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DTC PROJECT NO. 8-CO-160-UXO-021
REPORT NO. ATC-9005

STANDARDIZED

UXO TECHNOLOGY DEMONSTRATION SITE

MOGULS SCORING RECORD NO. 549

SITE LOCATION:
U.S. ARMY ABERDEEN PROVING GROUND

DEMONSTRATOR:
TETRA TECH FOSTER WHEELER
143 UNION BLVD., SUITE 1010
LAKEWOOD, CO 80212

TECHNOLOGY TYPE/PLATFORM:
EM61/SLING

PREPARED BY:
U.S. ARMY ABERDEEN TEST CENTER
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JULY 2005

Prepared for:
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14. ABSTRACT
This scoring record documents the efforts of Tetra Tech Foster Wheeler (TtFW) to detect and discriminate inert unexploded ordnance (UXO) utilizing the APG Standardized UXO Technology Demonstration Site Moguls. The scoring record was coordinated by Larry Overbay and 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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TABLE OF CONTENTS

PAGE

ACKNOWLEDGMENTS i

SECTION 1. GENERAL INFORMATION

1.1 BACKGROUND 1
1.2 SCORING OBJECTIVES 1
1.2.1 Scoring Methodology 1
1.2.2 Scoring Factors 3
1.3 STANDARD AND NONSTANDARD INERT ORDNANCE TARGETS 4

SECTION 2. DEMONSTRATION

2.1 DEMONSTRATOR INFORMATION 5
2.1.1 Demonstrator Point of Contact (POC) and Address 5
2.1.2 System Description 5
2.1.3 Data Processing Description 7
2.1.4 Data Submission Format 8
2.1.5 Demonstrator Quality Assurance (QA) and Quality Control (QC) 8
2.1.6 Additional Records 11
2.2 APG SITE INFORMATION 11
2.2.1 Location 11
2.2.2 Soil Type 11
2.2.3 Test Areas 11

SECTION 3. FIELD DATA

3.1 DATE OF FIELD ACTIVITIES 13
3.2 AREAS TESTED/NUMBER OF HOURS 13
3.3 TEST CONDITIONS 13
3.3.1 Weather Conditions 13
3.3.2 Field Conditions 13
3.3.3 Soil Moisture 13
3.4 FIELD ACTIVITIES 14
3.4.1 Setup/Mobilization 14
3.4.2 Calibration 14
3.4.3 Downtime Occasions 14
3.4.4 Data Collection 14
3.4.5 Demobilization 14
3.5 PROCESSING TIME 15
3.6 DEMONSTRATOR'S FIELD PERSONNEL 15
3.7 DEMONSTRATOR'S FIELD SURVEYING METHOD 15
3.8 SUMMARY OF DAILY LOGS 15

SECTION 4. TECHNICAL PERFORMANCE RESULTS

		PAGE
4.1	ROC CURVES USING ALL ORDNANCE CATEGORIES	17
4.2	ROC CURVES USING ORDNANCE LARGER THAN 20 MM	18
4.3	PERFORMANCE SUMMARIES	20
4.4	EFFICIENCY, REJECTION RATES, AND TYPE CLASSIFICATION	21
4.5	LOCATION ACCURACY	22

SECTION 5. ON-SITE LABOR COSTS

SECTION 6. COMPARISON OF RESULTS TO OPEN FIELD DEMONSTRATION

SECTION 7. APPENDIXES

A	TERMS AND DEFINITIONS	A-1
B	DAILY WEATHER LOGS	B-1
C	SOIL MOISTURE	C-1
D	DAILY ACTIVITY LOGS	D-1
E	REFERENCES	E-1
F	ABBREVIATIONS	F-1
G	DISTRIBUTION LIST	G-1

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 non-ordnance 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. Based on configuration of the ground truth at the standardized sites and the defined scoring methodology, there exists the possibility of having anomalies within overlapping halos and/or multiple anomalies within halos. In these cases, the following scoring logic is implemented:

(1) In situations where multiple anomalies exist within a single R_{halo}, the anomaly with the strongest response or highest ranking will be assigned to that particular ground truth item.

(2) For overlapping R_{halo} situations, ordnance has precedence over clutter. The anomaly with the strongest response or highest ranking that is closest to the center of a particular ground truth item gets assigned to that item. Remaining anomalies are retained until all matching is complete.

(3) Anomalies located within any R_{halo} that do not get associated with a particular ground truth item are thrown out and are not considered in the analysis.

f. 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 inert 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
HEAT = high-explosive antitank

SECTION 2. DEMONSTRATION

2.1 DEMONSTRATOR INFORMATION

2.1.1 Demonstrator Point of Contact (POC) and Address

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2.1.2 System Description (provided by the demonstrator)

The Geonics EM61-MKII TDEM geophysical sensor, Arc Second Constellation™ (CST) and Leica Series 1100 Robotic Total Station (RTS) laser positioning systems are proposed for APG.

The EM61-MKII uses time domain technology to facilitate the detection and discrimination of metallic objects. Two coils 100 by 100 cm are oriented in a horizontal coplanar fashion and separated by a vertical distance of 40-cm. The system is utilized either on nonmagnetic wheels or as a man-portable unit (terrain-dependent) with the lower coil 40 cm above the ground surface. In general, a transmit pulse of uni-polar rectangular current (25 percent duty) of very short duration is applied to the lower coil. This primary current creates a primary magnetic field that induces eddy currents in nearby metal objects. The current flowing in the metal object creates a secondary magnetic field that is detected by both the lower and upper coils. The transmitter pulse frequency is 75 Hertz (Hz), the pulse duration is 3.3 milliseconds, the peak power output is 50 watts, and the average power is 25 watts. Both coils possess zero decibels of gain.

The secondary magnetic field created by metal objects is sampled by the EM61 MKII electronics, which reside in the backpack, at times of 216 microseconds (μs), 366 μs, 660 μs on the bottom coil and 660 μs on the top coil after the turn-off of the transmit pulse. Digital data for these four individual time gates are integrated and recorded to a Juniper Allegro field computer at a rate of 12 Hz. The individual time gate data are converted into units of millivolts (mV), normalized, and gain is applied to each time gate by the EM61-MKII software v1.22 on the Juniper Allegro field computer. Normalization and gain parameters reside in the EM61-MKII manual, Appendix B.

Safety hazards for the EM61-MKII equipment include electromagnetic radiation. The electromagnetic field of the system could potentially detonate some types of specialized ordnance. The Hazards of Electromagnetic Radiation to Ordnance (HERO) distance for the EM61 MKII is 20 cm. The Army Corps of Engineers (ACE) recommends a ground clearance of at least 40 cm when electrically fuzed ordnance is present.

The CST consists of four laser transmitters and a field computer for logging the position data via wireless modem. Four Trimble Spectra Precision LS920 Laser Transmitters are positioned in a diamond or square geometry over 1/2 to 1 acre depending upon the tree density. The transmitters are leveled, and an automatic routine calculates the relative X-Y-Z- plane between the transmitters to a tolerance of 1 inch or less. A laser detector wand (i.e., receiver) is centered over the EM61-MKII coils on a Tetra Tech Foster Wheeler (TtFW)-designed fiberglass doghouse. The detector wand receives the laser pulses from the four transmitters simultaneously, and computes a position based on the known position of the laser transmitters. Only two of the laser transmitters are necessary to compute a reliable position to a relative accuracy of approximately 1 inch. The position data are updated at 2 to 3 Hz and sent via wireless modem to the field computer for storage.

The Leica Series 1100 RTS consists of a laser-based total station survey instrument (transmitter), prism (receiver), and RCS 100 remote control. The transmitter is positioned over a ground position point of known location, and an X-Y-Z Cartesian coordinate system is defined by occupying an additional known ground position with the receiver prism. The receiver prism is mounted on a TtFW doghouse centered over the EM61-MKII coils, and the RTS automatically tracks the prism at distances of several thousand feet to an accuracy of approximately 1 inch. Position data for the receiver prism are updated at a rate of 3 to 4 Hz and stored on a Personal Computer Memory Card International Association (PCMCIA) card located on the robotic total station.

EM61 and CST Positioning System:

EM61 configured as two man tethered carry (fig. 1) (proposed for use in dense woods and rougher surface areas at APG). Figure 1 shows light-moderate wooded areas at Fort McClellan, Alabama, where TtFW geophysicists have perfected the use of the CST laser-based positioning system.

Figure 1. EM61 and CST positioning system.

2.1.3 Data Processing Description (provided by demonstrator)

In the densely wooded area, the CST laser-based positioning system will be integrated with the EM61-MKII geophysical sensor, and used as a two man tethered system, or in areas where the surface terrain is judged to be smooth, as a one-man cart. The four transmitters will be organized in a diamond or square geometry over an area of 1/2 to 1 acre in size depending upon the area-specific vegetation density. At least two of the laser transmitter locations will be surveyed with the RTS instrument (located at a known control point) in order to position the data in the requested coordinate system.

The RTS laser based system will be used in conjunction with the EM61 MKII in the areas outside of the dense woods. The survey area will be divided into two-acre plots (grids), and wood survey lathe will be positioned at predefined grid corners using the RTS.

For this demonstration, a transect spacing of no more than 2 to 2.5 feet is required when using the proposed geophysical sensor to detect and discriminate objects as small as 20-mm projectiles.

Several fiberglass tape measures are laid out perpendicular to the direction of the data acquisition transects at intervals of approximately 50 to 100 feet. Specially modified traffic cones are positioned along the intended transect at the measuring tape locations; the data acquisition crew uses these cones as waypoints. When the crew reaches a waypoint, the sensor operator moves the cone sideways to the next intended transect (2 to 2.5 ft to the side), and continues navigating to the next waypoint (cone) along the current transect. The acquisition crew proceeds a minimum of 10 feet outside of the intended survey area, reverses direction, and proceeds along the next intended transect. When encountering an obstacle, the sensor operator pauses for 1 second, steps around the obstacle, and pauses for an additional second. In this manner, the highest quality spatial data is obtained around obstacles. In areas where rough terrain is present (moguls, slopes, etc.) pin flags may be employed rather than traffic cones, at intervals of 25 feet. A Juniper Allegro ruggedized data collector records the EM6- MKII data at 12 Hz. At a normal acquisition speed of 3 feet per second, samples along each acquisition transect are produced at intervals of approximately 3 to 4 inches. Geonics software DAT61MK2 v1.30 is used to convert the EM61-MKII data to units of mV with a corresponding time stamp for each record.

The CST positioning information is recorded via wireless modem to a binary file at 2 to 3 Hz to a field computer along with a corresponding time stamp for each recorded position. The positioning and EM61-MKII signal data are merged with the software Vulcproc v1.5 developed by TtFW.

Position data are collected with the RTS at a rate of 3 to 4 Hz and stored, along with a time stamp, on a PCMCIA card in the RTS. The positioning and EM61-MKII signal data are merged with the software RTSproc v2.2 developed by TtFW.

The data is leveled (background subtraction as determined by mode of data) during processing and are output as an ASCII file (X, Y, Z1, Z2, Z3, Z4, Z5) that contains the state planar coordinates of each measurement location in feet, EM61 MKII signal intensity for each time gate in millivolts, and a quality identifier for each recorded position (number 1 to 6, based on standard deviation).

The raw data for all three instruments (EM61, CTS, RTS) is uploaded to a PCMCIA card and transferred to the in-field processing computer and backed up on compact disk, read-only memory (CDROM).

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 (QA) and Quality Control (QC) (provided by demonstrator)

Overview of QC. Field personnel, data processors, and data interpreters implement our QC program in a consistent fashion. In general, our geophysics QC program consists of a battery of preproject tests, and once the project has started, a test regimen is applied for each acquisition session (usually 2 to 3 times per day-not just at the beginning of the day, or each week). The test regimen includes functional checks to ensure the position and geophysical sensor instrumentation is functioning properly prior to and at the end of each data acquisition session; processing checks to ensure the data collected are of sufficient quality and quantity to meet the project objectives, and interpretation checks to ensure the processed data are representative of the site conditions.

Pre-project tests include functional checks to ensure the position and geophysical sensor instrumentation is operating within their defined parameters. For all of our projects we perform a geophysical prove-out (GPO) or verification of detection system (VDS); during this project these tasks will be replaced by the Calibration Lane data. Specific preproject tests include the following:

- 15 minute Static tests for each EM61 MKII system.
- Cable integrity tests for each EM61 MKII system.
- Manufacturer suggested functional checks for CST, and RTS positioning systems.
- Time-stamp relative accuracy tests for position and EM61 MKII systems.
- PCMCIA card integrity checks.

Specific functional checks during the data acquisition program are slightly different depending upon the positioning system used, however, generic functional checks include the following:

- Acquisition personnel metal check (ensure no metal on acquisition personnel).
- Static position system check (accuracy and repeatability of position).
- Static geophysical sensor check (repeatability of measurements, influence of ambient noise).
- Static geophysical sensor check with test item (repeatability and comparability of measurements with metal present).
- Kinematic geophysical sensor check with test item (repeatability and comparability of measurements with sensor in motion).
- Repeatability of overall data (resurvey of portion of the survey area during each data acquisition session).
- Occupation of survey monuments to ensure comparability, accuracy, and repeatability of RTS and CST positioning systems.

Overview of QA. The Quality Assurance program designed by TtFW geophysicists is applied to ensure the QC system is functioning properly. The QA procedures applied during the processing phase of the project are performed each day in the field to ensure the integrity of the data. Data that is not of sufficient quality and quantity to meet the project objectives is documented and recollected. Procedural checks during the processing of the data include the following:

- Evaluation of the static position and EM61-MKII data. EM61-MKII static noise above a predefined threshold is documented and a root cause analysis is performed prior to collecting additional data.

- Evaluation of the kinematic geophysical sensor check. These data allow the processor to qualitatively and quantitatively monitor the noise level and repeatability of the data over a standard item, as well as ensure the data have been merged correctly using the time-stamp information (i.e., the data contain no time or position shift-also known as lag).

- Visual examination of the repeatability and of the track path (data are mathematically interpolated so that gaps present in the data show up as a white color in the color-coded image of the data-these areas are documented and provided to the field crew for additional data collection, if necessary).

- Repeat data for each acquisition session are assessed in terms of the adequacy of the background removal operation.

- Corner stake locations for the survey grid are compared to known survey data and verified.

- Sample density along transects is verified through statistics.

- EM61 measurement values outside of the range -5000 to +5000 mV are documented and compared to the site cultural features map.

TtFW geophysicists have developed internal software to meet some of the needs during merging, processing, and interpretation of the data. Quality assurance measures applied during the interpretation of the data are the following:

- Targets selected interactively by the user are compared to those selected automatically by EM61int v6.7 (TtFW) and/or UX Detect (Oasis Montaj). This process ensures that anomalies that meet a certain criteria for selection are not missed by the interpreter and thus included on the digsheet.

- Depths are calculated using two independent methods. These depths are compared and the most accurate solution obtained. Depths greater than 3.5 feet are documented and the characteristics of these anomalies (shape, number of transects detected on, signal intensity) are interactively assessed by the interpreter using the color-coded image and 1D profile data.

- Several aboveground metal features (e.g., fence posts, monitoring wells, etc.) are selected from each acquisition session for reacquisition by field personnel to verify accuracy of the interpreted position coordinates.

- Comparison of the position and EM61-MKII data to the site features map (e.g., above-ground cultural features are documented-should be variance in track path).

- Interpreted data characteristics are compared to the known responses acquired during the initial test program (e.g., calibration lane).

2.1.6 Additional Records

The following record(s) by this vendor can be accessed via the Internet as MicroSoft Word documents at www.uxotestsites.org. The counterparts to this report are the Blind Grid, Scoring Record No. 159, and the Woods, Scoring Record No. 457.

2.2 APG SITE INFORMATION

2.2.1 Location

The APG Standardized Test Site is located within a secured range area of the Aberdeen Area. 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 APG 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 www.uxotestsites.org 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 Test 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.
Open Field	A 4-hectare (10-acre) site containing open areas, dips, ruts and obstructions that challenge platform systems or hand held detectors. The challenges include a gravel road, wet areas and trees. The vegetation height varies from 15 to 25 cm.
Moguls	1.30-acre area consisting of two areas (the rectangular or driving portion of the course and the triangular section with more difficult, non-drivable terrain). A series of craters (as deep as 0.91m) and mounds (as high as 0.91m) encompass this section.

SECTION 3. FIELD DATA

3.1 DATE OF FIELD ACTIVITIES (11 and 12 November 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	1.62
Mogul	5.50

3.3 TEST CONDITIONS

3.3.1 Weather Conditions

An APG weather station located approximately one mile west of the test site was used to record average temperature and precipitation on a half hour basis for each day of operation. The temperatures listed in Table 4 represent the average temperature during field operations from 0700 to 1700 hours while precipitation data represents 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, °F	Total Daily Precipitation, in.
November 11	51.30	0.00
November 12	54.64	0.68

3.3.2 Field Conditions

Tetra Tech surveyed the Mogul area with the EM61 array on 11 and 12 November 2003. The Mogul area was muddy due to rain events which occurred before and during testing.

3.3.3 Soil Moisture

Three soil probes were placed at various locations within the site to capture soil moisture data: Blind Grid, Calibration, Open Field, and Wooded areas. Measurements were collected in percent moisture and were taken twice daily (morning and afternoon) from five different soil depths (1 to 6 in., 6 to 12 in., 12 to 24 in., 24 to 36 in., and 36 to 48 in.) from each probe. Soil moisture logs are included in Appendix C.

3.4 FIELD ACTIVITIES

3.4.1 Setup/Mobilization

These activities included initial mobilization and daily equipment preparation and break down. A three-person crew took 4 hours and 15 minutes to perform the initial setup and mobilization. There was 40 minutes of daily equipment preparation and end of the day equipment break down lasted 50 minutes.

3.4.2 Calibration

Tetra Tech spent a total of 1-hour and 37 minutes in the calibration lanes, of which 1-hour and 14 minutes was spent collecting data. An additional 10 minutes of calibration was conducted in the mogul area.

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 non-chargeable downtime for the purposes of calculating labor costs and are not discussed. Breaks and lunches are discussed in this section and billed to the total Site Survey area.

3.4.3.1 Equipment/data checks, maintenance. Equipment data checks and maintenance activities accounted for 10 minutes of site usage time. These activities included changing out batteries and routine data checks to ensure the data was being properly recorded/collected. Tetra Tech spent an additional 20 minutes for breaks and lunches.

3.4.3.2 Equipment failure or repair. No time was needed to resolve equipment failures that occurred while surveying the Mogul.

3.4.3.3 Weather. No weather delays occurred during the survey.

3.4.4 Data Collection

Tetra Tech spent a total time of 5 hours and 30 minutes in the Mogul area, 3 hours and 30 minutes of which was spent collecting data.

3.4.5 Demobilization

The Tetra Tech survey crew went on to conducted a full demonstration of the site. Therefore, demobilization did not occur until 13 November 2003. On that day, it took the crew 2 hours and 35 minutes to break down and pack up their equipment.

3.5 PROCESSING TIME

Tetra Tech submitted the raw data from the demonstration activities on the last day of the demonstration, as required. The scoring submittal data was also provided within the required 30-day timeframe.

3.6 DEMONSTRATOR'S FIELD PERSONNEL

Tim Deignan: Project Geophysicist
Mike McGuire: Geophysicist

3.7 DEMONSTRATOR'S FIELD SURVEYING METHOD

Tetra Tech set up grids of approximately 300ft. by 300ft and line spacing of 2 feet. Tetra Tech started in the southwest portion of the Mogul area and moved generally in a south/north direction.

3.8 SUMMARY OF DAILY LOGS

Daily logs capture all field activities during this demonstration and are located in Appendix D. Activities pertinent to this specific demonstration are indicated in highlighted text.

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 background alarm rate. 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.

The Demonstrator did not apply any discrimination algorithms; therefore the following ROC curves do not contain discrimination data.

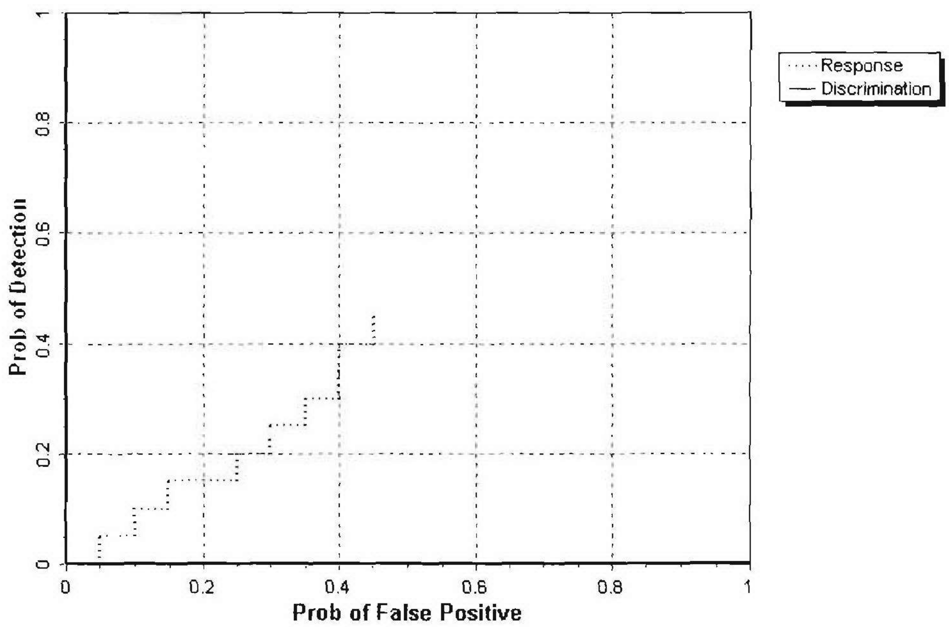

Figure 2. EM61/sling mogul probability of detection for response and discrimination stages versus their respective probability of false positive over all ordnance categories combined.

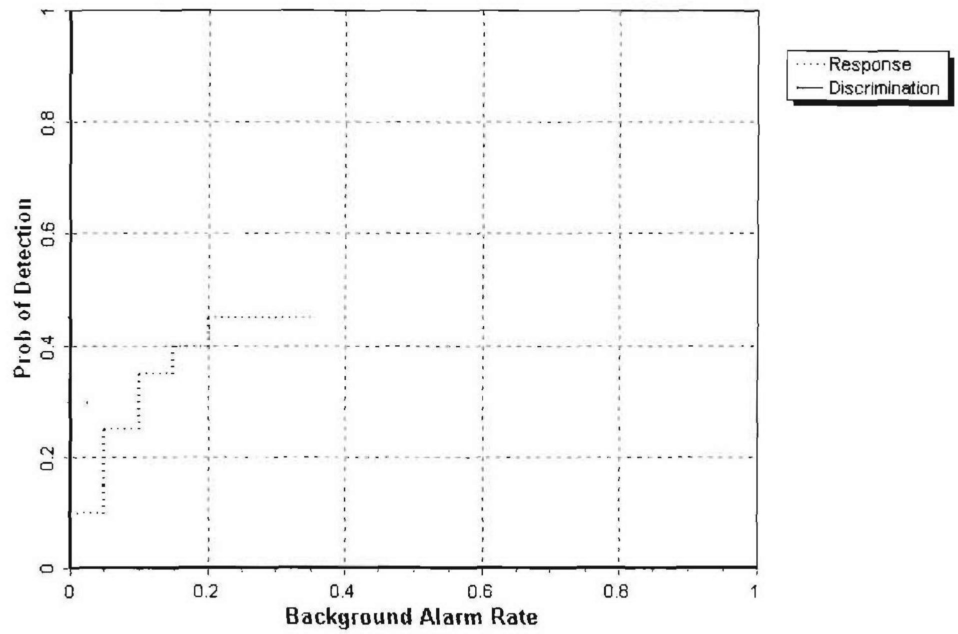

Figure 3. EM61/sling mogul probability of detection for response and discrimination stages versus their respective background alarm rate over all ordnance categories combined.

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 background alarm rate. 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.

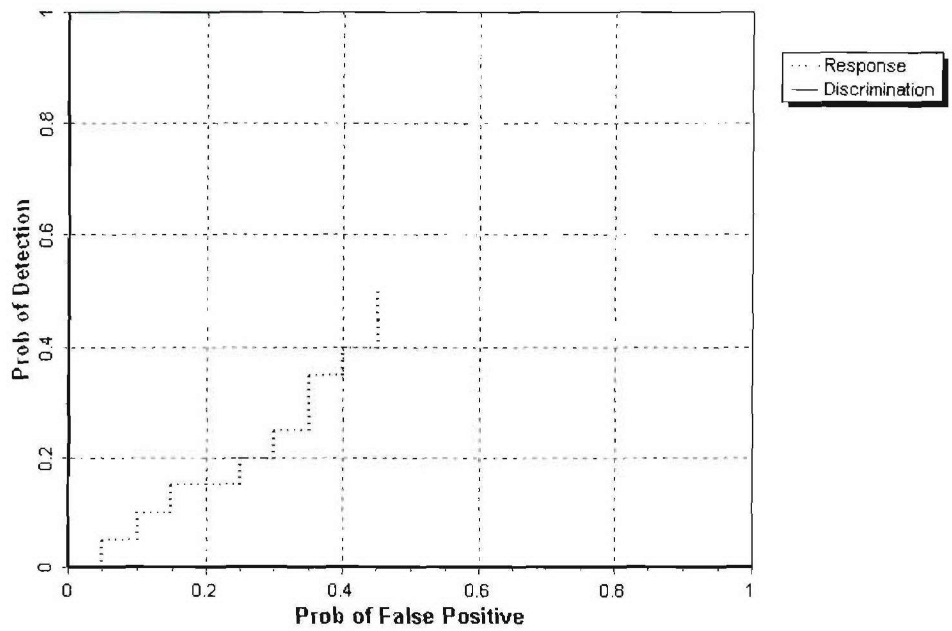

Figure 4. EM61/sling mogul probability of detection for response and discrimination stages versus their respective probability of false positive for all ordnance larger than 20 mm.

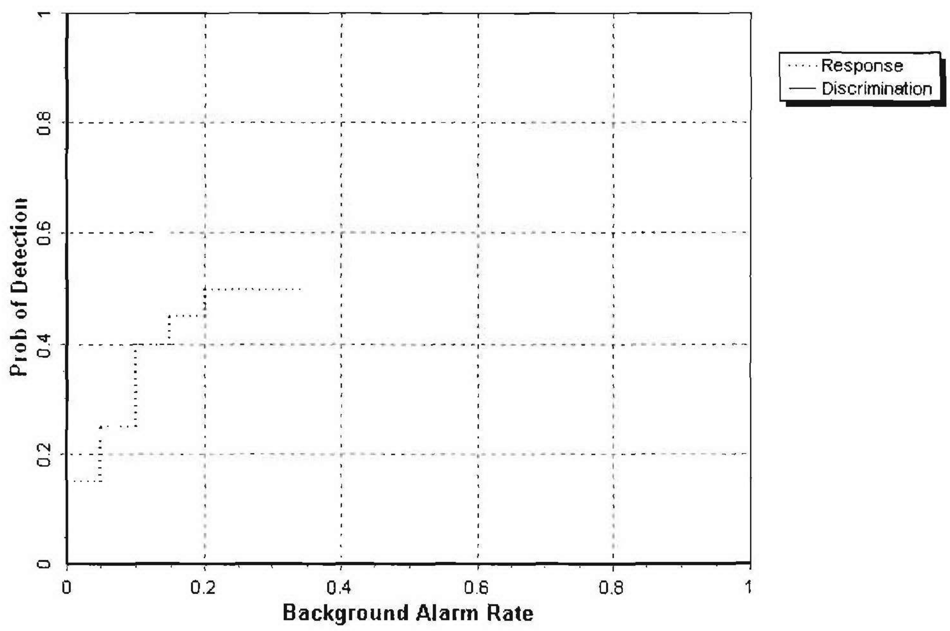

Figure 5. EM61/sling mogul probability of detection for response and discrimination stages versus their respective background alarm rate for all ordnance larger than 20 mm.

4.3 PERFORMANCE SUMMARIES

Results for the Mogul Area test broken out by size, depth and nonstandard ordnance are presented in Table 5 (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 app A for size definitions). The results are relative to the number of ordnance items emplaced. Depth is measured from the geometric center of anomalies.

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 P_{fp} was calculated assuming that the number of detections and false positives are binomially distributed random variables. All results in Table 5 have been rounded to protect the ground truth. However, lower confidence limits were calculated using actual results.

TABLE 5. SUMMARY OF MOGUL RESULTS FOR EM61/SLING

Metric	Overall	Standard	Nonstandard	By Size			By Depth, m		
				Small	Medium	Large	< 0.3	0.3 to <1	>= 1
RESPONSE STAGE									
P_d	0.45	0.50	0.40	0.45	0.45	0.60	0.55	0.50	0.15
P_d Low 90% Conf	0.42	0.45	0.33	0.37	0.39	0.43	0.48	0.40	0.05
P_d Upper 90% Conf	0.53	0.59	0.49	0.52	0.56	0.71	0.62	0.58	0.27
P_{fp}	0.45	-	-	-	-	-	0.50	0.45	0.20
P_{fp} Low 90% Conf	0.43	-	-	-	-	-	0.44	0.41	0.06
P_{fp} Upper 90% Conf	0.50	-	-	-	-	-	0.52	0.50	0.49
BAR	0.35	-	-	-	-	-	-	-	-
DISCRIMINATION STAGE									
P_d	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
P_d Low 90% Conf	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
P_d Upper 90% Conf	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
P_{fp}	N/A	-	-	-	-	-	N/A	N/A	N/A
P_{fp} Low 90% Conf	N/A	-	-	-	-	-	N/A	N/A	N/A
P_{fp} Upper 90% Conf	N/A	-	-	-	-	-	N/A	N/A	N/A
BAR	N/A	-	-	-	-	-	-	-	-

Response Stage Noise Level: 0.30
Recommended Discrimination Stage Threshold: 1.50

Note: The recommended discrimination stage threshold values are provided by the demonstrator.
No discrimination algorithm was applied; therefore, the discrimination stage results are not applicable.

4.4 EFFICIENCY, REJECTION RATES, AND TYPE CLASSIFICATION

The Demonstrator did not apply any discrimination algorithms; therefore, the following tables presented in this section are not applicable.

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 6.

TABLE 6. EFFICIENCY AND REJECTION RATES

	Efficiency (E)	False Positive Rejection Rate	Background Alarm Rejection Rate
At Operating Point	N/A	N/A	N/A
With No Loss of P_d	N/A	N/A	N/A

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 7). Correct type examples include "20-mm projectile, 105-mm HEAT Projectile, and 2.75-inch 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 7. CORRECT TYPE CLASSIFICATION OF TARGETS CORRECTLY DISCRIMINATED AS UXO

Size	Percentage Correct
Small	N/A
Medium	N/A
Large	N/A
Overall	N/A

4.5 LOCATION ACCURACY

The mean location error and standard deviations appear in Table 8. 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 8. MEAN LOCATION ERROR AND STANDARD DEVIATION (M)

	Mean	Standard Deviation
Northing	-0.08	0.21
Easting	-0.01	0.22
Depth	-0.04	0.24

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 9. 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 9. ON-SITE LABOR COSTS

	No. People	Hourly Wage	Hours	Cost
Initial Setup				
Supervisor	1	$95.00	4.25	$403.75
Data Analyst	1	57.00	4.25	242.25
Field Support	1	28.50	4.25	121.13
SubTotal				**$767.13**
Calibration				
Supervisor	1	$95.00	1.78	169.10
Data Analyst	1	57.00	1.78	101.46
Field Support	1	28.50	1.78	50.73
SubTotal				**$321.29**
Site Survey				
Supervisor	1	$95.00	5.33	$506.35
Data Analyst	1	57.00	5.33	303.81
Field Support	1	28.50	5.33	151.91
SubTotal				**$962.07**

See notes at end of table.

TABLE 9 (CONT'D)

	No. People	Hourly Wage	Hours	Cost
		Demobilization		
Supervisor	1	$95.00	2.58	$245.10
Data Analyst	1	57.00	2.58	147.06
Field Support	1	28.50	2.58	73.53
Subtotal				**$465.69**
Total				**$2,516.18**

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 OPEN FIELD DEMONSTRATION

No comparison was made due to demonstrator not surveying the Open Field with this particular system.

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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., non-ordnance item) buried by the government at a specified location in the test site.

R_{halo}: A pre-determined 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 meters in radius will be placed around the center of the object for all clutter and ordnance items less than 0.6 meters in length. When ordnance items are longer than 0.6 meters, 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-pound 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.

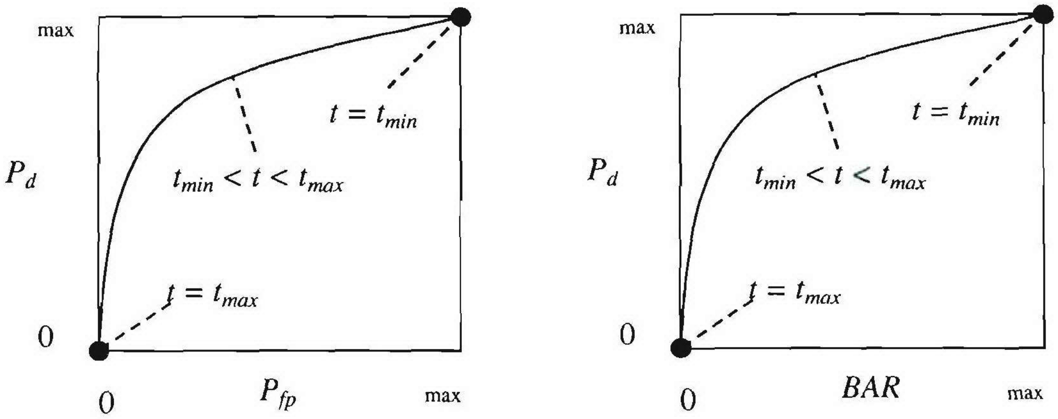

Figure A-1. ROC curves for open field testing. Each curve applies to both the response and discrimination stages.

[1]Strictly speaking, ROC curves plot the P_d versus P_{ba} over a pre-determined 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 tmin) 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 tmin). 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.

CHI-SQUARE COMPARISON EXPLANATION:

The Chi-square test for differences in probabilities (or 2 x 2 contingency table) is used to analyze two samples drawn from two different populations to see if both populations have the same or different proportions of elements in a certain category. More specifically, two random samples are drawn, one from each population, to test the null hypothesis that the probability of event A (some specified event) is the same for both populations (ref 3).

A 2 x 2 contingency table is used in the Standardized UXO Technology Demonstration Site Program to determine if there is reason to believe that the proportion of ordnance correctly detected/discriminated by demonstrator X's system is significantly degraded by the more challenging terrain feature introduced. The test statistic of the 2 x 2 contingency table is the

Chi-square distribution with one degree of freedom. Since an association between the more challenging terrain feature and relatively degraded performance is sought, a one-sided test is performed. A significance level of 0.05 is chosen which sets a critical decision limit of 2.71 from the Chi-square distribution with one degree of freedom. It is a critical decision limit because if the test statistic calculated from the data exceeds this value, the two proportions tested will be considered significantly different. If the test statistic calculated from the data is less than this value, the two proportions tested will be considered not significantly different.

An exception must be applied when either a 0 or 100 percent success rate occurs in the sample data. The Chi-square test cannot be used in these instances. Instead, Fischer's test is used and the critical decision limit for one-sided tests is the chosen significance level, which in this case is 0.05. With Fischer's test, if the test statistic is less than the critical value, the proportions are considered to be significantly different.

Standardized UXO Technology Demonstration Site examples, where blind grid results are compared to those from the open field and open field results are compared to those from one of the scenarios, follow. It should be noted that a significant result does not prove a cause and effect relationship exists between the two populations of interest; however, it does serve as a tool to indicate that one data set has experienced a degradation in system performance at a large enough level than can be accounted for merely by chance or random variation. Note also that a result that is not significant indicates that there is not enough evidence to declare that anything more than chance or random variation within the same population is at work between the two data sets being compared.

Demonstrator X achieves the following overall results after surveying each of the three progressively more difficult areas using the same system (results indicate the number of ordnance detected divided by the number of ordnance emplaced):

	Blind Grid	Open Field	Moguls
P_d^{res}	100/100 = 1.0	8/10 = .80	20/33 = .61
P_d^{disc}	80/100 = 0.80	6/10 = .60	8/33 = .24

P_d^{res}: BLIND GRID versus OPEN FIELD. Using the example data above to compare probabilities of detection in the response stage, all 100 ordnance out of 100 emplaced ordnance items were detected in the blind grid while 8 ordnance out of 10 emplaced were detected in the open field. Fischer's test must be used since a 100 percent success rate occurs in the data. Fischer's test uses the four input values to calculate a test statistic of 0.0075 that is compared against the critical value of 0.05. Since the test statistic is less than the critical value, the smaller response stage detection rate (0.80) is considered to be significantly less at the 0.05 level of significance. While a significant result does not prove a cause and effect relationship exists between the change in survey area and degradation in performance, it does indicate that the detection ability of demonstrator X's system seems to have been degraded in the open field relative to results from the blind grid using the same system.

P_d^{disc}: BLIND GRID versus OPEN FIELD. Using the example data above to compare probabilities of detection in the discrimination stage, 80 out of 100 emplaced ordnance items were correctly discriminated as ordnance in blind grid testing while 6 ordnance out of 10 emplaced were correctly discriminated as such in open field-testing. Those four values are used to calculate a test statistic of 1.12. Since the test statistic is less than the critical value of 2.71, the two discrimination stage detection rates are considered to be not significantly different at the 0.05 level of significance.

P_d^{res}: OPEN FIELD versus MOGULS. Using the example data above to compare probabilities of detection in the response stage, 8 out of 10 and 20 out of 33 are used to calculate a test statistic of 0.56. Since the test statistic is less than the critical value of 2.71, the two response stage detection rates are considered to be not significantly different at the 0.05 level of significance.

P_d^{disc}: OPEN FIELD versus MOGULS. Using the example data above to compare probabilities of detection in the discrimination stage, 6 out of 10 and 8 out of 33 are used to calculate a test statistic of 2.98. Since the test statistic is greater than the critical value of 2.71, the smaller discrimination stage detection rate is considered to be significantly less at the 0.05 level of significance. While a significant result does not prove a cause and effect relationship exists between the change in survey area and degradation in performance, it does indicate that the ability of demonstrator X to correctly discriminate seems to have been degraded by the mogul terrain relative to results from the flat open field using the same system.

APPENDIX B. DAILY WEATHER LOGS

TABLE B-1. WEATHER LOG

Weather Data from Phillips Airfield					
Date and Time	Average Temperature, °F	Maximum Temperature, °F	Minimum Temperature, °F	Relative Humidity, %	Total Precipitation, in.
11/03/2003 00:00:00	56.7	57.9	55.8	98.7	0
11/03/2003 01:00:00	55.4	56	54.8	98.9	0
11/03/2003 02:00:00	54.3	55	53.6	99.1	0
11/03/2003 03:00:00	54.4	55.1	53.5	99.3	0
11/03/2003 04:00:00	53.7	54.7	52.4	99.3	0
11/03/2003 05:00:00	52.7	53.4	51.7	99.4	0
11/03/2003 06:00:00	52.6	53.3	51.8	99.5	0
11/03/2003 07:00:00	51.7	52.4	51.1	99.5	0
11/03/2003 08:00:00	52.7	54.8	51.5	99.7	0
11/03/2003 09:00:00	58.4	61.4	54.6	99.8	0
11/03/2003 10:00:00	63.8	67.5	60.9	94.1	0
11/03/2003 11:00:00	70.6	73.3	67.2	74.86	0
11/03/2003 12:00:00	74.8	75.8	73	62.95	0
11/03/2003 13:00:00	76.4	77.8	75.3	55.86	0
11/03/2003 14:00:00	77.9	78.7	76.9	51.94	0
11/03/2003 15:00:00	78	78.4	77.6	51.56	0
11/03/2003 16:00:00	77.1	78.2	76	53.6	0
11/03/2003 17:00:00	74.3	76.5	71.7	58.49	0
11/03/2003 18:00:00	69.7	72	67	66.53	0
11/03/2003 19:00:00	65.4	67.3	62.3	76.28	0
11/03/2003 20:00:00	63.2	65.3	60.4	81.9	0
11/03/2003 21:00:00	62	63.6	60.4	85.5	0
11/03/2003 22:00:00	58.2	60.9	56.8	93.1	0
11/03/2003 23:00:00	56.8	58.7	55.5	96.1	0

TABLE B-1 (CONT'D)

Weather Data from Phillips Airfield					
Date and Time	Average Temperature, °F	Maximum Temperature, °F	Minimum Temperature, °F	Relative Humidity, %	Total Precipitation, in.
11/04/2003 00:00:00	56	57	54.8	97.9	0
11/04/2003 01:00:00	59.6	61.3	56.5	99.2	0
11/04/2003 02:00:00	58.7	61.3	56.9	99.2	0
11/04/2003 03:00:00	55.9	59.4	54.1	99.2	0
11/04/2003 04:00:00	55.5	56.6	54.2	99.6	0
11/04/2003 05:00:00	55.6	56.6	53.9	99.8	0
11/04/2003 06:00:00	55.8	56.3	55.4	99.8	0
11/04/2003 07:00:00	56.2	56.9	55.7	99.9	0
11/04/2003 08:00:00	58.7	60.8	56.5	100	0
11/04/2003 09:00:00	60.8	61.5	60.2	99.9	0
11/04/2003 10:00:00	61.9	63.6	60.9	99.9	0
11/04/2003 11:00:00	65.6	69	63.1	97.1	0
11/04/2003 12:00:00	69.4	70.9	68.5	82.6	0
11/04/2003 13:00:00	71.2	72.1	70.4	77.1	0
11/04/2003 14:00:00	75	77.3	71.3	61.89	0
11/04/2003 15:00:00	77	77.8	75.7	60.23	0
11/04/2003 16:00:00	75.5	77.3	73.6	66.87	0
11/04/2003 17:00:00	71.6	73.9	67.3	73.23	0
11/04/2003 18:00:00	67.5	68.5	66.1	82.3	0
11/04/2003 19:00:00	64.6	66.6	62.6	86.4	0
11/04/2003 20:00:00	62.4	63.1	61.6	90.9	0
11/04/2003 21:00:00	62.8	63.2	62.5	93	0
11/04/2003 22:00:00	62.3	63	61.5	96.4	0
11/04/2003 23:00:00	61.6	62	61.2	98.7	0

TABLE B-1 (CONT'D)

Weather Data from Phillips Airfield					
Date and Time	Average Temperature, °F	Maximum Temperature, °F	Minimum Temperature, °F	Relative Humidity, %	Total Precipitation, in.
11/05/2003 00:00:00	61.1	61.5	60.7	99.2	0
11/05/2003 01:00:00	60.9	61.4	60.4	99.5	0
11/05/2003 02:00:00	61	61.4	60.6	99.6	0
11/05/2003 03:00:00	61.3	61.6	60.9	99.6	0
11/05/2003 04:00:00	61.1	61.5	60.7	99.7	0
11/05/2003 05:00:00	60.7	61.3	60.3	99.7	0
11/05/2003 06:00:00	60.6	60.9	60.2	99.8	0
11/05/2003 07:00:00	60.6	61.2	60.1	99.8	0
11/05/2003 08:00:00	60.9	61.3	60.6	99.8	0
11/05/2003 09:00:00	61.4	62	60.8	99.9	0
11/05/2003 10:00:00	62.2	63	61.4	99.9	0
11/05/2003 11:00:00	62.9	64	62	99.9	0
11/05/2003 12:00:00	64.2	65.6	63.4	99.9	0
11/05/2003 13:00:00	67.7	69.6	65.5	99.8	0
11/05/2003 14:00:00	70.5	71.3	68.6	98.8	0
11/05/2003 15:00:00	72	73.3	70.9	93.2	0
11/05/2003 16:00:00	71.4	73.7	70	90.7	0
11/05/2003 17:00:00	69.8	70.2	69.1	94.1	0.02
11/05/2003 18:00:00	69.5	70.4	68.7	96.9	0.1
11/05/2003 19:00:00	69.2	70	68.7	97.9	0.05
11/05/2003 20:00:00	68.7	69.2	68.2	98.6	0.03
11/05/2003 21:00:00	68	68.6	67.2	99	0
11/05/2003 22:00:00	68.3	68.9	67.6	99.3	0
11/05/2003 23:00:00	68.9	69.3	68.4	99.2	0

TABLE B-1 (CONT'D)

Weather Data from Phillips Airfield					
Date and Time	Average Temperature, °F	Maximum Temperature, °F	Minimum Temperature, °F	Relative Humidity, %	Total Precipitation, in.
11/06/2003 00:00:00	68	68.7	67	99.2	0
11/06/2003 01:00:00	67.2	68.2	66.6	99.3	0.02
11/06/2003 02:00:00	66.8	67.2	66.5	99.4	0
11/06/2003 03:00:00	66.7	67	66.3	99.5	0
11/06/2003 04:00:00	66.4	66.8	66	99.5	0
11/06/2003 05:00:00	66.1	66.8	65.6	99.6	0
11/06/2003 06:00:00	65.8	66.2	65.3	99.7	0
11/06/2003 07:00:00	65.5	65.8	65	99.7	0
11/06/2003 08:00:00	64.5	65.4	64	99.8	0
11/06/2003 09:00:00	64.3	64.5	63.9	99.8	0.01
11/06/2003 10:00:00	64.4	64.7	64	99.6	0.03
11/06/2003 11:00:00	64.1	64.9	63.4	96.3	0
11/06/2003 12:00:00	63.5	63.9	63.2	96.2	0.02
11/06/2003 13:00:00	62.9	63.7	62.2	96.9	0.09
11/06/2003 14:00:00	62.4	62.8	62	96.9	0.04
11/06/2003 15:00:00	62	62.4	61.5	97	0.02
11/06/2003 16:00:00	62.4	62.7	62	96.6	0
11/06/2003 17:00:00	62.1	62.6	61.6	96.5	0.02
11/06/2003 18:00:00	61.6	62.1	61	97.1	0.06
11/06/2003 19:00:00	61	61.5	60.4	97.7	0.01
11/06/2003 20:00:00	60.5	60.8	60.1	97.4	0
11/06/2003 21:00:00	59.9	60.6	59.4	97.4	0
11/06/2003 22:00:00	59.6	60	59.4	97.8	0
11/06/2003 23:00:00	59.4	60	58.9	97.9	0

TABLE B-1 (CONT'D)

Weather Data from Phillips Airfield					
Date and Time	Average Temperature, °F	Maximum Temperature, °F	Minimum Temperature, °F	Relative Humidity, %	Total Precipitation, in.
11/07/2003 00:00:00	58.8	59.4	58.3	98.3	0.02
11/07/2003 01:00:00	58.6	58.9	58.3	98.5	0.01
11/07/2003 02:00:00	58.6	58.9	58.2	98.1	0
11/07/2003 03:00:00	58.3	58.8	57.9	97.9	0
11/07/2003 04:00:00	57.8	58.4	57.2	96.2	0
11/07/2003 05:00:00	57.4	57.7	57	95.8	0
11/07/2003 06:00:00	57	57.6	56.4	95.3	0
11/07/2003 07:00:00	56.3	56.9	55.7	88.2	0
11/07/2003 08:00:00	55.5	56	55.1	86.5	0
11/07/2003 09:00:00	55.3	55.8	55	82.8	0
11/07/2003 10:00:00	55.6	56.3	55	79.4	0
11/07/2003 11:00:00	55.8	57.7	54.7	76.8	0
11/07/2003 12:00:00	57.3	58.4	55.5	68.16	0
11/07/2003 13:00:00	58.6	60.2	57.6	56.83	0
11/07/2003 14:00:00	59.5	60.9	58.5	48.84	0
11/07/2003 15:00:00	60.1	61	59	44.86	0
11/07/2003 16:00:00	58.3	59.7	57.5	46.07	0
11/07/2003 17:00:00	56.6	57.8	54.3	53.22	0
11/07/2003 18:00:00	52.1	54.6	49.7	67.05	0
11/07/2003 19:00:00	49.8	52	48	73.88	0
11/07/2003 20:00:00	49.4	50.2	48.2	75.81	0
11/07/2003 21:00:00	51	52.5	48.9	64.81	0
11/07/2003 22:00:00	52.2	53	51.3	53.84	0
11/07/2003 23:00:00	51.5	53	49.2	48.53	0

TABLE B-1 (CONT'D)

Weather Data from Phillips Airfield					
Date and Time	Average Temperature, °F	Maximum Temperature, °F	Minimum Temperature, °F	Relative Humidity, %	Total Precipitation, in.
11/08/2003 00:00:00	49.5	50.2	48.6	56.35	0
11/08/2003 01:00:00	50.3	50.8	49.6	50.08	0
11/08/2003 02:00:00	50	50.9	48.6	37.29	0
11/08/2003 03:00:00	47.6	49.1	46.7	38.99	0
11/08/2003 04:00:00	45.8	47	44.5	42.26	0
11/08/2003 05:00:00	42.6	44.7	41	52.06	0
11/08/2003 06:00:00	41.7	42.4	40.5	54.25	0
11/08/2003 07:00:00	40.2	41.8	38.6	60.22	0
11/08/2003 08:00:00	42.2	44.4	39.8	58.77	0
11/08/2003 09:00:00	46	47.7	44.1	50.81	0
11/08/2003 10:00:00	47.6	48.4	47	46.72	0
11/08/2003 11:00:00	48.7	49.6	47.9	44.69	0
11/08/2003 12:00:00	48.8	50.4	46.9	46.64	0
11/08/2003 13:00:00	47.6	48.7	46.5	47.39	0
11/08/2003 14:00:00	46.8	47.6	46	44.97	0
11/08/2003 15:00:00	45.9	47.3	45	41.94	0
11/08/2003 16:00:00	44.9	45.6	43.8	37.58	0
11/08/2003 17:00:00	42.9	44.3	41	38.61	0
11/08/2003 18:00:00	40.5	41.3	39.4	41.07	0
11/08/2003 19:00:00	39.3	39.9	38.8	43	0
11/08/2003 20:00:00	38.9	39.3	38.4	42.13	0
11/08/2003 21:00:00	38.4	38.8	37.9	40.23	0
11/08/2003 22:00:00	38.1	38.5	37.6	37.94	0
11/08/2003 23:00:00	37.8	38.2	37.3	37.31	0

TABLE B-1 (CONT'D)

Weather Data from Phillips Airfield					
Date and Time	Average Temperature, °F	Maximum Temperature, °F	Minimum Temperature, °F	Relative Humidity, %	Total Precipitation, in.
11/09/2003 00:00:00	37.4	37.8	36.7	37.18	0
11/09/2003 01:00:00	36.4	37.3	35.2	37.59	0
11/09/2003 02:00:00	34.7	35.5	34	41.03	0
11/09/2003 03:00:00	33.6	34.4	32.6	43.24	0
11/09/2003 04:00:00	32.2	33.1	31.4	46.99	0
11/09/2003 05:00:00	31.2	32	30.7	50.54	0
11/09/2003 06:00:00	30.4	31.1	29.6	53.81	0
11/09/2003 07:00:00	29.8	30.2	29.4	56.49	0
11/09/2003 08:00:00	31.7	33.8	29.6	54.91	0
11/09/2003 09:00:00	35.1	36.7	33.4	46.47	0
11/09/2003 10:00:00	37.9	39	36.4	42.15	0
11/09/2003 11:00:00	39.5	40.5	38.5	39.16	0
11/09/2003 12:00:00	41.2	42.4	39.9	34.3	0
11/09/2003 13:00:00	43.3	45.3	41.7	30.22	0
11/09/2003 14:00:00	44.6	45.8	43.1	26.02	0
11/09/2003 15:00:00	45.6	46.7	44.4	23.61	0
11/09/2003 16:00:00	44.2	45.6	43.5	24.34	0
11/09/2003 17:00:00	42	43.7	40.7	24.2	0
11/09/2003 18:00:00	38.2	41	36.3	29.51	0
11/09/2003 19:00:00	34.4	36.6	32.8	40.71	0
11/09/2003 20:00:00	31.2	33.3	29.5	64.51	0
11/09/2003 21:00:00	29.5	30.1	28.6	74.18	0
11/09/2003 22:00:00	28.4	29.2	27.4	81	0
11/09/2003 23:00:00	28.7	31.3	27	73.32	0

TABLE B-1 (CONT'D)

Weather Data from Phillips Airfield					
Date and Time	Average Temperature, °F	Maximum Temperature, °F	Minimum Temperature, °F	Relative Humidity, %	Total Precipitation, in.
11/10/2003 00:00:00	27.8	28.8	27	80.6	0
11/10/2003 01:00:00	26.8	27.8	25.8	88.3	0
11/10/2003 02:00:00	25.8	26.5	25.1	91.7	0
11/10/2003 03:00:00	25.2	25.8	24.6	90.4	0
11/10/2003 04:00:00	24.7	25.2	24.1	93.2	0
11/10/2003 05:00:00	24.5	25.2	23.9	94.6	0
11/10/2003 06:00:00	23.8	24.5	23.2	95.9	0
11/10/2003 07:00:00	23.5	24.1	22.9	96.3	0
11/10/2003 08:00:00	28.3	31.3	24	90.7	0
11/10/2003 09:00:00	36.9	41.2	31.1	80.7	0
11/10/2003 10:00:00	42	44.5	39.6	62.2	0
11/10/2003 11:00:00	45	46.2	43.8	37.03	0
11/10/2003 12:00:00	46.7	47.9	45.6	36.82	0
11/10/2003 13:00:00	47.8	48.6	46.8	38.44	0
11/10/2003 14:00:00	48.5	49.2	47.8	34.04	0
11/10/2003 15:00:00	48.9	49.3	48.4	34.51	0
11/10/2003 16:00:00	48.6	49.1	48	36.98	0
11/10/2003 17:00:00	46.3	48.4	44.3	42.5	0
11/10/2003 18:00:00	42.9	44.6	40	48.62	0
11/10/2003 19:00:00	39.2	41.6	37.4	61.7	0
11/10/2003 20:00:00	36.3	37.5	35	75.53	0
11/10/2003 21:00:00	35.3	36.1	34.6	79.26	0
11/10/2003 22:00:00	34.6	35.4	33.7	84.7	0
11/10/2003 23:00:00	34.4	35.9	33.3	85.7	0

TABLE B-1 (CONT'D)

Weather Data from Phillips Airfield					
Date and Time	Average Temperature, °F	Maximum Temperature, °F	Minimum Temperature, °F	Relative Humidity, %	Total Precipitation, in.
11/11/2003 00:00:00	35.1	36.1	33.8	89	0
11/11/2003 01:00:00	34.3	35.1	33.3	92.2	0
11/11/2003 02:00:00	33.6	34.6	32.8	95.3	0
11/11/2003 03:00:00	34	36.8	32.9	93.4	0
11/11/2003 04:00:00	33.6	34.9	32.7	96.9	0
11/11/2003 05:00:00	34.5	35.9	32.7	97.3	0
11/11/2003 06:00:00	34	35.5	32.8	98.1	0
11/11/2003 07:00:00	34.4	37.5	32.6	99.1	0
11/11/2003 08:00:00	39.8	45	36.7	93.3	0
11/11/2003 09:00:00	47.5	49.5	44.6	81.1	0
11/11/2003 10:00:00	51.7	53.2	49.3	80.2	0
11/11/2003 11:00:00	53.3	54.6	52.2	80.1	0
11/11/2003 12:00:00	54.8	55.4	54.2	80.4	0
11/11/2003 13:00:00	55.9	56.5	55.1	77.78	0
11/11/2003 14:00:00	56.2	57.7	54.8	78.04	0
11/11/2003 15:00:00	57.3	58.1	56.7	72.77	0
11/11/2003 16:00:00	56.8	57.2	56.5	71.21	0
11/11/2003 17:00:00	56.6	57.1	55.9	74.34	0
11/11/2003 18:00:00	56.5	57.1	55.8	76.62	0
11/11/2003 19:00:00	55.8	56.4	55.3	80.4	0
11/11/2003 20:00:00	54.8	55.8	53.6	84.9	0
11/11/2003 21:00:00	53.6	54.3	53	92.1	0
11/11/2003 22:00:00	53.1	53.6	52.6	94.4	0
11/11/2003 23:00:00	53.1	53.9	52.1	92	0

TABLE B-1 (CONT'D)

Weather Data from Phillips Airfield					
Date and Time	Average Temperature, °F	Maximum Temperature, °F	Minimum Temperature, °F	Relative Humidity, %	Total Precipitation, in.
11/12/2003 00:00:00	52.6	52.9	52.2	94.8	0
11/12/2003 01:00:00	52.5	52.9	52.2	95.6	0.03
11/12/2003 02:00:00	52.6	52.9	52.2	97.7	0.04
11/12/2003 03:00:00	52.7	53	52.3	98.3	0.07
11/12/2003 04:00:00	52.7	52.9	52.2	98.7	0.02
11/12/2003 05:00:00	52.9	53.2	52.4	99.1	0.2
11/12/2003 06:00:00	52.9	53.2	52.6	99.3	0.13
11/12/2003 07:00:00	52.8	53	52.4	99.4	0.07
11/12/2003 08:00:00	52.8	53.2	52.6	99.5	0.09
11/12/2003 09:00:00	53.1	53.4	52.7	99.6	0.01
11/12/2003 10:00:00	53.6	54.2	52.9	99.5	0
11/12/2003 11:00:00	54.6	55.2	53.6	98.7	0
11/12/2003 12:00:00	54.8	55.5	54.1	97.5	0
11/12/2003 13:00:00	55.8	56.3	55	95.1	0
11/12/2003 14:00:00	56	56.5	55.8	94.9	0
11/12/2003 15:00:00	55.8	56.2	55.4	96.8	0
11/12/2003 16:00:00	55.9	56.5	55.4	97.1	0
11/12/2003 17:00:00	55.8	56.6	55.2	96.7	0
11/12/2003 18:00:00	55.4	55.7	55.1	98.2	0
11/12/2003 19:00:00	55.7	56	55.3	98.2	0
11/12/2003 20:00:00	55.7	56	55.3	98	0
11/12/2003 21:00:00	55.5	55.8	55.2	98.1	0
11/12/2003 22:00:00	56.2	57.7	55.2	98.5	0
11/12/2003 23:00:00	58.8	60	57.5	97.7	0.02

TABLE B-1 (CONT'D)

Weather Data from Phillips Airfield					
Date and Time	Average Temperature, °F	Maximum Temperature, °F	Minimum Temperature, °F	Relative Humidity, %	Total Precipitation, in.
11/13/2003 00:00:00	60.3	60.8	59.5	97.5	0
11/13/2003 01:00:00	60.9	61.4	60.4	97.5	0
11/13/2003 02:00:00	60.6	61	60.1	97.4	0
11/13/2003 03:00:00	60.3	60.8	60	97.2	0
11/13/2003 04:00:00	59.9	61.8	58.8	92.4	0
11/13/2003 05:00:00	61	62	59.6	54.85	0
11/13/2003 06:00:00	57.9	60.1	55.5	39	0
11/13/2003 07:00:00	52.6	55.7	49.9	43.56	0
11/13/2003 08:00:00	49.5	50.2	48.4	50.59	0
11/13/2003 09:00:00	49.4	50.8	48.4	45.75	0
11/13/2003 10:00:00	48.8	49.5	47.7	46.31	0
11/13/2003 11:00:00	48.9	49.5	48.1	43.07	0
11/13/2003 12:00:00	48.5	49.6	47.6	32.95	0
11/13/2003 13:00:00	49.2	50.4	47.4	29.37	0
11/13/2003 14:00:00	47.4	49.7	45.7	35.59	0
11/13/2003 15:00:00	46.3	47.2	45	36.44	0
11/13/2003 16:00:00	44.6	45.4	43.7	39.58	0
11/13/2003 17:00:00	43.3	44.1	42.2	43.6	0
11/13/2003 18:00:00	42.3	43	41.7	44.66	0
11/13/2003 19:00:00	41.8	42.5	41.2	46.95	0
11/13/2003 20:00:00	41.7	42.1	41.2	46.6	0
11/13/2003 21:00:00	41.6	42.2	41.3	43.61	0
11/13/2003 22:00:00	41.8	42.2	41.5	40.58	0
11/13/2003 23:00:00	41.6	42.1	41.2	40.44	0

APPENDIX C. SOIL MOISTURE

Daily Soil Moisture Logs

Demonstrator: TtFW
Date: 3 November 2003
Times: No AM Readings, 1300 hours (PM)

Probe Location	Layer, in.	AM Reading, %	PM Reading, %
Wet Area	0 to 6	No Readings Taken	No Readings Taken
	6 to 12		
	12 to 24		
	24 to 36		
	36 to 48		
Wooded Area	0 to 6	No Readings Taken	No Readings Taken
	6 to 12		
	12 to 24		
	24 to 36		
	36 to 48		
Open Area	0 to 6	No Readings Taken	No Readings Taken
	6 to 12		
	12 to 24		
	24 to 36		
	36 to 48		
Calibration Lanes	0 to 6	No Readings Taken	38.7
	6 to 12		36.9
	12 to 24		8.4
	24 to 36		5.1
	36 to 48		5.3
Blind Grid/Moguls	0 to 6	No Readings Taken	2.5
	6 to 12		15.2
	12 to 24		37.1
	24 to 36		36.8
	36 to 48		38.4

Daily Soil Moisture Logs

Demonstrator: TtFW
Date: 4 November 2003
Times: No AM Readings, 1245 hours (PM)

Probe Location	Layer, in.	AM Reading, %	PM Reading, %
Wet Area	0 to 6	No Readings Taken	No Readings Taken
	6 to 12		
	12 to 24		
	24 to 36		
	36 to 48		
Wooded Area	0 to 6	No Readings Taken	No Readings Taken
	6 to 12		
	12 to 24		
	24 to 36		
	36 to 48		
Open Area	0 to 6	No Readings Taken	23.9
	6 to 12		3.0
	12 to 24		20.0
	24 to 36		21.9
	36 to 48		38.6
Calibration Lanes	0 to 6	No Readings Taken	No Readings Taken
	6 to 12		
	12 to 24		
	24 to 36		
	36 to 48		
Blind Grid/Moguls	0 to 6	No Readings Taken	No Readings Taken
	6 to 12		
	12 to 24		
	24 to 36		
	36 to 48		

Daily Soil Moisture Logs

Demonstrator: TtFW
Date: 5 November 2003
Times: 1130 hours (AM), 1400 hours (PM)

Probe Location	Layer, in.	AM Reading, %	PM Reading, %
Wet Area	0 to 6	No Readings Taken	No Readings Taken
	6 to 12		
	12 to 24		
	24 to 36		
	36 to 48		
Wooded Area	0 to 6	No Readings Taken	No Readings Taken
	6 to 12		
	12 to 24		
	24 to 36		
	36 to 48		
Open Area	0 to 6	13.7	13.6
	6 to 12	1.1	1.5
	12 to 24	16.0	15.8
	24 to 36	20.0	20.9
	36 to 48	27.9	28.5
Calibration Lanes	0 to 6	11.1	No Readings Taken
	6 to 12	37.7	
	12 to 24	7.8	
	24 to 36	4.5	
	36 to 48	4.6	
Blind Grid/Moguls	0 to 6	2.2	No Readings Taken
	6 to 12	14.5	
	12 to 24	36.4	
	24 to 36	36.3	
	36 to 48	38.1	

Daily Soil Moisture Logs

Demonstrator: TtFW

Date: 6 November 2003

Times: 0900 hours (AM), 1400 hours (PM)

Probe Location	Layer, in.	AM Reading, %	PM Reading, %
Wet Area	0 to 6	88.3	89.7
	6 to 12	77.3	77.7
	12 to 24	69.3	69.9
	24 to 36	52.1	52.8
	36 to 48	49.1	49.2
Wooded Area	0 to 6	No Readings Taken	No Readings Taken
	6 to 12		
	12 to 24		
	24 to 36		
	36 to 48		
Open Area	0 to 6	21.2	21.7
	6 to 12	1.5	1.7
	12 to 24	38.8	38.1
	24 to 36	59.1	59.3
	36 to 48	54.7	54.6
Calibration Lanes	0 to 6	No Readings Taken	No Readings Taken
	6 to 12		
	12 to 24		
	24 to 36		
	36 to 48		
Blind Grid/Moguls	0 to 6	No Readings Taken	No Readings Taken
	6 to 12		
	12 to 24		
	24 to 36		
	36 to 48		

Daily Soil Moisture Logs

Demonstrator: TtFW
Date: 7 November 2003
Times: 0815 hours (AM), 1500 hours (PM)

Probe Location	Layer, in.	AM Reading, %	PM Reading, %
Wet Area	0 to 6	90.3	89.2
	6 to 12	76.8	76.1
	12 to 24	70.9	72.1
	24 to 36	53.2	53.8
	36 to 48	49.5	49.7
Wooded Area	0 to 6	No Readings Taken	No Readings Taken
	6 to 12		
	12 to 24		
	24 to 36		
	36 to 48		
Open Area	0 to 6	21.0	21.8
	6 to 12	1.0	0.8
	12 to 24	39.2	40.1
	24 to 36	58.2	58.7
	36 to 48	54.7	55.3
Calibration Lanes	0 to 6	No Readings Taken	No Readings Taken
	6 to 12		
	12 to 24		
	24 to 36		
	36 to 48		
Blind Grid/Moguls	0 to 6	No Readings Taken	No Readings Taken
	6 to 12		
	12 to 24		
	24 to 36		
	36 to 48		

Daily Soil Moisture Logs

Demonstrator: TtFW
Date: 10 November 2003
Times: 0800 hours (AM), 1310 hours (PM)

Probe Location	Layer, in.	AM Reading, %	PM Reading, %
Wet Area	0 to 6	82.9	82.4
	6 to 12	82.7	82.1
	12 to 24	75.1	75.3
	24 to 36	55.1	55.5
	36 to 48	51.3	51.0
Wooded Area	0 to 6	No Readings Taken	No Readings Taken
	6 to 12		
	12 to 24		
	24 to 36		
	36 to 48		
Open Area	0 to 6	20.4	20.2
	6 to 12	2.6	3.0
	12 to 24	17.3	16.9
	24 to 36	17.2	16.9
	36 to 48	34.3	34.1
Calibration Lanes	0 to 6	No Readings Taken	No Readings Taken
	6 to 12		
	12 to 24		
	24 to 36		
	36 to 48		
Blind Grid/Moguls	0 to 6	No Readings Taken	No Readings Taken
	6 to 12		
	12 to 24		
	24 to 36		
	36 to 48		

Daily Soil Moisture Logs

Demonstrator: TtFW
Date: 11 November 2003
Times: 0900 hours (AM), 1400 hours (PM)

Probe Location	Layer, in.	AM Reading, %	PM Reading, %
Wet Area	0 to 6	82.4	81.8
	6 to 12	82.2	82.7
	12 to 24	74.5	73.9
	24 to 36	54.4	55.2
	36 to 48	50.6	51.3
Wooded Area	0 to 6	76	No Readings Taken
	6 to 12	65.6	
	12 to 24	92.7	
	24 to 36	65.1	
	36 to 48	57.5	
Open Area	0 to 6	20.8	20.1
	6 to 12	2.8	2.6
	12 to 24	16.8	17.3
	24 to 36	16.9	17.1
	36 to 48	33.7	34.8
Calibration Lanes	0 to 6	No Readings Taken	No Readings Taken
	6 to 12		
	12 to 24		
	24 to 36		
	36 to 48		
Blind Grid/Moguls	0 to 6	No Readings Taken	2.3
	6 to 12		33.7
	12 to 24		35.8
	24 to 36		36.0
	36 to 48		38.1

Daily Soil Moisture Logs

Demonstrator: TtFW
Date: 12 November 2003
Times: 1000 hours (AM), No PM Readings

Probe Location	Layer, in.	AM Reading, %	PM Reading, %
Wet Area	0 to 6	No Readings Taken	No Readings Taken
	6 to 12		
	12 to 24		
	24 to 36		
	36 to 48		
Wooded Area	0 to 6	74.2	No Readings Taken
	6 to 12	78.5	
	12 to 24	91.2	
	24 to 36	64.8	
	36 to 48	58.0	
Open Area	0 to 6	No Readings Taken	No Readings Taken
	6 to 12		
	12 to 24		
	24 to 36		
	36 to 48		
Calibration Lanes	0 to 6	No Readings Taken	No Readings Taken
	6 to 12		
	12 to 24		
	24 to 36		
	36 to 48		
Blind Grid/Moguls	0 to 6	2.4	No Readings Taken
	6 to 12	34.8	
	12 to 24	37.3	
	24 to 36	36.6	
	36 to 48	38.5	

Daily Soil Moisture Logs

Demonstrator: TtFW
Date: 13 November 2003
Times: 1100 hours (AM), 1400 hours (PM)

Probe Location:	Layer, in.	AM Reading, %	PM Reading, %
Wet Area	0 to 6	No Readings Taken	No Readings Taken
	6 to 12		
	12 to 24		
	24 to 36		
	36 to 48		
Wooded Area	0 to 6	90.3	90.1
	6 to 12	64.8	65.3
	12 to 24	93.7	93.6
	24 to 36	67.7	67.8
	36 to 48	63.7	63.9
Open Area	0 to 6	No Readings Taken	No Readings Taken
	6 to 12		
	12 to 24		
	24 to 36		
	36 to 48		
Calibration Lanes	0 to 6	No Readings Taken	No Readings Taken
	6 to 12		
	12 to 24		
	24 to 36		
	36 to 48		
Blind Grid/Moguls	0 to 6	No Readings Taken	No Readings Taken
	6 to 12		
	12 to 24		
	24 to 36		
	36 to 48		

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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	
						RTS						
11/3/2003	3	CALIBRATION LANE	0915	1330	255	INITIAL SET UP	INITIAL SET UP	LASER	NA	LINEAR	SUNNY	MUDDY
11/3/2003	3	CALIBRATION LANE	1330	1335	5	CALIBRATE	CALIBRATE USING METAL ROD	LASER	NA	LINEAR	SUNNY	MUDDY
11/3/2003	3	CALIBRATION LANE	1335	1425	50	COLLECT DATA	COLLECT DATA	LASER	NA	LINEAR	SUNNY	MUDDY
11/3/2003	3	CALIBRATION LANE	1425	1426	1	CALIBRATE	CALIBRATE USING METAL ROD	LASER	NA	LINEAR	SUNNY	MUDDY
11/3/2003	3	CALIBRATION LANE	1426	1430	4	COLLECT DATA	COLLECT DATA	LASER	NA	LINEAR	SUNNY	MUDDY
11/3/2003	3	CALIBRATION LANE	1430	1435	5	DOWNTIME/MAINTENANCE CHECK	CHANGE BATTERY	LASER	NA	LINEAR	SUNNY	MUDDY
11/3/2003	3	CALIBRATION LANE	1435	1436	1	CALIBRATE	CALIBRATE USING METAL ROD	LASER	NA	LINEAR	SUNNY	MUDDY
11/3/2003	3	CALIBRATION LANE	1436	1455	19	COLLECT DATA	COLLECT DATA	LASER	NA	LINEAR	SUNNY	MUDDY
11/3/2003	3	CALIBRATION LANE	1455	1456	1	CALIBRATE	CALIBRATE USING METAL ROD	LASER	NA	LINEAR	SUNNY	MUDDY
11/3/2003	3	CALIBRATION LANE	1456	1457	1	COLLECT DATA	COLLECT DATA	LASER	NA	LINEAR	SUNNY	MUDDY
11/3/2003	3	CALIBRATION LANE	1457	1507	10	BREAK/LUNCH	BREAK/LUNCH	LASER	NA	LINEAR	SUNNY	MUDDY
11/3/2003	3	BLIND TEST GRID	1507	1512	5	CALIBRATE	CALIBRATE USING METAL ROD	LASER	NA	LINEAR	SUNNY	MUDDY
11/3/2003	3	BLIND TEST GRID	1512	1612	60	COLLECT DATA	COLLECT DATA	LASER	NA	LINEAR	SUNNY	MUDDY
11/3/2003	3	BLIND TEST GRID	1612	1613	1	CALIBRATE	CALIBRATE USING METAL ROD	LASER	NA	LINEAR	SUNNY	MUDDY
11/3/2003	3	BLIND TEST GRID	1613	1635	22	DAILY START/STOP	EQUIPMENT BREAKDOWN END OF DAILY OPERATIONS	LASER	NA	LINEAR	SUNNY	MUDDY
11/4/2003	3	OPEN FIELD	1300	1350	50	COLLECT DATA	COLLECT DATA	LASER	NA	LINEAR	SUNNY	MUDDY
11/4/2003	3	OPEN FIELD	1350	1405	15	EQUIPMENT FAILURE	PVC ON CART FELL APART, GLUED BACK TOGETHER	LASER	NA	LINEAR	SUNNY	MUDDY
11/4/2003	3	OPEN FIELD	1405	1420	15	BREAK/LUNCH	BREAK/LUNCH	LASER	NA	LINEAR	SUNNY	MUDDY
11/4/2003	3	OPEN FIELD	1420	1600	100	COLLECT DATA	COLLECT DATA	LASER	NA	LINEAR	SUNNY	MUDDY
11/4/2003	1	OPEN FIELD	1600	1630	30	DAILY START/STOP	EQUIPMENT BREAKDOWN END OF DAILY OPERATIONS	LASER	NA	LINEAR	SUNNY	MUDDY

Note: Activities pertinent to this specific demonstration are indicated in highlighted text.

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	
11/5/2003	1	OPEN FIELD	1000	1230	150	COLLECT DATA	COLLECT DATA	LASER	NA	LINEAR	SUNNY	MUDDY
11/5/2003	1	OPEN FIELD	1230	1250	20	DOWNTIME/MAINTENANCE CHECK	CHANGE BATTERY	LASER	NA	LINEAR	SUNNY	MUDDY
11/5/2003	1	OPEN FIELD	1250	1320	30	COLLECT DATA	COLLECT DATA	LASER	NA	LINEAR	SUNNY	MUDDY
11/5/2003	1	OPEN FIELD	1320	1340	20	DAILY START/STOP	SET UP PIN FLAGS AND TAPES	LASER	NA	LINEAR	SUNNY	MUDDY
11/5/2003	1	OPEN FIELD	1340	1410	30	COLLECT DATA	COLLECT DATA	LASER	NA	LINEAR	SUNNY	MUDDY
11/5/2003	1	OPEN FIELD	1410	1430	20	BREAK/LUNCH	BREAK/LUNCH	LASER	NA	LINEAR	SUNNY	MUDDY
11/5/2003	1	OPEN FIELD	1430	1450	20	DAILY START/STOP	SET UP PIN FLAGS AND TAPES	LASER	NA	LINEAR	SUNNY	MUDDY
11/5/2003	1	OPEN FIELD	1450	1520	30	DOWNTIME/MAINTENANCE CHECK	DATA CHECK	LASER	NA	LINEAR	SUNNY	MUDDY
11/5/2003	1	OPEN FIELD	1520	1605	45	COLLECT DATA	COLLECT DATA	LASER	NA	LINEAR	SUNNY	MUDDY
11/5/2003	1	OPEN FIELD	1605	1608	3	CALIBRATE	CALIBRATE USING METAL ROD	LASER	NA	LINEAR	SUNNY	MUDDY
11/5/2003	1	OPEN FIELD	1608	1625	17	DAILY START/STOP	EQUIPMENT BREAKDOWN END OF DAILY OPERATIONS	LASER	NA	LINEAR	SUNNY	MUDDY
11/6/2003	1	OPEN FIELD	0730	0840	70	DAILY START/STOP	START OF DAILY OPERATIONS	LASER	NA	LINEAR	RAINY	MUDDY
11/6/2003	1	OPEN FIELD	0840	0845	5	CALIBRATE	CALIBRATE USING METAL ROD	LASER	NA	LINEAR	RAINY	MUDDY
11/6/2003	1	OPEN FIELD	0845	0930	45	COLLECT DATA	COLLECT DATA	LASER	NA	LINEAR	RAINY	MUDDY
11/6/2003	1	OPEN FIELD	0930	0935	5	CALIBRATE	CALIBRATE USING METAL ROD	LASER	NA	LINEAR	RAINY	MUDDY
11/6/2003	1	OPEN FIELD	0935	0950	15	BREAK/LUNCH	BREAK/LUNCH	LASER	NA	LINEAR	RAINY	MUDDY
11/6/2003	1	OPEN FIELD	0950	1030	40	DAILY START/STOP	SET UP PIN FLAGS AND TAPES	LASER	NA	LINEAR	RAINY	MUDDY
11/6/2003	1	OPEN FIELD	1030	1100	30	BREAK/LUNCH	BREAK/LUNCH	LASER	NA	LINEAR	RAINY	MUDDY
11/6/2003	1	OPEN FIELD	1100	1120	20	DOWNTIME/MAINTENANCE CHECK	CHANGE BATTERY	LASER	NA	LINEAR	RAINY	MUDDY
11/6/2003	1	OPEN FIELD	1120	1125	5	CALIBRATE	CALIBRATE USING METAL ROD	LASER	NA	LINEAR	RAINY	MUDDY
11/6/2003	1	OPEN FIELD	1125	1145	20	COLLECT DATA	COLLECT DATA	LASER	NA	LINEAR	RAINY	MUDDY
11/6/2003	1	OPEN FIELD	1145	1235	50	COLLECT DATA	COLLECT DATA	LASER	NA	LINEAR	RAINY	MUDDY
11/6/2003	1	OPEN FIELD	1235	1305	30	BREAK/LUNCH	BREAK/LUNCH	LASER	NA	LINEAR	RAINY	MUDDY
11/6/2003	1	OPEN FIELD	1305	1310	5	CALIBRATE	CALIBRATE USING METAL ROD	LASER	NA	LINEAR	RAINY	MUDDY
11/6/2003	1	OPEN FIELD	1310	1415	65	COLLECT DATA	COLLECT DATA	LASER	NA	LINEAR	RAINY	MUDDY
11/6/2003	1	OPEN FIELD	1415	1455	40	DAILY START/STOP	EQUIPMENT BREAKDOWN END OF DAILY OPERATIONS	LASER	NA	LINEAR	RAINY	MUDDY
11/7/2003	1	OPEN FIELD	0745	0910	85	DAILY START/STOP	START OF DAILY OPERATIONS	LASER	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	
11/7/2003	1	OPEN FIELD	0910	0912	2	CALIBRATE	CALIBRATE USING METAL ROD	LASER	NA	LINEAR	CLOUDY	MUDDY
11/7/2003	1	OPEN FIELD	0912	1030	78	COLLECT DATA	COLLECT DATA	LASER	NA	LINEAR	CLOUDY	MUDDY
11/7/2003	1	OPEN FIELD	1030	1045	15	BREAK/LUNCH	BREAK/LUNCH	LASER	NA	LINEAR	CLOUDY	MUDDY
11/7/2003	1	OPEN FIELD	1045	1105	20	DAILY START/STOP	SET UP PIN FLAGS AND TAPES	LASER	NA	LINEAR	CLOUDY	MUDDY
11/7/2003	1	OPEN FIELD	1105	1108	3	CALIBRATE	CALIBRATE USING METAL ROD	LASER	NA	LINEAR	CLOUDY	MUDDY
11/7/2003	1	OPEN FIELD	1108	1210	62	COLLECT DATA	COLLECT DATA	LASER	NA	LINEAR	CLOUDY	MUDDY
11/7/2003	1	OPEN FIELD	1210	1225	15	BREAK/LUNCH	BREAK/LUNCH	LASER	NA	LINEAR	CLOUDY	MUDDY
11/7/2003	1	OPEN FIELD	1225	1400	95	DAILY START/STOP	SET UP PIN FLAGS AND TAPES	LASER	NA	LINEAR	CLOUDY	MUDDY
11/7/2003	1	OPEN FIELD	1400	1406	6	CALIBRATE	CALIBRATE USING METAL ROD	LASER	NA	LINEAR	CLOUDY	MUDDY
11/7/2003	1	OPEN FIELD	1406	1510	64	COLLECT DATA	COLLECT DATA	LASER	NA	LINEAR	CLOUDY	MUDDY
11/7/2003	1	OPEN FIELD	1510	1540	30	DAILY START/STOP	EQUIPMENT BREAKDOWN END OF DAILY OPERATIONS	LASER	NA	LINEAR	CLOUDY	MUDDY
11/10/2003	1	OPEN FIELD	0745	0825	40	DAILY START/STOP	START OF DAILY OPERATIONS	LASER	NA	LINEAR	SUNNY	MUDDY
11/10/2003	1	OPEN FIELD	0825	0830	5	CALIBRATE	CALIBRATE USING METAL ROD	LASER	NA	LINEAR	SUNNY	MUDDY
11/10/2003	1	OPEN FIELD	0830	1010	100	COLLECT DATA	COLLECT DATA	LASER	NA	LINEAR	SUNNY	MUDDY
11/10/2003	1	OPEN FIELD	1010	1020	10	DAILY START/STOP	SET UP PIN FLAGS AND TAPES	LASER	NA	LINEAR	SUNNY	MUDDY
11/10/2003	1	OPEN FIELD	1020	1100	40	BREAK/LUNCH	BREAK/LUNCH	LASER	NA	LINEAR	SUNNY	MUDDY
11/10/2003	1	OPEN FIELD	1100	1140	40	DAILY START/STOP	SET UP PIN FLAGS AND TAPES	LASER	NA	LINEAR	SUNNY	MUDDY
11/10/2003	1	OPEN FIELD	1140	1205	25	DOWNTIME/MAINTENANCE CHECK	CHANGE BATTERY	LASER	NA	LINEAR	SUNNY	MUDDY
11/10/2003	1	OPEN FIELD	1205	1405	120	COLLECT DATA	COLLECT DATA	LASER	NA	LINEAR	SUNNY	MUDDY
11/10/2003	1	OPEN FIELD	1405	1435	30	DOWNTIME/MAINTENANCE CHECK	CHANGE BATTERY	LASER	NA	LINEAR	SUNNY	MUDDY
11/10/2003	1	OPEN FIELD	1435	1515	40	COLLECT DATA	COLLECT DATA	LASER	NA	LINEAR	SUNNY	MUDDY
11/10/2003	1	OPEN FIELD	1515	1610	55	DAILY START/STOP	EQUIPMENT BREAKDOWN END OF DAILY OPERATIONS	LASER	NA	LINEAR	SUNNY	MUDDY
11/11/2003	1	OPEN FIELD	0735	0915	100	DAILY START/STOP	START OF DAILY OPERATIONS	LASER	NA	LINEAR	SUNNY	MUDDY
11/11/2003	1	OPEN FIELD	0915	0920	5	CALIBRATE	CALIBRATE USING METAL ROD	LASER	NA	LINEAR	SUNNY	MUDDY
11/11/2003	1	OPEN FIELD	0920	1100	100	COLLECT DATA	COLLECT DATA	LASER	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	
11/11/2003	1	OPEN FIELD	1100	1130	30	DOWNTIME/MAINTENANCE CHECK	CHANGE BATTERY	LASER	NA	LINEAR	SUNNY	MUDDY
11/11/2003	1	WOODED AREA	1130	1205	35	DAILY START/STOP	SET UP PIN FLAGS AND TAPES	LASER	NA	LINEAR	SUNNY	MUDDY
11/11/2003	1	WOODED AREA	1205	1207	2	CALIBRATE	CALIBRATE USING METAL ROD	LASER	NA	LINEAR	SUNNY	MUDDY
11/11/2003	1	WOODED AREA	1207	1310	63	COLLECT DATA	COLLECT DATA	LASER	NA	LINEAR	SUNNY	MUDDY
11/11/2003	1	WOODED AREA	1310	1330	20	DAILY START/STOP	SET UP PIN FLAGS AND TAPES	LASER	NA	LINEAR	SUNNY	MUDDY
11/11/2003	1	WOODED AREA	1330	1450	80	DAILY START/STOP	EQUIPMENT BREAKDOWN END OF DAILY OPERATIONS	LASER	NA	LINEAR	SUNNY	MUDDY
						RTS 2						
11/5/2003	2	OPEN FIELD	1320	1500	100	DAILY START/STOP	START OF DAILY OPERATIONS	LASER	NA	LINEAR	CLOUDY	MUDDY
11/5/2003	2	OPEN FIELD	1500	1505	5	CALIBRATE	CALIBRATE USING METAL ROD	LASER	NA	LINEAR	CLOUDY	MUDDY
11/5/2003	2	OPEN FIELD	1505	1600	55	COLLECT DATA	COLLECT DATA	LASER	NA	LINEAR	CLOUDY	MUDDY
11/5/2003	2	OPEN FIELD	1600	1625	25	DAILY START/STOP	EQUIPMENT BREAKDOWN END OF DAILY OPERATIONS	LASER	NA	LINEAR	CLOUDY	MUDDY
11/6/2003	2	OPEN FIELD	0730	0910	100	DAILY START/STOP	START OF DAILY OPERATIONS, USED NO WHEELS	LASER	NA	LINEAR	RAINY	MUDDY
11/6/2003	2	OPEN FIELD	0910	0915	5	CALIBRATE	CALIBRATE USING METAL ROD	LASER	NA	LINEAR	RAINY	MUDDY
11/6/2003	2	OPEN FIELD	0915	1020	65	COLLECT DATA	COLLECT DATA	LASER	NA	LINEAR	RAINY	MUDDY
11/6/2003	2	OPEN FIELD	1020	1027	7	CALIBRATE	CALIBRATE USING METAL ROD	LASER	NA	LINEAR	RAINY	MUDDY
11/6/2003	2	OPEN FIELD	1027	1120	53	COLLECT DATA	COLLECT DATA	LASER	NA	LINEAR	RAINY	MUDDY
11/6/2003	2	OPEN FIELD	1120	1145	25	DOWNTIME/MAINTENANCE CHECK	CHANGE BATTERY	LASER	NA	LINEAR	RAINY	MUDDY
11/6/2003	2	OPEN FIELD	1145	1147	2	CALIBRATE	CALIBRATE USING METAL ROD	LASER	NA	LINEAR	RAINY	MUDDY
11/6/2003	2	OPEN FIELD	1147	1305	78	COLLECT DATA	COLLECT DATA	LASER	NA	LINEAR	RAINY	MUDDY
11/6/2003	2	OPEN FIELD	1305	1330	25	DOWNTIME/MAINTENANCE CHECK	CHANGE BATTERY	LASER	NA	LINEAR	RAINY	MUDDY
11/6/2003	2	OPEN FIELD	1330	1340	50	CALIBRATE	CALIBRATE USING METAL ROD	LASER	NA	LINEAR	RAINY	MUDDY
11/6/2003	2	OPEN FIELD	1340	1415	35	COLLECT DATA	COLLECT DATA	LASER	NA	LINEAR	RAINY	MUDDY
11/6/2003	2	OPEN FIELD	1415	1455	40	DAILY START/STOP	EQUIPMENT BREAKDOWN END OF DAILY OPERATIONS	LASER	NA	LINEAR	RAINY	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	
11/7/2003	2	OPEN FIELD	0745	0950	125	DAILY START/STOP	START OF DAILY OPERATIONS, USED NO WHEELS	LASER	NA	LINEAR	CLOUDY	MUDDY
11/7/2003	2	OPEN FIELD	0950	0952	2	CALIBRATE	CALIBRATE USING METAL ROD	LASER	NA	LINEAR	CLOUDY	MUDDY
11/7/2003	2	OPEN FIELD	0952	1210	138	COLLECT DATA	COLLECT DATA	LASER	NA	LINEAR	CLOUDY	MUDDY
11/7/2003	2	OPEN FIELD	1210	1240	30	BREAK/LUNCH	BREAK/LUNCH	LASER	NA	LINEAR	CLOUDY	MUDDY
11/7/2003	2	OPEN FIELD	1240	1243	3	CALIBRATE	CALIBRATE USING METAL ROD	LASER	NA	LINEAR	CLOUDY	MUDDY
11/7/2003	2	OPEN FIELD	1243	1320	37	COLLECT DATA	COLLECT DATA	LASER	NA	LINEAR	CLOUDY	MUDDY
11/7/2003	2	OPEN FIELD	1320	1335	15	EQUIPMENT FAILURE	HAD TO MOVE VAN, IN WAY OF SENSOR	LASER	NA	LINEAR	CLOUDY	MUDDY
11/7/2003	2	OPEN FIELD	1335	1410	35	COLLECT DATA	COLLECT DATA	LASER	NA	LINEAR	CLOUDY	MUDDY
11/7/2003	2	OPEN FIELD	1410	1420	10	BREAK/LUNCH	BREAK/LUNCH	LASER	NA	LINEAR	CLOUDY	MUDDY
11/7/2003	2	OPEN FIELD	1420	1422	2	CALIBRATE	CALIBRATE USING METAL ROD	LASER	NA	LINEAR	CLOUDY	MUDDY
11/7/2003	2	OPEN FIELD	1422	1430	8	COLLECT DATA	COLLECT DATA	LASER	NA	LINEAR	CLOUDY	MUDDY
11/7/2003	2	OPEN FIELD	1430	1450	20	DOWNTIME/MAINTENANCE CHECK	DOWNLOAD DATA	LASER	NA	LINEAR	CLOUDY	MUDDY
11/7/2003	2	OPEN FIELD	1450	1453	3	CALIBRATE	CALIBRATE USING METAL ROD	LASER	NA	LINEAR	CLOUDY	MUDDY
11/7/2003	2	OPEN FIELD	1453	1505	12	COLLECT DATA	COLLECT DATA	LASER	NA	LINEAR	CLOUDY	MUDDY
11/7/2003	2	OPEN FIELD	1505	1510	5	DOWNTIME/MAINTENANCE CHECK	EQUIPMENT CHECK	LASER	NA	LINEAR	CLOUDY	MUDDY
11/7/2003	2	OPEN FIELD	1510	1540	30	DAILY START/STOP	EQUIPMENT BREAKDOWN END OF DAILY OPERATIONS	LASER	NA	LINEAR	CLOUDY	MUDDY
11/10/2003	2	OPEN FIELD	0745	0850	65	DAILY START/STOP	START OF DAILY OPERATIONS, USED NO WHEELS	LASER	NA	LINEAR	SUNNY	MUDDY
11/10/2003	2	OPEN FIELD	0850	0855	5	CALIBRATE	CALIBRATE USING METAL ROD	LASER	NA	LINEAR	SUNNY	MUDDY
11/10/2003	2	OPEN FIELD	0855	0930	35	COLLECT DATA	COLLECT DATA	LASER	NA	LINEAR	SUNNY	MUDDY
11/10/2003	2	OPEN FIELD	0930	0950	20	DAILY START/STOP	SET UP PIN FLAGS AND TAPES	LASER	NA	LINEAR	SUNNY	MUDDY
11/10/2003	2	OPEN FIELD	0950	1005	15	DOWNTIME/MAINTENANCE CHECK	EQUIPMENT CHECK	LASER	NA	LINEAR	SUNNY	MUDDY
11/10/2003	2	OPEN FIELD	1005	1010	5	CALIBRATE	CALIBRATE USING METAL ROD	LASER	NA	LINEAR	SUNNY	MUDDY
11/10/2003	2	OPEN FIELD	1010	1020	10	BREAK/LUNCH	BREAK/LUNCH	LASER	NA	LINEAR	SUNNY	MUDDY
11/10/2003	2	OPEN FIELD	1020	1025	5	CALIBRATE	CALIBRATE USING METAL ROD	LASER	NA	LINEAR	SUNNY	MUDDY
11/10/2003	2	OPEN FIELD	1025	1100	35	COLLECT DATA	COLLECT DATA	LASER	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	
11/10/2003	2	OPEN FIELD	1100	1120	20	DOWNTIME/MAINTENANCE CHECK	CHANGE BATTERY	LASER	NA	LINEAR	SUNNY	MUDDY
11/10/2003	2	OPEN FIELD	1120	1235	75	COLLECT DATA	COLLECT DATA	LASER	NA	LINEAR	SUNNY	MUDDY
11/10/2003	2	OPEN FIELD	1235	1300	25	BREAK/LUNCH	BREAK/LUNCH	LASER	NA	LINEAR	SUNNY	MUDDY
11/10/2003	2	OPEN FIELD	1300	1345	45	COLLECT DATA	COLLECT DATA	LASER	NA	LINEAR	SUNNY	MUDDY
11/10/2003	2	OPEN FIELD	1345	1420	35	DOWNTIME/MAINTENANCE CHECK	CHANGE BATTERY	LASER	NA	LINEAR	SUNNY	MUDDY
11/10/2003	2	OPEN FIELD	1420	1425	5	COLLECT DATA	COLLECT DATA	LASER	NA	LINEAR	SUNNY	MUDDY
11/10/2003	2	OPEN FIELD	1425	1450	25	BREAK/LUNCH	BREAK/LUNCH	LASER	NA	LINEAR	SUNNY	MUDDY
11/10/2003	2	OPEN FIELD	1450	1600	70	CALIBRATE	CALIBRATE USING METAL ROD	LASER	NA	LINEAR	SUNNY	MUDDY
11/10/2003	2	OPEN FIELD	1600	1610	10	DAILY START/STOP	EQUIPMENT BREAKDOWN END OF DAILY OPERATIONS	LASER	NA	LINEAR	SUNNY	MUDDY
11/11/2003	2	OPEN FIELD	1000	1130	90	DAILY START/STOP	START OF DAILY OPERATIONS	LASER	NA	LINEAR	SUNNY	MUDDY
11/11/2003	2	OPEN FIELD	1130	1135	5	CALIBRATE	CALIBRATE USING METAL ROD	LASER	NA	LINEAR	SUNNY	MUDDY
11/11/2003	2	OPEN FIELD	1135	1200	25	COLLECT DATA	COLLECT DATA	LASER	NA	LINEAR	SUNNY	MUDDY
11/11/2003	2	MOGUL AREA	1200	1220	20	COLLECT DATA	COLLECT DATA	LASER	NA	LINEAR	SUNNY	MUDDY
11/11/2003	2	MOGUL AREA	1220	1245	25	COLLECT DATA	COLLECT DATA	LASER	NA	LINEAR	SUNNY	MUDDY
11/11/2003	2	MOGUL AREA	1245	1305	20	BREAK/LUNCH	BREAK/LUNCH	LASER	NA	LINEAR	SUNNY	MUDDY
11/11/2003	2	MOGUL AREA	1305	1308	3	CALIBRATE	CALIBRATE USING METAL ROD	LASER	NA	LINEAR	SUNNY	MUDDY
11/11/2003	2	MOGUL AREA	1308	1400	52	COLLECT DATA	COLLECT DATA	LASER	NA	LINEAR	SUNNY	MUDDY
11/11/2003	3	MOGUL AREA	1400	1450	50	DAILY START/STOP	EQUIPMENT BREAKDOWN END OF DAILY OPERATIONS	LASER	NA	LINEAR	SUNNY	MUDDY
11/12/2003	3	MOGUL AREA	0730	0810	40	DAILY START/STOP	START OF DAILY OPERATIONS	LASER	NA	LINEAR	CLOUDY	RAIN
11/12/2003	3	MOGUL AREA	0810	0815	5	CALIBRATE	CALIBRATE USING METAL ROD	LASER	NA	LINEAR	CLOUDY	RAIN
11/12/2003	3	MOGUL AREA	0815	0950	95	COLLECT DATA	COLLECT DATA	LASER	NA	LINEAR	CLOUDY	RAIN
11/12/2003	3	MOGUL AREA	0950	1000	10	DOWNTIME/MAINTENANCE CHECK	CHANGE BATTERY	LASER	NA	LINEAR	CLOUDY	RAIN
11/12/2003	3	MOGUL AREA	1000	1002	2	CALIBRATE	CALIBRATE USING METAL ROD	LASER	NA	LINEAR	CLOUDY	RAIN
11/12/2003	3	MOGUL AREA	1002	1020	18	COLLECT DATA	COLLECT DATA	LASER	NA	LINEAR	CLOUDY	RAIN

Note: Activities pertinent to this specific demonstration are indicated in highlighted text.

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	
						CST						
11/4/2003	2	CALIBRATION LANE	0730	1300	330	DAILY START/STOP	START OF DAILY OPERATIONS	LASER	NA	LINEAR	SUNNY	MUDDY
11/5/2003	2	CALIBRATION LANE	0730	0900	90	DAILY START/STOP	START OF DAILY OPERATIONS	LASER	NA	LINEAR	SUNNY	MUDDY
11/5/2003	2	CALIBRATION LANE	0900	0935	35	COLLECT DATA	COLLECT DATA	LASER	NA	LINEAR	SUNNY	MUDDY
11/5/2003	2	BLIND TEST GRID	0935	1045	70	DAILY START/STOP	SET UP EQUIPMENT IN BLIND TEST GRID	LASER	NA	LINEAR	SUNNY	MUDDY
11/5/2003	2	BLIND TEST GRID	1045	1200	75	COLLECT DATA	COLLECT DATA	LASER	NA	LINEAR	SUNNY	MUDDY
11/5/2003	2	BLIND TEST GRID	1200	1320	80	DAILY START/STOP	EQUIPMENT BREAKDOWN END OF DAILY OPERATIONS	LASER	NA	LINEAR	SUNNY	MUDDY
11/11/2003	3	WOODED AREA	0735	1000	145	DAILY START/STOP	START OF DAILY OPERATIONS	LASER	NA	LINEAR	SUNNY	MUDDY
11/12/2003	3	WOODED AREA	1020	1145	85	DAILY START/STOP	START OF DAILY OPERATIONS	LASER	NA	LINEAR	RAINY	MUDDY
11/12/2003	3	WOODED AREA	1145	1210	25	DAILY START/STOP	EQUIPMENT BREAKDOWN END OF DAILY OPERATIONS	LASER	NA	LINEAR	RAINY	MUDDY
11/13/2003	3	WOODED AREA	0830	0940	70	DAILY START/STOP	START OF DAILY OPERATIONS	LASER	NA	LINEAR	SUNNY	WINDY
11/13/2003	3	WOODED AREA	0940	0950	10	CALIBRATE	CALIBRATE USING METAL ROD	LASER	NA	LINEAR	SUNNY	WINDY
11/13/2003	3	WOODED AREA	0950	1100	70	COLLECT DATA	COLLECT DATA	LASER	NA	LINEAR	SUNNY	WINDY
11/13/2003	3	WOODED AREA	1100	1205	75	DAILY START/STOP	SET UP PIN FLAGS AND TAPES	LASER	NA	LINEAR	SUNNY	WINDY
11/13/2003	3	WOODED AREA	1205	1210	5	CALIBRATE	CALIBRATE USING METAL ROD	LASER	NA	LINEAR	SUNNY	WINDY
11/13/2003	3	WOODED AREA	1210	1315	65	COLLECT DATA	COLLECT DATA	LASER	NA	LINEAR	SUNNY	WINDY
11/13/2003	3	WOODED AREA	1315	1550	155	DEMOBILIZATION	DEMOBILIZATION	LASER	NA	LINEAR	SUNNY	WINDY

Note: Activities pertinent to this specific demonstration are indicated in highlighted text.

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.

4. Practical Nonparametric Statistics, W.J. Conover, John Wiley & Sons, 1980, pages 144 through 151.

APPENDIX F. ABBREVIATIONS

ACE	=	Army Corps of Engineers
AEC	=	U.S. Army Environmental Center
APG	=	Aberdeen Proving Ground
ATC	=	U.S. Army Aberdeen Test Center
CD-ROM	=	compact disk-read only memory
CST	=	Arc Second Constellation™
EQT	=	Army Environmental Quality Technology Program
ERDC	=	U.S. Army Corps of Engineers Engineering, Research and Development Center
ESTCP	=	Environmental Security Technology Certification Program
GPO	=	geophysical prove-out
HERO	=	Hazards of Electromagnetic Radiation to Ordnance
JPG	=	Jefferson Proving Ground
PCMIA	=	Personal Computer Memory Card International Association
POC	=	point of contact
QA	=	quality assurance
QC	=	quality control
ROC	=	receiver-operating characteristic
RTS	=	Robotic Total Station
SERDP	=	Strategic Environmental Research and Development Program
TtFW	=	Tetra Tech Foster Wheeler
UXO	=	unexploded ordnance
VDS	=	verification of detection system
YPG	=	U.S. Army Yuma Proving Ground

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