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DTC PROJECT NO. 8-CO-160-UXO-021
REPORT NO. ATC-8741

STANDARDIZED

UXO TECHNOLOGY DEMONSTRATION SITE

BLIND GRID SCORING RECORD NO. 125

SITE LOCATION:
ABERDEEN PROVING GROUND

DEMONSTRATOR:
GEOPHEX, LTD.
605 MERCURY STREET
RALEIGH, NC 2603-2343

PREPARED BY:
U.S. ARMY ABERDEEN TEST CENTER
ABERDEEN PROVING GROUND, MD 21005-5059

DECEMBER 2003

Prepared for:
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ABERDEEN PROVING GROUND, MD 21010-5401

U.S. ARMY DEVELOPMENTAL TEST COMMAND
ABERDEEN PROVING GROUND, MD 21005-5055

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14. ABSTRACT
This scoring record documents the efforts of Geophex, Ltd. to detect and discriminate inert unexploded ordnance (UXO) utilizing the APG Standardized UXO Technology Demonstration Site Blind Grid. The firing record was coordinated by Larry Overbay and by the Standardized UXO Technology Demonstration Site Scoring Committee. Organizations on the committee include the U.S. Army Corps of Engineers, the Environmental Security Technology Certification Program, the Strategic Environmental Research and Development Program, the Institute for Defense Analysis, the U.S. Army Environmental Center, and the U.S. Army Aberdeen Test Center.

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SECTION 1. GENERAL INFORMATION

1.1 BACKGROUND

Technologies under development for the detection and discrimination of unexploded ordnance (UXO) require testing so that their performance can be characterized. To that end, Standardized Test Sites have been developed at Aberdeen Proving Ground (APG), Maryland and U.S. Army Yuma Proving Ground (YPG), Arizona. These test sites provide a diversity of geology, climate, terrain, and weather as well as diversity in ordnance and clutter. Testing at these sites is independently administered and analyzed by the government for the purposes of characterizing technologies, tracking performance with system development, comparing performance of different systems, and comparing performance in different environments.

The Standardized UXO Technology Demonstration Site Program is a multi-agency program spearheaded by the U.S. Army Environmental Center (AEC). The U.S. Army Aberdeen Test Center (ATC) and the U.S. Army Corps of Engineers Engineering Research and Development Center (ERDC) provide programmatic support. The program is being funded and supported by the Environmental Security Technology Certification Program (ESTCP), the Strategic Environmental Research and Development Program (SERDP) and the Army Environmental Quality Technology Program (EQT).

1.2 SCORING OBJECTIVES

The objective in the Standardized UXO Technology Demonstration Site Program is to evaluate the detection and discrimination capabilities of a given technology under various field and soil conditions. Inert munitions and clutter items are positioned in various orientations and depths in the ground.

The evaluation objectives are as follows:

a. To determine detection and discrimination effectiveness under realistic scenarios that vary targets, geology, clutter, topography, and vegetation.

b. To determine cost, time and manpower requirements to operate the technology.

c. To determine demonstrator's ability to analyze survey data in a timely manner and provide prioritized "Target Lists" with associated confidence levels.

d. To provide independent site management to enable the collection of high quality, ground-truth, geo-referenced data for post-demonstration analysis.

1.2.1 Scoring Methodology

a. The scoring of the demonstrator's performance is conducted in two stages. These two stages are termed the RESPONSE STAGE and DISCRIMINATION STAGE. For both stages, the probability of detection (P_d) and the false alarms are reported as receiver-operating

characteristic (ROC) curves. False alarms are divided into those anomalies that correspond to emplaced clutter items, measuring the probability of false positive (P_{fp}), and those that do not correspond to any known item, termed background alarms.

b. The RESPONSE STAGE scoring evaluates the ability of the system to detect emplaced targets without regard to ability to discriminate ordnance from other anomalies. For the blind grid RESPONSE STAGE, the demonstrator provides the scoring committee with a target response from each and every grid square along with a noise level below which target responses are deemed insufficient to warrant further investigation. This list is generated with minimal processing and, since a value is provided for every grid square, will include signals both above and below the system noise level.

c. The DISCRIMINATION STAGE evaluates the demonstrator's ability to correctly identify ordnance as such and to reject clutter. For the blind grid DISCRIMINATION STAGE, the demonstrator provides the scoring committee with the output of the algorithms applied in the discrimination-stage processing for each grid square. The values in this list are prioritized based on the demonstrator's determination that a grid square is likely to contain ordnance. Thus, higher output values are indicative of higher confidence that an ordnance item is present at the specified location. For digital signal processing, priority ranking is based on algorithm output. For other discrimination approaches, priority ranking is based on human (subjective) judgment. The demonstrator also specifies the threshold in the prioritized ranking that provides optimum performance, (i.e., that is expected to retain all detected ordnance and rejects the maximum amount of clutter).

d. The demonstrator is also scored on EFFICIENCY and REJECTION RATIO, which measures the effectiveness of the discrimination stage processing. The goal of discrimination is to retain the greatest number of ordnance detections from the anomaly list, while rejecting the maximum number of anomalies arising from nonordnance items. EFFICIENCY measures the fraction of detected ordnance retained after discrimination, while the REJECTION RATIO measures the fraction of false alarms rejected. Both measures are defined relative to performance at the demonstrator-supplied level below which all responses are considered noise, i.e., the maximum ordnance detectable by the sensor and its accompanying false positive rate or background alarm rate.

e. All scoring factors are generated utilizing the Standardized UXO Probability and Plot Program, version 3.1.1.

1.2.2 Scoring Factors

Factors to be measured and evaluated as part of this demonstration include:

a. Response Stage ROC curves:

(1) Probability of Detection (P_d^{res}).

(2) Probability of False Positive (P_{fp}^{res}).

(3) Background Alarm Rate (BAR^{res}) or Probability of Background Alarm (P_{BA}^{res}).

b. Discrimination Stage ROC curves:

(1) Probability of Detection (P_d^{disc}).

(2) Probability of False Positive (P_{fp}^{disc}).

(3) Background Alarm Rate (BAR^{disc}) or Probability of Background Alarm (P_{BA}^{disc}).

c. Metrics:

(1) Efficiency (E).

(2) False Positive Rejection Rate (R_{fp}).

(3) Background Alarm Rejection Rate (R_{BA}).

d. Other:

(1) Probability of Detection by Size and Depth.

(2) Classification by type (i.e., 20-, 40-, 105-mm, etc.).

(3) Location accuracy.

(4) Equipment setup, calibration time and corresponding man-hour requirements.

(5) Survey time and corresponding man-hour requirements.

(6) Reacquisition/resurvey time and man-hour requirements (if any).

(7) Downtime due to system malfunctions and maintenance requirements.

1.3 STANDARD AND NONSTANDARD INERT ORDNANCE TARGETS

The standard and nonstandard ordnance items emplaced in the test areas are listed in Table 1. Standardized targets are members of a set of specific ordnance items that have identical properties to all other items in the set (caliber, configuration, size, weight, aspect ratio, material, filler, magnetic remanence, and nomenclature). Nonstandard targets are ordnance items having properties that differ from those in the set of standardized targets.

TABLE 1. INERT ORDNANCE TARGETS

Standard Type	Nonstandard (NS)
20-mm Projectile M55	20-mm Projectile M55
	20-mm Projectile M97
40-mm Grenades M385	40-mm Grenades M385
40-mm Projectile MKII Bodies	40-mm Projectile M813
BDU-28 Submunition	
BLU-26 Submunition	
M42 Submunition	
57-mm Projectile APC M86	
60-mm Mortar M49A3	60-mm Mortar (JPG)
	60-mm Mortar M49
2.75-inch Rocket M230	2.75-inch Rocket M230
	2.75-inch Rocket XM229
MK 118 ROCKEYE	
81-mm Mortar M374	81-mm Mortar (JPG)
	81-mm Mortar M374
105-mm Heat Rounds M456	
105-mm Projectile M60	105-mm Projectile M60
155-mm Projectile M483A1	155-mm Projectile M483A
	500-lb Bomb

JPG = Jefferson Proving Ground.

SECTION 2. DEMONSTRATION

2.1 DEMONSTRATOR INFORMATION

2.1.1 Demonstrator Point of Contact (POC) and Address

Address: Geophex, Ltd.
605 Mercury Street
Raleigh, NC 2603-2343
(919) 839-8515

2.1.2 System Description (Provided by Demonstrator)

GEM-3 electromagnetic interference (EMI) sensors are multifrequency (up to ten frequencies logarithmically spaced in the 30- to 47,930-Hz range) sensors consisting of three concentric coils and digital electronics. The outer coil is the primary transmitter, the inner coil the receiver, and the annular coil is a secondary (bucking) transmitter that creates a primary field cavity around the transmitter. The electronics includes a digitally controlled switching H-bridge transmitter current-source, a 24-bit analog to digital (A/D), and a digital signal processor (DSP) with random access memory (RAM), flash memory and serial data ports (RS-232). A user interface consists of a palm pack computer with Geophex software; commercial differential Global Positioning System (DGPS) is fully integrated.

The system is a continuous wave frequency domain system in which data are recorded while the transmitter is on; the transmitter waveform consists of a continuous mix of superposed sine waves at the specified frequencies. The measured raw time-series data are voltages (preamplified) measured by the receiver coil and by a small reference coil located in the transmitter primary/bucking coil annular space (proportional to primary field and phase referenced to primary field), and sampled by the A/D. Data are preprocessed in units of 30-Hz intervals (base periods) and averaged over a selectable number of base periods, typically two for cart-survey operation (net output rate of 15 Hz).

The cart-mounted configuration, with a 96-cm diameter coil disk mounted on either a manually pushed, composite-material wheeled cart or an all terrain vehicle (ATV)-towed, wooden wheeled cart, is used in environments where a large sensor on a wheeled cart is practical and wide-area coverage required, such as flat, open terrain. The ATV-towed system is augmented with a navigation system that provides the driver with steering indicators in order to maintain preplanned survey lines, but it requires greater room for turning than the hand pushed cart. The actual sensors are identical and can be interchanged. A DGPS is integrated with the GEM console, and the antenna mounted directly above the sensor, provides geo-referenced data, which are recorded in the GEM console flash memory and/or the system computer (laptop personal computer (PC)). Data are post-processed for target detection/classification.

Figure 1. Demonstrator's system.

2.1.3 Data Processing Description (Provided by Demonstrator)

The front-end data processing is performed in real-time by the system DSP. This processing consists of performing a partial Digital Fourier Transform (DFT) on the receiver and reference time series provided by the A/D at 96 kHz. The DFT frequency samples correspond to the logarithmically spaced transmitted frequencies characterizing the hybrid current waveform. Complex division of the receiver and reference DFT outputs are performed and system transfer function (calibration) corrections are applied to generate inphase and quadrature measurements at each frequency. These data are recorded in the console flash memory and/or output to the system computer.

Further processing, performed during post-processing, consists of color-contour map generation using commercial software such as Geosoft©. Target detection utilizes either a composite measurement such as the sum of the quadratures over all frequencies, or a weighted average apparent conductivity over all frequencies. Anomalies identified from the maps may be further scrutinized in profile format. For target discrimination, a spectral matching algorithm compares the measurement with a library of known possible target spectra; this algorithm allows for a linear combination of the intrinsic longitudinal and transverse target response. The quality of the best fit (i.e., root mean square (rms) or mean absolute error) is compared with a threshold for clutter declaration and used as a confidence measure.

The survey method in the calibration and blind grids will be applied by occupying the potential target location points, preceded with a nearby background reading or (optionally) utilizing a continuous filtered background reading, and operator initiated data sampling/storing for two seconds. Target locations will be identified in the data files via line numbers. The raw data will be post-processed as described above.

In the open area, the cart will be towed with an ATV at walking speed along half-meter spaced lines; these lines will be maintained using the on-board navigation system based on DGPS. The console and downloading software, as well as the system computer logging the data, will perform geo-referencing of the GEM data automatically. The GEM and Global Positioning System (GPS) data will be post-processed to provide geo-referenced dig lists as described above. The cart will be manually pushed, as needed, where maneuvering the ATV is difficult and in small patches that extend outside the main area.

2.1.4 Data Submission Format

Data were submitted for scoring in accordance with data submission protocols outlined in the Standardized UXO Technology Demonstration Site Handbook. These submitted data are not included in this report in order to protect ground truth information.

2.1.5 Demonstrator Quality Assurance and Quality Control (Provided by Demonstrator)

Quality control will be performed by testing the systems with a test target (ferrite) each day, and verifying proper and consistent system measurements. Quality assurance will include a review of recorded data at the end of each day.

2.1.6 Additional Records

Previous records by this vendor can be accessed via the Internet as MS Word files at http://aec.army.mil/usaec/technology/uxo03.html. Currently, no other records are available for this demonstrator.

2.2 ABERDEEN PROVING GROUND SITE INFORMATION

2.2.1 Location

The APG Standardized Test Site is located within a secured range area of the Aberdeen Area of APG. The Aberdeen Area of APG is located approximately 30 miles northeast of Baltimore at the northern end of the Chesapeake Bay. The Standardized Test Site encompasses 17 acres of upland and lowland flats, woods and wetlands.

2.2.2 Soil Type

According to the soils survey conducted for the entire area of Aberdeen Proving Ground in 1998, the test site consists primarily of Elkton Series type soil (ref 2). The Elkton Series consist of very deep, slowly permeable, poorly drained soils. These soils formed in silty aeolin sediments and the underlying loamy alluvial and marine sediments. They are on upland and lowland flats and in depressions of the Mid-Atlantic Coastal Plain. Slopes range from 0 to 2 percent.

ERDC conducted a site-specific analysis in May of 2002 (ref 3). The results basically matched the soil survey mentioned above. Seventy percent of the samples taken were classified as silty loam. The majority (77 percent) of the soil samples had a measured water content between 15- and 30-percent with the water content decreasing slightly with depth.

For more details concerning the soil properties at the APG test site, go to http://aec.army.mil/usaec/technology/uxo-soils.pdf on the web to view the entire soils description report.

2.2.3 Test Areas

A description of the test site areas at APG is included in Table 2.

TABLE 2. TEST SITE AREAS

Area	Description
Calibration Grid	Contains 14 standard ordnance items buried in six positions at various angles and depths to allow demonstrator to calibrate their equipment.
Blind Grid	Contains 400 grid cells in a 0.2-hectare (0.5 acre) site. The center of each grid cell contains ordnance, clutter or nothing.

SECTION 3. FIELD DATA

3.1 DATE OF FIELD ACTIVITIES (1 to 3 and 5 May 2003)

3.2 AREAS TESTED/NUMBER OF HOURS

Areas tested and total number of hours operated at each site are summarized in Table 3.

TABLE 3. AREAS TESTED AND NUMBER OF HOURS

Area	Number of Hours
Calibration Lanes	6.6
Blind Grid	0.9

3.3 TEST CONDITIONS

3.3.1 Weather Conditions

An ATC weather station located approximately 2 miles west of the test site was used to record average temperature and precipitation on an hourly basis for each day of operation. The temperatures listed in Table 4 represent the average temperature during field operations from 0700 through 1700 hours while the precipitation data represent a daily total amount of rainfall. Hourly weather logs used to generate this summary are provided in Appendix B.

TABLE 4. TEMPERATURE/PRECIPITATION DATA SUMMARY

Date, 2003	Average Temperature, ^{o}F	Total Daily Precipitation, in.
1 May	67.04	0.05
2 May	71.07	0.00
3 May	60.28	0.00
5 May	51.19	0.03

3.3.2 Field Conditions

Geophex surveyed the Blind Grid 28 April through 7 May 2003. The Blind Grid area was muddy due to prior rain events before testing.

3.3.3 Soil Moisture

The soil moisture logs are included in Appendix C. Three soil probes were placed at various locations of the site to capture soil moisture data: open field, open field lowland (wet) and open field scenario No. 1 wooded area. Measurements were collected in percent moisture and were taken twice daily (morning and afternoon) from five different soil layers (0 to 6 in., 6 to 12 in., 12 to 24 in., 24 to 36 in. and 36 to 48 in.) from each probe.

The soil moisture data collected are summarized in Table 5. The average moisture content was calculated by averaging the morning and afternoon measurements for each layer of each probe for the duration of the field operations in the Blind Grid.

TABLE 5. SOIL MOISTURE DATA SUMMARY

Layer, in.	Average Moisture Content, %	Standard Deviation, %
Open Field Probe		
0 to 6	10.33	4.84
6 to 12	0.63	0.72
12 to 24	19.73	8.11
24 to 36	27.17	11.22
36 to 48	40.20	16.99

3.4 FIELD ACTIVITIES

3.4.1 Setup/Mobilization

These activities included initial mobilization and daily equipment preparation and break down. The two-person crew took 4 hours and 37 minutes to perform the initial setup and mobilization. Equipment preparation took 644 minutes while end of day equipment breakdown lasted 111 minutes. (Equipment breakdowns on the other days are captured in either calibration or demobilization times.) Daily start/stop activities totaled 597 minutes for the Blind Grid.

3.4.2 Calibration

Due to the similarity of the sensor used on the pushcart configuration, no specific calibration activities were performed for this platform. Calibration data from the pushcart demonstration were utilized to calibrate the towed array sensor. The demonstrator spent 6 hours and 35 minutes in the Calibration Lanes on 28 April 2003 with the push cart system. Therefore, this time will be used for the towed array system as well. No other calibration activities were conducted while operating in the Blind Grid.

3.4.3 Downtime Occasions

Occasions of downtime are grouped into five categories: equipment/data checks or equipment maintenance, equipment failure and repair, weather, Demonstration Site issues, or breaks/lunch. All downtime is included for the purposes of calculating labor costs (section 5) except for downtime due to Demonstration Site issues. Demonstration Site issues, while noted in the Daily Log, are considered nonchargeable downtime for the purposes of calculating labor costs and are not discussed. Breaks and lunches are not discussed either.

3.4.3.1 Equipment/data checks, maintenance. Total downtime due to equipment/data checks or maintenance was 264 minutes.

3.4.3.2 Equipment failure or repair. One equipment failure occurred in the Blind Grid. The GPS console had to be replaced because of a broken pin. The GPS console from the pushcart was installed on the towed cart. Major delays were the result of software issues that totaled 37 hours and 36 minutes.

3.4.3.3 Weather. Two weather delays occurred in the Blind Grid. Both occurred on 5 May 2003. One delay lasted 11 minutes while the other lasted 65 minutes.

3.4.4 Data Collection

The demonstrator required 52 minutes to collect data in the Blind Grid. Appendix D shows that Geophex spent only 26 minutes in the Blind Grid completing half of the survey area. It was estimated that 52 minutes would be required for the system to make a complete survey of the Blind Grid. This time excludes break/lunches and downtimes described in section 3.4.3.

3.4.5 Demobilization

The demobilization time for the towed array took 1 hour and 7 minutes. Demobilization was accomplished by two individuals.

3.5 PROCESSING TIME

Geophex submitted the raw data from demonstration activities on the last day of the demonstration, as required. The scoring submission data were also provided within the required 30-day timeframe.

3.6 DEMONSTRATOR'S FIELD PERSONNEL

Deleted for public release.

3.7 DEMONSTRATOR'S FIELD SURVEYING METHOD

Geophex started surveying the Blind Grid in the southwest corner in a north/south direction. Geophex simultaneously surveyed the Blind Grid and the Open Field. As the towed array went through the open field it went through the Blind Grid in a circular fashion.

3.8 SUMMARY OF DAILY LOGS

Software issues accounted for major delays in the demonstration. No significant events occurred during the demonstration. Appendix D contains a detailed description of field operations.

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SECTION 4. TECHNICAL PERFORMANCE RESULTS

4.1 ROC CURVES USING ALL ORDNANCE CATEGORIES

Figure 2 shows the probability of detection for the response stage (P_d^{res}) and the discrimination stage (P_d^{disc}) versus their respective probability of false positive. Figure 3 shows both probabilities plotted against their respective probability of background alarm. Both figures use horizontal lines to illustrate the performance of the demonstrator at two demonstrator-specified points: at the system noise level for the response stage, representing the point below which targets are not considered detectable, and at the demonstrator's recommended threshold level for the discrimination stage, defining the subset of targets the demonstrator would recommend digging based on discrimination. Note that all points have been rounded to protect the ground truth.

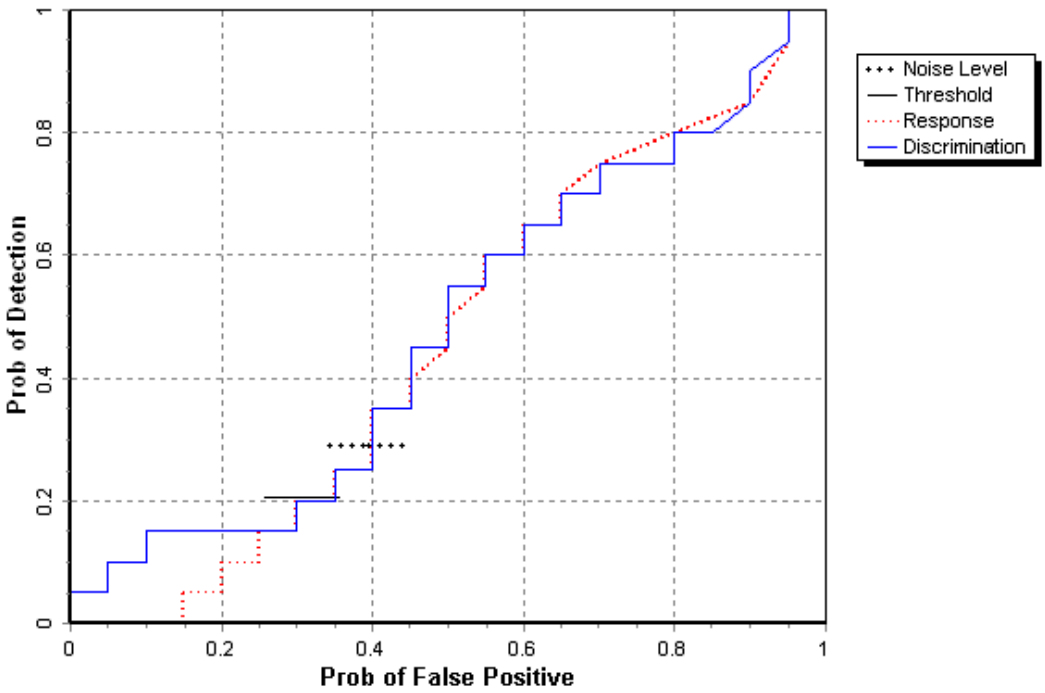

Figure 2. GEM-3 towed array blind grid probability of detection for response and discrimination stages versus their respective probability of false positive over all ordnance categories combined.

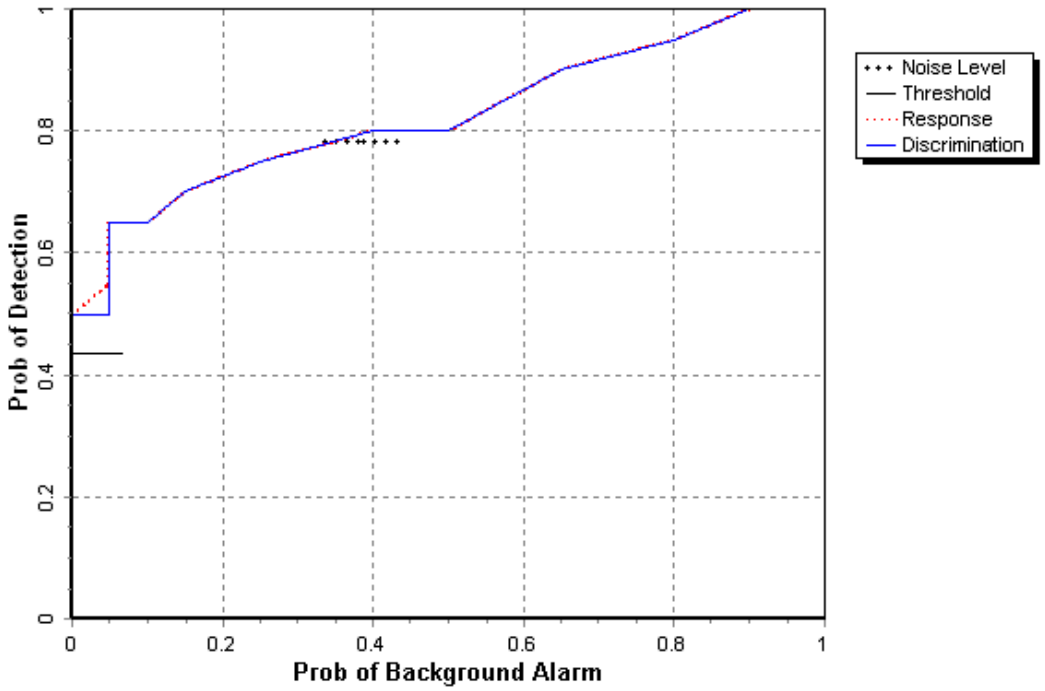

Figure 3. GEM-3 towed array blind grid probability of detection for response and discrimination stages versus their respective probability of background alarm over all ordnance categories combined.

4.2 ROC CURVES USING ORDNANCE LARGER THAN 20 MM

Figure 4 shows the probability of detection for the response stage (P_d^{res}) and the discrimination stage (P_d^{disc}) versus their respective probability of false positive when only targets larger than 20 mm are scored. Figure 5 shows both probabilities plotted against their respective probability of background alarm. Both figures use horizontal lines to illustrate the performance of the demonstrator at two demonstrator-specified points: at the system noise level for the response stage, representing the point below which targets are not considered detectable, and at the demonstrator's recommended threshold level for the discrimination stage, defining the subset of targets the demonstrator would recommend digging based on discrimination. Note that all points have been rounded to protect the ground truth.

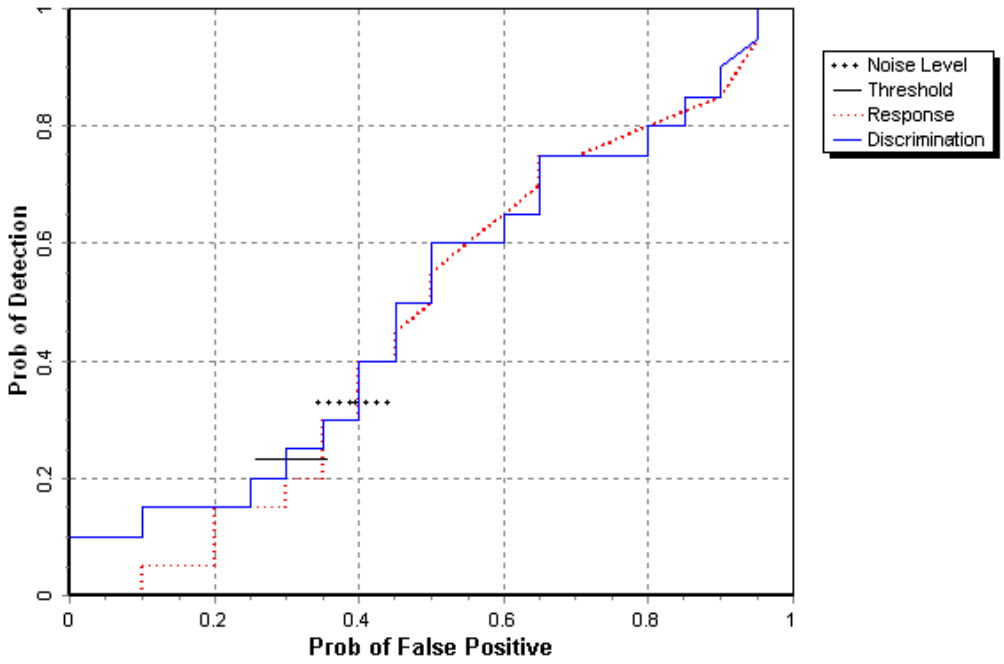

Figure 4. GEM-3 towed array blind grid probability of detection for response and discrimination stages versus their respective probability of false positive for all ordnance larger than 20 mm.

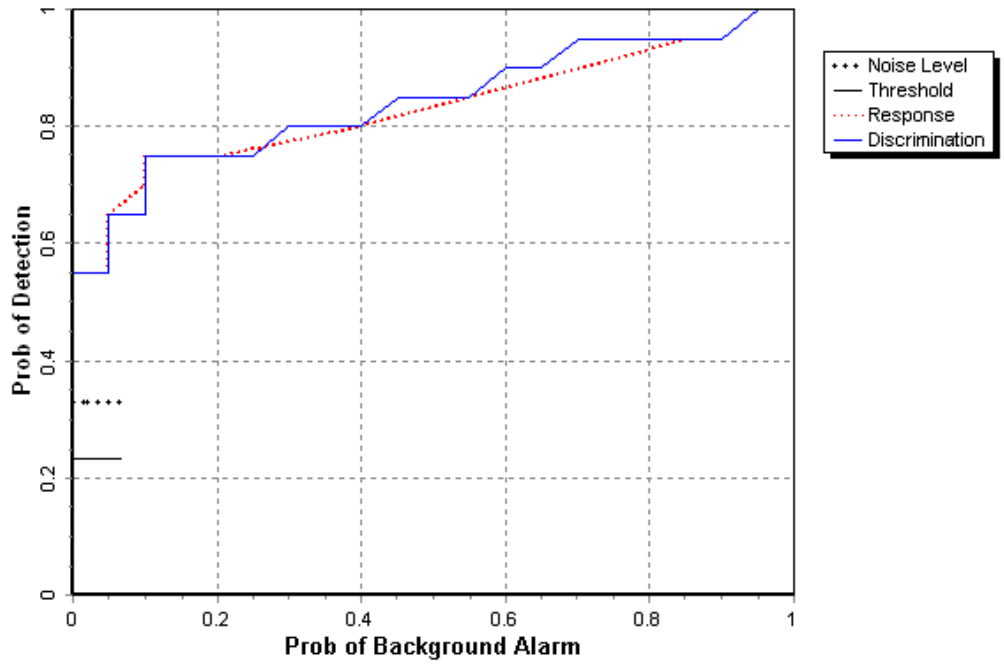

Figure 5. GEM-3 towed array blind grid probability of detection for response and discrimination stages versus their respective probabilities of background alarm for all ordnance larger than 20 mm.

4.3 PERFORMANCE SUMMARIES

Results for the Blind Grid test broken out by size, depth and nonstandard ordnance are presented in Table 6. (For cost results, see section 5.) Results by size and depth include both standard and nonstandard ordnance. The results by size show how well the demonstrator did at detecting/discriminating ordnance of a certain caliber range. (See Appendix A for size definitions.) The results are relative to the number of ordnances emplaced. Depth is measured from the closest point of anomaly to the ground surface.

The RESPONSE STAGE results are derived from the list of anomalies above the demonstrator-provided noise level. The results for the DISCRIMINATION STAGE are derived from the demonstrator's recommended threshold for optimizing UXO field cleanup by minimizing false digs and maximizing ordnance recovery. The lower 90-percent confidence limit on probability of detection and probability of false positive was calculated assuming that the number of detections and false positives are binomially distributed random variables. All results in Table 6 have been rounded to protect the ground truth. However, lower confidence limits were calculated using actual results.

TABLE 6. SUMMARY OF BLIND GRID RESULTS FOR GEM-3 TOWED ARRAY

Metric	Overall	Standard	Nonstandard	By Size			By Depth, m		
				Small	Medium	Large	< 0.3	0.3 to <1	>= 1
Response Stage									
P_d	0.30	0.30	0.25	0.20	0.35	0.40	0.45	0.20	0.00
P_d Low 90% Conf	0.22	0.23	0.15	0.13	0.24	0.19	0.32	0.10	0.00
P_{fp}	0.40	-	-	-	-	-	0.45	0.35	0.20
P_{fp} Low 90% Conf	0.33	-	-	-	-	-	0.37	0.24	0.02
P_{ba}	0.00	-	-	-	-	-	-	-	-
Discrimination Stage									
P_d	0.20	0.20	0.20	0.10	0.30	0.30	0.30	0.15	0.00
P_d Low 90% Conf	0.15	0.13	0.13	0.04	0.21	0.12	0.19	0.08	0.00
P_{fp}	0.30	-	-	-	-	-	0.35	0.30	0.20
P_{fp} Low 90% Conf	0.25	-	-	-	-	-	0.25	0.19	0.02
P_{ba}	0.00	-	-	-	-	-	-	-	-

Response Stage Noise Level: 0.20.
Recommended Discrimination Stage Threshold: 4.50.

Note: The response stage noise level and recommended discrimination stage threshold values are provided by the demonstrator.

4.4 EFFICIENCY, REJECTION RATES, AND TYPE CLASSIFICATION

Efficiency and rejection rates are calculated to quantify the discrimination ability at specific points of interest on the ROC curve: (1) at the point where no decrease in P_d is suffered (i.e., the efficiency is by definition equal to one) and (2) at the operator selected threshold. These values are reported in Table 7.

TABLE 7. EFFICIENCY AND REJECTION RATES FOR GEM-3 TOWED ARRAY

	Efficiency (E)	False Positive Rejection Rate	Background Alarm Rejection Rate
At Operating Point	0.71	0.22	0.00
With No Loss of P_d	1.00	0.00	0.00

At the demonstrator's recommended setting, the ordnance items that were detected and correctly discriminated were further scored on whether their correct type could be identified (table 8). Correct type examples include "20-mm projectile, 105-mm HEAT Projectile, and 2.75-in. Rocket". A list of the standard type declaration required for each ordnance item was provided to demonstrators prior to testing. For example, the standard type for the three example items are 20mmP, 105H, and 2.75in, respectively.

TABLE 8. CORRECT TYPE CLASSIFICATION OF TARGETS CORRECTLY DISCRIMINATED AS UXO

Size	% Correct
Small	100.0
Medium	50.0
Large	33.3
Overall	58.8

4.5 LOCATION ACCURACY

The mean location error and standard deviations appear in Table 9. These calculations are based on average missed depth for ordnance correctly identified in the discrimination stage. Depths are measured from the closest point of the ordnance to the surface. For the Blind Grid, only depth errors are calculated, since (x, y) positions are known to be the centers of each grid square.

TABLE 9. MEAN LOCATION ERROR AND STANDARD DEVIATION (M) FOR GEM-3 TOWED ARRAY

	Mean	Standard Deviation
Depth	0.18	0.16

SECTION 5. ON-SITE LABOR COSTS

A standardized estimate for labor costs associated with this effort was calculated as follows: the first person at the test site was designated "supervisor", the second person was designated "data analyst", and the third and following personnel were considered "field support". Standardized hourly labor rates were charged by title: supervisor at $95.00/hour, data analyst at $57.00/hour, and field support at $28.50/hour.

Government representatives monitored on-site activity. All on site activities were grouped into one of ten categories: initial setup/mobilization, daily setup/stop, calibration, collecting data, downtime due to break/lunch, downtime due to equipment failure, downtime due to equipment/data checks or maintenance, downtime due to weather, downtime due to demonstration site issue, or demobilization. See Appendix D for the daily activity log. See section 3.4 for a summary of field activities.

The standardized cost estimate associated with the labor needed to perform the field activities is presented in Table 10. Note that calibration time includes time spent in the Calibration Lanes as well as field calibrations. "Site survey time" includes daily setup/stop time, collecting data, breaks/lunch, downtime due to equipment/data checks or maintenance, downtime due to failure, and downtime due to weather.

TABLE 10. ON-SITE LABOR COSTS

	No. People	Hourly Wage	Hours	Cost
Initial Setup				
Supervisor	1	$95.00	4.6	$437.00
Data Analyst	1	57.00	4.6	262.20
Field Support	1	28.50	4.6	131.10
Subtotal				**$830.30**
Calibration				
Supervisor	1	$95.00	6.6	$627.00
Data Analyst	1	57.00	6.6	376.20
Field Support	1	28.50	6.6	188.10
Subtotal				**$1191.30**
Site Survey				
Supervisor	1	$95.00	0.9	$85.50
Data Analyst	1	57.00	0.9	51.30
Field Support	1	28.50	0.9	25.65
Subtotal				**$162.45**

See notes at end of table.

TABLE 10 (CONT'D)

	No. People	Hourly Wage	Hours	Cost
Demobilization				
Supervisor	1	$95.00	1.12	$106.40
Data Analyst	1	57.00	1.12	63.84
Field Support	0	28.50	1.12	0.00
SubTotal				**$170.24**
TOTAL				**$2354.29**

Notes: Calibration time includes time spent in the Calibration Lanes as well as calibration before each data run.

Site survey time includes daily setup/stop time, collecting data, breaks/lunch, downtime due to system maintenance, failure, and weather.

SECTION 6. COMPARISON OF RESULTS TO DATE

No comparisons to date.

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SECTION 7. APPENDIXES

APPENDIX A. TERMS AND DEFINITIONS

GENERAL DEFINITIONS

Anomaly: Location of a system response deemed to warrant further investigation by the demonstrator for consideration as an emplaced ordnance item.

Detection: An anomaly location that is within R_{halo} of an emplaced ordnance item.

Emplaced Ordnance: An ordnance item buried by the government at a specified location in the test site.

Emplaced Clutter: A clutter item (i.e., nonordnance item) buried by the government at a specified location in the test site.

R_{halo}: A predetermined radius about the periphery of an emplaced item (clutter or ordnance) within which a location identified by the demonstrator as being of interest is considered to be a response from that item. If multiple declarations lie within R_{halo} of any item (clutter or ordnance), the declaration with the highest signal output within the R_{halo} will be utilized. For the purpose of this program, a circular halo 0.5 meter in radius will be placed around the center of the object for all clutter and ordnance items less than 0.6 meter in length. When ordnance items are longer than 0.6 meter, the halo becomes an ellipse where the minor axis remains 1 meter and the major axis is equal to the length of the ordnance plus 1 meter.

Small Ordnance: Caliber of ordnance less than or equal to 40 mm (includes 20-mm projectile, 40-mm projectile, submunitions BLU-26, BLU-63, and M42).

Medium Ordnance: Caliber of ordnance greater than 40 mm and less than or equal to 81 mm (includes 57-mm projectile, 60-mm mortar, 2.75 in. Rocket, MK118 Rockeye, 81-mm mortar).

Large Ordnance: Caliber of ordnance greater than 81 mm (includes 105-mm HEAT, 105-mm projectile, 155-mm projectile, 500-lb bomb).

Shallow: Items buried less than 0.3 meter below ground surface.

Medium: Items buried greater than or equal to 0.3 meter and less than 1 meter below ground surface.

Deep: Items buried greater than or equal to 1 meter below ground surface.

Response Stage Noise Level: The level that represents the point below which anomalies are not considered detectable. Demonstrators are required to provide the recommended noise level for the Blind Grid test area.

Discrimination Stage Threshold: The demonstrator selected threshold level that they believe provides optimum performance of the system by retaining all detectable ordnance and rejecting the maximum amount of clutter. This level defines the subset of anomalies the demonstrator would recommend digging based on discrimination.

Binomially Distributed Random Variable: A random variable of the type which has only two possible outcomes, say success and failure, is repeated for n independent trials with the probability p of success and the probability 1-p of failure being the same for each trial. The number of successes x observed in the n trials is an estimate of p and is considered to be a binomially distributed random variable.

RESPONSE AND DISCRIMINATION STAGE DATA

The scoring of the demonstrator's performance is conducted in two stages. These two stages are termed the RESPONSE STAGE and DISCRIMINATION STAGE. For both stages, the probability of detection (P_d) and the false alarms are reported as receiver operating characteristic (ROC) curves. False alarms are divided into those anomalies that correspond to emplaced clutter items, measuring the probability of false positive (P_{fp}) and those that do not correspond to any known item, termed background alarms.

The RESPONSE STAGE scoring evaluates the ability of the system to detect emplaced targets without regard to ability to discriminate ordnance from other anomalies. For the RESPONSE STAGE, the demonstrator provides the scoring committee with the location and signal strength of all anomalies that the demonstrator has deemed sufficient to warrant further investigation and/or processing as potential emplaced ordnance items. This list is generated with minimal processing (e.g., this list will include all signals above the system noise threshold). As such, it represents the most inclusive list of anomalies.

The DISCRIMINATION STAGE evaluates the demonstrator's ability to correctly identify ordnance as such, and to reject clutter. For the same locations as in the RESPONSE STAGE anomaly list, the DISCRIMINATION STAGE list contains the output of the algorithms applied in the discrimination-stage processing. This list is prioritized based on the demonstrator's determination that an anomaly location is likely to contain ordnance. Thus, higher output values are indicative of higher confidence that an ordnance item is present at the specified location. For electronic signal processing, priority ranking is based on algorithm output. For other systems, priority ranking is based on human judgment. The demonstrator also selects the threshold that the demonstrator believes will provide "optimum" system performance, (i.e., that retains all the detected ordnance and rejects the maximum amount of clutter).

Note: The two lists provided by the demonstrator contain identical numbers of potential target locations. They differ only in the priority ranking of the declarations.

RESPONSE STAGE DEFINITIONS

Response Stage Probability of Detection (P_d^{res}): P_d^{res} = (No. of response-stage detections)/ (No. of emplaced ordnance in the test site).

Response Stage False Positive (fp^{res}): An anomaly location that is within R_{halo} of an emplaced clutter item.

Response Stage Probability of False Positive (P_{fp}^{res}): P_{fp}^{res} = (No. of response-stage false positives)/(No. of emplaced clutter items).

Response Stage Background Alarm (ba^{res}): An anomaly in a blind grid cell that contains neither emplaced ordnance nor an emplaced clutter item. An anomaly location in the open field or scenarios that is outside R_{halo} of any emplaced ordnance or emplaced clutter item.

Response Stage Probability of Background Alarm (P_{ba}^{res}): Blind Grid only: P_{ba}^{res} = (No. of response-stage background alarms)/(No. of empty grid locations).

Response Stage Background Alarm Rate (BAR^{res}): Open Field only: BAR^{res} = (No. of response-stage background alarms)/(arbitrary constant).

Note that the quantities P_d^{res}, P_{fp}^{res}, P_{ba}^{res}, and BAR^{res} are functions of t^{res}, the threshold applied to the response-stage signal strength. These quantities can therefore be written as $P_d^{res}(t^{res})$, $P_{fp}^{res}(t^{res})$, $P_{ba}^{res}(t^{res})$, and $BAR^{res}(t^{res})$.

DISCRIMINATION STAGE DEFINITIONS

Discrimination: The application of a signal processing algorithm or human judgment to response-stage data that discriminates ordnance from clutter. Discrimination should identify anomalies that the demonstrator has high confidence correspond to ordnance, as well as those that the demonstrator has high confidence correspond to nonordnance or background returns. The former should be ranked with highest priority and the latter with lowest.

Discrimination Stage Probability of Detection (P_d^{disc}): P_d^{disc} = (No. of discrimination-stage detections)/(No. of emplaced ordnance in the test site).

Discrimination Stage False Positive (fp^{disc}): An anomaly location that is within R_{halo} of an emplaced clutter item.

Discrimination Stage Probability of False Positive (P_{fp}^{disc}): P_{fp}^{disc} = (No. of discrimination stage false positives)/(No. of emplaced clutter items).

Discrimination Stage Background Alarm (ba^{disc}): An anomaly in a blind grid cell that contains neither emplaced ordnance nor an emplaced clutter item. An anomaly location in the open field or scenarios that is outside R_{halo} of any emplaced ordnance or emplaced clutter item.

Discrimination Stage Probability of Background Alarm (P_{ba}^{disc}): P_{ba}^{disc} = (No. of discrimination-stage background alarms)/(No. of empty grid locations).

Discrimination Stage Background Alarm Rate (BAR^{disc}): BAR^{disc} = (No. of discrimination-stage background alarms)/(arbitrary constant).

Note that the quantities P_d^{disc}, P_{fp}^{disc}, P_{ba}^{disc}, and BAR^{disc} are functions of t^{disc}, the threshold applied to the discrimination-stage signal strength. These quantities can therefore be written as $P_d^{disc}(t^{disc})$, $P_{fp}^{disc}(t^{disc})$, $P_{ba}^{disc}(t^{disc})$, and $BAR^{disc}(t^{disc})$.

RECEIVER-OPERATING CHARACERISTIC (ROC) CURVES

ROC curves at both the response and discrimination stages can be constructed based on the above definitions. The ROC curves plot the relationship between P_d versus P_{fp} and P_d versus BAR or P_{ba} as the threshold applied to the signal strength is varied from its minimum (t_{min}) to its maximum (t_{max}) value.[1] Figure A-1 shows how P_d versus P_{fp} and P_d versus BAR are combined into ROC curves. Note that the "res" and "disc" superscripts have been suppressed from all the variables for clarity.

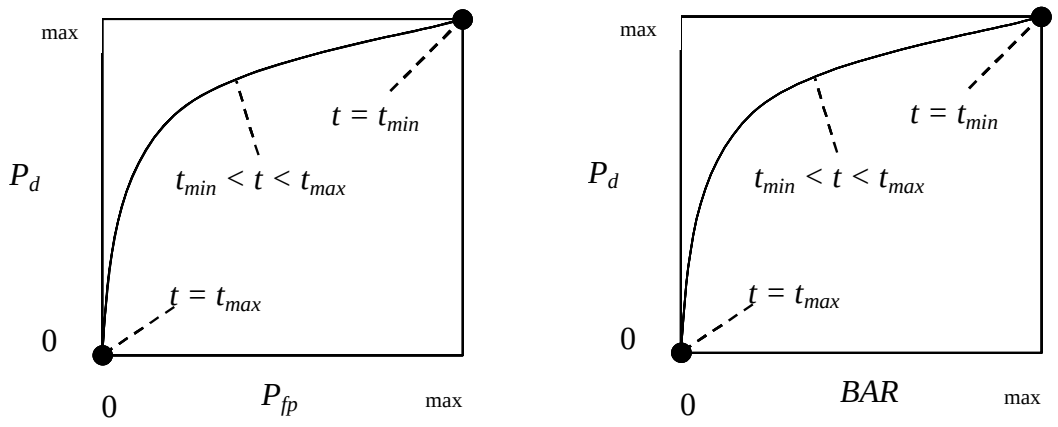

Figure A-1. ROC curves for open-field testing. Each curve applies to both the response and discrimination stages.

[1]Strictly speaking, ROC curves plot the P_d versus P_{ba} over a predetermined and fixed number of detection opportunities (some of the opportunities are located over ordnance and others are located over clutter or blank spots). In an Open Field scenario, each system suppresses its signal strength reports until some bare-minimum signal response is received by the system. Consequently, the open field ROC curves do not have information from low signal-output locations, and, furthermore, different contractors report their signals over a different set of locations on the ground. These ROC curves are thus not true to the strict definition of ROC curves as defined in textbooks on detection theory. Note, however, that the ROC curves obtained in the Blind Grid test sites are true ROC curves.

METRICS TO CHARACTERIZE THE DISCRIMINATION STAGE

The demonstrator is also scored on efficiency and rejection ratio, which measure the effectiveness of the discrimination stage processing. The goal of discrimination is to retain the greatest number of ordnance detections from the anomaly list, while rejecting the maximum number of anomalies arising from nonordnance items. The efficiency measures the amount of detected ordnance retained by the discrimination, while the rejection ratio measures the fraction of false alarms rejected. Both measures are defined relative to the entire response list, i.e., the maximum ordnance detectable by the sensor and its accompanying false positive rate or background alarm rate.

Efficiency (E): $E = P_d^{disc}(t^{disc})/P_d^{res}(t_{min}^{res})$: Measures (at a threshold of interest), the degree to which the maximum theoretical detection performance of the sensor system (as determined by the response stage t_{min}) is preserved after application of discrimination techniques. Efficiency is a number between 0 and 1. An efficiency of 1 implies that all of the ordnance initially detected in the response stage was retained at the specified threshold in the discrimination stage, t^{disc}.

False Positive Rejection Rate (R_{fp}): $R_{fp} = 1 - [P_{fp}^{disc}(t^{disc})/P_{fp}^{res}(t_{min}^{res})]$; Measures (at a threshold of interest), the degree to which the sensor system's false positive performance is improved over the maximum false positive performance (as determined by the response stage t_{min}). The rejection rate is a number between 0 and 1. A rejection rate of 1 implies that all emplaced clutter initially detected in the response stage were correctly rejected at the specified threshold in the discrimination stage.

Background Alarm Rejection Rate (R_{ba}):

Blind Grid: $R_{ba} = 1 - [P_{ba}^{disc}(t^{disc})/P_{ba}^{res}(t_{min}^{res})]$.
Open Field: $R_{ba} = 1 - [BAR^{disc}(t^{disc})/BAR^{res}(t_{min}^{res})]$.

Measures the degree to which the discrimination stage correctly rejects background alarms initially detected in the response stage. The rejection rate is a number between 0 and 1. A rejection rate of 1 implies that all background alarms initially detected in the response stage were rejected at the specified threshold in the discrimination stage.

(Page A-6 Blank)

APPENDIX B. DAILY WEATHER LOGS

TABLE B-1. WEATHER LOG

Weather Data from Phillips Airfield						
Date	Time, EDST	Average Temperature, °F	Maximum Temperature, °F	Minimum Temperature, °F	RH, %	Precipitation, in.
28-Apr-03	00:00	47.246	48.272	46.2362	89.30	0.00
28-Apr-03	01:00	46.562	47.912	45.158	90.40	0.00
28-Apr-03	02:00	45.8186	46.958	43.9574	93.40	0.00
28-Apr-03	03:00	43.592	45.3974	42.1628	96.90	0.00
28-Apr-03	04:00	42.701	43.8476	41.8244	97.60	0.00
28-Apr-03	05:00	42.0422	43.3868	41.2268	97.20	0.00
28-Apr-03	06:00	42.7118	44.2256	41.8262	96.90	0.00
28-Apr-03	07:00	49.082	53.798	43.9862	92.00	0.00
28-Apr-03	08:00	57.074	60.602	53.564	72.80	0.00
28-Apr-03	09:00	64.778	68.234	60.476	50.67	0.00
28-Apr-03	10:00	70.682	72.752	67.514	35.86	0.00
28-Apr-03	11:00	72.716	74.282	71.654	29.48	0.00
28-Apr-03	12:00	74.336	74.984	73.436	26.76	0.00
28-Apr-03	13:00	75.128	76.046	74.012	29.50	0.00
28-Apr-03	14:00	75.704	76.406	74.966	29.06	0.00
28-Apr-03	15:00	75.938	76.622	75.308	30.15	0.00
28-Apr-03	16:00	76.10	76.622	75.542	31.95	0.00
28-Apr-03	17:00	75.596	76.622	74.714	33.33	0.00
28-Apr-03	18:00	73.67	74.948	72.086	37.22	0.00
28-Apr-03	19:00	70.862	72.446	68.99	42.97	0.00
28-Apr-03	20:00	65.66	69.35	63.266	56.01	0.00
28-Apr-03	21:00	62.546	63.392	61.862	67.01	0.00
28-Apr-03	22:00	61.502	62.816	60.44	69.33	0.00
28-Apr-03	23:00	60.08	60.674	59.234	79.05	0.00
29-Apr-03	00:00	59.918	60.80	59.00	86.20	0.00
29-Apr-03	01:00	59.486	60.80	58.406	89.30	0.00
29-Apr-03	02:00	58.73	60.08	56.84	89.30	0.00
29-Apr-03	03:00	56.912	58.766	55.292	93.40	0.00
29-Apr-03	04:00	54.734	56.246	53.168	98.00	0.00
29-Apr-03	05:00	52.196	53.402	50.288	99.70	0.00
29-Apr-03	06:00	51.242	52.322	50.396	100.00	0.00
29-Apr-03	07:00	54.896	59.522	51.134	100.00	0.00
29-Apr-03	08:00	61.07	64.166	58.442	92.80	0.00
29-Apr-03	09:00	67.136	70.844	63.914	72.73	0.00
29-Apr-03	10:00	72.50	75.848	70.232	60.76	0.00
29-Apr-03	11:00	75.11	78.098	70.772	39.87	0.00
29-Apr-03	12:00	68.054	70.772	65.282	59.31	0.00
29-Apr-03	13:00	65.948	68.306	64.688	73.89	0.00
29-Apr-03	14:00	70.592	72.608	68.18	68.00	0.00
29-Apr-03	15:00	72.068	74.372	70.664	64.28	0.00

TABLE B-1 (CONT'D)

Weather Data from Phillips Airfield						
Date	Time, EDST	Average Temperature, °F	Maximum Temperature, °F	Minimum Temperature, °F	RH, %	Precipitation, in.
29-Apr-03	16:00	74.552	75.812	73.652	56.98	0.00
29-Apr-03	17:00	75.038	76.154	73.76	55.76	0.00
29-Apr-03	18:00	74.768	75.56	73.76	47.62	0.00
29-Apr-03	19:00	72.518	74.246	70.196	46.01	0.00
29-Apr-03	20:00	67.838	70.664	63.50	55.89	0.00
29-Apr-03	21:00	62.186	64.112	59.108	70.18	0.00
29-Apr-03	22:00	58.226	59.828	56.012	79.09	0.00
29-Apr-03	23:00	55.472	56.48	53.726	89.10	0.00
30-Apr-03	00:00	54.068	55.67	52.088	93.80	0.00
30-Apr-03	01:00	54.248	55.688	53.168	95.20	0.00
30-Apr-03	02:00	57.65	60.476	53.402	76.22	0.00
30-Apr-03	03:00	59.054	60.602	57.002	61.94	0.00
30-Apr-03	04:00	57.02	58.19	54.842	62.60	0.00
30-Apr-03	05:00	54.068	55.31	52.322	69.36	0.00
30-Apr-03	06:00	54.068	54.968	53.168	67.15	0.00
30-Apr-03	07:00	56.894	58.316	54.716	59.27	0.00
30-Apr-03	08:00	59.522	60.80	58.064	48.80	0.00
30-Apr-03	09:00	61.412	62.708	60.332	44.28	0.00
30-Apr-03	10:00	63.23	64.742	62.096	42.14	0.00
30-Apr-03	11:00	65.48	66.758	64.364	37.84	0.00
30-Apr-03	12:00	67.874	69.494	66.146	35.72	0.00
30-Apr-03	13:00	71.312	73.49	69.134	34.01	0.00
30-Apr-03	14:00	71.78	73.418	70.43	32.38	0.00
30-Apr-03	15:00	72.68	73.526	71.366	34.26	0.00
30-Apr-03	16:00	72.194	73.166	71.006	35.62	0.00
30-Apr-03	17:00	72.572	73.418	70.664	38.99	0.00
30-Apr-03	18:00	69.098	70.898	67.55	46.48	0.00
30-Apr-03	19:00	66.164	68.036	64.112	47.52	0.00
30-Apr-03	20:00	63.608	64.706	62.204	49.83	0.00
30-Apr-03	21:00	62.384	70.844	60.782	44.58	0.00
30-Apr-03	22:00	61.016	61.988	59.702	46.27	0.00
30-Apr-03	23:00	59.126	60.062	58.154	56.36	0.00
1-May-03	00:00	56.102	58.64	53.852	75.02	0.03
1-May-03	01:00	54.77	55.292	54.212	81.30	0.01
1-May-03	02:00	54.536	55.292	53.726	87.30	0.01
1-May-03	03:00	54.806	55.418	54.338	92.50	0.00
1-May-03	04:00	55.112	55.886	54.338	94.00	0.00
1-May-03	05:00	56.696	57.452	55.526	91.00	0.00
1-May-03	06:00	57.344	57.812	56.84	88.10	0.00
1-May-03	07:00	58.298	59.00	57.326	86.40	0.00
1-May-03	08:00	59.234	60.314	58.64	85.70	0.00
1-May-03	09:00	62.762	71.69	59.954	84.20	0.00
1-May-03	10:00	64.454	65.912	63.77	83.70	0.00

TABLE B-1 (CONT'D)

Weather Data from Phillips Airfield						
Date	Time, EDST	Average Temperature, °F	Maximum Temperature, °F	Minimum Temperature, °F	RH, %	Precipitation, in.
1-May-03	11:00	68.306	74.426	65.912	83.00	0.00
1-May-03	12:00	69.728	71.78	68.18	80.20	0.00
1-May-03	13:00	71.654	72.824	70.304	77.51	0.00
1-May-03	14:00	73.22	74.858	71.132	75.64	0.00
1-May-03	15:00	75.668	76.64	74.372	71.59	0.00
1-May-03	16:00	76.838	77.576	75.902	69.12	0.00
1-May-03	17:00	76.694	77.216	76.262	67.67	0.00
1-May-03	18:00	75.848	76.982	74.354	68.46	0.00
1-May-03	19:00	74.012	75.074	72.086	69.90	0.00
1-May-03	20:00	70.844	72.446	69.476	75.06	0.00
1-May-03	21:00	68.162	69.836	66.506	81.20	0.00
1-May-03	22:00	67.226	68.666	66.146	84.40	0.00
1-May-03	23:00	66.956	68.432	65.912	83.70	0.00
2-May-03	00.00	65.066	72.626	62.33	88.50	0.00
2-May-03	01:00	61.79	63.896	60.188	95.00	0.00
2-May-03	02:00	60.764	61.394	59.954	98.40	0.00
2-May-03	03:00	60.314	61.034	58.406	98.60	0.00
2-May-03	04:00	60.692	61.88	58.28	98.80	0.00
2-May-03	05:00	59.864	62.24	57.92	98.20	0.00
2-May-03	06:00	59.63	60.674	58.892	99.60	0.00
2-May-03	07:00	62.942	70.268	59.486	98.10	0.00
2-May-03	08:00	66.902	72.068	65.12	89.40	0.00
2-May-03	09:00	69.044	69.746	67.982	81.60	0.00
2-May-03	10:00	69.782	71.528	68.414	80.10	0.00
2-May-03	11:00	72.50	80.618	70.322	76.99	0.00
2-May-03	12:00	73.49	82.274	71.024	74.35	0.00
2-May-03	13:00	74.318	81.68	73.40	71.63	0.00
2-May-03	14:00	76.91	78.764	75.326	66.58	0.00
2-May-03	15:00	77.27	82.598	75.65	69.76	0.00
2-May-03	16:00	79.25	85.82	77.198	65.95	0.00
2-May-03	17:00	79.088	86.54	77.918	62.73	0.00
2-May-03	18:00	78.044	83.426	76.136	66.34	0.00
2-May-03	19:00	74.84	82.238	71.726	75.44	0.00
2-May-03	20:00	72.752	74.372	71.006	68.22	0.00
2-May-03	21:00	70.718	72.698	68.162	56.21	0.00
2-May-03	22:00	65.498	68.288	62.078	59.61	0.00
2-May-03	23:00	60.53	62.186	59.45	67.33	0.00
3-May-03	00:00	58.946	59.702	58.154	69.79	0.00
3-May-03	01:00	58.154	58.766	57.56	70.83	0.00
3-May-03	02:00	57.506	58.046	56.732	71.99	0.00
3-May-03	03:00	56.084	57.20	55.058	74.98	0.00
3-May-03	04:00	54.59	55.292	53.996	77.29	0.00
3-May-03	05:00	54.356	54.842	53.762	76.86	0.00

TABLE B-1 (CONT'D)

Weather Data from Phillips Airfield						
Date	Time, EDST	Average Temperature, °F	Maximum Temperature, °F	Minimum Temperature, °F	RH, %	Precipitation, in.
3-May-03	06:00	53.834	54.356	53.528	77.31	0.00
3-May-03	07:00	54.806	55.562	54.122	75.69	0.00
3-May-03	08:00	56.138	56.966	55.202	72.56	0.00
3-May-03	09:00	57.038	57.812	56.48	70.59	0.00
3-May-03	10:00	58.478	65.714	57.326	66.70	0.00
3-May-03	11:00	60.008	67.982	59.234	63.93	0.00
3-May-03	12:00	62.852	67.37	60.782	62.18	0.00
3-May-03	13:00	61.862	64.004	61.016	62.10	0.00
3-May-03	14:00	65.138	70.934	61.736	58.39	0.00
3-May-03	15:00	66.38	70.448	64.832	55.14	0.00
3-May-03	16:00	66.65	71.654	64.112	57.66	0.00
3-May-03	17:00	65.696	69.98	61.718	57.25	0.00
3-May-03	18:00	61.826	62.78	60.764	63.61	0.00
3-May-03	19:00	59.972	61.124	58.622	70.77	0.00
3-May-03	20:00	58.136	62.24	56.48	78.86	0.00
3-May-03	21:00	55.994	62.114	53.366	84.60	0.00
3-May-03	22:00	53.132	53.762	52.448	86.10	0.00
3-May-03	23:00	52.448	53.276	51.368	85.80	0.00
4-May-03	00:00	51.26	52.088	50.054	84.30	0.00
4-May-03	01:00	49.802	50.54	49.10	86.80	0.00
4-May-03	02:00	49.514	50.414	48.614	90.10	0.00
4-May-03	03:00	48.38	49.586	47.426	93.80	0.00
4-May-03	04:00	48.956	49.82	47.552	90.40	0.00
4-May-03	05:00	48.974	50.072	47.912	90.80	0.00
4-May-03	06:00	48.434	50.18	47.552	94.20	0.00
4-May-03	07:00	50.774	51.386	49.946	87.30	0.00
4-May-03	08:00	51.26	52.214	49.82	88.60	0.00
4-May-03	09:00	53.996	55.562	51.962	82.90	0.00
4-May-03	10:00	58.028	66.11	55.328	68.32	0.00
4-May-03	11:00	56.876	57.326	56.138	63.27	0.00
4-May-03	12:00	58.658	66.074	56.966	61.87	0.00
4-May-03	13:00	62.852	66.308	60.674	59.61	0.00
4-May-03	14:00	63.896	67.982	62.096	56.07	0.00
4-May-03	15:00	64.598	67.946	62.096	49.45	0.00
4-May-03	16:00	66.524	69.494	64.472	39.90	0.00
4-May-03	17:00	65.354	70.088	63.392	37.73	0.00
4-May-03	18:00	65.48	69.26	63.986	41.14	0.00
4-May-03	19:00	63.572	68.306	58.856	42.13	0.00
4-May-03	20:00	56.30	62.69	53.726	57.79	0.00
4-May-03	21:00	53.276	61.286	49.442	66.93	0.00
4-May-03	22:00	51.368	53.276	48.866	61.78	0.00
4-May-03	23:00	48.758	50.054	46.832	67.05	0.00

TABLE B-1 (CONT'D)

Weather Data from Phillips Airfield						
Date	Time, EDST	Average Temperature, °F	Maximum Temperature, °F	Minimum Temperature, °F	RH, %	Precipitation, in.
5-May-03	00:00	43.8872	47.318	42.1592	83.10	0.00
5-May-03	01:00	42.9242	44.321	41.8244	85.90	0.00
5-May-03	02:00	40.7552	42.4256	38.5862	92.10	0.00
5-May-03	03:00	39.2342	39.9074	38.4674	96.10	0.00
5-May-03	04:00	40.0172	40.5068	39.1874	97.30	0.00
5-May-03	05:00	40.3466	41.3456	39.5474	96.30	0.00
5-May-03	06:00	41.8154	42.6668	40.9856	93.90	0.00
5-May-03	07:00	45.6638	49.136	42.4256	92.10	0.00
5-May-03	08:00	50.54	51.278	49.136	82.90	0.00
5-May-03	09:00	50.954	51.62	50.432	79.71	0.00
5-May-03	10:00	52.988	54.842	51.386	75.79	0.00
5-May-03	11:00	54.248	55.076	53.51	54.84	0.00
5-May-03	12:00	54.698	55.778	53.51	50.15	0.00
5-May-03	13:00	54.572	55.526	53.618	57.31	0.00
5-May-03	14:00	53.546	54.212	53.006	72.03	0.01
5-May-03	15:00	53.258	54.338	52.196	75.57	0.00
5-May-03	16:00	50.846	52.43	49.442	75.27	0.01
5-May-03	17:00	49.046	49.802	48.254	76.85	0.00
5-May-03	18:00	48.38	49.10	47.408	70.36	0.01
5-May-03	19:00	47.174	47.894	46.706	75.79	0.00
5-May-03	20:00	47.912	48.254	47.30	82.00	0.00
5-May-03	21:00	48.938	49.46	48.02	81.40	0.00
5-May-03	22:00	49.55	49.946	49.10	82.50	0.00
5-May-03	23:00	49.766	50.288	49.334	83.60	0.00
6-May-03	00:00	50.36	50.756	49.928	85.10	0.00
6-May-03	01:00	50.486	50.882	50.036	92.90	0.00
6-May-03	02:00	50.774	51.008	50.396	95.30	0.00
6-May-03	03:00	50.864	51.116	50.522	98.40	0.00
6-May-03	04:00	50.918	51.242	50.522	99.00	0.01
6-May-03	05:00	50.954	51.242	50.648	99.20	0.00
6-May-03	06:00	51.044	51.476	50.522	99.30	0.01
6-May-03	07:00	51.566	51.962	51.008	99.00	0.00
6-May-03	08:00	51.908	52.556	51.242	98.40	0.00
6-May-03	09:00	52.448	53.042	51.962	98.30	0.00
6-May-03	10:00	53.078	54.086	52.43	97.60	0.00
6-May-03	11:00	54.608	55.76	53.618	95.00	0.00
6-May-03	12:00	56.462	57.56	55.166	91.90	0.00
6-May-03	13:00	57.848	58.874	56.966	89.00	0.00
6-May-03	14:00	59.486	60.908	58.622	84.30	0.00
6-May-03	15:00	61.538	62.816	59.954	80.10	0.00
6-May-03	16:00	60.818	62.096	60.278	82.10	0.00
6-May-03	17:00	60.728	61.25	60.17	81.90	0.00
6-May-03	18:00	61.214	61.862	60.656	80.90	0.00

TABLE B-1 (CONT'D)

Weather Data from Phillips Airfield						
Date	Time, EDST	Average Temperature, °F	Maximum Temperature, °F	Minimum Temperature, °F	RH, %	Precipitation, in.
6-May-03	19:00	60.278	61.142	58.982	84.30	0.00
6-May-03	20:00	57.254	59.234	55.526	91.80	0.00
6-May-03	21:00	54.968	56.12	53.366	96.80	0.00
6-May-03	22:00	53.24	54.356	52.07	99.10	0.00
6-May-03	23:00	52.61	54.59	51.368	99.00	0.00
7-May-03	00:00	51.71	52.916	49.928	99.60	0.00
7-May-03	01:00	51.17	52.196	50.522	99.70	0.00
7-May-03	02:00	50.486	51.476	49.082	99.90	0.00
7-May-03	03:00	50.468	51.728	48.848	100.00	0.00
7-May-03	04:00	50.234	51.476	49.442	100.00	0.00
7-May-03	05:00	49.658	51.026	47.534	100.00	0.00
7-May-03	06:00	48.866	50.666	47.66	100.00	0.00
7-May-03	07:00	53.024	55.796	50.414	100.00	0.00
7-May-03	08:00	56.678	57.812	55.562	100.00	0.00
7-May-03	09:00	58.748	60.674	57.452	99.80	0.00
7-May-03	10:00	62.924	66.542	60.314	90.40	0.00
7-May-03	11:00	68.234	69.746	66.29	81.20	0.00
7-May-03	12:00	68.648	69.836	67.82	81.60	0.00
7-May-03	13:00	73.094	75.092	69.584	72.75	0.00
7-May-03	14:00	75.434	76.496	74.606	68.01	0.00
7-May-03	15:00	77.00	78.404	75.776	66.81	0.00
7-May-03	16:00	78.512	79.358	77.324	64.78	0.00
7-May-03	17:00	76.514	78.638	74.696	70.01	0.00
7-May-03	18:00	73.832	74.93	72.932	74.64	0.00
7-May-03	19:00	71.402	73.292	69.584	84.30	0.00
7-May-03	20:00	69.296	69.98	68.306	91.80	0.19
7-May-03	21:00	67.91	68.54	67.226	97.90	0.01
7-May-03	22:00	67.298	67.694	66.974	99.20	0.00
7-May-03	23:00	66.938	67.334	66.506	99.40	0.36

APPENDIX C. SOIL MOISTURE

Daily Soil Moisture Logs

Demonstrator: Geophex, Ltd.
Date: 28 April 2003.
Times: 0905 hours (AM), 1605 hours (PM).

Probe Location	Layer, in.	AM Reading, %	PM Reading, %
Wet Area	0 to 6	77.8	78.2
	6 to 12	65.9	66.8
	12 to 24	73.1	77.1
	24 to 36	61.9	62.1
	36 to 48	52.3	51.2
Wooded Area	0 to 6	No Readings (Submerged Probe)	
	6 to 12		
	12 to 24		
	24 to 36		
	36 to 48		
Open Area	0 to 6	15.8	16.2
	6 to 12	1.2	1.3
	12 to 24	22.7	22.9
	24 to 36	30.2	29.9
	36 to 48	42.8	43.1

Demonstrator: Geophex, Ltd.
Date: 29 April 2003.
Times: 0920 hours (AM), 1605 hours (PM).

Probe Location	Layer, in.	AM Reading, %	PM Reading, %
Wet Area	0 to 6	78.4	77.2
	6 to 12	64.2	65.8
	12 to 24	73.8	74.1
	24 to 36	62.9	60.3
	36 to 48	51.1	50.9
Wooded Area	0 to 6	84.3	84.9
	6 to 12	64.8	64.9
	12 to 24	62.9	63.4
	24 to 36	88.3	87.9
	36 to 48	48.3	48.7
Open Area	0 to 6	13.1	16.2
	6 to 12	0.6	1.4
	12 to 24	21.9	22.9
	24 to 36	29.0	29.5
	36 to 48	41.9	42.7

Daily Soil Moisture Logs

Demonstrator: Geophex, Ltd.
Date: 30 April 2003.
Times: 0910 hours (AM), 1515 hours (PM).

Probe Location	Layer, in.	AM Reading, %	PM Reading, %
Wet Area	0 to 6	77.7	77.2
	6 to 12	66.2	65.7
	12 to 24	73.9	74.3
	24 to 36	61.2	60.8
	36 to 48	51.3	51.8
Wooded Area	0 to 6	82.1	82.1
	6 to 12	65.1	65.4
	12 to 24	63.1	63.7
	24 to 36	87.6	87.9
	36 to 48	49.1	49.0
Open Area	0 to 6	3.1	3.0
	6 to 12	0.2	0.3
	12 to 24	19.9	19.2
	24 to 36	27.9	28.7
	36 to 48	40.7	40.3

Demonstrator: Geophex, Ltd.
Date: 1 May 2003.
Time: 0905 hours (AM), 1450 hours (PM).

Probe Location	Layer, in.	AM Reading, %	PM Reading, %
Wet Area	0 to 6	77.9	77.3
	6 to 12	66.8	65.9
	12 to 24	73.5	74.2
	24 to 36	60.8	59.8
	36 to 48	52.1	51.4
Wooded Area	0 to 6	82.0	81.2
	6 to 12	66.1	67.3
	12 to 24	63.3	62.9
	24 to 36	86.8	85.9
	36 to 48	49.8	49.3
Open Area	0 to 6	6.2	8.4
	6 to 12	1.2	0.9
	12 to 24	18.7	19.3
	24 to 36	28.5	28.1
	36 to 48	39.8	40.3

Daily Soil Moisture Logs

Demonstrator: Geophex, Ltd.
Date: 2 May 2003.
Times: 0815 hours (AM), 1410 hours (PM).

Probe Location	Layer, in.	AM Reading, %	PM Reading, %
Wet Area	0 to 6	78.3	77.8
	6 to 12	66.2	66.2
	12 to 24	75.3	75.1
	24 to 36	64.1	63.8
	36 to 48	50.1	49.8
Wooded Area	0 to 6	76.9	76.3
	6 to 12	64.2	63.8
	12 to 24	86.9	86.9
	24 to 36	63.5	63.1
	36 to 48	50.9	50.2
Open Area	0 to 6	11.9	11.4
	6 to 12	0.7	0.3
	12 to 24	20.8	20.2
	24 to 36	26.9	26.3
	36 to 48	41.2	40.7

Demonstrator: Geophex, Ltd.
Date: 3 May 2003.
Times: 0850 hours (AM), 1515 hours (PM).

Probe Location	Layer, in.	AM Reading, %	PM Reading, %
Wet Area	0 to 6	78.7	78.3
	6 to 12	67.0	66.4
	12 to 24	74.2	74.8
	24 to 36	62.9	62.5
	36 to 48	50.4	50.6
Wooded Area	0 to 6	77.6	77.6
	6 to 12	63.3	63.1
	12 to 24	85.8	86.5
	24 to 36	62.7	61.9
	36 to 48	49.9	48.2
Open Area	0 to 6	11.7	11.6
	6 to 12	0.3	0.5
	12 to 24	20.0	20.4
	24 to 36	27.3	26.9
	36 to 48	40.0	40.3

Daily Soil Moisture Logs

Demonstrator: Geophex, Ltd.
Date: 5 May 2003.
Times: 0840 hours (AM), 1510 hours (PM).

Probe Location	Layer, in.	AM Reading, %	PM Reading, %
Wet Area	0 to 6	77.3	80.4
	6 to 12	65.6	66.2
	12 to 24	74.5	72.2
	24 to 36	61.5	59.7
	36 to 48	49.9	31.7
Wooded Area	0 to 6	No Readings	53.4
	6 to 12		65.8
	12 to 24		91.4
	24 to 36		64.2
	36 to 48		51.5
Open Area	0 to 6	11.1	Faulty Reading
	6 to 12	0.5	
	12 to 24	18.7	
	24 to 36	26.2	
	36 to 48	38.8	

Demonstrator: Geophex, Ltd.
Date: 6 May 2003.
Times: 0830 hours (AM), 1420 hours (PM).

Probe Location	Layer, in.	AM Reading, %	PM Reading, %
Wet Area	0 to 6	60.7	83.0
	6 to 12	72.5	74.2
	12 to 24	75.7	75.3
	24 to 36	62.1	61.7
	36 to 48	49.6	49.5
Wooded Area	0 to 6	73.0	73.0
	6 to 12	71.3	72.8
	12 to 24	93.4	92.4
	24 to 36	60.5	62.4
	36 to 48	51.7	52.4
Open Area	0 to 6	12.2	9.7
	6 to 12	1.0	0.5
	12 to 24	18.4	18.0
	24 to 36	25.4	25.0
	36 to 48	37.9	37.7

Daily Soil Moisture Logs

Demonstrator: Geophex, Ltd.
Date: 7 May 2003.
Times: 0905 hours (AM), 1310 hours (PM).

Probe Location	Layer, in.	AM Reading, %	PM Reading, %
Wet Area	0 to 6	84.1	77.6
	6 to 12	73.0	76.8
	12 to 24	75.5	76.3
	24 to 36	62.0	62.3
	36 to 48	49.1	49.3
Wooded Area	0 to 6	No Readings	73.3
	6 to 12		73.6
	12 to 24		93.7
	24 to 36		60.1
	36 to 48		50.1
Open Area	0 to 6	10.2	10.0
	6 to 12	0.2	0.2
	12 to 24	18.1	17.8
	24 to 36	25.0	24.6
	36 to 48	37.4	37.1

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APPENDIX D. DAILY ACTIVITY LOGS

Date	No. of People	Area Tested	Status Start Time	Status Stop Time	Duration, min	Operational Status	Operational Status - Comments	Track Method	Track Method=Other Explain	Pattern	Field Conditions	
28-Apr-03	2	OPEN FIELD	0845	1810	630	EQUIPMENT FAILURE	SOFTWARE ISSUE, NEVER GOT STARTED	NA	NA	NA	SUNNY	MUDDY
28-Apr-03	2	OPEN FIELD	1810	1915	65	SET UP/DAILY START/STOP	END OF DAILY OPERATIONS/EQUIPMENT BREAKDOWN	NA	NA	NA	SUNNY	MUDDY
29-Apr-03	3	OPEN FIELD	0800	1510	430	EQUIPMENT FAILURE	SOFTWARE ISSUE, NEVER GOT STARTED	NA	NA	NA	CLOUDY	MUDDY
29-Apr-03	1	OPEN FIELD	1510	1840	210	EQUIPMENT FAILURE	SOFTWARE ISSUE, NEVER GOT STARTED	NA	NA	NA	CLOUDY	MUDDY
29-Apr-03	1	OPEN FIELD	1840	1930	50	SET UP/DAILY START/STOP	END OF DAILY OPERATIONS/EQUIPMENT BREAKDOWN	NA	NA	NA	CLOUDY	MUDDY
30-Apr-03	3	OPEN FIELD	0800	1015	135	EQUIPMENT FAILURE	SOFTWARE ISSUE, NEVER GOT STARTED	NA	NA	NA	CLOUDY	MUDDY
30-Apr-03	1	OPEN FIELD	1015	1305	170	EQUIPMENT FAILURE	SOFTWARE ISSUE, NEVER GOT STARTED	NA	NA	NA	CLOUDY	MUDDY
30-Apr-03	3	OPEN FIELD	1305	1900	355	EQUIPMENT FAILURE	SOFTWARE ISSUE, NEVER GOT STARTED	NA	NA	NA	CLOUDY	MUDDY
30-Apr-03	3	OPEN FIELD	1900	1915	15	SET UP/DAILY START/STOP	END OF DAILY OPERATIONS/EQUIPMENT BREAKDOWN	NA	NA	NA	CLOUDY	MUDDY
1-May-03	3	OPEN FIELD	0803	1030	147	SET UP/DAILY START/STOP	SET UP/MOBILIZATION	NA	NA	NA	SUNNY	MUDDY
1-May-03	3	OPEN FIELD	1030	1035	5	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY	MUDDY
1-May-03	3	MINE GRID	1035	1036	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY	MUDDY
1-May-03	3	OPEN FIELD	1036	1038	2	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY	MUDDY
1-May-03	3	MINE GRID	1038	1039	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY	MUDDY
1-May-03	3	OPEN FIELD	1039	1041	2	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY	MUDDY
1-May-03	3	MINE GRID	1041	1042	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY	MUDDY

Date	No. of People	Area Tested	Status Start Time	Status Stop Time	Duration, min	Operational Status	Operational Status - Comments	Track Method	Track Method=Other Explain	Pattern	Field Conditions	
1-May-03	3	OPEN FIELD	1042	1044	2	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY	MUDDY
1-May-03	3	MINE GRID	1044	1045	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY	MUDDY
1-May-03	3	OPEN FIELD	1045	1047	2	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY	MUDDY
1-May-03	3	MINE GRID	1047	1048	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY	MUDDY
1-May-03	3	OPEN FIELD	1048	1054	6	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY	MUDDY
1-May-03	3	MINE GRID	1054	1055	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY	MUDDY
1-May-03	3	OPEN FIELD	1055	1058	3	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY	MUDDY
1-May-03	3	MINE GRID	1058	1059	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY	MUDDY
1-May-03	3	OPEN FIELD	1059	1100	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY	MUDDY
1-May-03	3	MINE GRID	1100	1101	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY	MUDDY
1-May-03	3	OPEN FIELD	1101	1103	2	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY	MUDDY
1-May-03	3	MINE GRID	1103	1104	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY	MUDDY
1-May-03	3	OPEN FIELD	1104	1208	64	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY	MUDDY
1-May-03	3	OPEN FIELD	1208	1228	20	DOWNTIME DUE TO EQUIPMENT MAINTENANCE CHECK	CHANGE BATTERY	NA	NA	NA	SUNNY	MUDDY
1-May-03	3	OPEN FIELD	1228	1255	27	DOWNTIME DUE TO EQUIPMENT MAINTENANCE CHECK	DOWNLOAD DATA	NA	NA	NA	SUNNY	MUDDY
1-May-03	3	OPEN FIELD	1255	1414	79	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY	MUDDY
1-May-03	3	OPEN FIELD	1414	1444	30	DOWNTIME DUE TO EQUIPMENT MAINTENANCE CHECK	DOWNLOAD DATA	NA	NA	NA	SUNNY	MUDDY

Date	No. of People	Area Tested	Status Start Time	Status Stop Time	Duration, min	Operational Status	Operational Status - Comments	Track Method	Track Method=Other Explain	Pattern	Field Conditions	Date
1-May-03	3	OPEN FIELD	1444	1530	46	DOWNTIME DUE TO EQUIPMENT MAINTENANCE CHECK	CHECK DATA	NA	NA	NA	SUNNY	MUDDY
1-May-03	4	OPEN FIELD	1530	1621	51	DOWNTIME DUE TO EQUIPMENT MAINTENANCE CHECK	CHECK DATA	NA	NA	NA	SUNNY	MUDDY
1-May-03	4	OPEN FIELD	1621	1635	14	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY	MUDDY
1-May-03	4	OPEN FIELD	1635	1651	16	DOWNTIME DUE TO EQUIPMENT MAINTENANCE CHECK	CHECK DATA	NA	NA	NA	SUNNY	MUDDY
1-May-03	4	OPEN FIELD	1651	1717	26	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY	MUDDY
1-May-03	4	BLIND GRID	1717	1718	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY	MUDDY
1-May-03	4	OPEN FIELD	1718	1720	2	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY	MUDDY
1-May-03	4	BLIND GRID	1720	1721	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY	MUDDY
1-May-03	4	OPEN FIELD	1721	1723	2	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY	MUDDY
1-May-03	4	BLIND GRID	1723	1724	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY	MUDDY
1-May-03	4	OPEN FIELD	1724	1726	2	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY	MUDDY
1-May-03	4	BLIND GRID	1726	1727	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY	MUDDY
1-May-03	4	OPEN FIELD	1727	1730	3	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY	MUDDY
1-May-03	4	BLIND GRID	1730	1731	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY	MUDDY
1-May-03	4	OPEN FIELD	1731	1732	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY	MUDDY
1-May-03	4	BLIND GRID	1732	1733	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY	MUDDY

Date	No. of People	Area Tested	Status Start Time	Status Stop Time	Duration, min	Operational Status	Operational Status - Comments	Track Method	Track Method=Other Explain	Pattern	Field Conditions	
1-May-03	4	OPEN FIELD	1733	1736	3	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY	MUDDY
1-May-03	4	BLIND GRID	1736	1737	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY	MUDDY
1-May-03	4	OPEN FIELD	1737	1739	2	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY	MUDDY
1-May-03	4	BLIND GRID	1739	1740	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY	MUDDY
1-May-03	4	OPEN FIELD	1740	1743	3	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY	MUDDY
1-May-03	4	BLIND GRID	1743	1744	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY	MUDDY
1-May-03	4	OPEN FIELD	1744	1745	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY	MUDDY
1-May-03	4	BLIND GRID	1745	1746	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY	MUDDY
1-May-03	4	OPEN FIELD	1746	1749	3	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY	MUDDY
1-May-03	4	BLIND GRID	1749	1750	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY	MUDDY
1-May-03	4	OPEN FIELD	1750	1751	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY	MUDDY
1-May-03	4	BLIND GRID	1751	1752	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY	MUDDY
1-May-03	4	OPEN FIELD	1752	1755	3	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY	MUDDY
1-May-03	4	BLIND GRID	1755	1756	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY	MUDDY
1-May-03	4	OPEN FIELD	1756	1757	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY	MUDDY
1-May-03	4	OPEN FIELD	1757	1813	16	DOWNTIME DUE TO EQUIPMENT MAINTENANCE CHECK	CHECK DATA	NA	NA	NA	SUNNY	MUDDY
1-May-03	4	OPEN FIELD	1813	1910	57	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY	MUDDY

Date	No. of People	Area Tested	Status Start Time	Status Stop Time	Duration, min	Operational Status	Operational Status - Comments	Track Method	Track Method=Other Explain	Pattern	Field Conditions	Date
1-May-03	4	OPEN FIELD	1910	1930	20	SET UP/DAILY START/STOP	END OF DAILY OPERATIONS/EQUIPMENT BREAKDOWN	NA	NA	NA	SUNNY	MUDDY
2-May-03	5	OPEN FIELD	0755	1112	197	SET UP/DAILY START/STOP	SET UP/MOBILIZATION	NA	NA	NA	CLOUDY	MUDDY
2-May-03	5	OPEN FIELD	1112	1113	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	CLOUDY	MUDDY
2-May-03	5	BLIND GRID	1113	1114	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	CLOUDY	MUDDY
2-May-03	5	OPEN FIELD	1114	1120	6	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	CLOUDY	MUDDY
2-May-03	5	BLIND GRID	1120	1121	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	CLOUDY	MUDDY
2-May-03	5	OPEN FIELD	1121	1131	10	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	CLOUDY	MUDDY
2-May-03	5	BLIND GRID	1131	1132	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	CLOUDY	MUDDY
2-May-03	5	OPEN FIELD	1132	1140	8	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	CLOUDY	MUDDY
2-May-03	5	OPEN FIELD	1140	1557	257	EQUIPMENT FAILURE	REPLACE GPS CONSOLE, BROKEN PIN	NA	NA	NA	CLOUDY	MUDDY
2-May-03	5	OPEN FIELD	1557	1558	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	CLOUDY	MUDDY
2-May-03	5	BLIND GRID	1558	1559	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	CLOUDY	MUDDY
2-May-03	5	OPEN FIELD	1559	1605	6	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	CLOUDY	MUDDY
2-May-03	5	BLIND GRID	1605	1606	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	CLOUDY	MUDDY
2-May-03	5	OPEN FIELD	1606	1613	7	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	CLOUDY	MUDDY
2-May-03	5	BLIND GRID	1613	1614	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	CLOUDY	MUDDY
2-May-03	5	OPEN FIELD	1614	1620	6	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	CLOUDY	MUDDY

Date	No. of People	Area Tested	Status Start Time	Status Stop Time	Duration, min	Operational Status	Operational Status - Comments	Track Method	Track Method=Other Explain	Pattern	Field Conditions	
2-May-03	5	BLIND GRID	1620	1621	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	CLOUDY	MUDDY
2-May-03	6	OPEN FIELD	1621	1628	7	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	CLOUDY	MUDDY
2-May-03	6	BLIND GRID	1628	1629	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	CLOUDY	MUDDY
2-May-03	6	OPEN FIELD	1629	1636	7	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	CLOUDY	MUDDY
2-May-03	6	BLIND GRID	1636	1637	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	CLOUDY	MUDDY
2-May-03	6	OPEN FIELD	1637	1644	7	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	CLOUDY	MUDDY
2-May-03	6	BLIND GRID	1644	1645	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	CLOUDY	MUDDY
2-May-03	6	OPEN FIELD	1645	1652	7	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	CLOUDY	MUDDY
2-May-03	6	BLIND GRID	1652	1653	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	CLOUDY	MUDDY
2-May-03	6	OPEN FIELD	1653	1658	5	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	CLOUDY	MUDDY
2-May-03	6	BLIND GRID	1658	1659	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	CLOUDY	MUDDY
2-May-03	6	OPEN FIELD	1659	1706	7	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	CLOUDY	MUDDY
2-May-03	6	BLIND GRID	1706	1707	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	CLOUDY	MUDDY
2-May-03	6	OPEN FIELD	1707	1745	38	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	CLOUDY	MUDDY
2-May-03	6	OPEN FIELD	1745	1815	30	SET UP/DAILY START/STOP	END OF DAILY OPERATIONS/EQUIPMENT BREAKDOWN	NA	NA	NA	CLOUDY	MUDDY
3-May-03	2	OPEN FIELD	0748	1108	200	SET UP/DAILY START/STOP	SET UP/MOBILIZATION	NA	NA	NA	SUNNY	MUDDY
3-May-03	2	OPEN FIELD	1108	1116	8	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY	MUDDY
3-May-03	2	MINE GRID	1116	1117	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY	MUDDY

Date	No. of People	Area Tested	Status Start Time	Status Stop Time	Duration, min	Operational Status	Operational Status - Comments	Track Method	Track Method=Other Explain	Pattern	Field Conditions	
3-May-03	2	OPEN FIELD	1117	1124	7	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY	MUDDY
3-May-03	2	MINE GRID	1124	1125	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY	MUDDY
3-May-03	2	OPEN FIELD	1125	1133	8	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY	MUDDY
3-May-03	2	BLIND GRID	1133	1134	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY	MUDDY
3-May-03	2	OPEN FIELD	1134	1144	70	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY	MUDDY
3-May-03	2	MINE GRID	1144	1145	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY	MUDDY
3-May-03	2	OPEN FIELD	1145	1152	7	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY	MUDDY
3-May-03	2	MINE GRID	1152	1153	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY	MUDDY
3-May-03	2	OPEN FIELD	1153	1200	7	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY	MUDDY
3-May-03	2	MINE GRID	1200	1201	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY	MUDDY
3-May-03	2	OPEN FIELD	1201	1207	6	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY	MUDDY
3-May-03	2	OPEN FIELD	1207	1216	9	DOWNTIME DUE TO EQUIPMENT MAINTENANCE CHECK	CHECK DATA	NA	NA	NA	SUNNY	MUDDY
3-May-03	2	OPEN FIELD	1216	1217	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY	MUDDY
3-May-03	2	MINE GRID	1217	1218	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY	MUDDY
3-May-03	2	OPEN FIELD	1218	1224	6	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY	MUDDY
3-May-03	2	MINE GRID	1224	1225	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY	MUDDY
3-May-03	2	OPEN FIELD	1225	1231	6	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY	MUDDY

Date	No. of People	Area Tested	Status Start Time	Status Stop Time	Duration, min	Operational Status	Operational Status - Comments	Track Method	Track Method=Other Explain	Pattern	Field Conditions	
3-May-03	2	MINE GRID	1231	1232	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY	MUDDY
3-May-03	2	OPEN FIELD	1232	1238	6	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY	MUDDY
3-May-03	2	MINE GRID	1238	1239	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY	MUDDY
3-May-03	2	OPEN FIELD	1239	1244	5	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY	MUDDY
3-May-03	2	MINE GRID	1244	1245	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY	MUDDY
3-May-03	2	OPEN FIELD	1245	1252	7	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY	MUDDY
3-May-03	2	MINE GRID	1252	1253	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY	MUDDY
3-May-03	2	OPEN FIELD	1253	1259	6	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY	MUDDY
3-May-03	2	MINE GRID	1259	1300	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY	MUDDY
3-May-03	2	OPEN FIELD	1300	1305	5	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY	MUDDY
3-May-03	2	MINE GRID	1305	1306	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY	MUDDY
3-May-03	2	OPEN FIELD	1306	1312	6	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY	MUDDY
3-May-03	2	MINE GRID	1312	1313	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY	MUDDY
3-May-03	2	OPEN FIELD	1313	1319	6	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY	MUDDY
3-May-03	2	MINE GRID	1319	1320	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY	MUDDY
3-May-03	2	OPEN FIELD	1320	1326	6	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY	MUDDY
3-May-03	2	OPEN FIELD	1326	1341	15	DOWNTIME DUE TO EQUIPMENT MAINTENANCE CHECK	DOWNLOAD DATA	NA	NA	NA	SUNNY	MUDDY
3-May-03	2	MINE GRID	1341	1342	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY	MUDDY

Date	No. of People	Area Tested	Status Start Time	Status Stop Time	Duration, min	Operational Status	Operational Status - Comments	Track Method	Track Method=Other Explain	Pattern	Field Conditions	Date
3-May-03	2	OPEN FIELD	1342	1347	5	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY	MUDDY
3-May-03	2	MINE GRID	1347	1348	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY	MUDDY
3-May-03	2	OPEN FIELD	1348	1433	45	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY	MUDDY
3-May-03	2	OPEN FIELD	1433	1445	12	DOWNTIME DUE TO EQUIPMENT MAINTENANCE CHECK	DOWNLOAD DATA	NA	NA	NA	SUNNY	MUDDY
3-May-03	2	OPEN FIELD	1445	1620	95	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY	MUDDY
3-May-03	2	OPEN FIELD	1620	1650	30	SET UP/DAILY START/STOP	END OF DAILY OPERATIONS/EQUIPMENT BREAKDOWN	NA	NA	NA	SUNNY	MUDDY
5-May-03	2	OPEN FIELD	0805	0945	100	SET UP/DAILY START/STOP	SET UP/MOBILIZATION	NA	NA	NA	CLOUDY	MUDDY, RAIN
5-May-03	2	OPEN FIELD	0945	1106	81	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	CLOUDY	MUDDY, RAIN
5-May-03	2	OPEN FIELD	1106	1121	15	BREAK/LUNCH	BREAK/LUNCH	NA	NA	NA	CLOUDY	MUDDY, RAIN
5-May-03	2	OPEN FIELD	1121	1145	24	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	CLOUDY	MUDDY, RAIN
5-May-03	2	OPEN FIELD	1145	1156	11	WEATHER ISSUE	RAIN	NA	NA	NA	CLOUDY	MUDDY, RAIN
5-May-03	2	OPEN FIELD	1156	1209	13	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	CLOUDY	MUDDY, RAIN
5-May-03	2	OPEN FIELD	1209	1231	22	DOWNTIME DUE TO EQUIPMENT MAINTENANCE CHECK	DOWNLOAD DATA	NA	NA	NA	CLOUDY	MUDDY, RAIN
5-May-03	2	OPEN FIELD	1231	1258	27	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	CLOUDY	MUDDY, RAIN
5-May-03	2	OPEN FIELD	1258	1303	65	WEATHER ISSUE	RAIN	NA	NA	NA	CLOUDY	MUDDY, RAIN
5-May-03	2	OPEN FIELD	1303	1410	67	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	CLOUDY	MUDDY, RAIN
5-May-03	2	OPEN FIELD	1410	1428	18	BREAK/LUNCH	BREAK/LUNCH	NA	NA	NA	CLOUDY	MUDDY, RAIN

Date	No. of People	Area Tested	Status Start Time	Status Stop Time	Duration, min	Operational Status	Operational Status - Comments	Track Method	Track Method=Other Explain	Pattern	Field Conditions	Date
5-May-03	2	OPEN FIELD	1428	1550	82	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	CLOUDY	MUDDY, RAIN
5-May-03	2	OPEN FIELD	1550	1621	31	SET UP/DAILY START/STOP	END OF DAILY OPERATIONS/EQUIPMENT BREAKDOWN	NA	NA	NA	CLOUDY	MUDDY, RAIN
6-May-03	2	OPEN FIELD	0738	0925	107	SET UP/DAILY START/STOP	SET UP/MOBILIZATION	NA	NA	NA	SUNNY	MUDDY
6-May-03	2	OPEN FIELD	0925	1035	70	EQUIPMENT FAILURE	BAD CABLE CONNECTION, SODERED CABLE	NA	NA	NA	SUNNY	MUDDY
6-May-03	2	OPEN FIELD	1035	1204	89	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY	MUDDY
6-May-03	2	OPEN FIELD	1204	1240	36	BREAK/LUNCH	BREAK/LUNCH	NA	NA	NA	SUNNY	MUDDY
6-May-03	1	OPEN FIELD	1240	1422	102	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY	MUDDY
6-May-03	1	OPEN FIELD	1422	1450	28	BREAK/LUNCH	BREAK/LUNCH	NA	NA	NA	SUNNY	MUDDY
6-May-03	1	OPEN FIELD	1450	1619	89	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY	MUDDY
6-May-03	1	OPEN FIELD	1619	1635	16	DOWNTIME DUE TO EQUIPMENT MAINTENANCE CHECK	DOWNLOAD DATA	NA	NA	NA	SUNNY	MUDDY
6-May-03	1	OPEN FIELD	1635	1710	35	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY	MUDDY
6-May-03	2	OPEN FIELD	1710	1844	94	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY	MUDDY
6-May-03	2	OPEN FIELD	1844	1918	34	SET UP/DAILY START/STOP	END OF DAILY OPERATIONS/EQUIPMENT BREAKDOWN	NA	NA	NA	SUNNY	MUDDY
7-May-03	2	OPEN FIELD	0800	0900	60	SET UP/DAILY START/STOP	SET UP/MOBILIZATION, PUTTING SLED TOGETHER	NA	NA	NA	SUNNY	MUDDY
7-May-03	1	OPEN FIELD	0900	0929	29	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY	MUDDY
7-May-03	1	OPEN FIELD	0929	0931	2	BREAK/LUNCH	BREAK/LUNCH	NA	NA	NA	SUNNY	MUDDY
7-May-03	1	OPEN FIELD	0931	1041	70	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY	MUDDY

APPENDIX E. REFERENCES

1. Standardized UXO Technology Demonstration Site Handbook, DTC Project No. 8-CO-160-000-473, Report No. ATC-8349, March 2002.

2. Aberdeen Proving Ground Soil Survey Report, October 1998.

3. Data Summary, UXO Standardized Test Site: APG Soils Description, May 2002.

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APPENDIX F. ABBREVIATIONS

AEC	=	U.S. Army Environmental Center
A/D	=	analog to digital
APG	=	Aberdeen Proving Ground
ATC	=	U.S. Army Aberdeen Test Center
ATV	=	all terrain vehicle
CAD	=	computer-aided design
DFT	=	Digital Fourier Transform
DGPS	=	differential Global Positioning System
DSP	=	digital signal processor
EMI	=	electromagnetic interference
ERDC	=	U.S. Army Corp of Engineers Engineering, Research and Development Center
ESTCP	=	Environmental Security Technology Certification Program
EQT	=	Army Environmental Quality Technology Program
GPR	=	ground-penetrating radar
GPS	=	Global Positioning System
GX	=	Geosoft executable
HH	=	handheld
JPG	=	Jefferson Proving Ground
MS	=	Microsoft
PC	=	personal computer
POC	=	point of contact
PVC	=	polyvinyl chloride
QC	=	quality control
RAM	=	random access memory
rms	=	root mean square
ROC	=	receiver-operating characteristic
RTK	=	real time kinematic
SAR	=	synthetic-aperture radar
SERDP	=	Strategic Environmental Research and Development Program
UXO	=	unexploded ordnance
YPG	=	U.S. Army Yuma Proving Ground

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