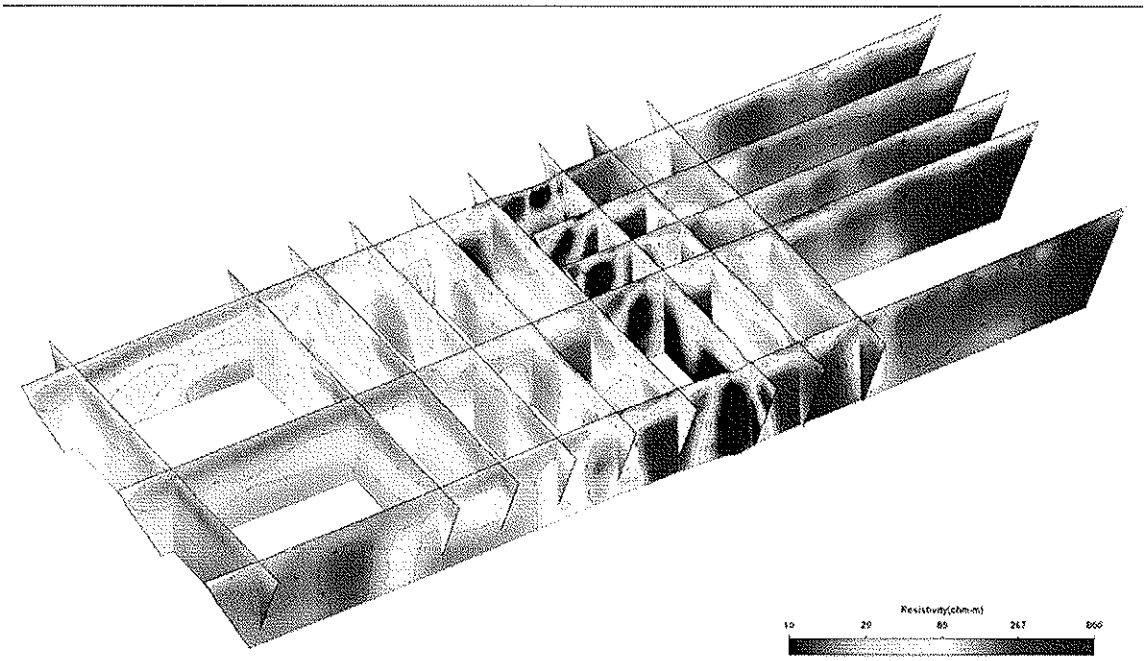


9985

ERI Vertical Cross Sections for Phase IIB Helipad Site

Fence Diagram





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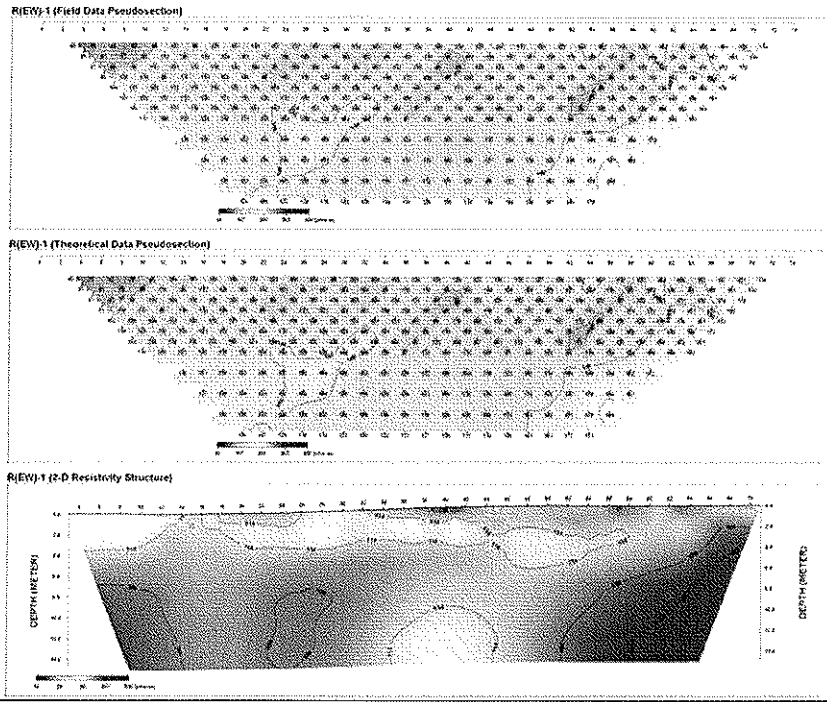

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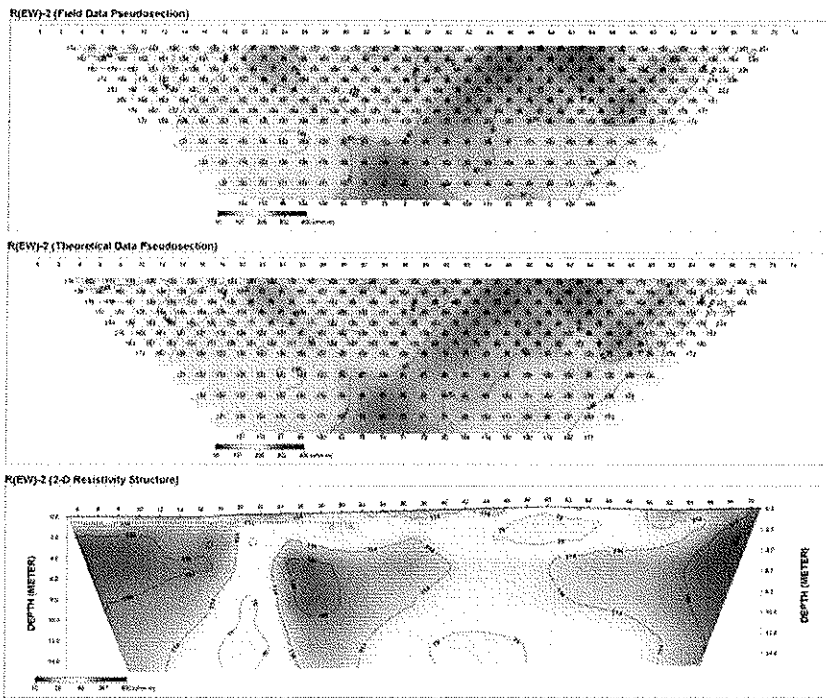

ERI Vertical Cross Sections for Phase IIB Helipad Site

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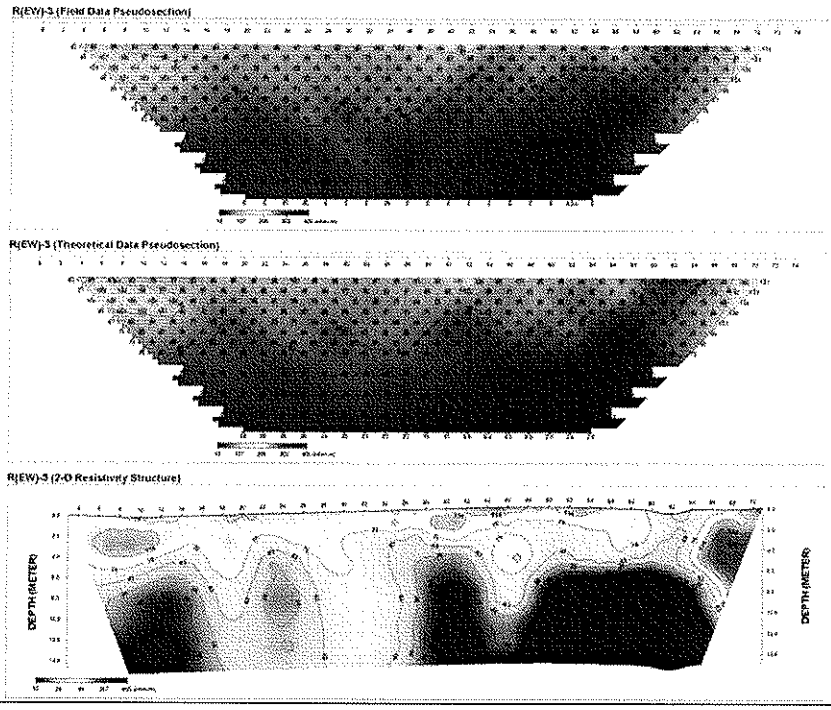

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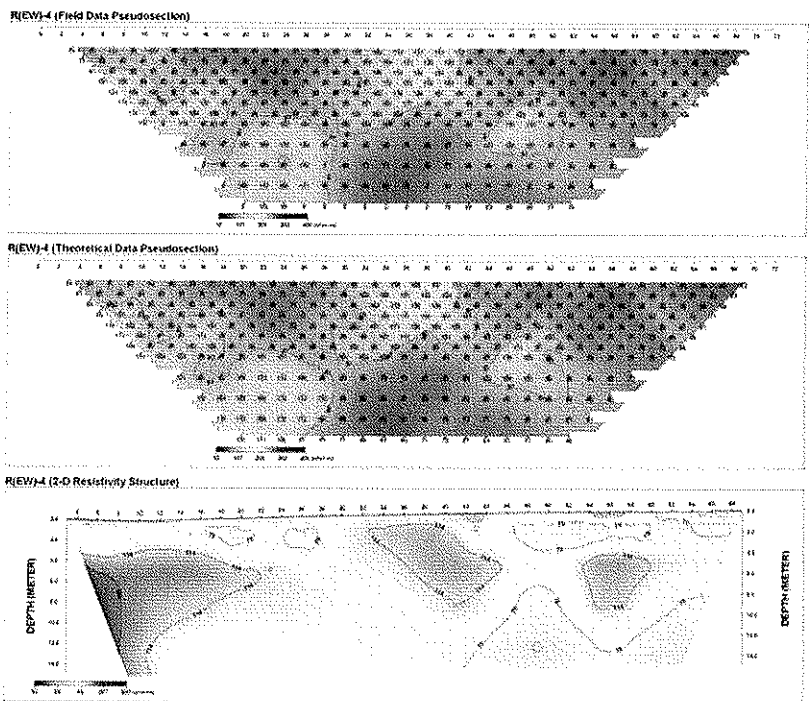

ERI Vertical Cross Sections for Phase IIB Helipad Site

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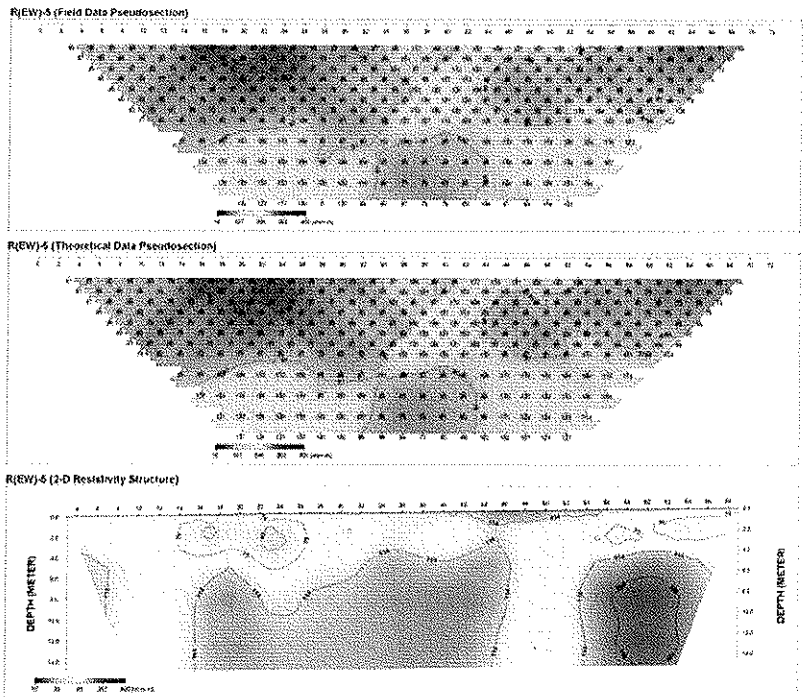

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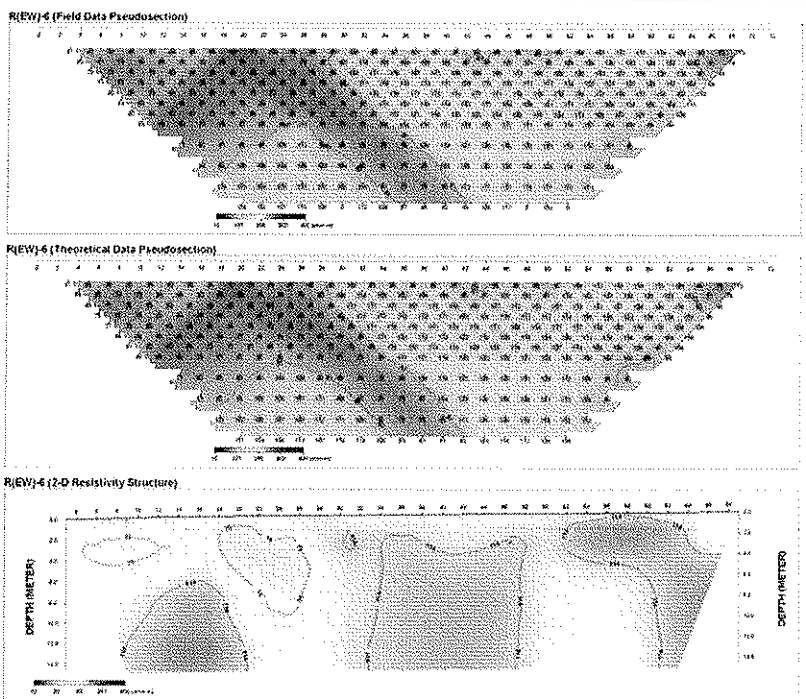

ERI Vertical Cross Sections for Phase IIB Helipad Site

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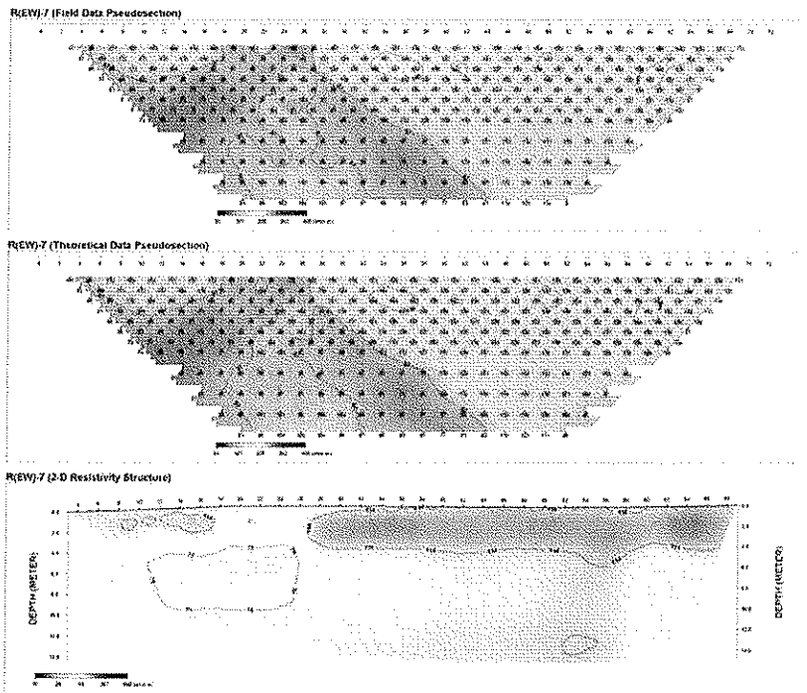

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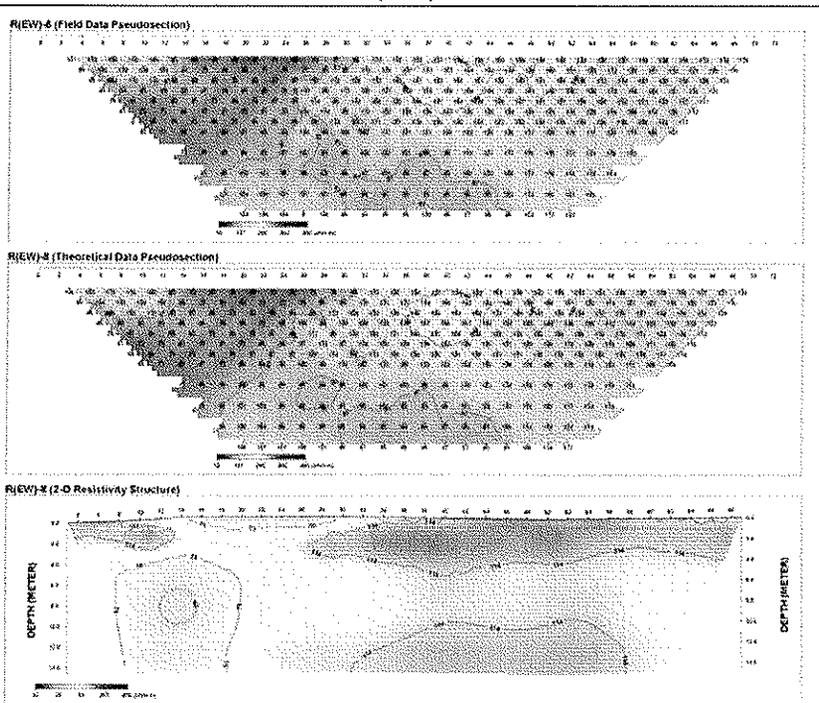

ERI Vertical Cross Sections for Phase IIB Helipad Site

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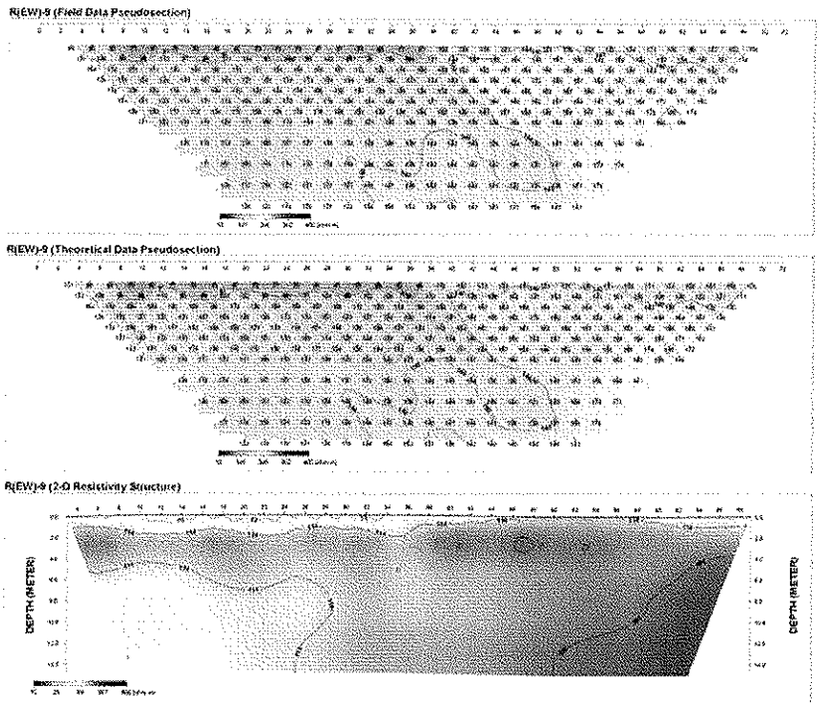

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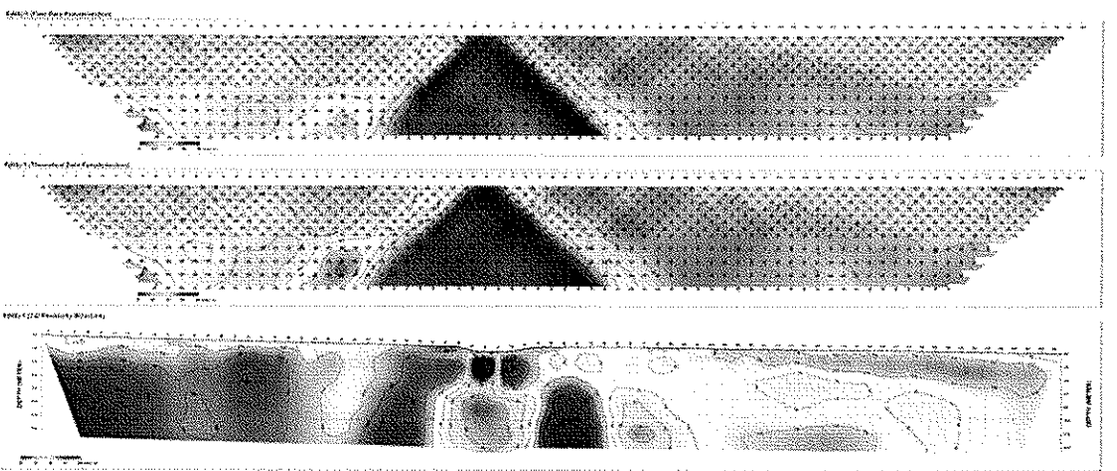

ERI Vertical Cross Sections for Phase IIB Helipad Site

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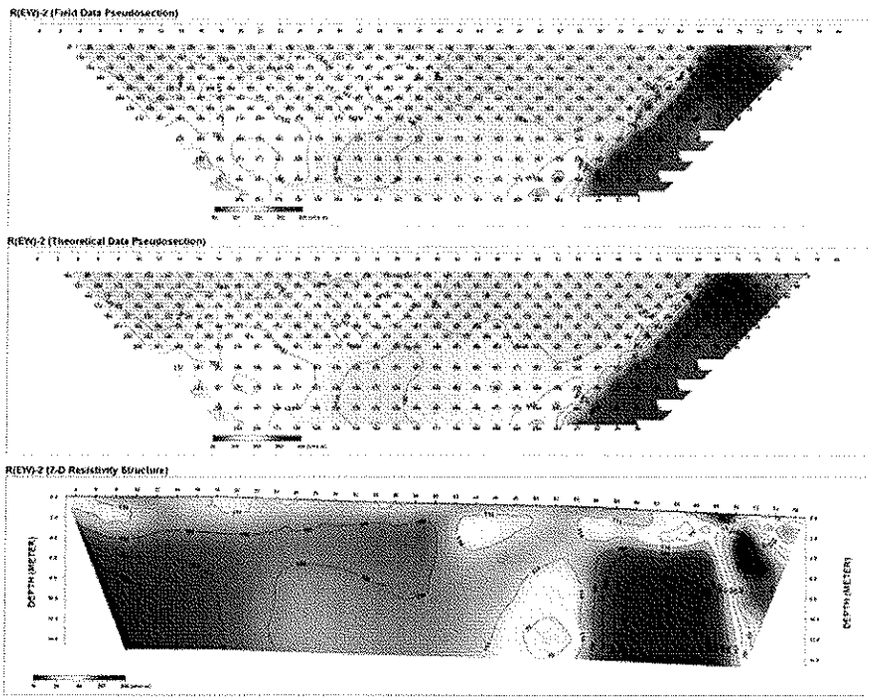

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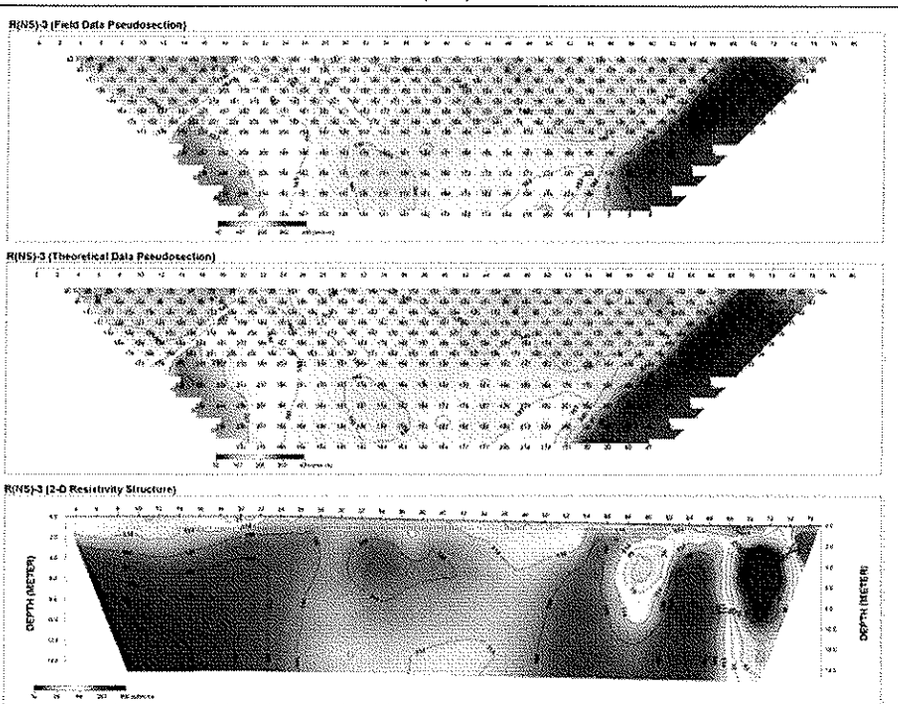

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ERI Vertical Cross Sections for Phase IIB Helipad Site

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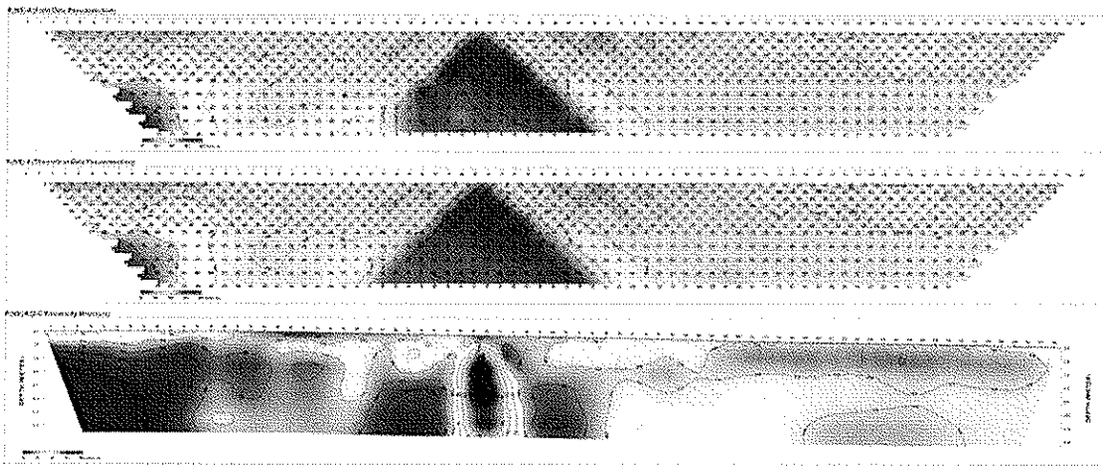

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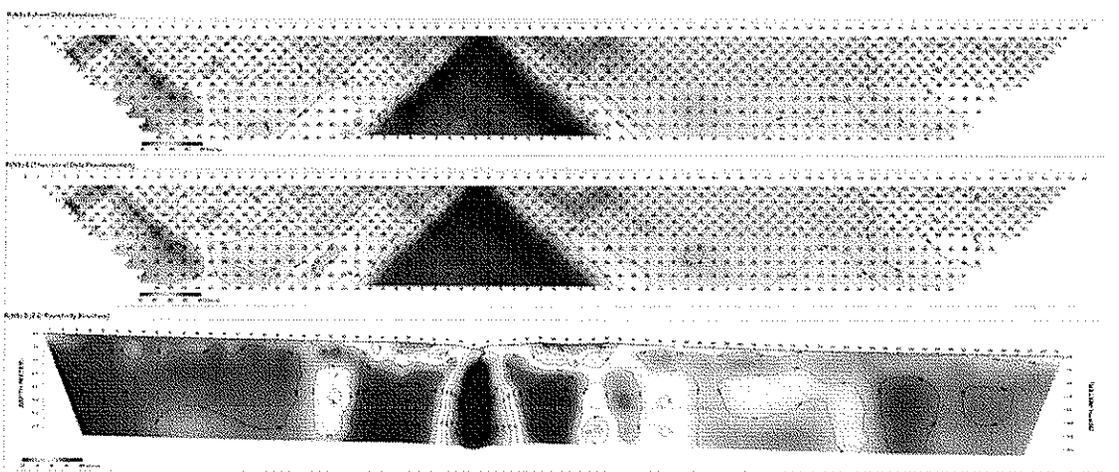

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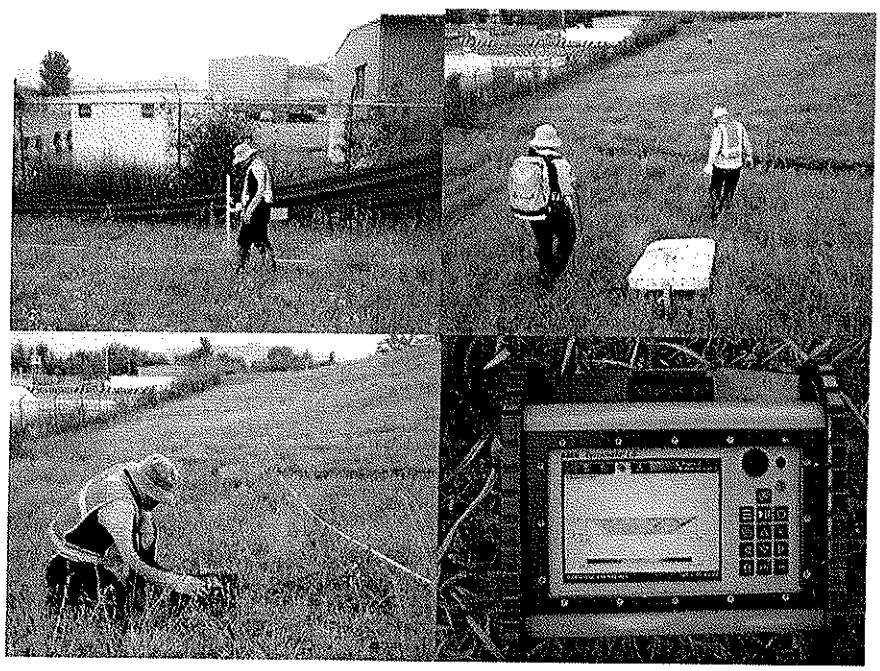
US Army Corps of Engineers
Far East District

SLOPE SITE GEOPHYSICAL SURVEY REPORT

Camp Carroll
U.S. Army Garrison Daegu, Republic of Korea



August 10, 2011

Prepared By:

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EXECUTIVE SUMMARY

This report presents the results of a geophysical survey that was conducted for the Slope site located on Camp Carroll, Republic of Korea (ROK). The Slope site is located to the south and southwest immediately adjacent to three sites at the southeastern portion of Camp Carroll where geophysical investigations have already been completed (Figure ES-1). The Slope site was identified as the location where drums of hazardous material and waste were allegedly buried between the years 1977 and 1982 by an eyewitness. The purpose of the survey was to identify and locate buried foreign objects, especially steel drums and delimit the approximate vertical and horizontal coordinates of the burial if they exist.

Geophysical Survey Procedure

The Slope site survey area measures approximately 30 m to 50 m from north to south and 140 m east to west. The geophysical survey was conducted using three non-intrusive techniques: magnetic gradiometry, ground penetrating radar (GPR), and electrical resistivity imaging (ERI).

The magnetic gradiometry survey utilized a grid system with 1 m intervals. Including endpoints, this resulted in 4,762 intersections points. Magnetic readings were taken at each of the intersection points using a Bartington Instrument Ltd (United Kingdom) model Grad601 gradiometer.

The GPR survey was conducted using a MALÅ GeoScience (Sweden) model ProExTM Professional Explorer GPR. The survey utilized a 2 m interval transects in the east-west direction (36 transects). An input frequency of 100 megahertz (MHz) was selected.

The ERI survey was conducted using an ABEM Instrument AB (Sweden) model Terrameter LS direct current resistivity meter. The survey was conducted along three transects.

Geophysical Survey Results and Conclusions

The survey results were combined and a final interpretation of the data and subsurface anomaly zones are shown on Figure ES-2. The conclusions are summarized as follows:

- The Magnetic Gradiometry survey results indicated one subsurface anomaly. The anomaly is attributed to interference from the nearby metal chain link fence and building structure.
- The GPR survey results indicate six subsurface anomalies. The anomalies are attributed to subsurface geologic features such as changes in soil stratum and disturbed soil (soil that has been excavated and backfilled).
- The ERI survey results indicate two subsurface anomalies. The survey results indicate that the anomalies are most likely due to geological structures such as fracture zone in bedrock and ground water level.

- The combined results indicate that the subsurface anomalies that were identified during the geophysical survey can be attributed to existing structures at the site and activities such as excavation and backfilling. The results do not indicate the presence of buried foreign objects such as steel drums.

Figure ES-1. Slope Site Geophysical Survey Location Map

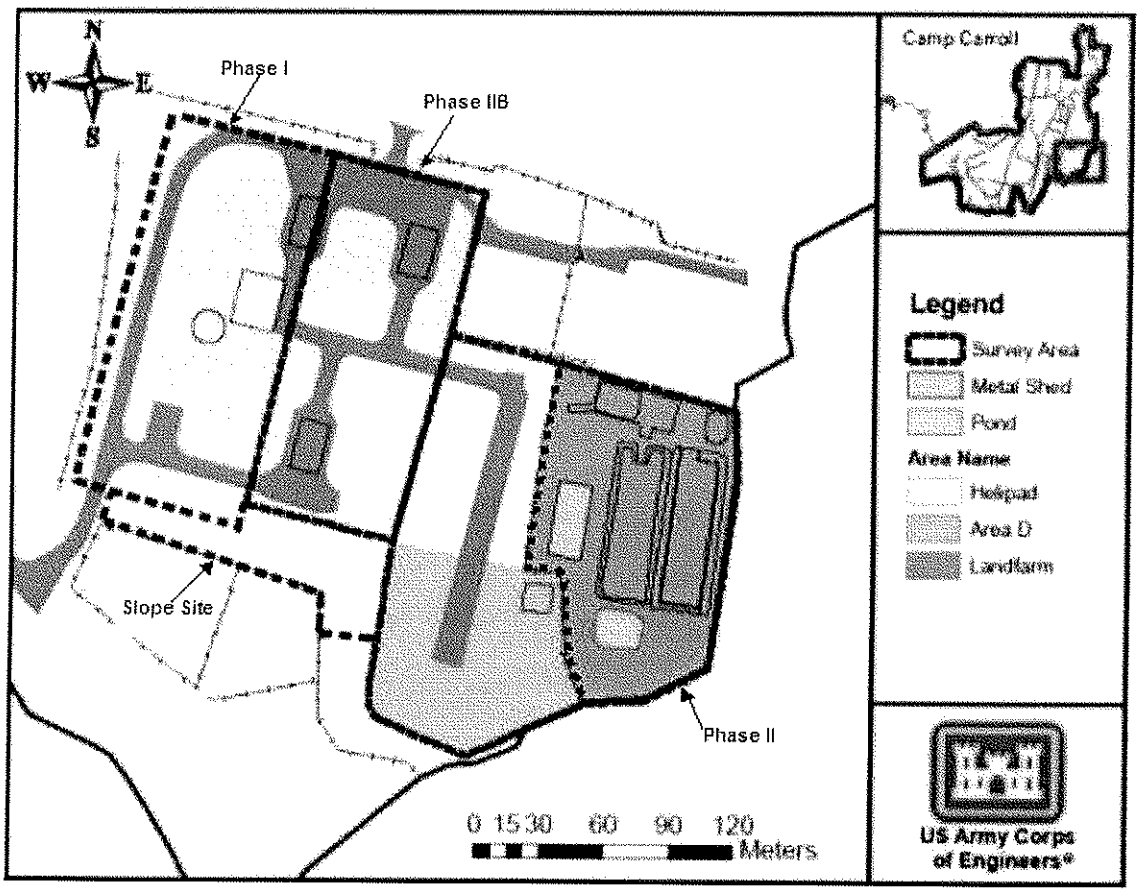
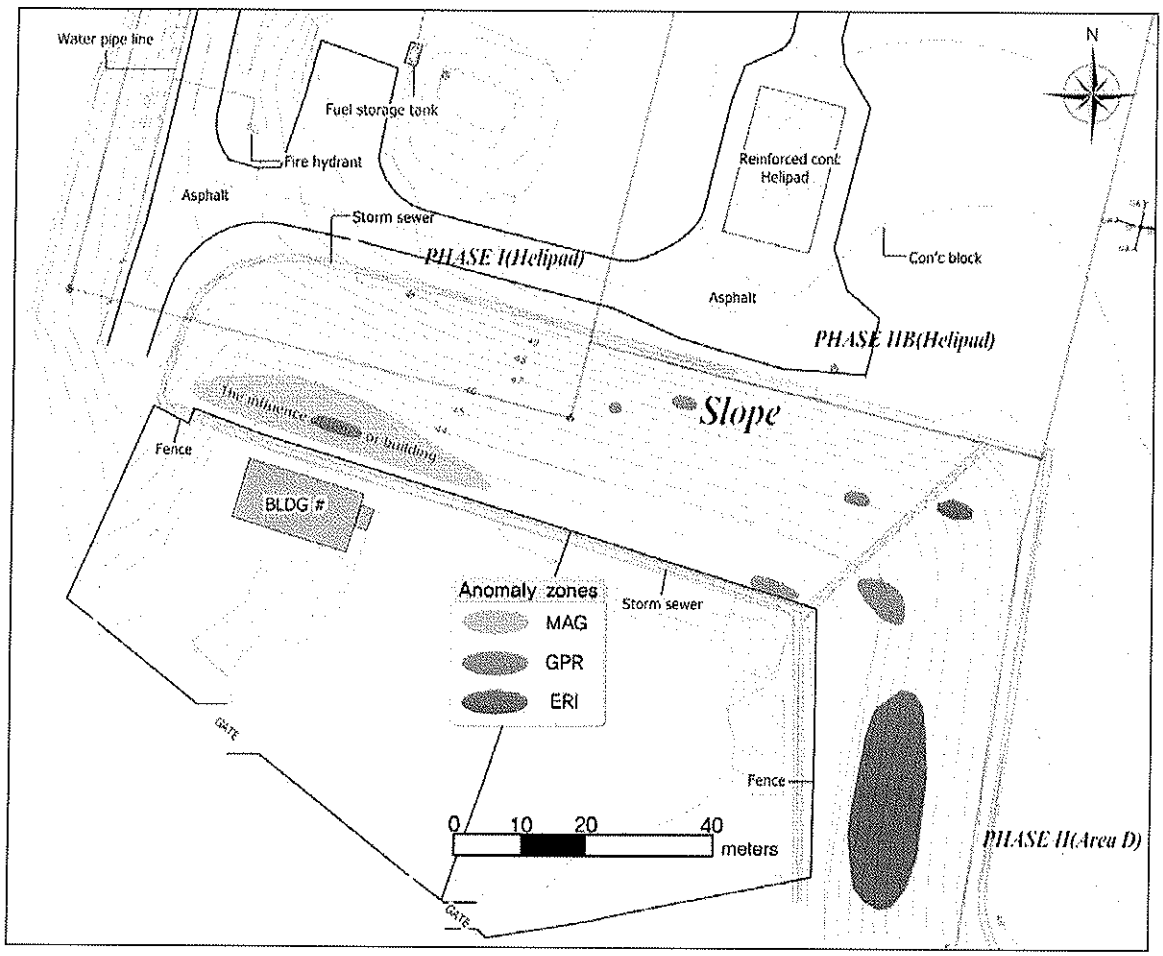


Figure ES-2. Slope Site Subsurface Anomalies



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