US Army Corps of Engineers

AD-A230 150

MINE/COUNTERMINE PROGRAM

TECHNICAL REPORT EL-90-8

SITE CHARACTERIZATION FOR RADAR EXPERIMENTS

by

Katherine S. Long

Environmental Laboratory

DEPARTMENT OF THE ARMY
Waterways Experiment Station, Corps of Engineers
3909 Halls Ferry Road, Vicksburg, Mississippi 39180-6199

August 1990

Final Report

Prepared for DEPARTMENT OF THE ARMY
US Army Corps of Engineers
Washington, DC 20314-1000

Unclassified

SECURITY CLASSIFICATION OF THIS PAGE

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1a. REPORT SECURITY CLASSIFICATION: Unclassified

1b. RESTRICTIVE MARKINGS:

2a. SECURITY CLASSIFICATION AUTHORITY:

2b. DECLASSIFICATION / DOWNGRADING SCHEDULE:

3. DISTRIBUTION / AVAILABILITY OF REPORT: Approved for public release; distribution unlimited.

4. PERFORMING ORGANIZATION REPORT NUMBER(S): Technical Report EL-90-8

5. MONITORING ORGANIZATION REPORT NUMBER(S):

6a. NAME OF PERFORMING ORGANIZATION: USAEWES Environmental Laboratory

6b. OFFICE SYMBOL (If applicable):

7a. NAME OF MONITORING ORGANIZATION:

6c. ADDRESS (City, State, and ZIP Code): 3909 Halls Ferry Road, Vicksburg, MS 39180-6199

7b. ADDRESS (City, State, and ZIP Code):

8a. NAME OF FUNDING / SPONSORING ORGANIZATION: US Army Corps of Engineers

8b. OFFICE SYMBOL (If applicable):

9. PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER:

8c. ADDRESS (City, State, and ZIP Code): Washington, DC 20314-1000

10. SOURCE OF FUNDING NUMBERS

PROGRAM ELEMENT NO.	PROJECT NO.	TASK NO.	WORK UNIT ACCESSION NO.

11. TITLE (Include Security Classification): Site Characterization for Radar Experiments

12. PERSONAL AUTHOR(S): Long, Katherine S.

13a. TYPE OF REPORT: Final report

13b. TIME COVERED: FROM ________ TO ________

14. DATE OF REPORT (Year, Month, Day): August 1990

15. PAGE COUNT: 177

16. SUPPLEMENTARY NOTATION: Available from National Technical Information Service, 5285 Port Royal Road, Springfield, VA 22161.

17. COSATI CODES

FIELD	GROUP	SUB-GROUP

18. SUBJECT TERMS (Continue on reverse if necessary and identify by block number): See reverse.

19. ABSTRACT (Continue on reverse if necessary and identify by block number)

In conjunction with the Massachusetts Institute of Technology/Lincoln Laboratories, the US Army Engineer Waterways Experiment Station (WES) planned and executed a field characterization effort designed to furnish the data necessary to support the interpretation of products obtained by an airborne radar imaging mission. Not only were three different types of small mines precisely located relative to established benchmarks, but the surface topography, surface composition, vegetation, and micrometeorology were also characterized. This effort was executed with sufficient precision so that modelers might be able to characterize the "clutter" surrounding the objects (targets) imaged. Three 38- by 44-m plots were characterized by recording elevation differences as small as 1 cm for each of the three plots in its entirety and 0.1 cm for three 1-m subplots within each of the larger plots. Roughness measurements at a scale likely to influence the radar returns were calculated. Soil composition was determined, and the locations of the samples are shown in

(Continued)

20. DISTRIBUTION / AVAILABILITY OF ABSTRACT: ☒ UNCLASSIFIED/UNLIMITED ☐ SAME AS RPT. ☐ DTIC USERS

21. ABSTRACT SECURITY CLASSIFICATION: Unclassified

22a. NAME OF RESPONSIBLE INDIVIDUAL:

22b. TELEPHONE (Include Area Code):

22c. OFFICE SYMBOL:

DD Form 1473, JUN 86 — Previous editions are obsolete.

SECURITY CLASSIFICATION OF THIS PAGE

Unclassified

Unclassified
SECURITY CLASSIFICATION OF THIS PAGE

18. SUBJECT TERMS (Continued).

Mines	M-20	Site description
M-15	M75	Surface characterization
M-19	Site characterization	Surface geometry
35-GHz airborne radar	Vegetation	

19. ABSTRACT (Continued).

reference to the plot coordinates. Principal soil types were also sampled for moisture content, specific gravity, and grain size distribution; dielectric measurements of permittivity and conductivity to 30 cm in depth were made around the perimeters of each of the three plots. Physical and floristic attributes of the vegetation communities present were determined using both field and laboratory methods. Keywords: Airborne [illegible]; Antitank mines/detection; Sites; Pattern recognition; Topography; Massachusetts; Vegetation/soils; Target recognition; Radio waves; [illegible]; [illegible]; Massachusetts; Micrometeorology; [illegible]

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PREFACE

The study reported herein was conducted by the US Army Engineer Waterways Experiment Station (WES) in conjunction with the Massachusetts Institute of Technology/Lincoln Laboratories (MIT/LL) to characterize areas and targets imaged with their Advanced Detection Technology Sensor (ADTS). Such characterization results are to be used in the analysis of the collected data to understand the capability of such technology to accomplish specific tasks defined by the US Army. The WES portion of the study was funded under the Standoff Minefield Detection portion of the Mine/Countermine Program, Dr. Victor C. Barber, Program Manager, and was sponsored by Headquarters, US Army Corps of Engineers (HQUSACE). The HQUSACE Technical Monitor was Mr. R. Tofferi. The subtask in the program under which the field data collection was accomplished was "New Mine Detection Technologies," Mr. Jack Stoll, Principal Investigator.

The Environmental Systems Division (ESD) of the Environmental Laboratory (EL) began coordinating with personnel of MIT/LL in early 1988, with Ms. Katherine S. Long of the Battlefield Environment Group (BEG), WES, and Mr. Steve Bong of Hilton Systems visiting the proposed study site in March to select specific locations for the test plots. The field data collection team included Messrs. Kenneth G. Hall, Charles D. Hahn, David L. Leese and Thomas E. Berry of the Environmental Assessment Group (Mr. Harold W. West, Chief), Ms. Long, and Ms. Terri Justice, Mr. J. Fairchild, and Mr. Keith Martin, contract students assigned to the ESD. Mr. Bong was responsible for dielectric measurements, and Messrs. Hall, Hahn, and Berry conducted the surface geometry measurements; Mr. Hahn reduced the data and produced many of the figures appearing herein. Mr. Leese was responsible for collecting and reducing the meteorological data. Mr. Jack Casey of MIT/LL coordinated the flyovers and set the trihedral reflectors. Mr. John Henry was the Principal Investigator for the MIT/LL ADTS study.

This report was prepared by Ms. Long under the direct supervision of Mr. Stoll, Project Manager, and Mr. Jerry R. Lundien, then Chief, BEG, ESD. Editor was Ms. Lee T. Byrne of the Information Technology Laboratory. The study was under the general supervision of Dr. Victor E. LaGarde III, Chief, ESD, and Dr. John Harrison, Chief, EL.

Commander and Director of WES during preparation of this report was COL Larry B. Fulton, EN. Dr. Robert W. Whalin was Technical Director.

This report should be cited as follows:

Long, Katherine S. 1990. "Site Characterization for Radar Experiments," Technical Report EL-90-8, US Army Engineer Waterways Experiment Station, Vicksburg, MS.

CONTENTS

CONVERSION FACTORS, NON-SI TO SI (METRIC) UNITS OF MEASUREMENT

Non-SI units of measurement used in this report can be converted to SI (metric) units as follows:

Multiply	By	To Obtain
degrees (angle)	0.01745329	radians
Fahrenheit degrees	5/9	Celsius degrees or kelvins*
feet	0.3048	metres
inches	25.4	millimetres
pounds (mass)	0.4535924	kilograms
square feet	0.09290304	square metres
square inches	6.4516	square centimetres

* To obtain Celsius (C) temperature readings from Fahrenheit (F) readings, use the following formula: $C = (5/9)(F - 32)$. To obtain Kelvin (K) readings, use: $K = (5/9)(F - 32) + 273.15$.

SITE CHARACTERIZATION FOR RADAR EXPERIMENTS

PART I: INTRODUCTION

Background

1. In 1987 personnel from the Environmental Laboratory (EL), US Army Engineer Waterways Experiment Station (WES), were invited to a briefing sponsored by the Defense Advanced Research Projects Agency (DARPA) in which the Massachusetts Institute of Technology/Lincoln Laboratory (MIT/LL) described an airborne 35-GHz radar imaging system. The MIT/LL would employ various kinds of processing on the data collected to produce a fully calibrated, fully polarimetric signal, resulting in a digital image with a ground resolution of 1 ft.* This system is called the Advanced Detection Technology Sensor (ADTS).**

2. A liaison was established between EL and MIT/LL, and an agreement was reached that a cooperative field test should be planned and conducted. Personnel from MIT/LL arranged for a site at Fort Devens, MA, where WES could locate and describe plots on which a specific number, pattern, and configuration of three different antitank (AT) mines would be placed. In turn, MIT/LL would plan flyovers in which the ADTS system would image an area including the WES plots and the targets placed within them. The aforementioned tasks, including the site characterization, target placement, and the subsequent flyovers, were scheduled for 11-22 July 1988. Immediately prior (virtually coincident) to the overflights, WES would describe quantitatively and with sufficient precision the surface geometry, surface composition, vegetation, and micrometeorology parameters presumed to influence the nature of the radar return. Personnel from WES planned to put the small targets in place on the day of the imaging mission by the ADTS.

3. The plots to be used in the study were to have relatively gentle slopes and not be vegetated with large woody plants, thereby providing a

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* A table of factors for converting non-SI units of measurement to SI (metric) units is presented on page 4.

** MIT/LL, 1988, "An Approach to Target Detection and Classification Based on Millimeter-Wave Radar," Draft report, Lexington, MA.

"benign" but "natural" background upon which to place the targets where they would be most likely to be detected. Additionally, sufficient numbers of distinct plots were desired to represent two different colors for two of the target types (this option for another remote sensing, not radar, experiment) and to represent two of the target types in both a surface and a buried configuration. Each plot needed to be large enough to accommodate a number and spacing of targets as might be encountered in a realistic battlefield scenario. Minimally satisfying these criteria would require seven plots 38 by 44 m in dimension (Figure 1). The common names for the three different military target types to be used appear within the sketch representing the individual plots planned, as well as their proposed colors and whether they were to be surface-laid or buried. (These variables, colors, and surface configuration were introduced to answer questions in other areas of the "New Mine Detection Technologies" work unit.)

4. Personnel from EL and MIT/LL made a pretest visit to Fort Devens in May 1988 to inspect the site (Range 6A) (Figures 2 and 3) chosen for the study by MIT/LL personnel. Unfortunately, the space available to the WES team at Fort Devens was not sufficient to satisfy all of the desired criteria. The team therefore used only three plots of the prescribed dimensions. This meant that the targets would have to be buried between successive overflights in order to introduce the desired variation of imaging them in a buried configuration. Paint color was deleted as a variable to be considered in this exercise.

Purpose

5. As stated in the MIT/LL draft document, the ADTS data are targeted to perform (or allow to be performed) the following functions:

a. "Create the data base needed to understand and develop the next generation of millimetre wave (MMW) target detection and classification algorithms."

b. "Understand and quantify the phenomenology of the radar scattering properties of targets in clutter."

c. "Develop and evaluate new detection and classification algorithms based on our evolving understanding of the phenomenology."

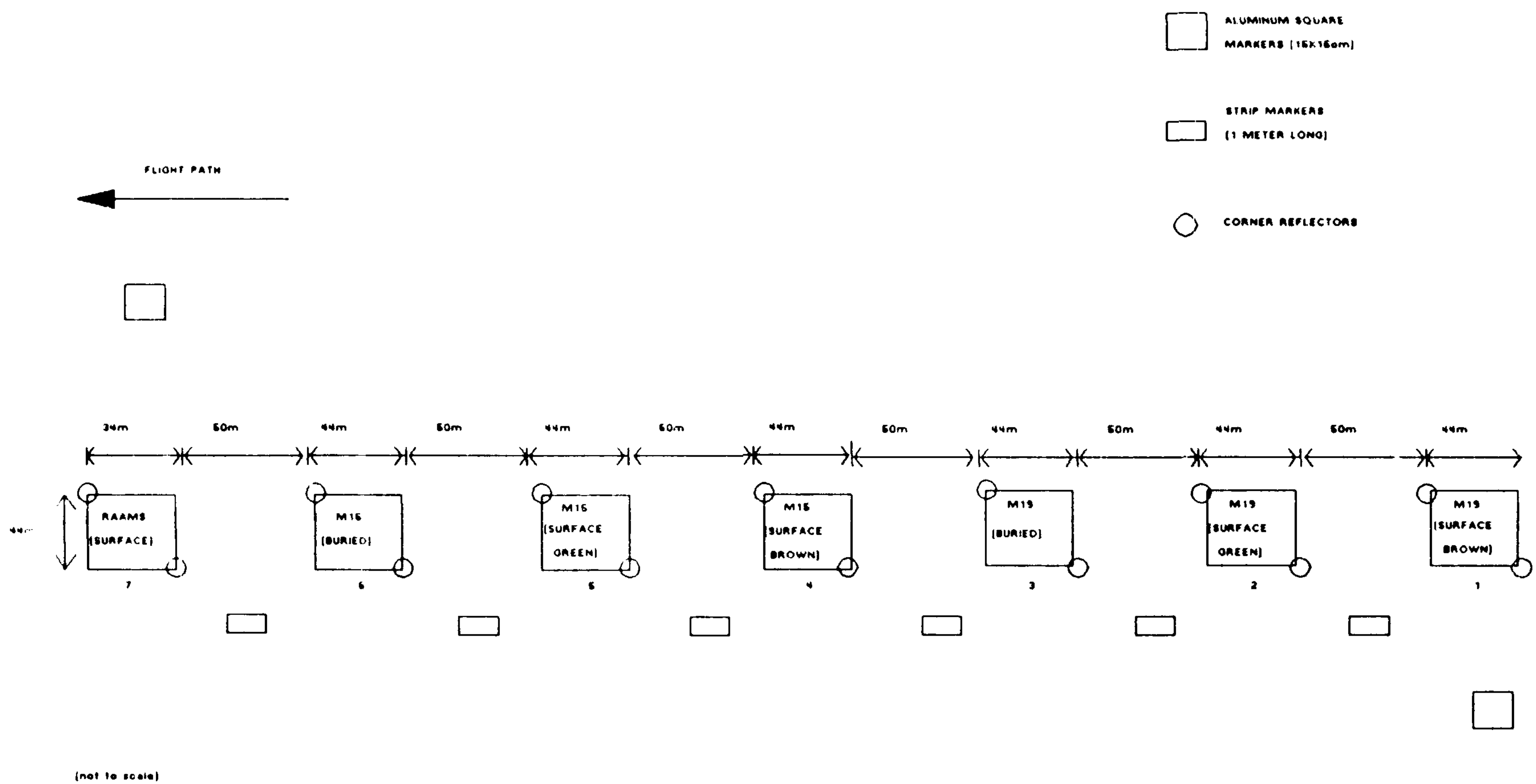

Figure 1. Proposed layout of the target plots

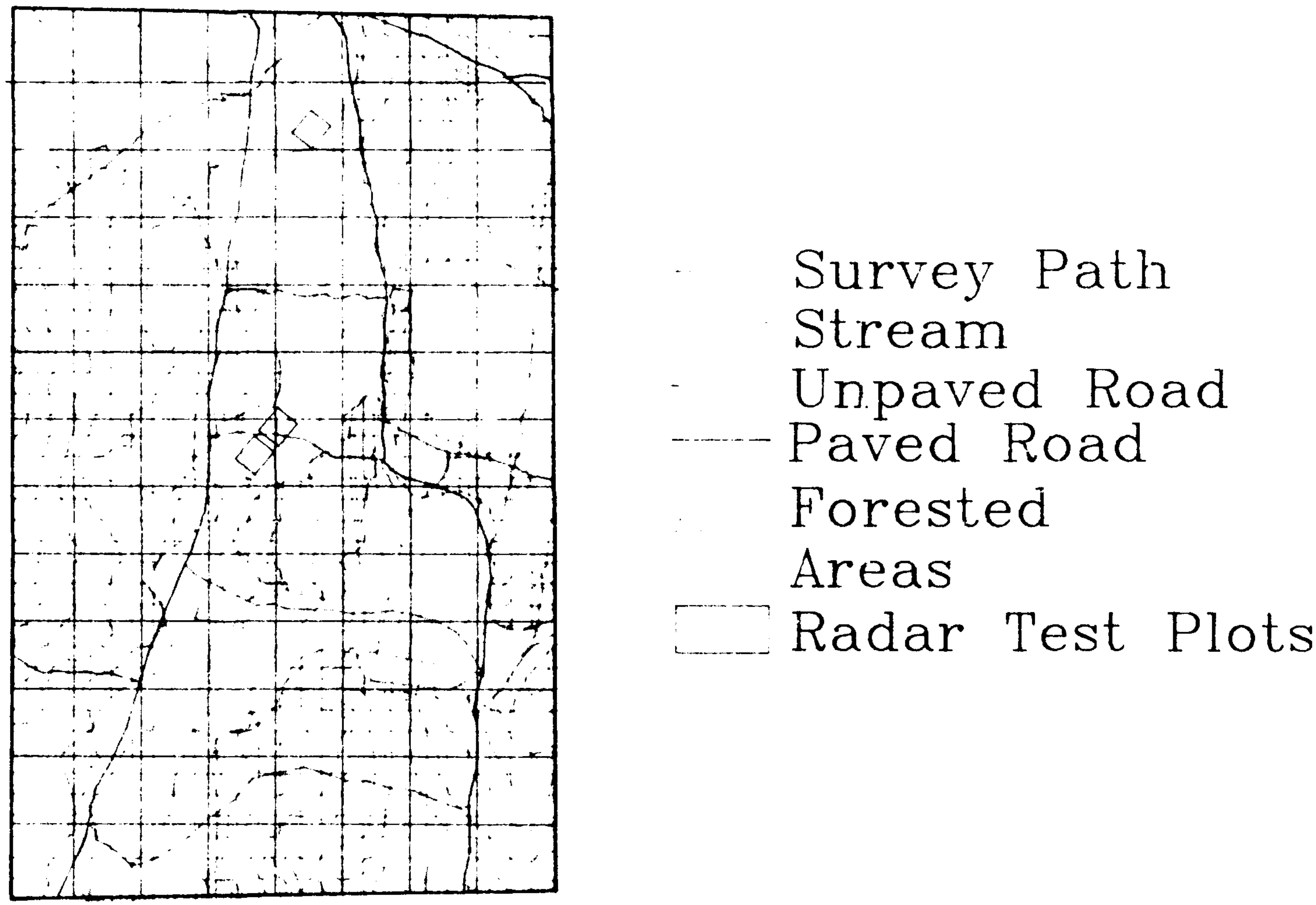

Figure 2. Actual plot location at Fort Devens, MA

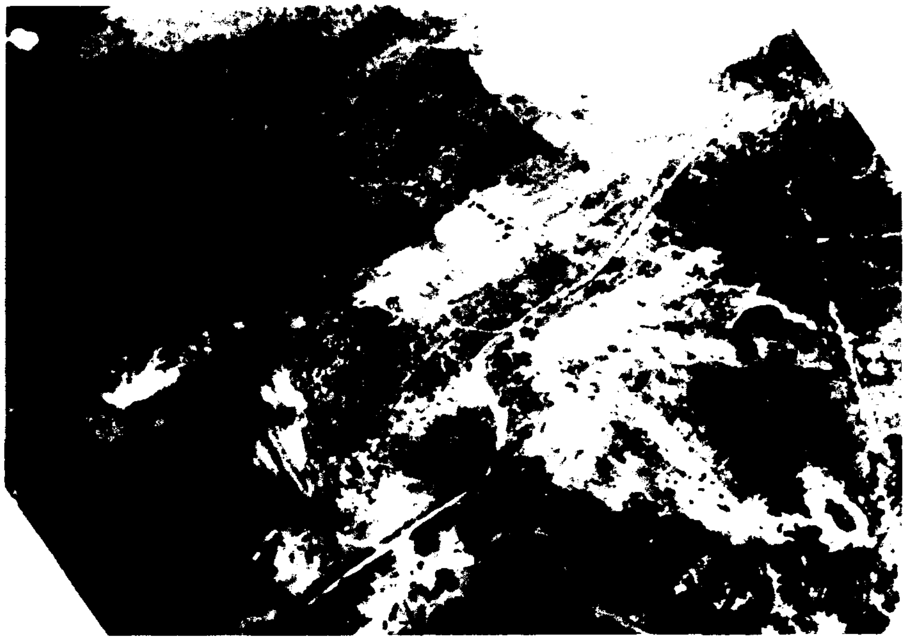

Figure 3. Aerial photograph of site location (spring 1988, courtesy of MIT/LL)

6. Because WES has had extensive experience in site characterization* (Mason and Long 1981; Long, Williams, and Davis 1985; Dardeau and Zappi 1977; and others), WES agreed to collect data and provide site characterization information in support of the previously mentioned ADTS objectives. The MIT/LL would furnish fully calibrated, fully polarimetric data images of the study plots to WES when they had completed the data-gathering mission and the required processing. The WES would then compare the MIT/LL-supplied data with the parameters obtained during the site characterization of July 1988. Similarly, it was the intent of MIT/LL to include the WES data in conjunction with the ADTS radar imagery as part of their effort toward reaching their stated objectives.

Scope of Work

7. The WES scope of work included preflight sampling and measurement of surface geometry, surface composition (soils description and measurement of

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* J. L. Tingle, J. K. Stoll, C. L. Bond, and C. M. Allen, 1987, "Environmental Monitoring of the Advanced Wastewater Treatment Facility," unpublished report, WES, Vicksburg, MS.

dielectric properties), vegetation, and onsite meteorology (during the time of the radar overflight). Data to be collected were to some degree determined by a limited (because of the short lead time prior to the conducting of the field data collection) literature review. Data collected were reduced to a form likely to contribute to the analysis of the processed digital radar images and signals to be produced by the MIT/LL imaging radar. These measurements and observations will be presented in the following sections. A limited statistical analysis was applied to the surface geometry measurements, and some inferences were drawn relative to the possible differences that might be disclosed in the ADTS imagery.

Plan and Content of Report

8. This report is organized according to the following scheme: Part II contains a brief literature review including a history of radar for locating and detecting stationary objects and other works of direct relevance to the study reported herein. Part III contains a detailed description of the methods and materials employed to perform the site characterization at Fort Devens, MA, in July 1988, as well as a display of the reduced data in graphic form. Part IV documents the manner in which the three different mine types were placed inside the three areas designated as "Plots." Part V presents a brief analysis of the data collected and some discussion of the effect these site conditions may produce on the radar imagery. The entire effort is briefly summarized in Part VI.

PART II: LITERATURE REVIEW

9. A literature review was conducted to determine the design of a field collection program that would best answer the purposes as set forth in Part I. Several parameters required definition if the data collection effort would be fully complementary to the acquisition of radar imagery. For example, that the mines could be seen/discriminated even minimally with the ADTS radar has not yet been established. This fact is determined by the "footprint" of the radar and the power reflected from the mine. Polarization of the mine signal could be expected to influence detection/discrimination. The references cited in the following paragraphs were consulted to determine that the types of parameters which could be measured at ground level would influence the nature of a coincident radar return signal.

History

10. In 1886, Hertz first demonstrated that radio waves could be reflected from both metallic and dielectric objects. However, detecting and locating objects with radar were not practiced extensively until World War II. Since that time the use of radar has expanded to include many private and commercial applications as well as military ones. Development of new hardware and software has made these applications possible (Eaves 1986).

11. To detect and locate a stationary object depend not only on the electromagnetic response of the object, but also on that of its surrounds. The strength of the original signal, the size and shape of the object, its orientation to the radar signal, its dielectric response to the specific radar frequency, and other attributes of both the radar and the target (and its surroundings) influence the response to the radar systems and thus the detectability of the target. A summary of radar potential regarding detection of soil anomalies was prepared for the WES Mine/Countermine Program by Kraft, Moore, and Moore (in preparation).

12. The simple form of the radar equation (Brakke et al. 1981) is

$$P_r = \frac{P_t G^2 \lambda^2 \sigma}{(4\pi)^3 R^4} \qquad (1)$$

where

P_r = power received, watts

P_t = power transmitted, watts

G = attenna gain

λ = wavelength, m

R = range, m

σ = radar cross section, sq m

Equation 1 is acceptable for rough calculations, although atmospheric losses and hardware losses need to be considered also when greater precision is required. These considerations are beyond the scope of this document, except for σ. Radar cross-section measurements of the specific mines imaged in this exercise were made in the MIT/LL laboratory and are discussed later.

Review of Previous Work

Previous radar studies of vegetation and soils

13. Radar has been examined (with mixed success) for its ability to determine characteristics of the soil and vegetation (Allen and Ulaby 1984; Andreyev, Potapov, and Khokhlov 1982; Batlivala and Ulaby 1977; Bradley and Ulaby 1981; Brakke et al. 1981; and others). Few of these studies, however, examine the frequency and depression angle used with the ADTS radar, i.e., 35 GHz and 45 deg. Moreover, open literature has not addressed the use of such systems for finding mines. Rather, objectives of these studies largely had to do with correlating soil and canopy characteristics with measured radar backscatter while controlling other parameters such as frequency, polarization, and depression angle. Brakke et al. (1981) studied four frequencies (8.6, 13.0, 17.0, and 35.6 GHz) and three depression angles (70, 40, and 20 deg) in an effort to correlate radar responses (σ) of leaf-area index, canopy moisture, and dry weight of wheat, corn, and sorghum. Results obtained showed higher correlation with canopy moisture at 17 GHz (horizontally transmitted, vertically received (cross-polarized) (HV)) at 30 deg and 13 GHz (vertically transmitted, vertically received (copolarized) (VV)) at 30 deg. Dry plant weights exhibited greater correlations at greater angles. Soil moisture estimation is best at low incident angles and low frequencies. Restated, radar backscattering recorded in the Fort Devens exercise may not

correlate well with soil moisture (or plant moisture) as determined at the time of the overflight. This is not necessarily bad, because the "natural" environment found at the site may be sufficiently "neutral" to contrast well with the targets emplaced upon it.

Flashlight radar measurements

14. A short-range scatterometer fabricated by MIT/LL was used to measure the backscatter of the three WES targets to be placed at Fort Devens for imaging with the ADTS. To obtain comparable measurements to the ADTS radar cross-section (RCS) measurements obtained, further processing is required. This "flashlight" radar was fabricated to mimic the action of the MIT/LL's airborne ADTS in a laboratory environment. It used an unfocused, scalar, horn-lens antenna. The radar has a radar center frequency at 35 GHz. Polarization matrices obtained using this radar to obtain backscattering measurements of the three WES targets can be found in a letter report by Dr. R. L. Ferranti of MIT/LL, 23 September 1988 (47C-1443)(Appendix D). For the targets designated 1 (RAAM), 2 (M15/M20), and 3 (M19) (smallest to largest), RCS magnitudes for three downlook angles (5, 9, and 45 deg) ranged from 0 dBsm to -50 dBsm for all polarizations, both linear and circular. The results of the flashlight measurements corresponding to the downlook angle (45 deg) of the actual overflight indicate that target 2 will have the highest return at horizontally transmitted, horizontally received (copolarized) (HH) and VV and at right handedly transmitted, right handedly received (copolarized) (RR) and MIT/LL in the linear and circular senses, respectively. Targets like target 2 imaged by the flashlight radar are located in Plot B at Fort Devens, Range 6A, in the WES field characterization performed in July 1988.

15. An extract of Ferranti's measurements applicable to the WES exercise are presented in the tabulation below:

Target	Depression angle, deg	RCS Magnitudes for all Polarizations, dBsm — Linear: HH*	HV	VH	VV	Circular: RR	RL	LR	LL
1	45	-19	-41	-41	-19	-20	-23	-24	-21
2	45	-5	-26	-27	-11	-9	-15	-16	-7
3 (off broadside)	45	-22	-24	-24	-20	-32	-30	-30	-16
3 (45-deg rotation)	45	-18	-30	-30	-25	-24	-24	-23	-21

* HH = horizontally transmitted, horizontally received (copolarized).
HV = horizontally transmitted, vertically received (cross-polarized).
VH = vertically transmitted, horizontally received (cross-polarized).
VV = vertically transmitted, vertically received (copolarized).
RR = right handedly transmitted, right handedly received (copolarized).
RL = right handedly transmitted, left handedly received (cross-polarized).
LR = left handedly transmitted, right handedly received (cross-polarized).
LL = left handedly transmitted, left handedly received (copolarized).

16. In the tabulation, target 3 is a square, shallow, enclosed box 13 in. across, whereas target 1 is a much smaller cylinder. That the orientation in the horizontal plane of the square target 3 will affect the return from it seems apparent from the flashlight measurements. Cross-polarized signals from the small cylinder (target 1) show a marked difference from the other measurements. (Since the values in the above tabulation are logarithms, large negative numbers indicate very small absolute magnitudes.) Ranking the means of the eight polarizations for all targets examined yields the following order: HH (-15.8), LL (-16.2), VV (-18.5), RR (-21), RL (-22.8), LR (-23.2), HV (-30), and VH (-30.2). Other elementary statistics can be found in Appendix D.

17. Ulaby et al. (1983) records measured backscattering coefficient values for mature wheat (frequency = 35.6 GHz) of -12.20 and -11.50 dB, with VV polarization and a depression angle of 50 deg. These backscatter measurements, if comparable to Ferranti's measurements of the WES targets, are higher; therefore, mature wheat may be distinguishable from the targets using those polarizations of the radar return data MIT/LL supplies. This observation is pertinent since there is a significant wheat population at Plot A at Fort Devens, as described later in this document. On the other hand, it is

possible that individual backscattering magnitudes alone may not be sufficient to discriminate between targets and the wheat background found at the Fort Devens site. Ulaby's data base should soon be available allowing more data on which to make the judgment as to whether or not it is likely that radar backscatter differences between mines and vegetated and bare-soil backgrounds, respectively, are sufficient for discrimination. Discrimination/recognition attempts have had to employ every wave-form parameter (amplitude, frequency, phase, polarization) singly and in combination to recognize and discriminate potential targets from their backgrounds (Holm 1986). Consideration of the target array pattern in the Fort Devens study plots also has the potential to enhance the discrimination success.

18. The study supported by the data contained herein has to do with locating mines of varying sizes and shapes in relatively "benign" backgrounds, but the background clutter may be similar in nature to the vegetation and soils described by Brakke et al. (1981). Moreover, the frequency and depression angle used was dictated by MIT/LL, e.g., ~35 GHz and 45 deg; so frequency and incident angle dependence cannot be investigated to the extent it has been in some of the references reviewed here.

19. Guided by a limited literature review and by personal communications with workers in the field, those parameters in the "background" presumed most likely to affect the 35-GHz radar return were measured at the three plots established at Fort Devens. These parameters and the methods used to quantify them are set forth in Part III.

PART III: SITE DESCRIPTIONS AND DATA COLLECTION

Site Description

General comments

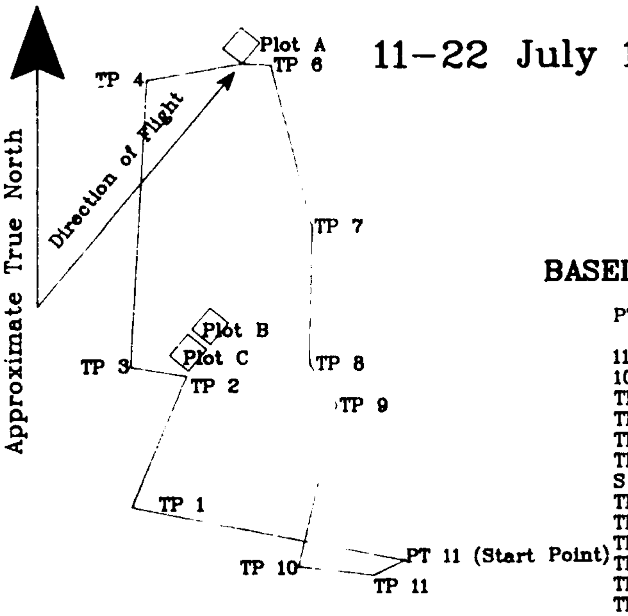
20. Fort Devens, chosen by MIT/LL for the study site because of its close proximity and availability, can be reached by Route 2 from Concord, MA. The area in which the study plots were located is Range 6A, Fort Devens (Figure 2). Wooded areas and strong relief characterize most of the Fort Devens training area. However, the location MIT/LL and WES personnel selected for the study plots had gentle relief (delta z < 2 m) and contained mostly low herbaceous vegetation with occasional shrubs. The area had been cleared of most of its vegetation for use by the US Army Reserve training units for the operation of tanks; therefore, what vegetation was present, with the exception of the few shrubs, was 1-year growth.

21. Three locations within Range 6A, Fort Devens, were designated as meeting the prescribed criteria (Figure 2). The plots selected for intense measurements (to be presented herein) are located in the southern part of the Fort Devens Military Reservation. It can be reached by Shirley Road, which runs alongside the site including the three plots. Military grid coordinates for the (0,0) position of the southernmost plot are 80814 E 6889 N (geographic coordinates ~42°28'N 71°40'W). The three rectangular test plots (38 by 44 m) were aligned with their lengths parallel to the proposed ADTS heading of 55 deg of magnetic north (40 deg of true north).

22. The three study plots were located where there was room to accommodate them and to satisfy the criteria of relatively gentle relief, little woody vegetation, a line-of-sight with the airborne ADTS, each plot of a sufficient size for the prescribed target array, etc. The approximate military grid coordinates enclosing the test site layout are 80780-80980E, 6800-7500N. Topographic survey and plot location were performed prior to the other procedures, except for some documenting photography. The three rectangular 38- by 44-m plots were marked with stakes at each corner with each long side placed parallel to the proposed MIT/LL radar flight line of 55 deg of magnetic north (40 deg of approximate true north) (Figure 4). They were designated Plot A, Plot B, and Plot C.

Ft. Devens Site Layout
Training Area 6A

11–22 July 1988



COORDINATE TABLE
BASED ON MIT/LL MAY 88 SURVEY

PT. NO	EASTING	NORTHING	ELEVATION
11 (start pt)	81181	6571	134.068
10 (ref pt)	81179	6451	128.938
TP1	80753	6653	95.457
TP2	80839	6858	97.536
TP3	80752	6872	95.255
TP4	80777	7322	94.603
S A	80927	7349	99.420
TP6	80971	7347	101.441
TP7	81036	7091	110.376
TP8	81032	6878	119.225
TP9	81073	6814	122.656
TP10	81015	6559	115.582
TP11	81132	6547	130.704
CLOSE	81182	6571	134.293

Figure 4. Radar test site layout

23. Prior to the overflight, EL personnel described the study plots, measuring parameters known or suspected to affect radar return. Three different types of mines were placed in carefully determined positions and configurations to ascertain if such targets could be discriminated from the background using the 35-GHz radar and the algorithms designed to process the radar signals. Immediately prior to the overflight, MIT/LL personnel placed reflectors of known backscattering properties adjacent to the plots in which the mines had been placed. These reflectors were placed to be compatible with the depression angle(s) for the side-looking radar as well as to locate exactly the test plots in the images resulting from the processing of the airborne data collection.

24. A cursory inspection of each of the three selected plots revealed differences among them. Plot A was situated at a slightly higher elevation than the other two plots, and the soil had significant clay and silt content in what was otherwise predominantly sand. One corner of the plot included a monoculture of overmature wheat apparently planted for wildlife food. The rest of the plot was sparsely covered with low grasses and forbs.

25. Plot B likewise had a surface composition of predominantly coarse-grained materials. The elevation of Plot B was less than that of Plot A. Additionally, Plot B enclosed pools of standing water surrounded by cattails: these water bodies and the lush vegetation associated with them should be apparent in appropriately processed radar images. The rest of the plants sparsely covering the plot were assorted annuals. Many large rocks (10 to 50 cm in diameter) were present on the soil surface.

26. Plot C was covered with coarse-grained materials and was essentially bare of vegetation when the EL team arrived. By the time of the overflight, however, some small grasses and forbs had begun to appear, though generally of no greater height than 10 cm. Because Plot C had little or no vegetation during the time of the field characterization, vegetation data collection at Plot C was not attempted. Surface geometry and composition were described, however.

Data Collection

Surface geometry

27. Surveying tasks were accomplished with a Wild Herbrugg laser theodolite (Figure 5), automatically recording location data into a GRE4 recorder/computer (Figure 6). Points stored as survey locations were measured

Figure 5. Onsite use of laser theodolite with automatic recorder

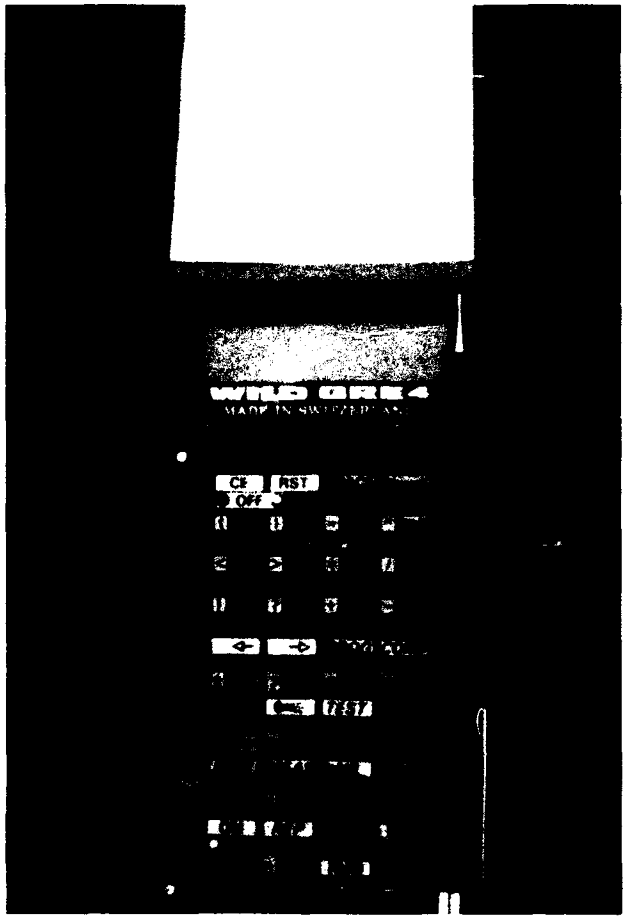
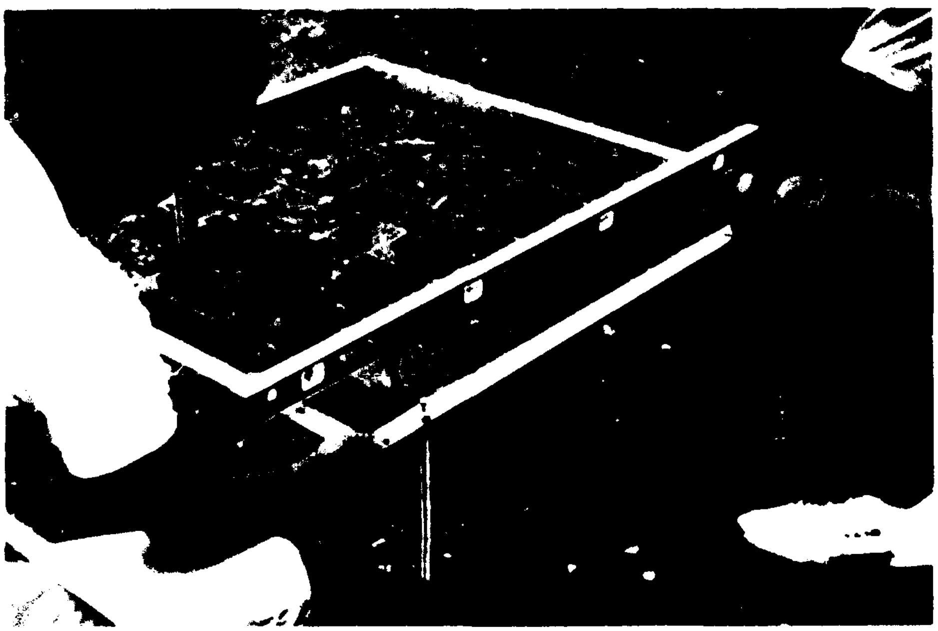


Figure 6. Recorder/computer used in survey

in the field and read back later for processing by a portable computer (Zenith SuperSport Flattop) with software (Surfer from Golden Software) producing contour plots. Microgeometry at a finer scale was also measured at selected locations within the plots using a leveled 1-m-square sampling grid. The coordinates were measured and recorded to a vertical resolution of 0.1 cm and to a horizontal resolution of 10 cm (Figure 7).

28. The precision implicit in this survey technique was in part dictated by the behavior of electromagnetic waves as they encounter a reflecting surface. Figure 8 depicts the theoretical effects of roughness on the reflected radar signal. For this illustration, wavelength (λ) and depression angle (γ) were held constant. Therefore, surface "roughness" is the only independent variation. Small changes in height of ground features should affect both the character and magnitude of the radar return. When the radar data are analyzed and compared with the ground measurements, the roughness

a. Vertical resolution



b. Horizontal resolution

Figure 7. Setup for measuring microgeometry

effect can perhaps be quantified and qualified. Abscissa axis labels can be modified to read in units of surface roughness σ_h. According to the Rayleigh criterion for rms to be met where specular and diffuse components are exactly equal, $\sigma_h = \lambda/(8 \sin \gamma)$. In this study (0.86/8 * 0.707 = 0.152 cm). Thus, the microgeometry measurements should relate to the roughness sensed by the radar. With less roughness, the diffuse scattering can be neglected. With greater roughness, the specular component of the relationship shown in Figure 8 can be neglected.

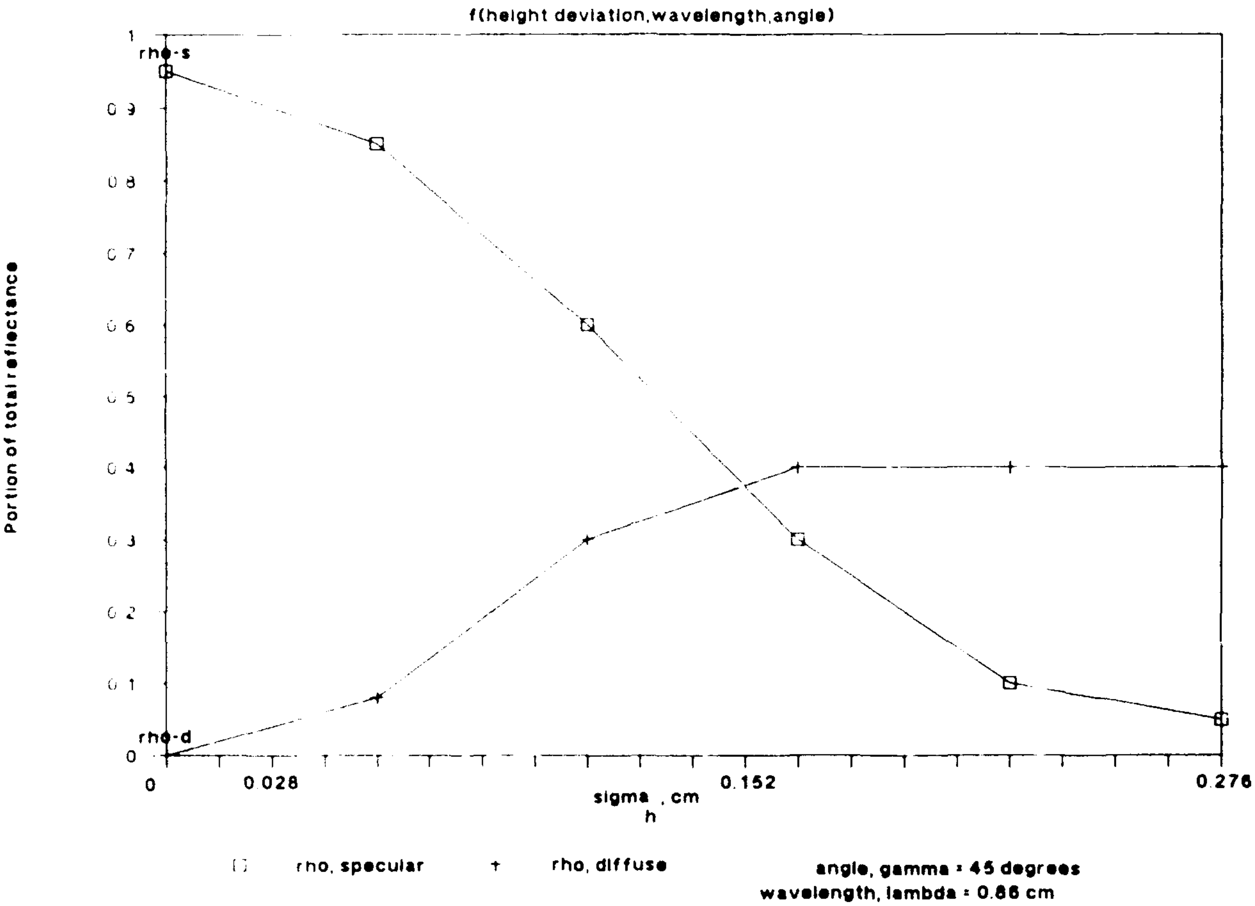


Figure 8. Specular and diffuse reflectance as functions of roughness (from Ostrovityanov and Basalov 1982)

Surface composition

29. Soil data including bulk samples and moisture-density measurements were also taken. Bulk samples were collected from the surface to a depth of about 20 cm. At least 2 lb of soil material was removed with a shovel and

placed in a large plastic bag with an identification tag enclosed. This amount of soil is considered adequate to run the laboratory analyses, including gradation of particle sizes and plasticity measurements. Density was determined from a sample taken with the 3-in. drive sampler. This instrument is a handle and rod with a 1.8-kg hammer (Figure 9). In collecting the density sample, a thin-walled metal cylinder (drive ring) was driven into the soil until it was approximately 1 in. below the surface. The handle and rod were then detached, and the drive ring and the sample were dug from the surrounding soil. The exterior of the cylinder was rubbed free of all soil stuck to the outside. The top and bottom of the soil sample were then carefully trimmed flush with the upper and lower rims of the drive ring. The sample and drive ring were then weighed with a triple beam balance (Figure 9).

30. Weights and densities were determined as follows:

Wet weight of soil = total weight - weight of drive ring (engraved on the outside of the cylinder)

Wet density (g/cc) = wet weight/volume (drive rings contain 302.6 cc in volume)

A portion of the soil was removed from the ring and placed in a moisture content can. The can and the soil were then weighed. These cans were sealed for transport to the WES for supplementary laboratory measurements. The numbers engraved on the cans were recorded in a logbook along with the location and date that the sample was collected.

31. Moisture content only (wet basis) was also determined throughout the site with Speedy Moisture Tester (Figure 10). Some dry densities were deduced at the site using the Speedy Moisture measurements of soil samples collected with the soil sampler described in the previous paragraph, using the following formula:

$$\text{Moisture content (dry basis)} = \frac{(\text{wet soil mass, g}) \times \text{Speedy Moisture content}}{\text{wet soil mass} - \text{wet soil mass} \times \text{Speedy Moisture content}}$$

Dry density (g/cc = wet density/(1 + moisture content, dry weight basis)

32. Soil moisture determinations were made in the borings surrounding Plots B and C where dielectric parameters, conductivity (mmhos/metre), and permittivity (designated sigma and epsilon, respectively) were measured with a dielectric probe (DICON designed and built under contract by the Ohio State University, Contract Number DACA39-83-K-0001, 1985) and were recorded by depth (Figures 11a and b).

a. The drive sampler

b. Drive ring and sample

c. Mass determination of soil sample

Figure 9. Soil density sampling

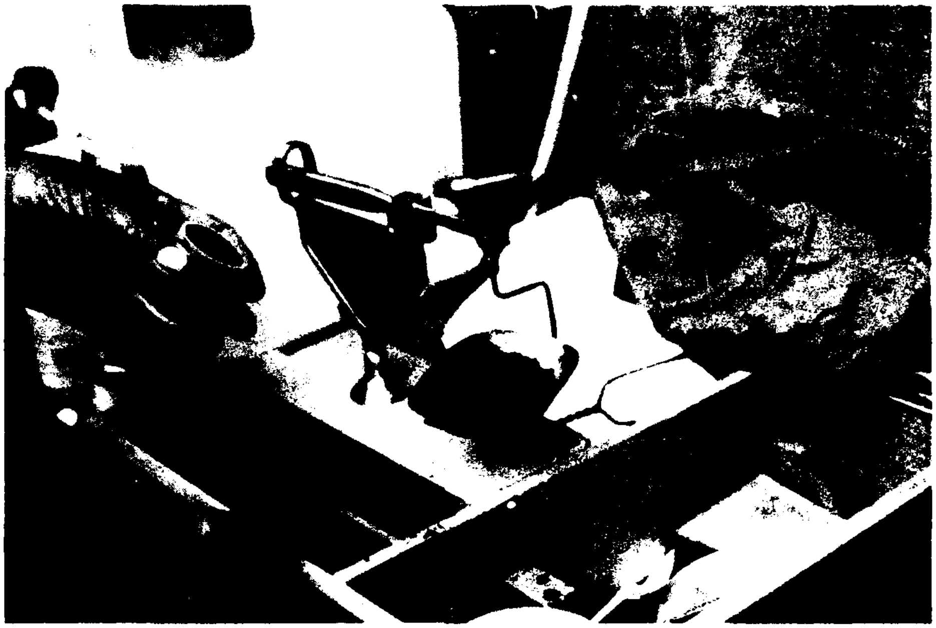


Figure 10. Determination of soil moisture content using the Speedy Moisture Tester

a. Preparing location for dielectric measurements at depths

b. Measuring conductivity and relative permittivity

Figure 11. Determining dielectric parameters

Vegetation

33. The number of vegetation samples taken within each plot was arbitrary. (Locations in parentheses refer to the local coordinates system of each plot. Reference (0,0) is the southeasterly corner of the 38- by 44-m plot.) Plot A was first sampled on 14 July with the 1-m-square frame, sampling alternate square metres from (44,0) to (44,32) in the 38- by 44-m plot (19 samples). Plot B was sampled in like manner from (44,38) to (6,38) (19 samples). Plot A was again sampled on 19 July from (1,0) to (1,37) 13 samples). Plots out of the sampling line were sampled as well to describe special situations, e.g., a monoculture wheat stand or an occasional shrub. According to the species:area curve technique employed by WES,* the plots were oversampled with respect to the species diversity found at each plot (Figure 12). According to the technique, the minimum sample size dictated is reached when a 10-percent increase in cumulative sample size yields no more than a 10-percent increase in individual species encountered. The three sampling series (Plot A, 14 July; Plot B, 14 July; and Plot A, 19 July) were performed using 1-m-square sampling frames further subdivided equally into 10- by 10-cm-square subsampling areas. Each of the curves shown in Figure 12 flattens well before the last sample is plotted, indicating a sufficient sample of plant-type diversity by the above criterion.

34. Vegetation data for Plots A and B were collected using the vegetation data form specifically designed for the Fort Devens exercise (Figure 13). The grid in the upper right corner refers to the internal coordinates designated for the plot being described. The approximate location(s) of the metre-square vegetation sampling grid(s) can be (and were) indicated on this graph. Referring to the tabular part of the form, each plant species type was identified by the plot name (A, B, or C) and the sequence in which the plant type was first encountered. This identification was retained when distinguishing plants were collected for later field and laboratory measurements, such as mass, volume, and moisture content. Sequencing was re-initiated for resampling of Plot A when it was performed. (Sequential letters, A, B, etc., were employed instead of Arabic numerals in the resampling of Plot A at a later time and in a different location within the plot.) Coordinates (x,y) refer to the position relative to the plot displayed on the upper right of the data

* Tingle et al., op. cit.

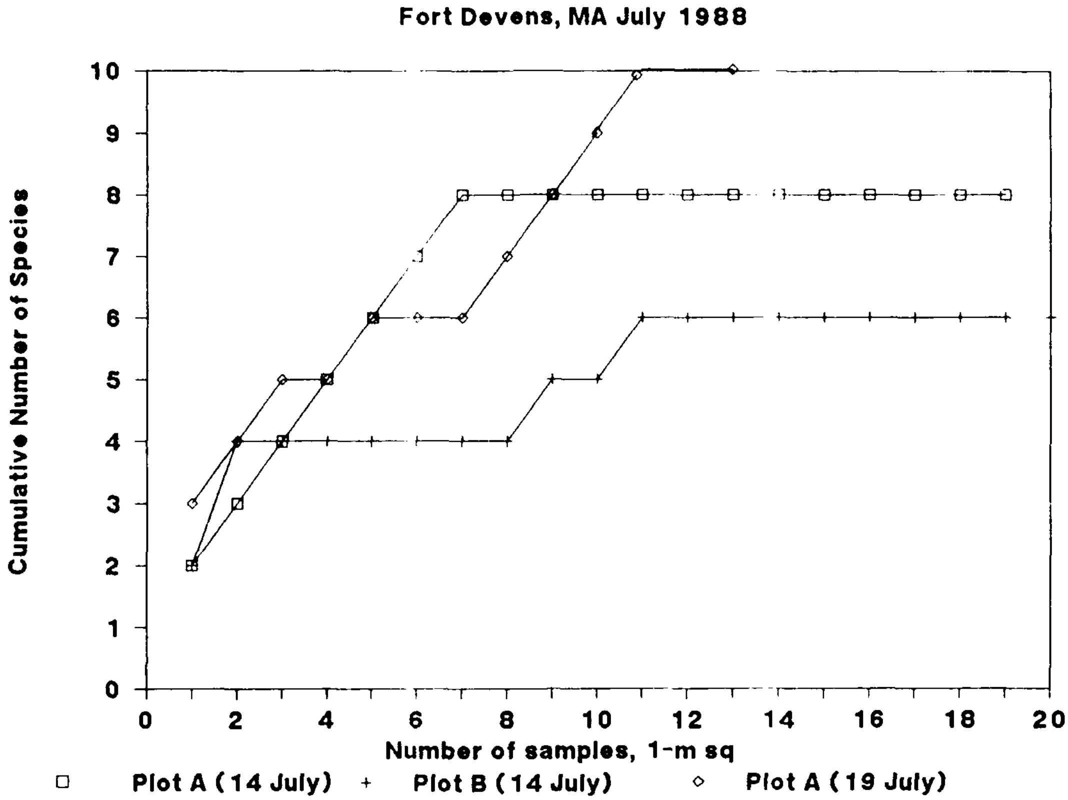


Figure 12. Species-area curves to determine adequacy of sample size

sheet. Other parameters include plant height, height of crown bottom, width, leaf width, and length ("width" being the broadest dimension at a right angle to the length and "length" being the long axis of the leaf). The parameters A and B provide an estimate of coverage and abundance: A is the number of individual plants being described in the "typical" subsample square (10 by 10 cm), and B is the number of squares of the 100 subsample squares in the 1-m-square sampling grid in which the plant being described appears. The product of the parameters A and B yields an estimate of density, the number of plants falling within the metre-square sampling frame.

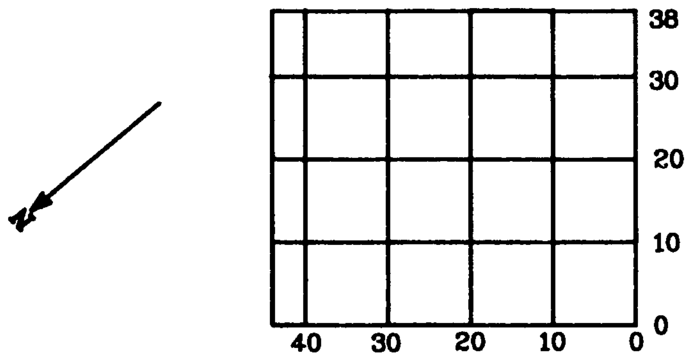
35. Figure 14 shows data collection at Plot B. Each plant type and its frequency in the 1-m-square area were recorded. Prevalent plant types at each plot were collected for fresh weight and volume determinations. They were identified on the tag by common name (e.g., Queen Anne's lace, milkwort, etc.), date of collection, and plot identification (Figure 15a). Figure 15b shows the plant identification scheme with the associated common names of the most frequently occurring plants (determined by visual inspection) in the two vegetated Fort Devens plots (A and B). Heights were measured, and leaf area

VEGETATION DATA SHEET

FT DEVENS MA RADAR SITE

DATE ____________

PLOT NO ____________



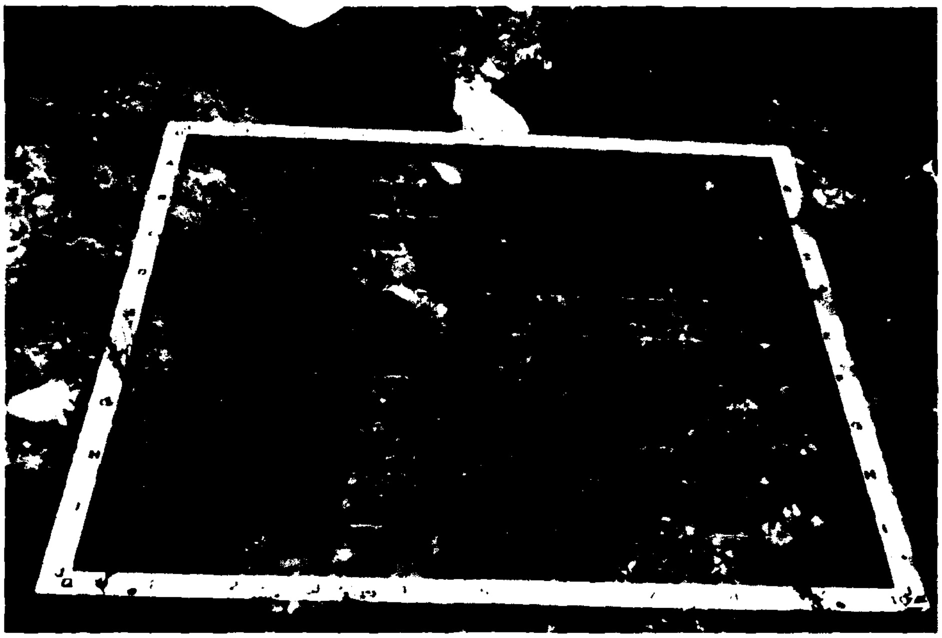
PLANT NO.	X	Y	PLANT HEIGHT	CROWN BOTTOM	CROWN WIDTH	PLANT SHAPE	LEAF WIDTH	LEAF LENGTH	A*	B*	Roll,Frame

Collected by :

A* – Number of Plants per 100 square cm
B* – Number of Squares per square meter containing this plant

Page ________ of ________

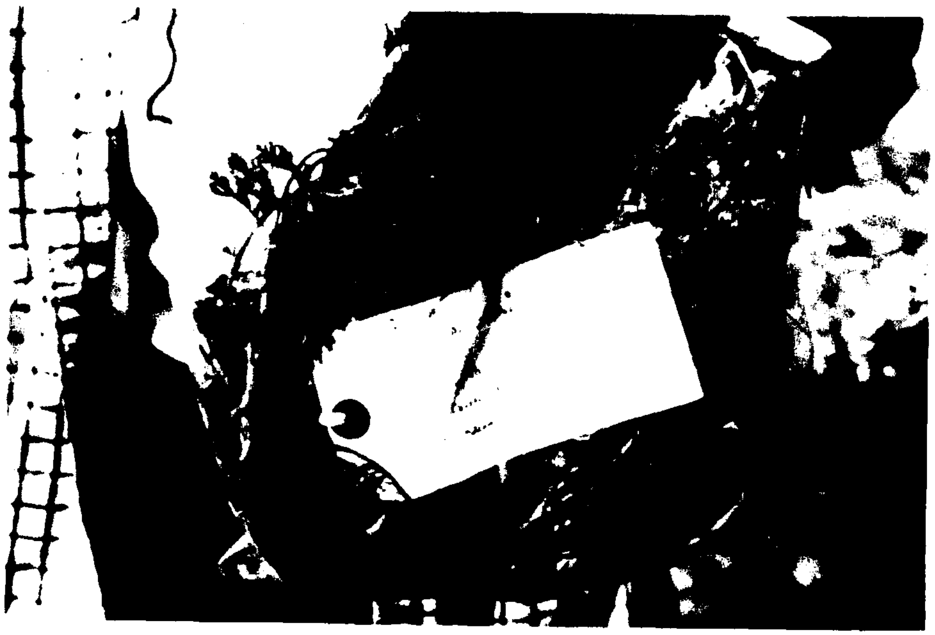
Figure 13. Data sheet used to collect vegetation data



a. Using the 1-m-square to estimate coverage and abundance

b. Determining height of cattails in plot B

Figure 14. Data collection at Plot B. Each plant type and its frequency in the 1-m-square area were recorded



a. Vegetation sample collected for laboratory analysis

Vegetation Described at Fort Devens, MA

14-19 July 1988

Plant Id.	Common Name	Botanical Name
A-01	wheat	*Triticum* sp.
A-02	grass	Family *Graminae*
A-03	shasta daisy	*Rudbeckia* sp.
A-04	black-eyed susan	Family *Compositae*
A-05	scripus	*Scirpus* sp.
A-06	forb	Undetermined
A-07	small grass	Family *Graminae*
A-08	Low forbs	Undetermined
A-A	marigold'	Undetermined
A-B	grass	Family *Graminae*
A-C	forb	Undetermined
A-D	shrub	*Elaeagnus* sp.
A-E	wheat	*Triticum* sp.
A-F	Eve.Primrose	*Oenothera* sp.
A-G	Br.grass	Family *Graminae*
A-H	milkwort	*Polygala* sp.
A-I	vine	Undetermined
A-J	low forbs	Undetermined
B-01	daisy fleabane	*Erigeron* sp.
B-02	Queen Anne's lace	*Daucus* sp.
B-03	hop clover	*Trifolium* sp.
B-04	milkwort	*Polygala* sp.
B-05	grass	Family *Graminae*
B-06	buttercup	*Ranunculus* sp.
B-07	red clover	*Trifolium* sp.
B-08	red clover (dead)	*Trifolium* sp.
B-09	succulent	Undetermined
B-10	shrub	*Elaeagnus* sp.
B-11	cattails	*Typha latifolia*
B-12	black-eyed susan	*Rudbeckia hirta*
B-13	scirpus	*Scirpus* sp.

b. Legend of plant identification codes

Figure 15. Collection of plants for fresh weight and volume determinations

was determined with the Bruning Areagraph (Figure 16), a transparent sheet containing series of rectangles, each of which contains 10 randomly placed dots at a density of 30 dots/sq in. As stated on Figure 16, 90-percent accuracy is obtained if a total of 10 sq in. is measured. Areas of typical leaves were determined, and these values were converted to square centimetres. The number of leaves on typical plants was counted, allowing estimates of plant leaf area to be derived later.

36. Soon after collection, fresh weights (Figure 17) and fresh volumes (Figure 18) were determined and recorded, while plant moisture content values were determined later in the laboratory from samples brought back in sealed plastic bags. Each bag and the identifying tag to be enclosed were weighed onsite, and those values were recorded by plant number and plot number. The sample plants and their corresponding tags were placed in the appropriate bag, the bag was sealed, and then the bag and its contents were weighed again. Fresh weights of the samples to be used later in moisture content determinations were recorded. One group of plants was treated in this manner after the principal plant parts (leaves, stems, and flower or fruit) were segregated and weighed. When the collected plant samples arrived at WES, they were weighed again and transferred to paper bags for drying in the oven for 24 hr at 200° F. They were then weighed, and moisture contents were determined from the results. The plant samples that had been segregated into principal parts were treated separately so that moisture distribution within each plant could be quantified.

37. Volumes of aboveground parts of fresh plants were determined by the displacement method. An apparatus to determine volume under field conditions was fabricated of simple materials. A 10-in.-outside diameter (OD), polyvinyl chloride (PVC) pipe 28 in. high was closed at the bottom and fitted with a 3/8-in.-inside diameter (ID) metal tube 4 in. from the open top. The tube protruded 1/2 in. from the PVC cylinder, and a 12-in. length of flexible tubing (5/8-in. OD, 1/4-in. ID) was fitted to it; this tubing was allowed to drain into a 1,000-ml graduated cylinder. A 10-in. circle of 3/4-in. plywood and a wire basket were included to aid in handling the plant materials. To determine volume of a plant sample, the container was filled with water, and the wire basket and wooden "top" were gently immersed into the container. The water was allowed to drain through the tube until no more water came out. After the overflow was reduced to drops, 3 min were allowed to elapse before

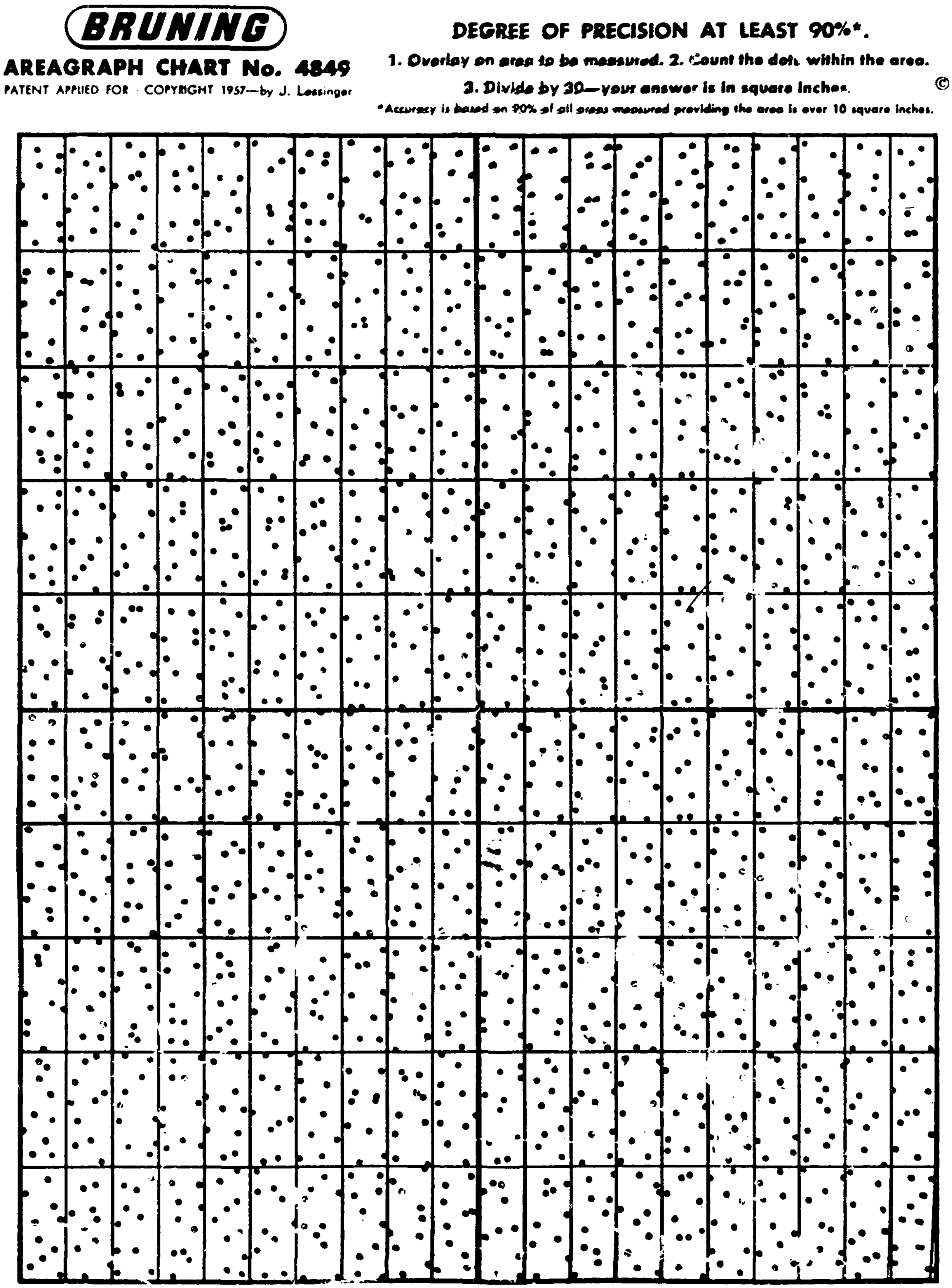


Figure 16. Chart used for determining leaf area
(reduced from 3 rectangles = 1 sq in.)

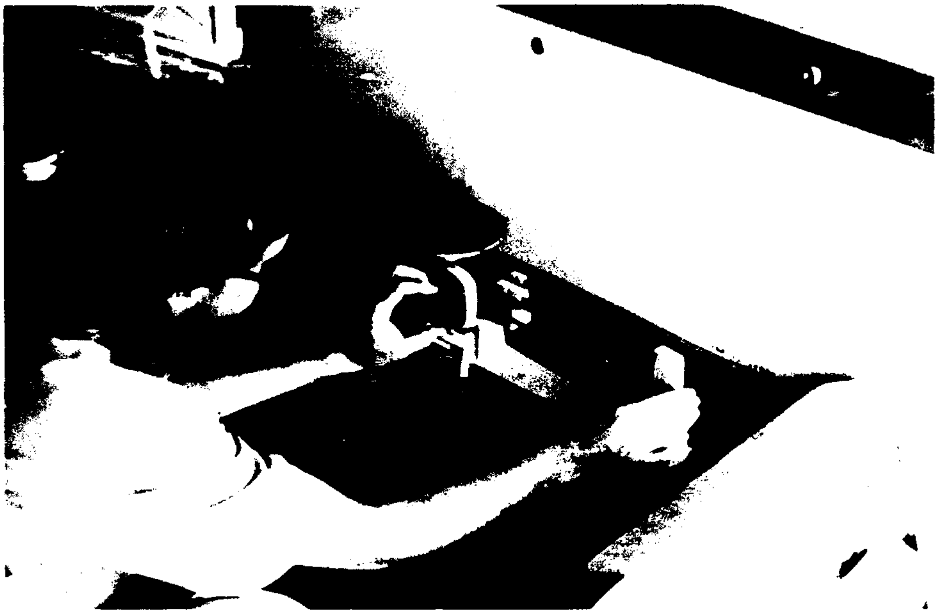


Figure 17. Weighing of *Scirpus*

Figure 18. Determining volume

plant volume measurements were begun. The wooden top and wire basket were then carefully raised with the tube held upward to prevent further overflow. The items whose volumes were to be determined were placed carefully in the basket, and the top and the basket with the sample were slowly lowered into the container. The wooden top was placed so that plant parts would not float to the surface. The hose outflow was placed in the graduated cylinder to collect the displaced water. The hose was allowed to drip 3 min after the flow stopped. The amount of liquid in the graduated cylinder is the volume in millilitres of the plant sample submersed. Immediately outside the perimeter of Plot A at location (28,-2), a square metre of the aforementioned wheat stand was cut, counted, and weighed with wheat and "non-wheat" differentiated (Figure 19). The areal extent of this cultivated plant material was measured in the overall site survey, even as it extended beyond the boundaries of the designated plots (Figure 20). The measurements and estimates derived from them with respect to this "unnatural" vegetation stand were subsequently used to refine the estimates done using the data of other 1-m-square vegetation samples taken inside Plot A but outside the wheat plot.

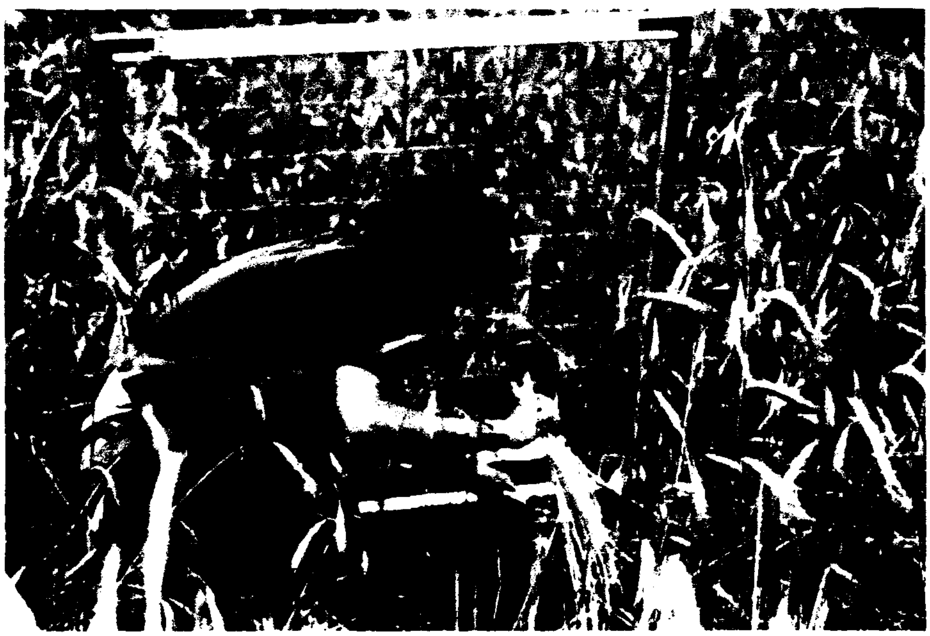


Figure 19. Cropping a 1-m-square wheat sample just outside the Plot A boundary

Meteorology

38. Meteorology stations with microloggers were placed just outside Plot A (15,-5) and between Plots B (60,34) and C, respectively (Figure 21). Air and soil temperatures and relative humidity, solar loading, and wind speed and direction were sampled, averaged, and recorded every 5 min on 20 July 1988, the day of the overflights. Microloggers recorded from 1000 hr to 2400 hr to ensure coincidence with the ADTS flyover scheduled for 1300 hr.

Figure 20. Meteorological station near Plot A

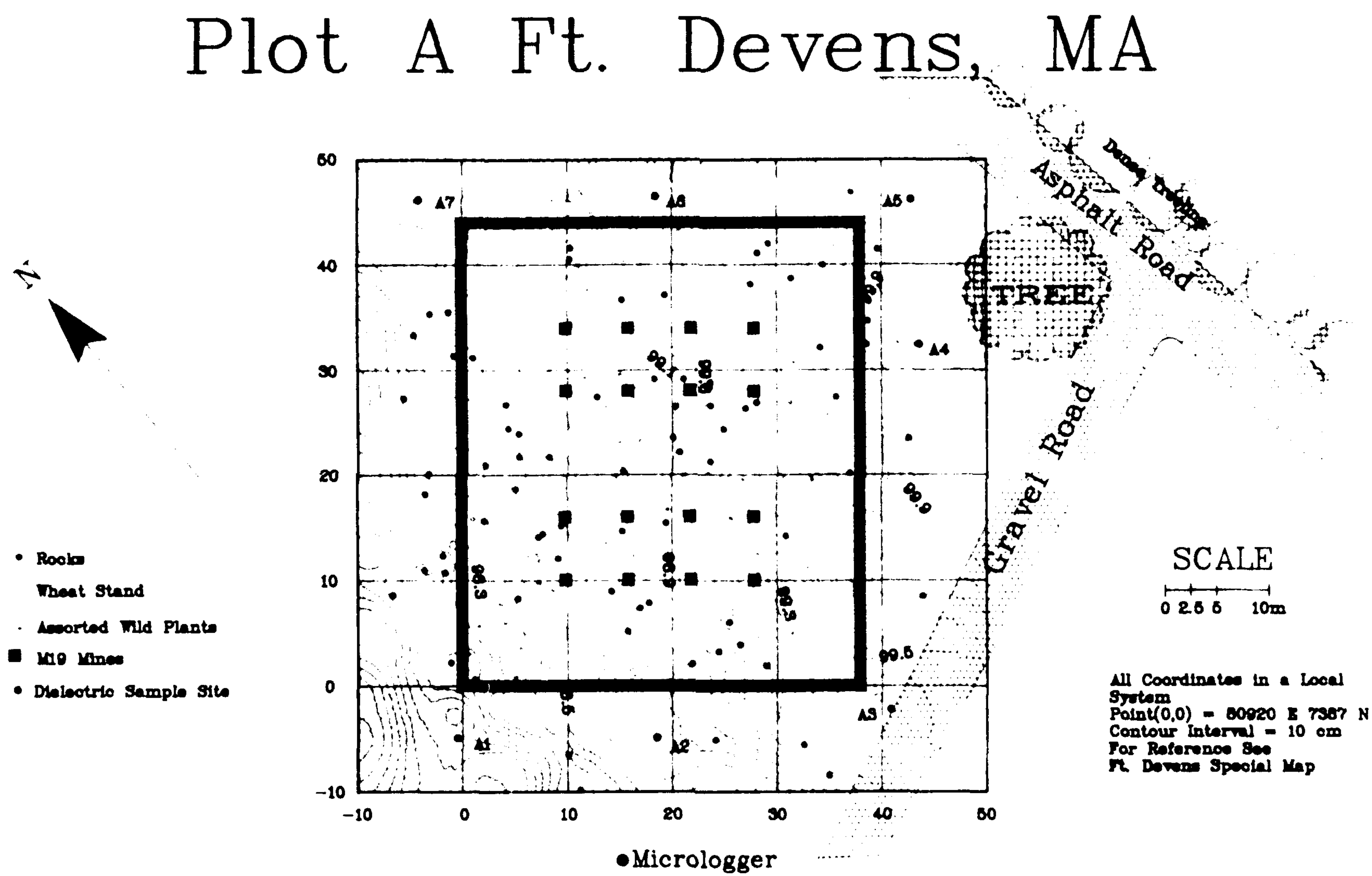
Rainfall data were not collected; however, Fort Devens weather station records, including rainfall data for 20 July 1988, were obtained later.

Data Reduction and Presentation

Surface geometry

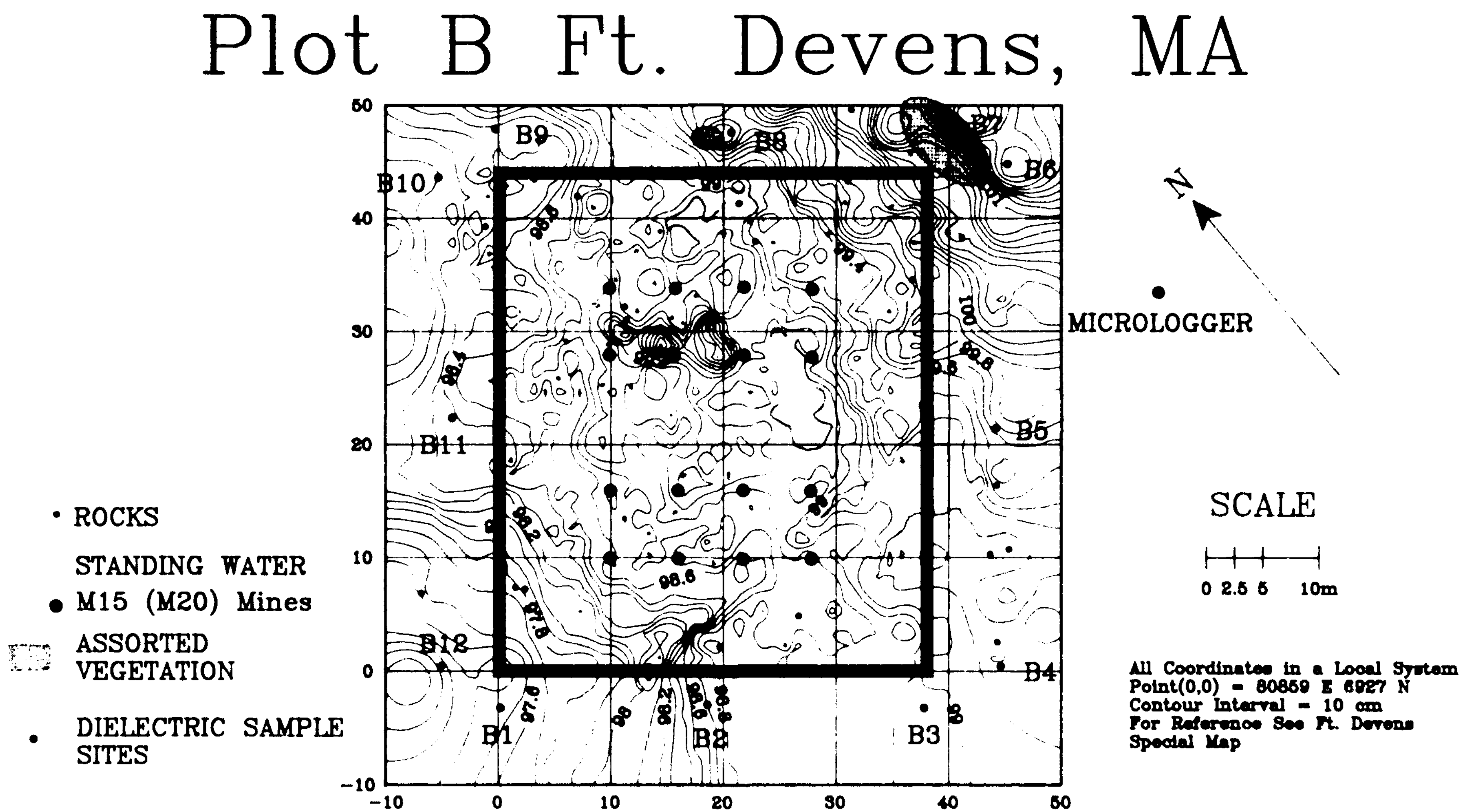
39. Surface geometry data collected for each of the three plots are shown in Appendix A (Tables A1, A2, and A3). These data were used in an interpolation algorithm that produced contour maps as they are exhibited throughout this report. Selected microgeometry plots are shown in their relation to Plot C (Figure 22). Three microgeometry subplots were measured in Plots A, B, and C, respectively. The (x, y, z) data for each of the microgeometry subplots (three in each plot) are presented as Appendix A (Tables A4, A5, and A6).

40. Basic statistics describing the population of elevations (z) of Plots A, B, and C are presented in Appendix C. Figure 23 shows the relative location of each elevation sampling point in the respective plots. The (0,0) points refer to the origin of the coordinate system set up for each respective plot of 38 by 44 m. Sampling density was considerably greater in Plot B because of its more irregular features, with the frequency of sampling points in large part determined by the frequent changes in slope. Figure 24



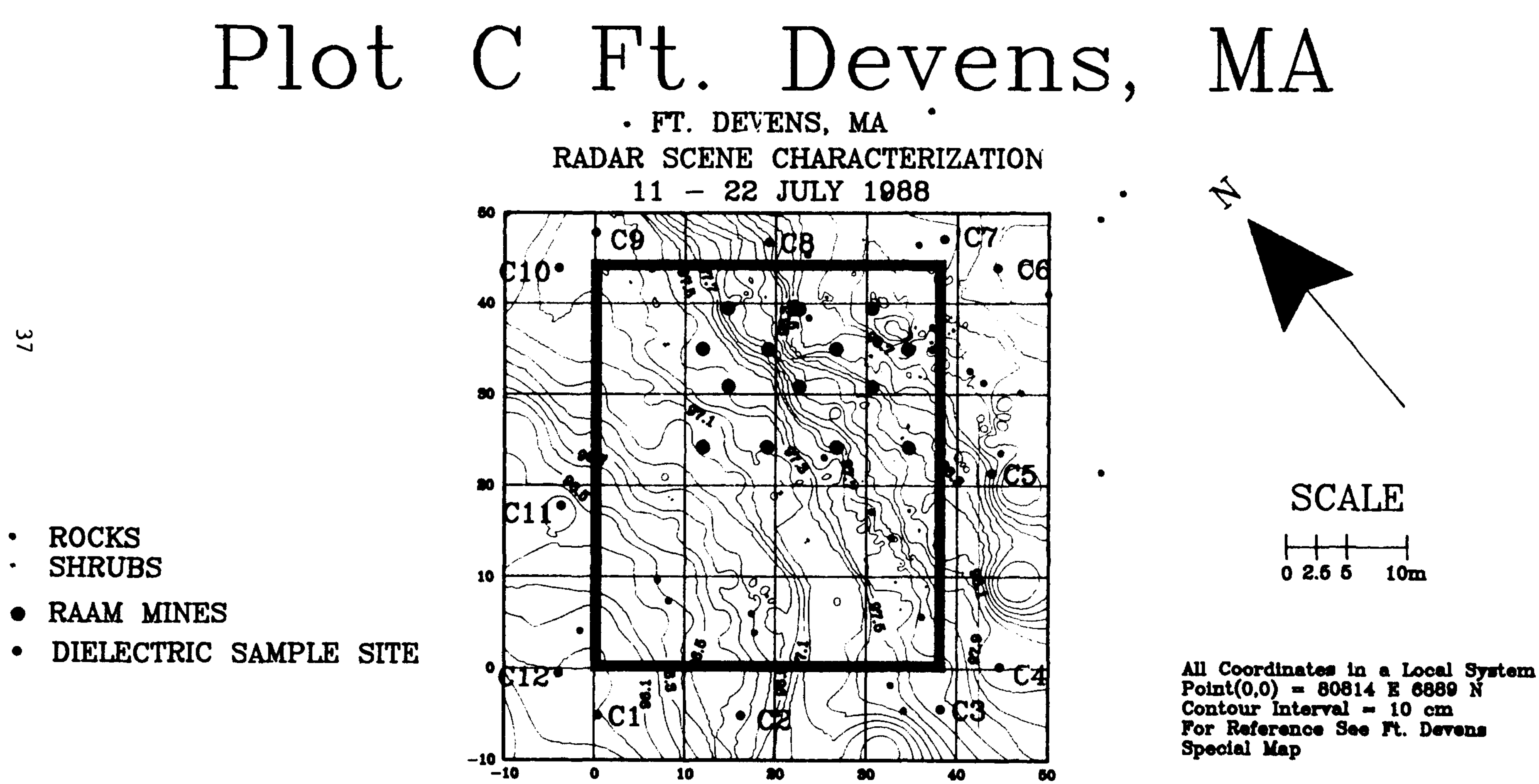
a. Plot A

Figure 21. Locations of measurements and targets (Sheet 1 of 3)



b. Plot B

Figure 21. (Sheet 2 of 3)



c. Plot C

Figure 21. (Sheet 3 of 3)

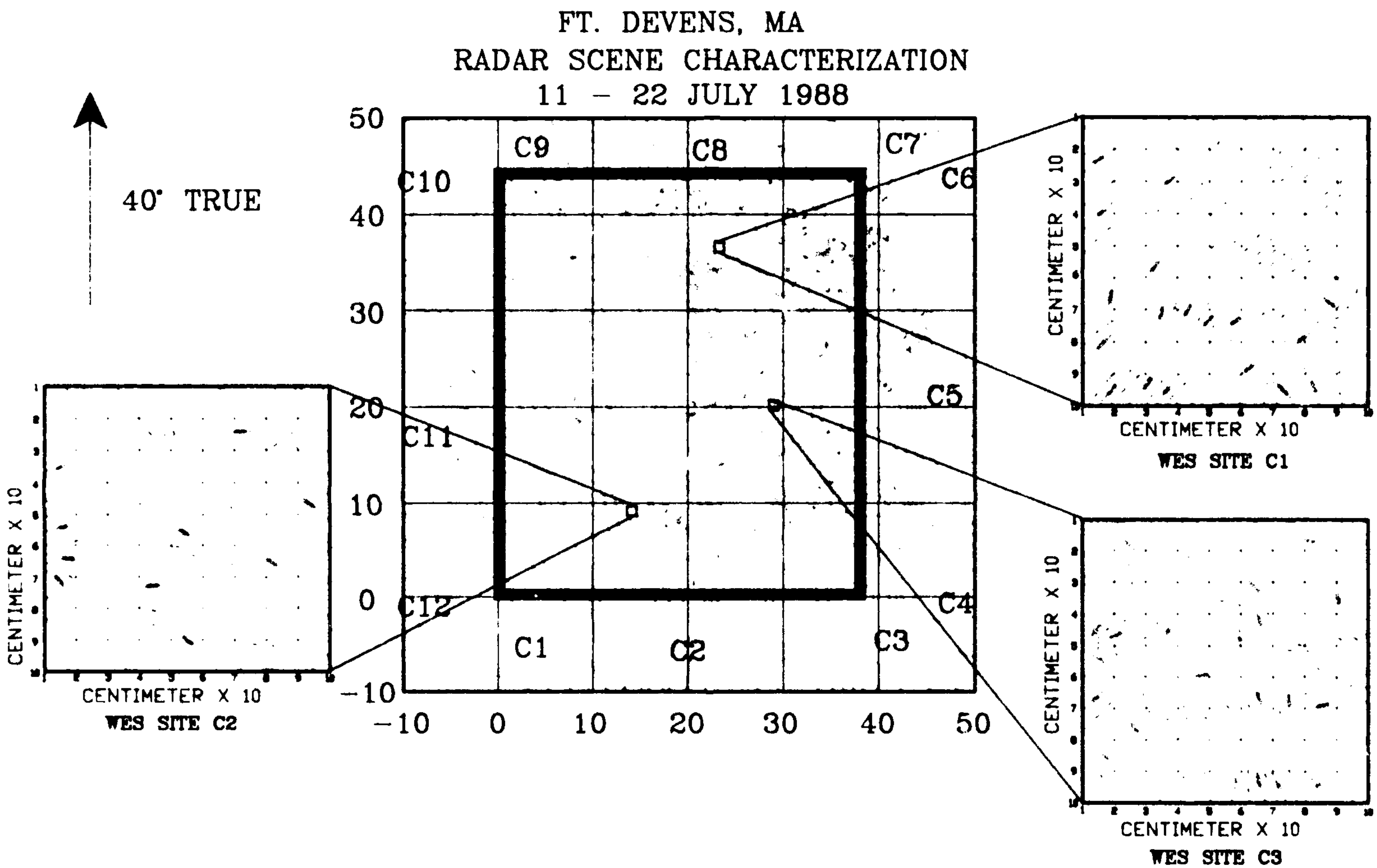
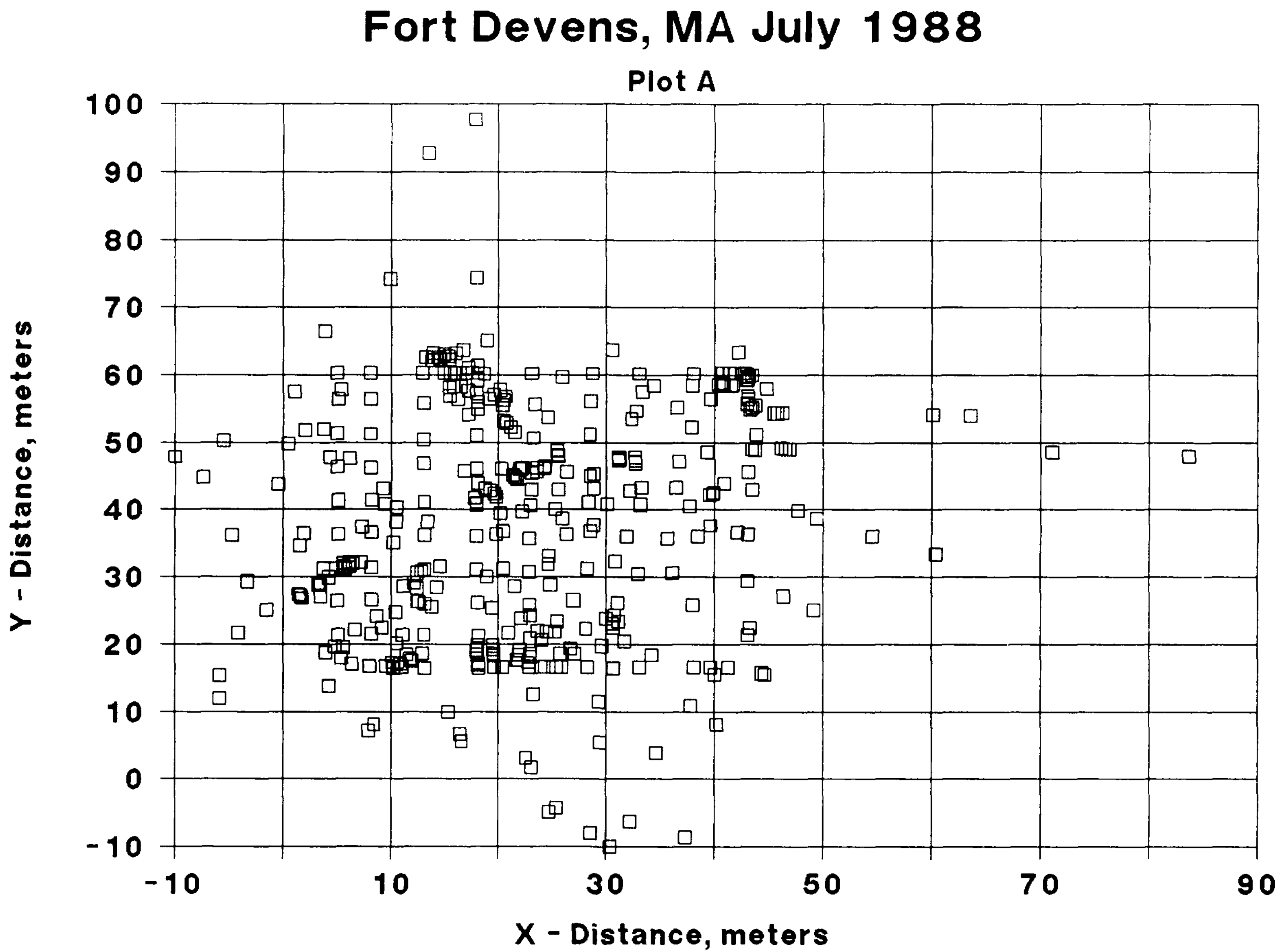
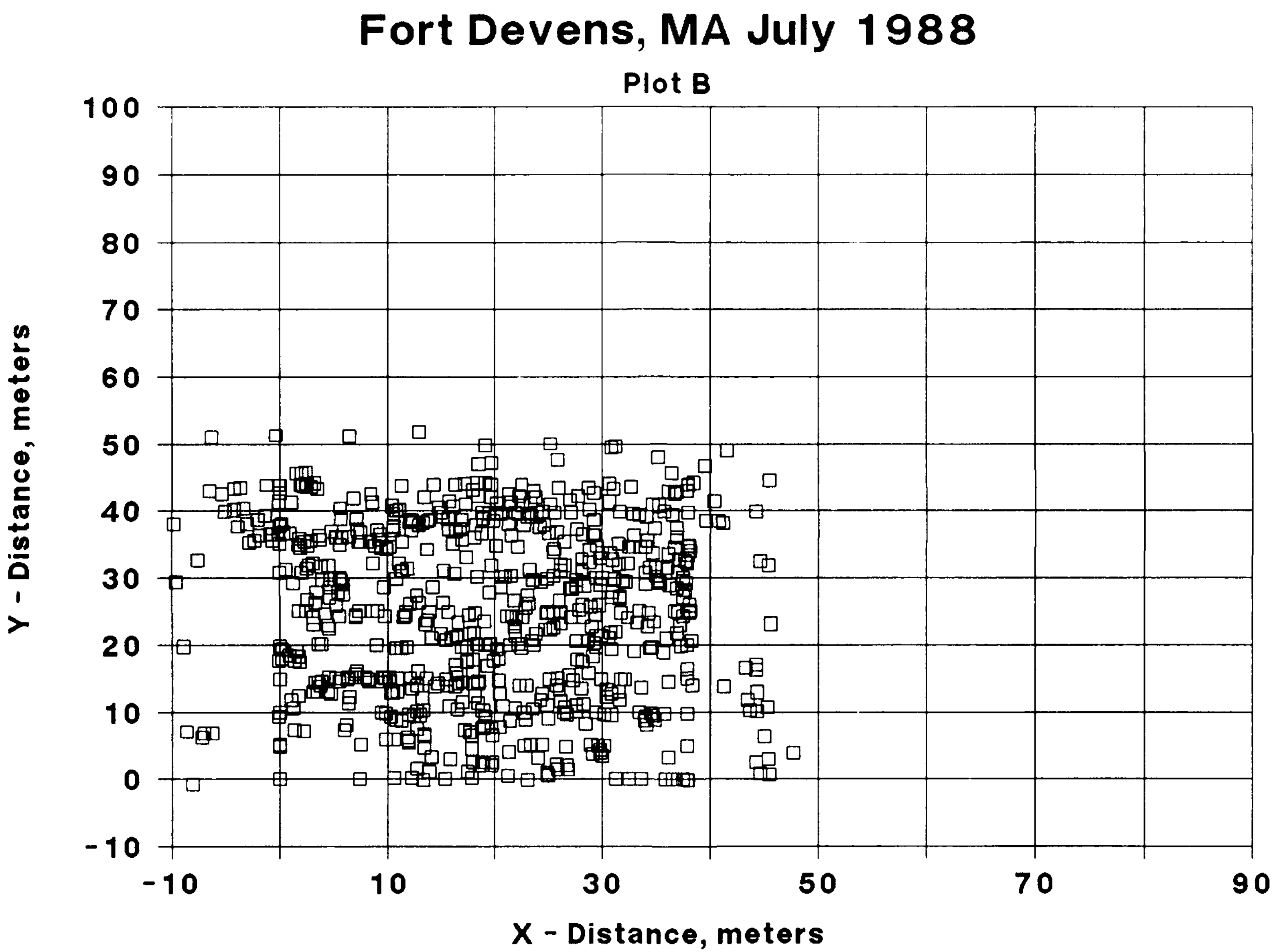


Figure 22. Microgeometry subplots at Plot C



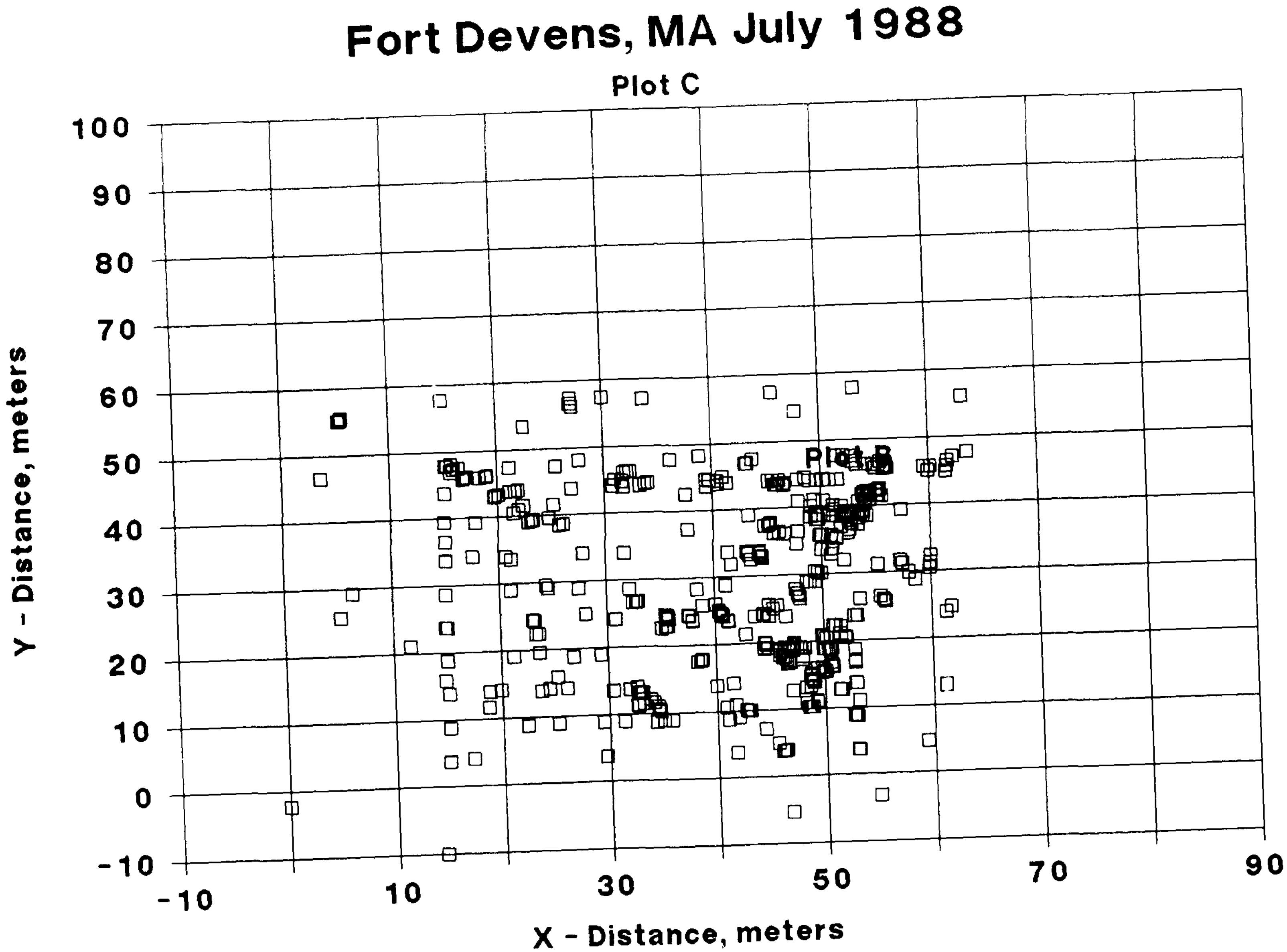
a. Plot A

Figure 23. Elevation sampling points at Plots A, B, and C (Sheet 1 of 3)



b. Plot B

Figure 23. (Sheet 2 of 3)



c. Plot C

Figure 23. (Sheet 3 of 3)

illustrates the elevation difference relative to the respective plot arithmetic mean. Figure 25 shows locations of special features surveyed in each plot. Figure 25 gives the locations at which 1-m-square grids were used to measure relative elevations at 10-cm intervals (microgeometry subplots) in Appendix A.

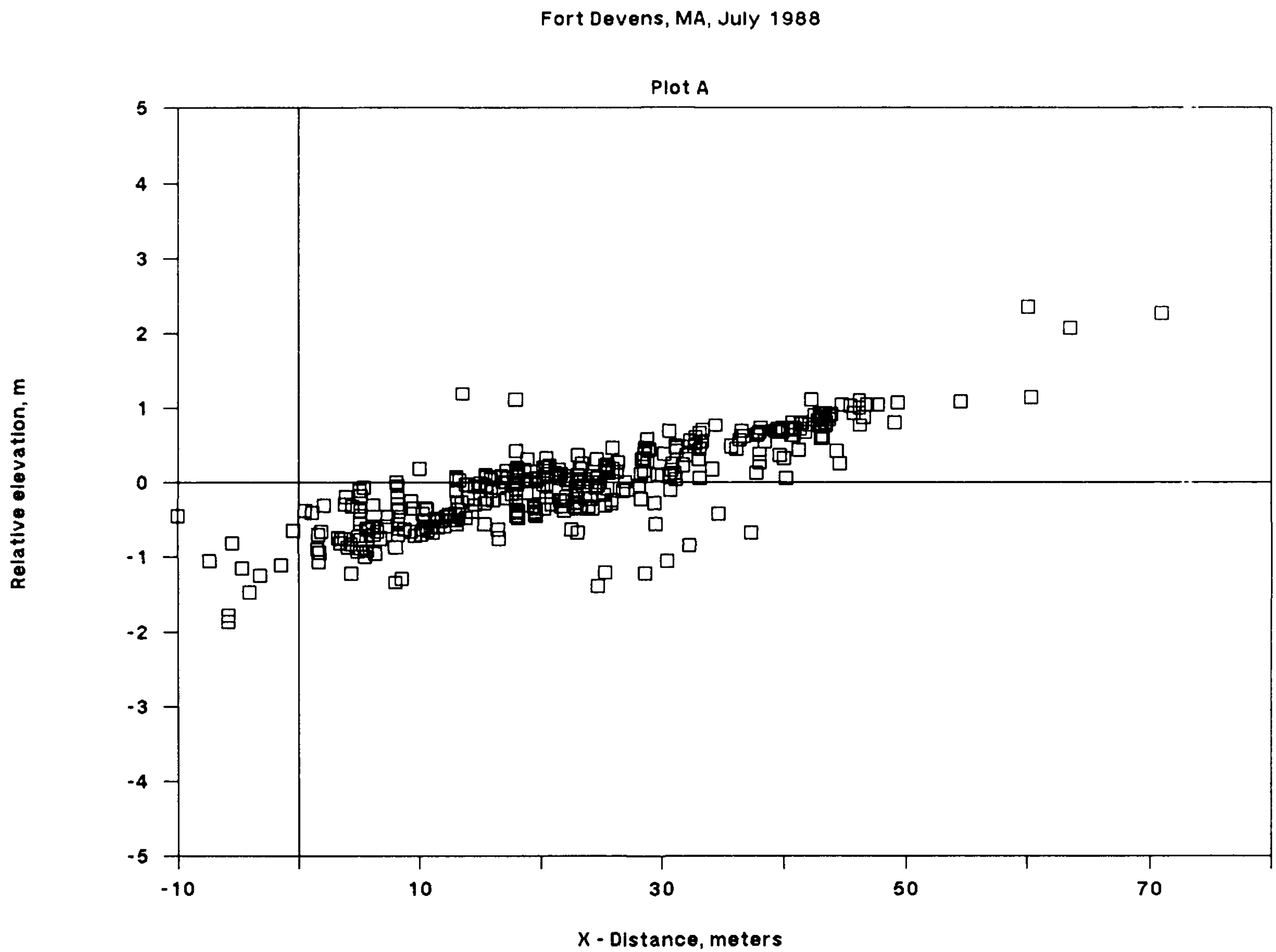
Surface composition

41. Field determinations of moisture content and density of the surface materials of the three Fort Devens plots are shown in Appendix B and the sampling locations in Figures 26 and 27. These parameters are presented graphically as Figure 28. Additionally, surface moisture contents were determined using the Speedy Moisture Tester when the dielectric measurements were made around Plots B and C. Samples of two dielectric parameters, conductivity (mmhos/m) and permittivity, were taken along the respective perimeters of Plots A, B, and C. The locations of the dielectric measurements are denoted in Figure 21 as A1-A7, B1-B12, and C1-C12. These values, and elementary statistics concerning them, are found in Appendix C.

42. Figure 29 shows the relation between dielectrics and mean depth for each boring location. The dielectric data obtained at Fort Devens did not agree with other previous WES measurements very closely; therefore, additional tests of two Fort Devens soil samples taken from Plot A and Plot C, respectively, were conducted at the WES under more controlled conditions than those taken in July 1988. These results are given in Figure 30. The latter results seem to indicate that the measurement instrument was malfunctioning during the July 1988 exercise, causing the improbable measurements.

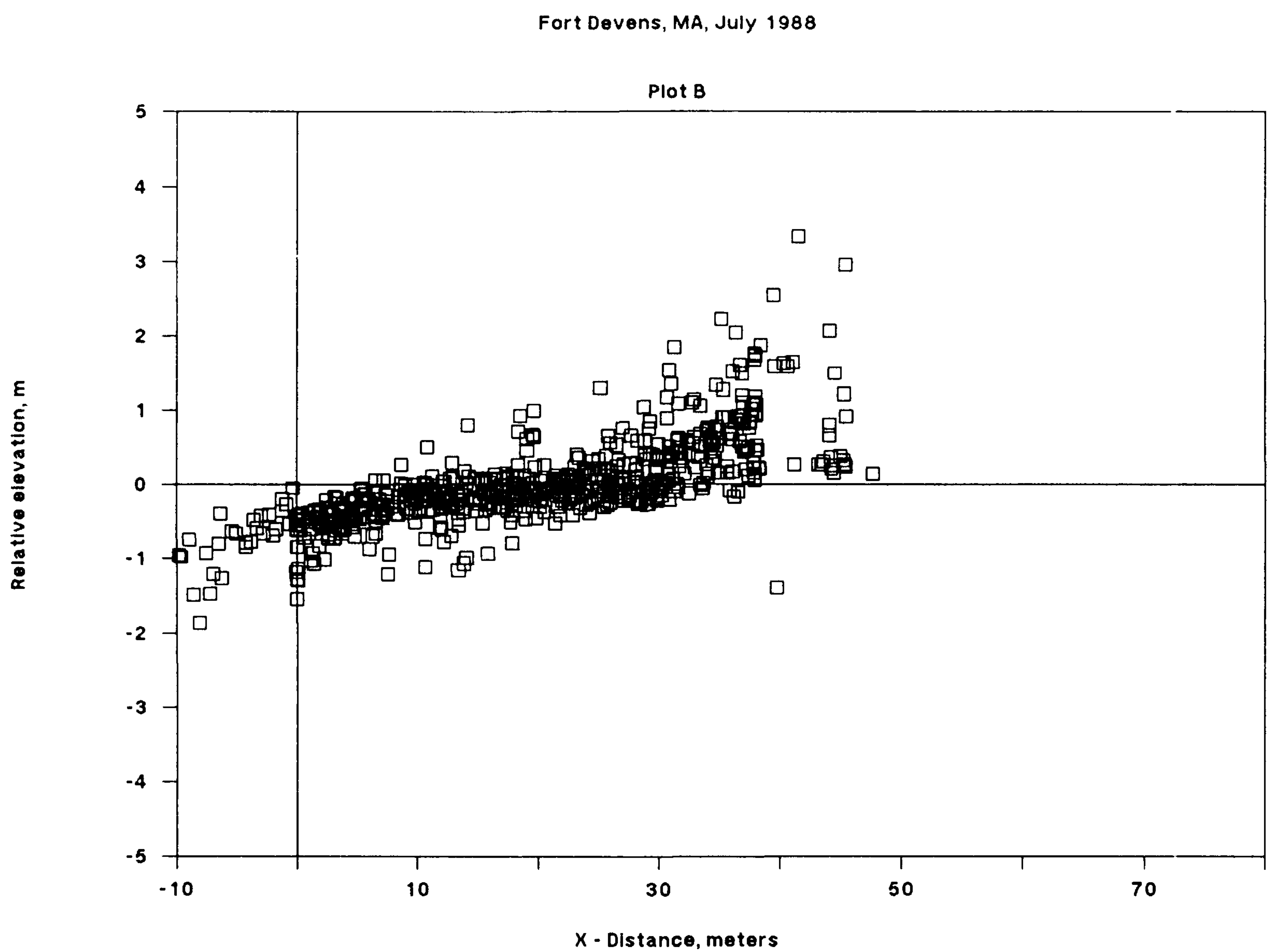
43. Upon inspecting the relationships exhibited in Figures 29 and 30 and comparing them to similar measurements conducted previously at WES, it was decided that the Fort Devens soils be measured for dielectric properties under closely controlled laboratory conditions. Two soil samples were sent to WES from Fort Devens, one sample from Plot A and one from Plot C. The curves in Figure 30 display the results obtained in the laboratory, prompting a reconditioning of the field measurement device because of the disparities between the field measurements and the laboratory measurements.

44. Laboratory analyses were performed on 11 soil samples brought back to WES from the various Fort Devens plots. Generally, they were gray or brown sand, with gravel, silt, and/or clay. A summary of the analyses can be found in Appendix C with the gradation analyses.



a. Plot A

Figure 24. Elevations relative to respective elevations means of Plots A, B, and C
(Sheet 1 of 3)

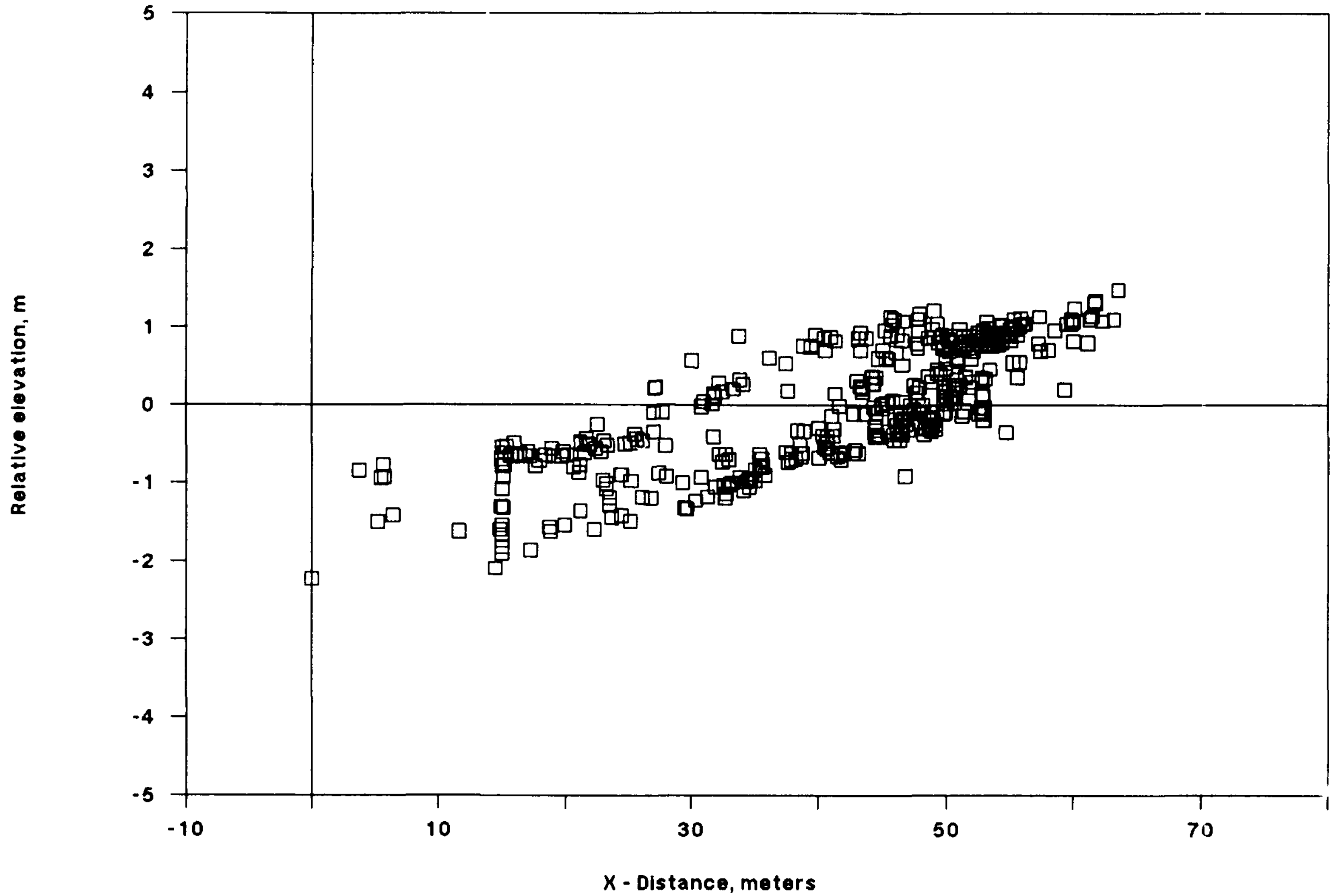


b. Plot B

Figure 24. (Sheet 2 of 3)

Fort Devens, MA, July 1988

Plot C



c. Plot C

Figure 24. (Sheet 3 of 3)

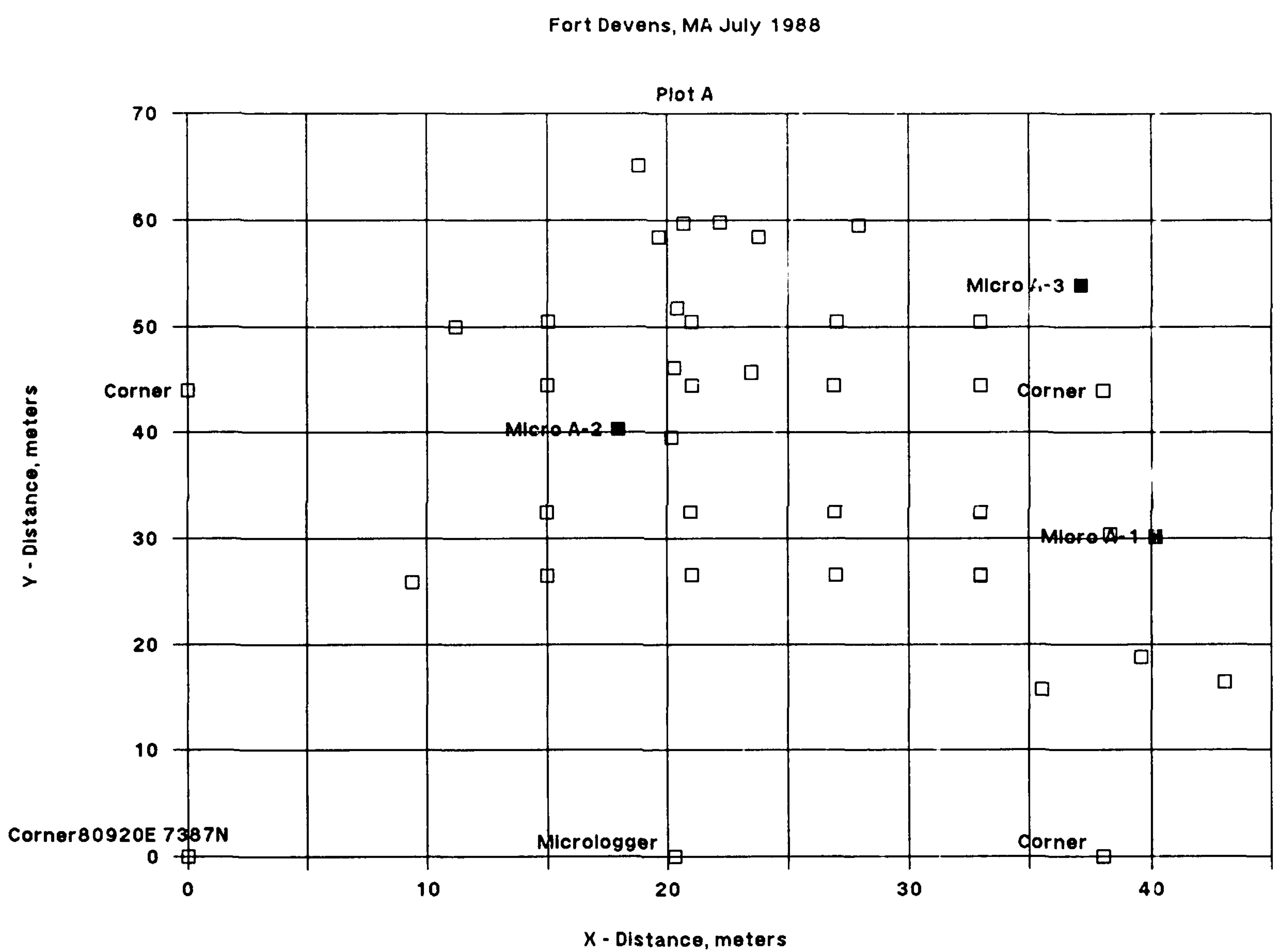


Figure 25. Location of microgeometry subplots (Sheet 1 of 3)

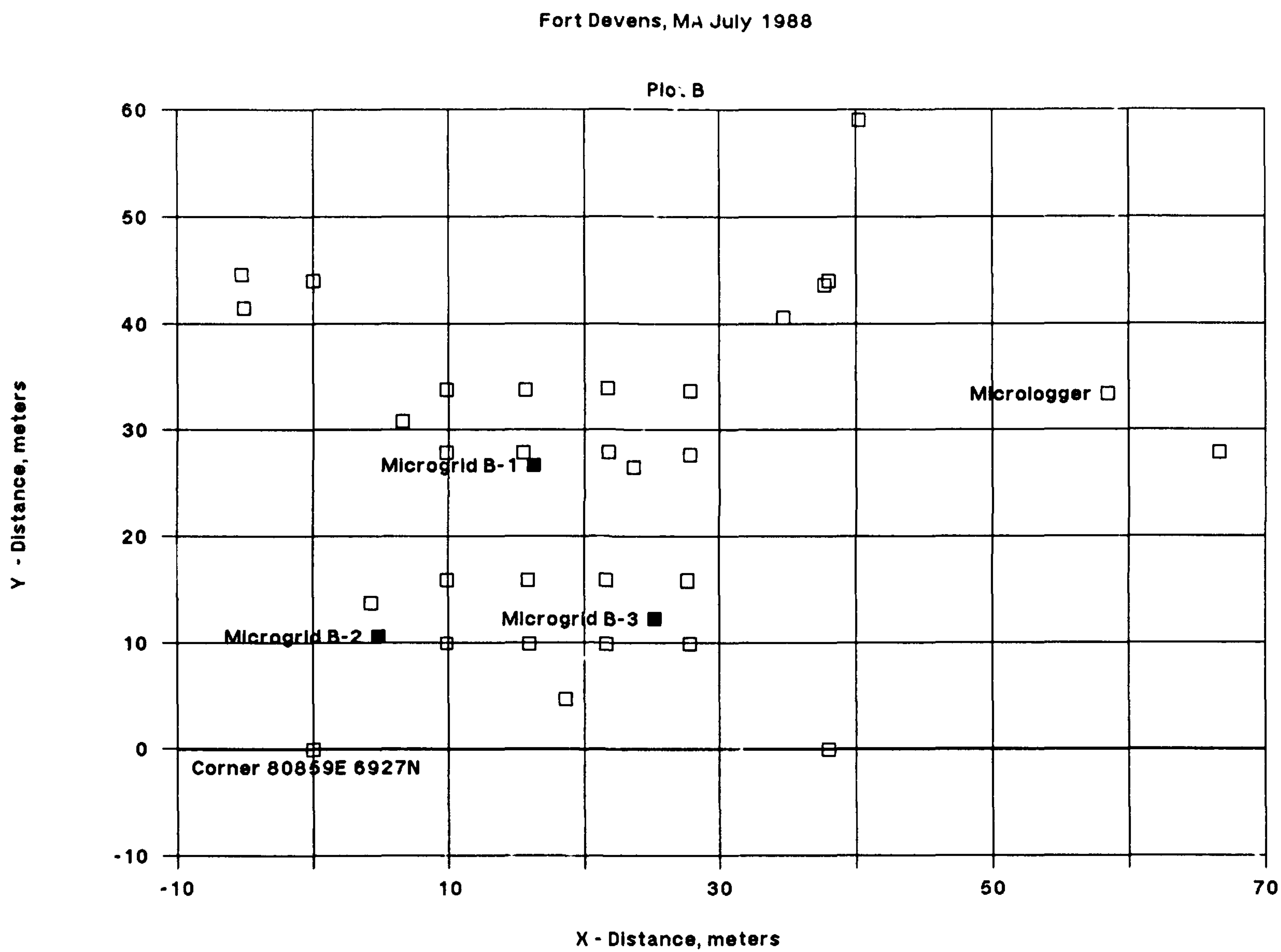


Figure 25. (Sheet 2 of 3)

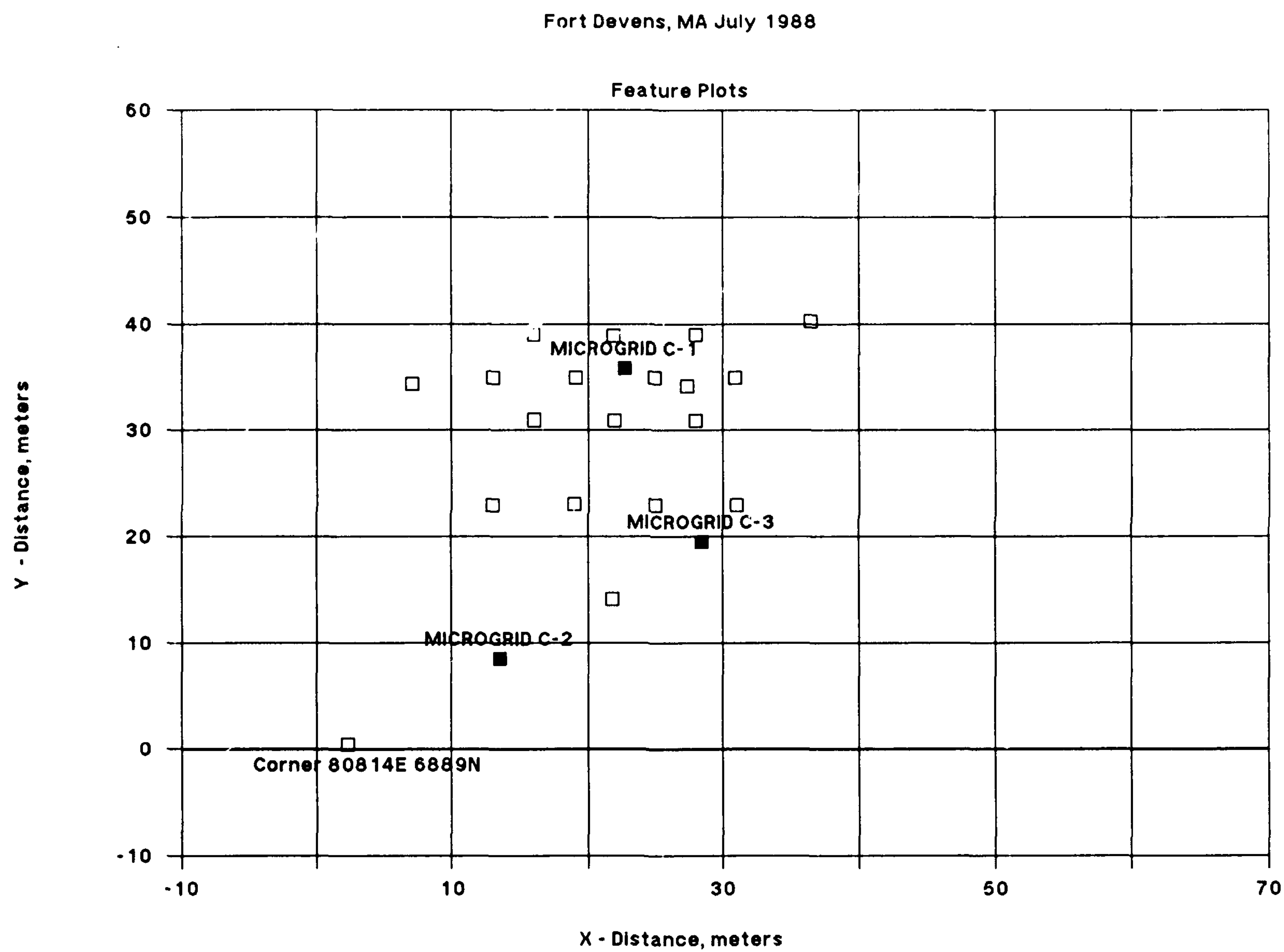
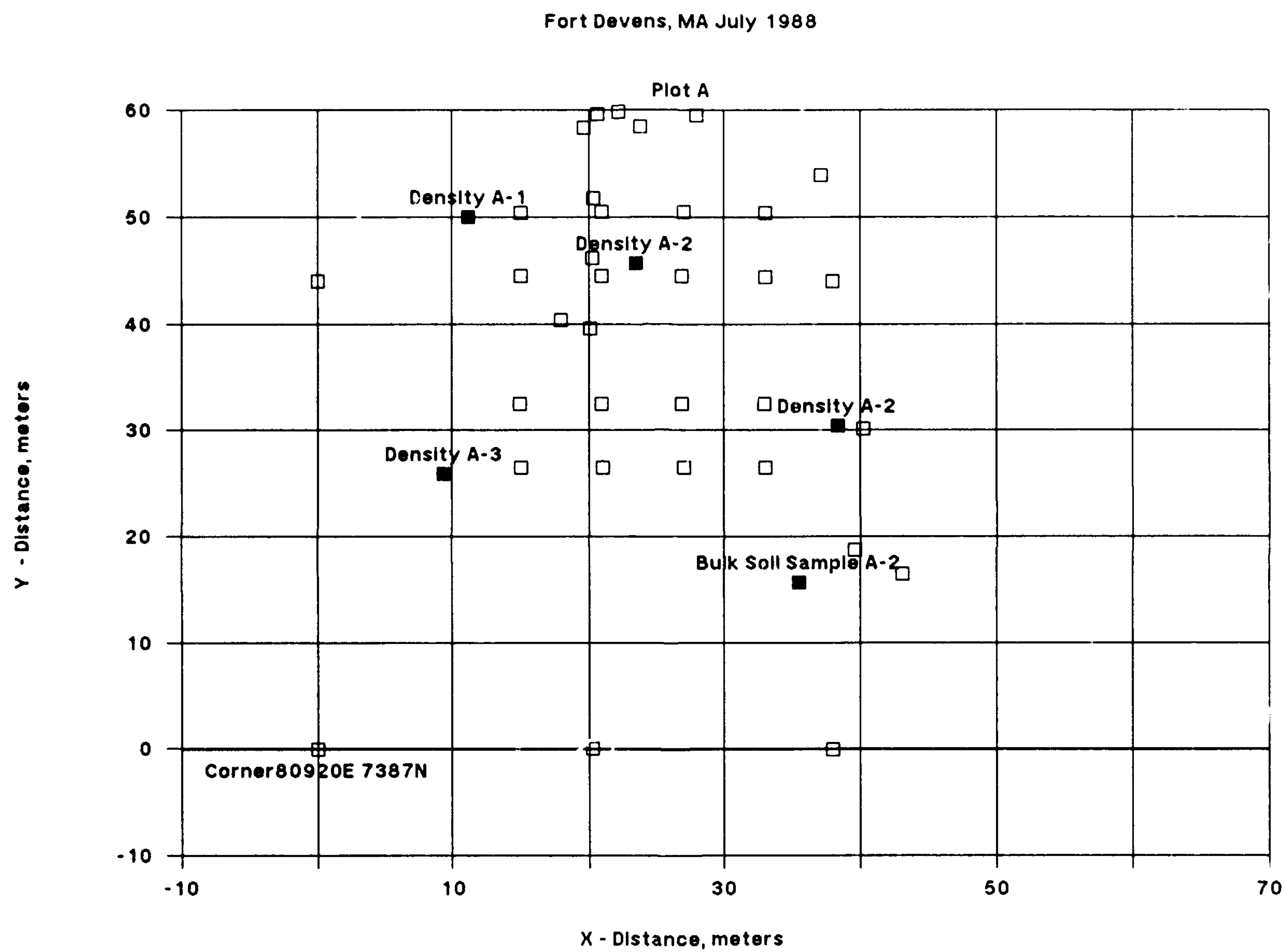
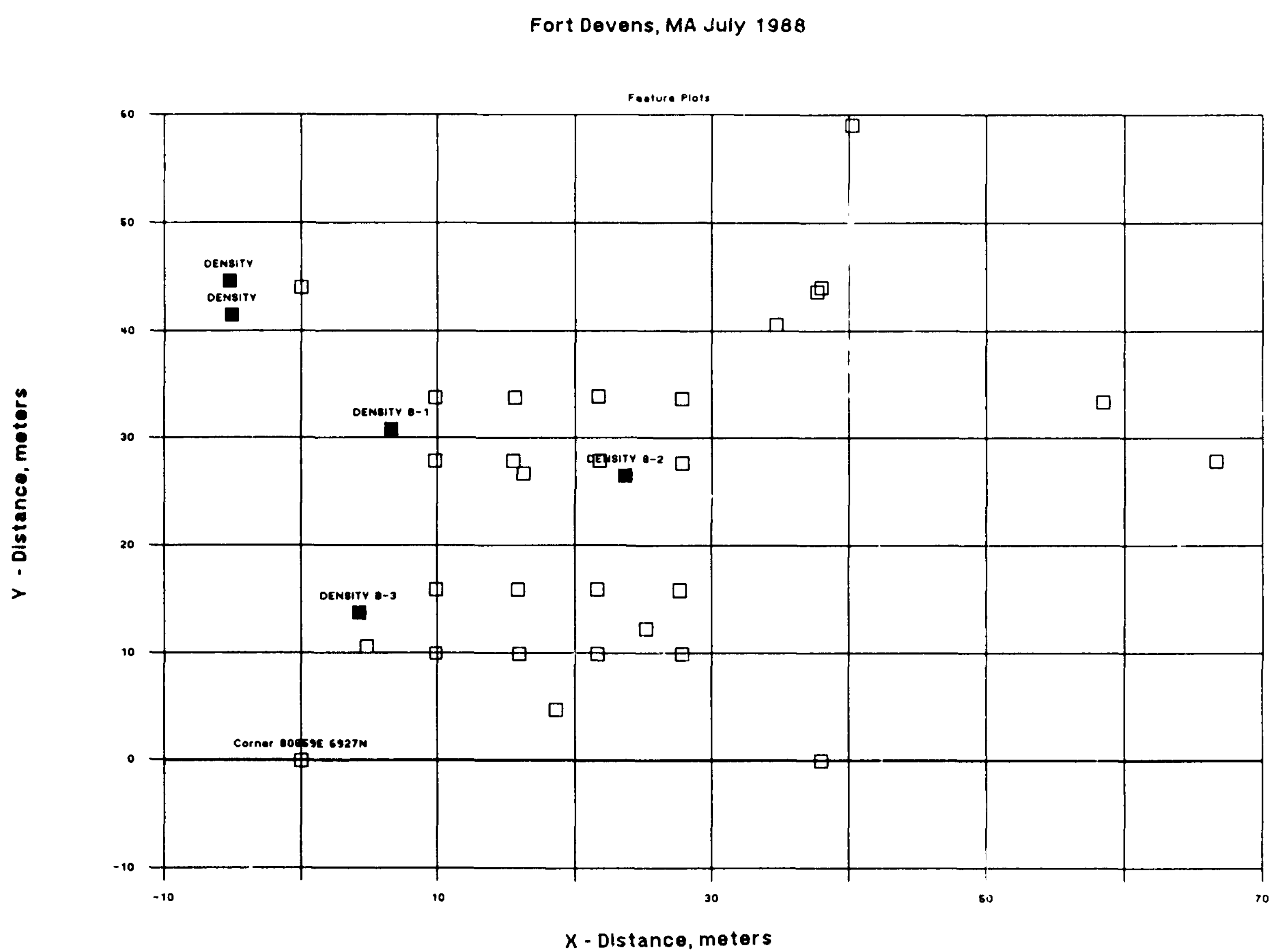


Figure 25. (Sheet 3 of 3)



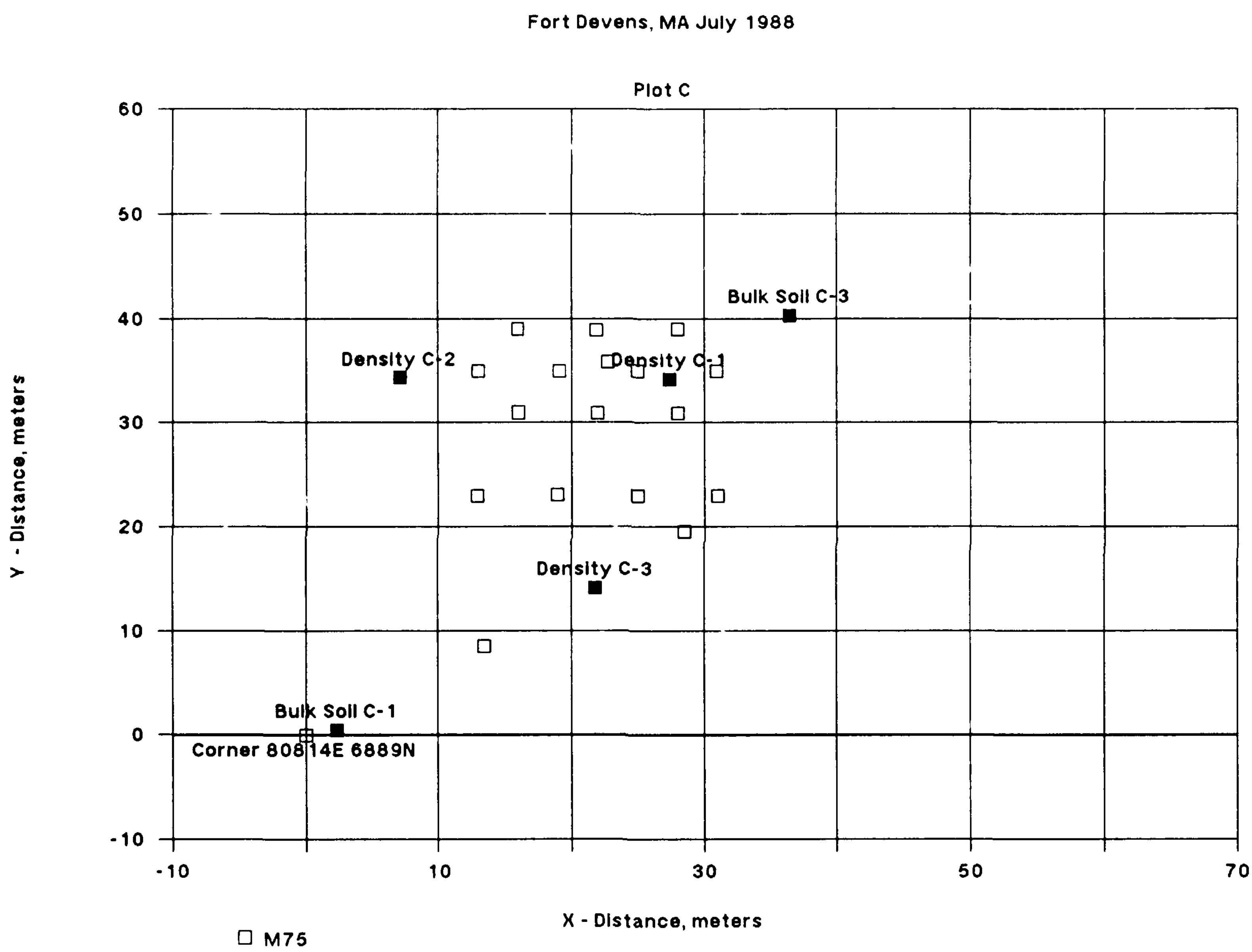
a. Plot a

Figure 26. Location of soil samples (Sheet 1 of 3)



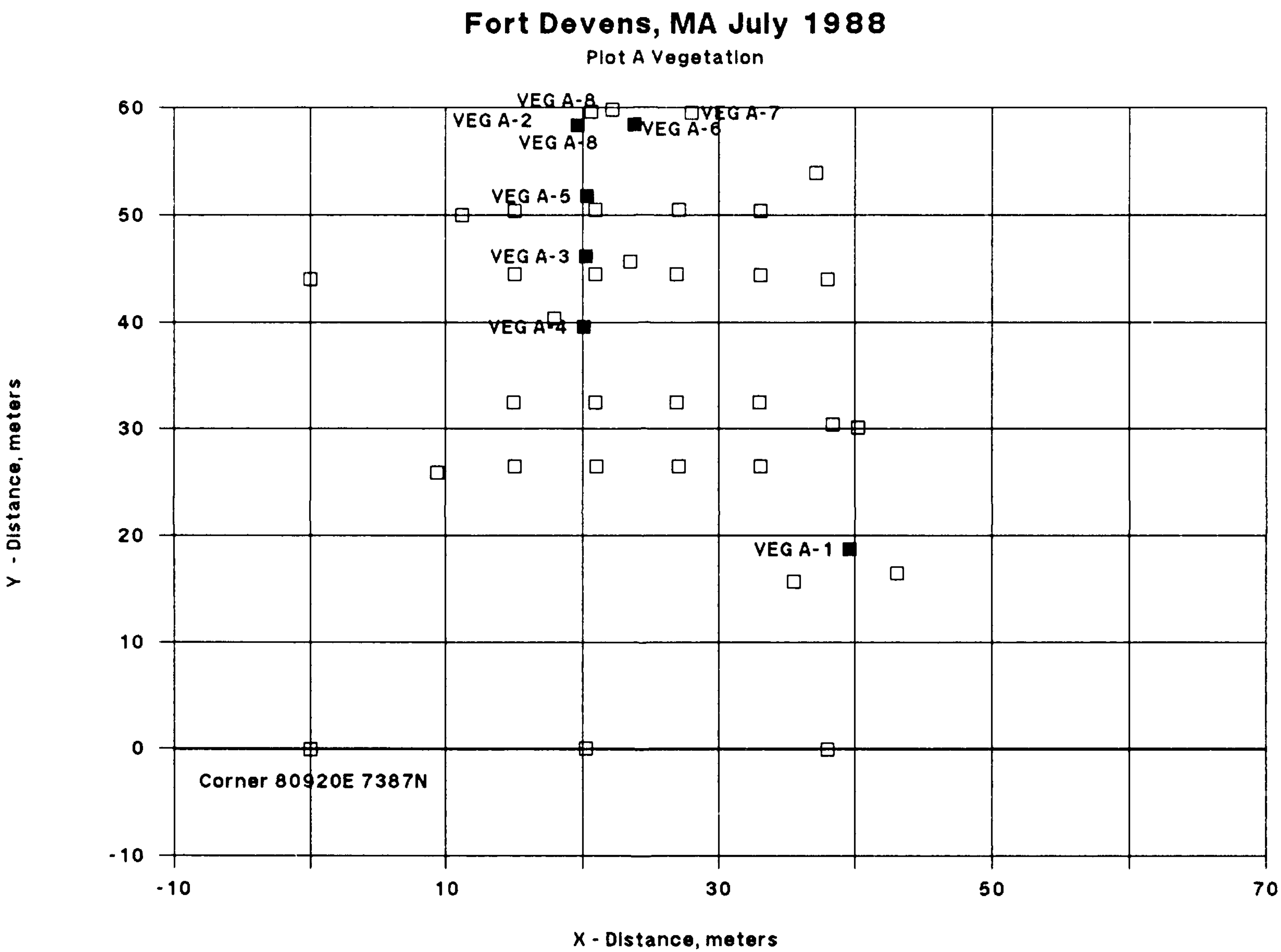
b. Feature plots

Figure 26. (Sheet 2 of 3)



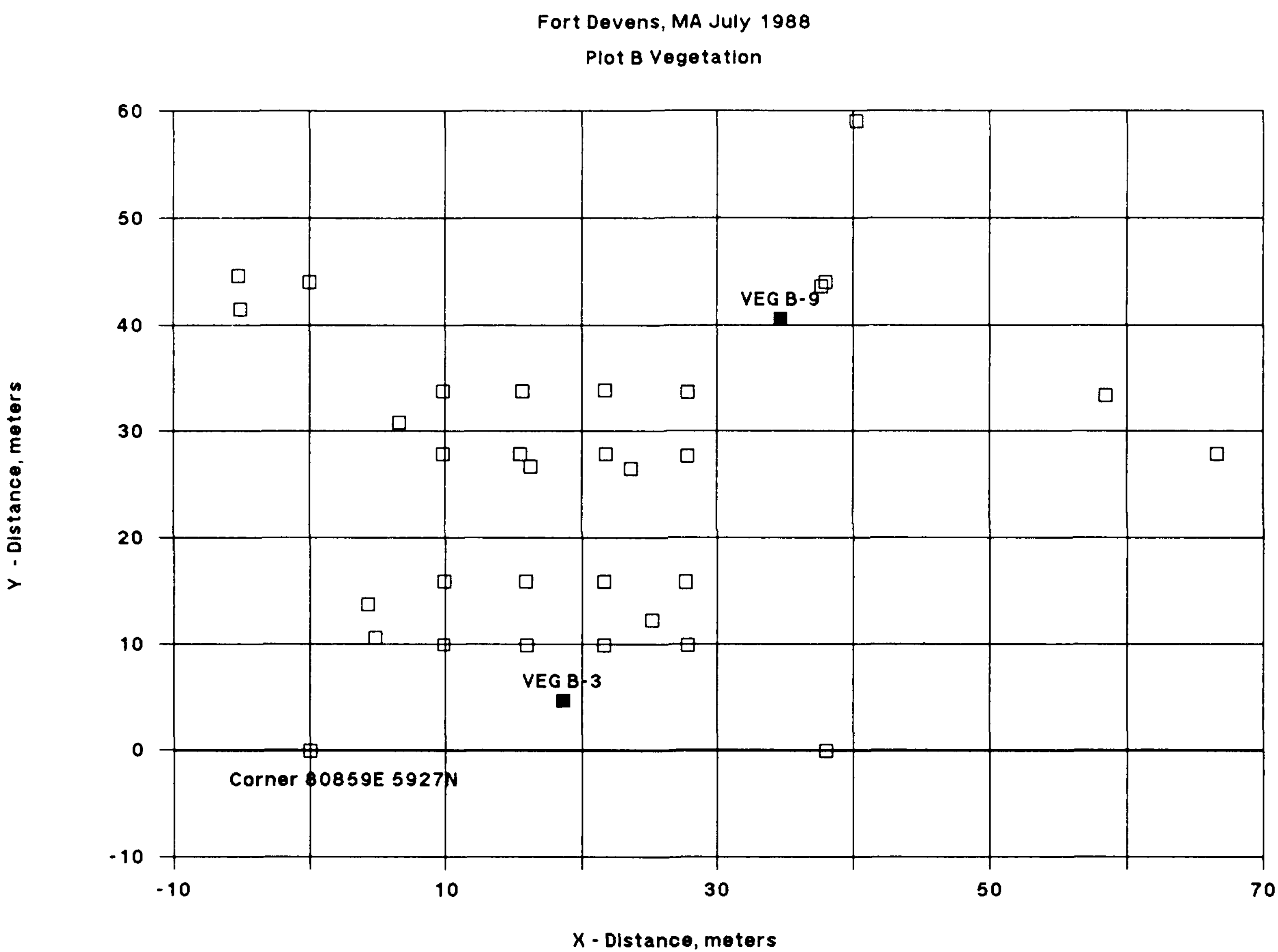
c. Plot c

Figure 26. (Sheet 3 of 3)



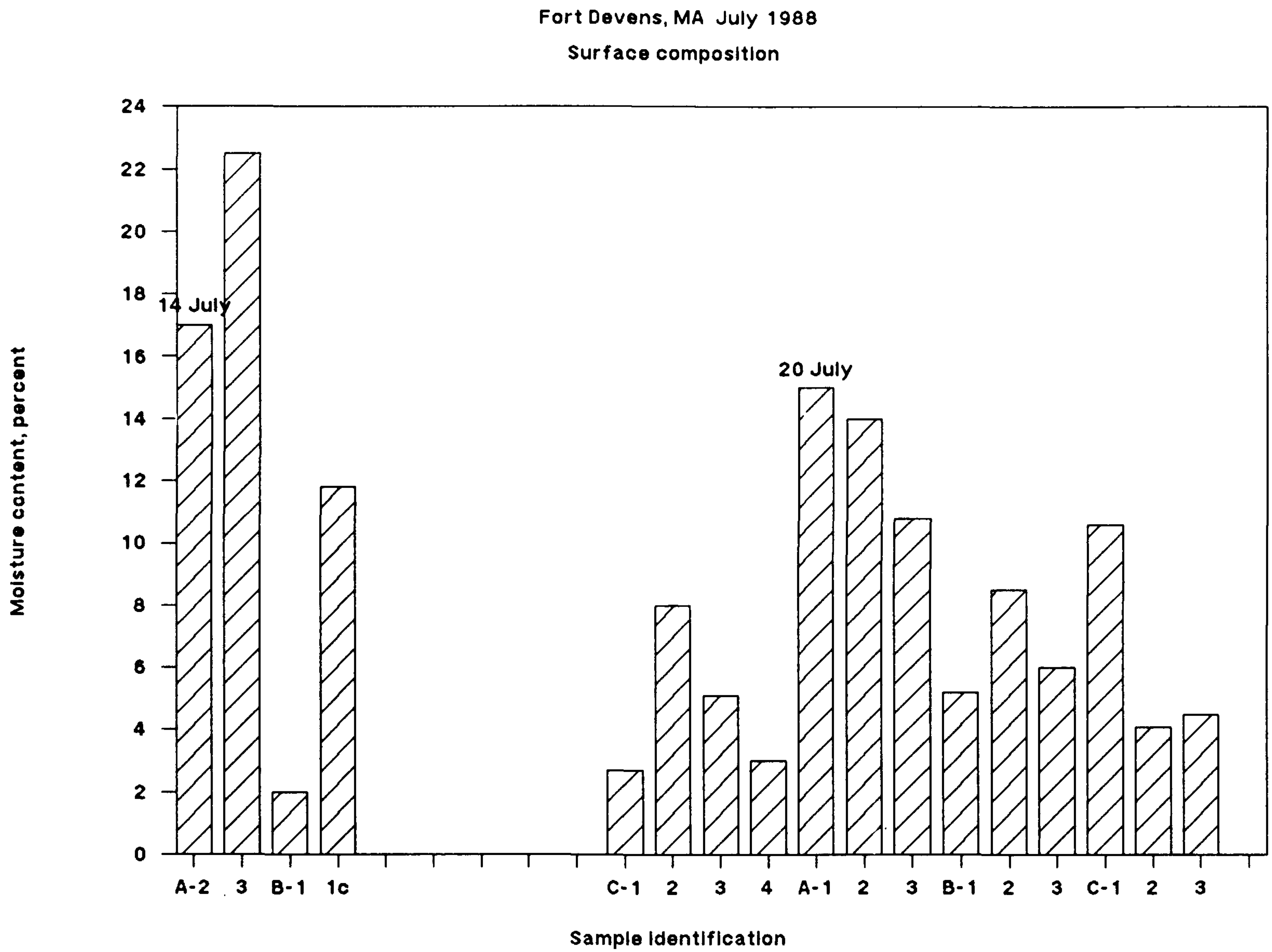
a. Plot A

Figure 27. Location of certain vegetation types (Continued)



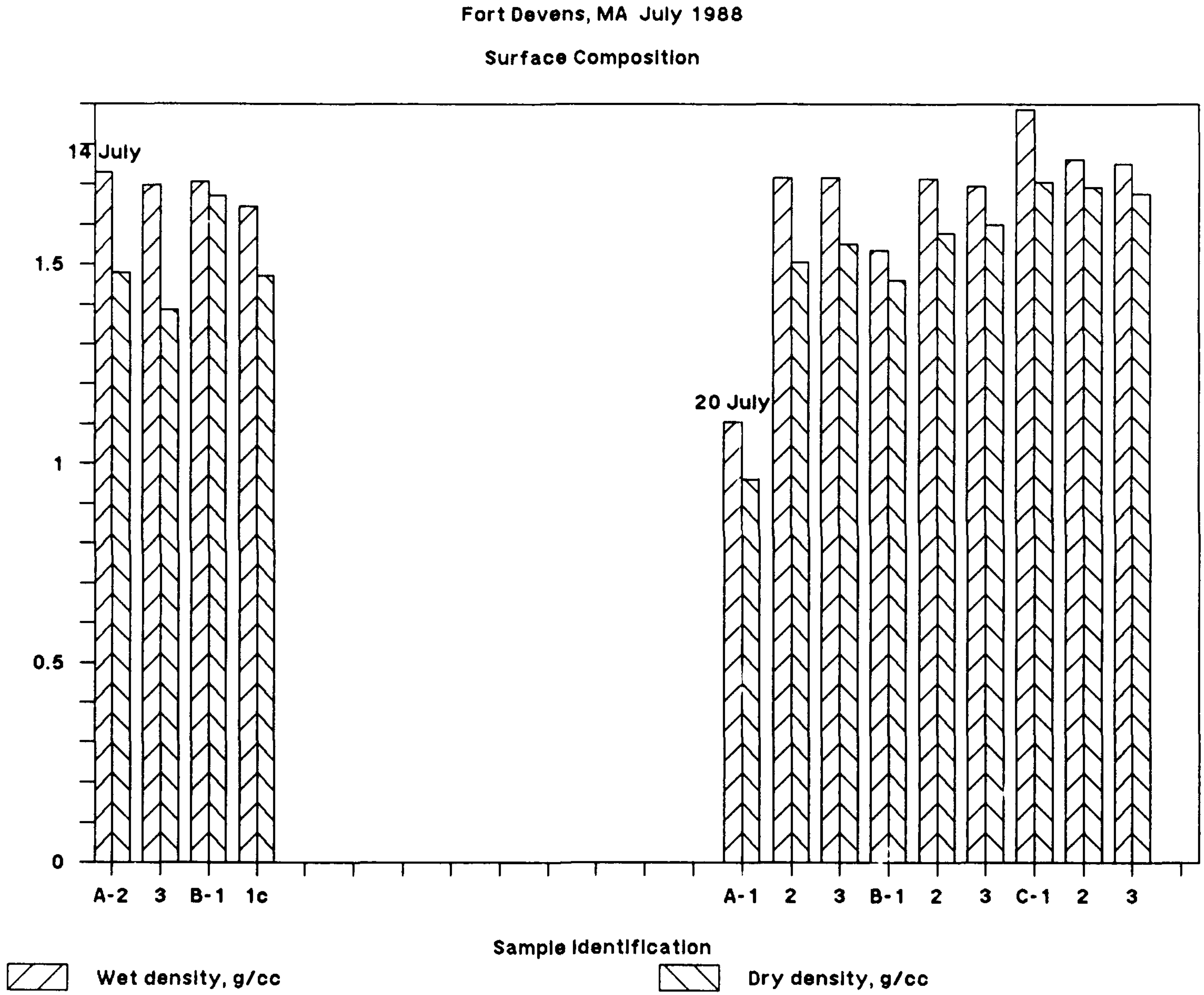
b. Plot B

Figure 27. (Concluded)



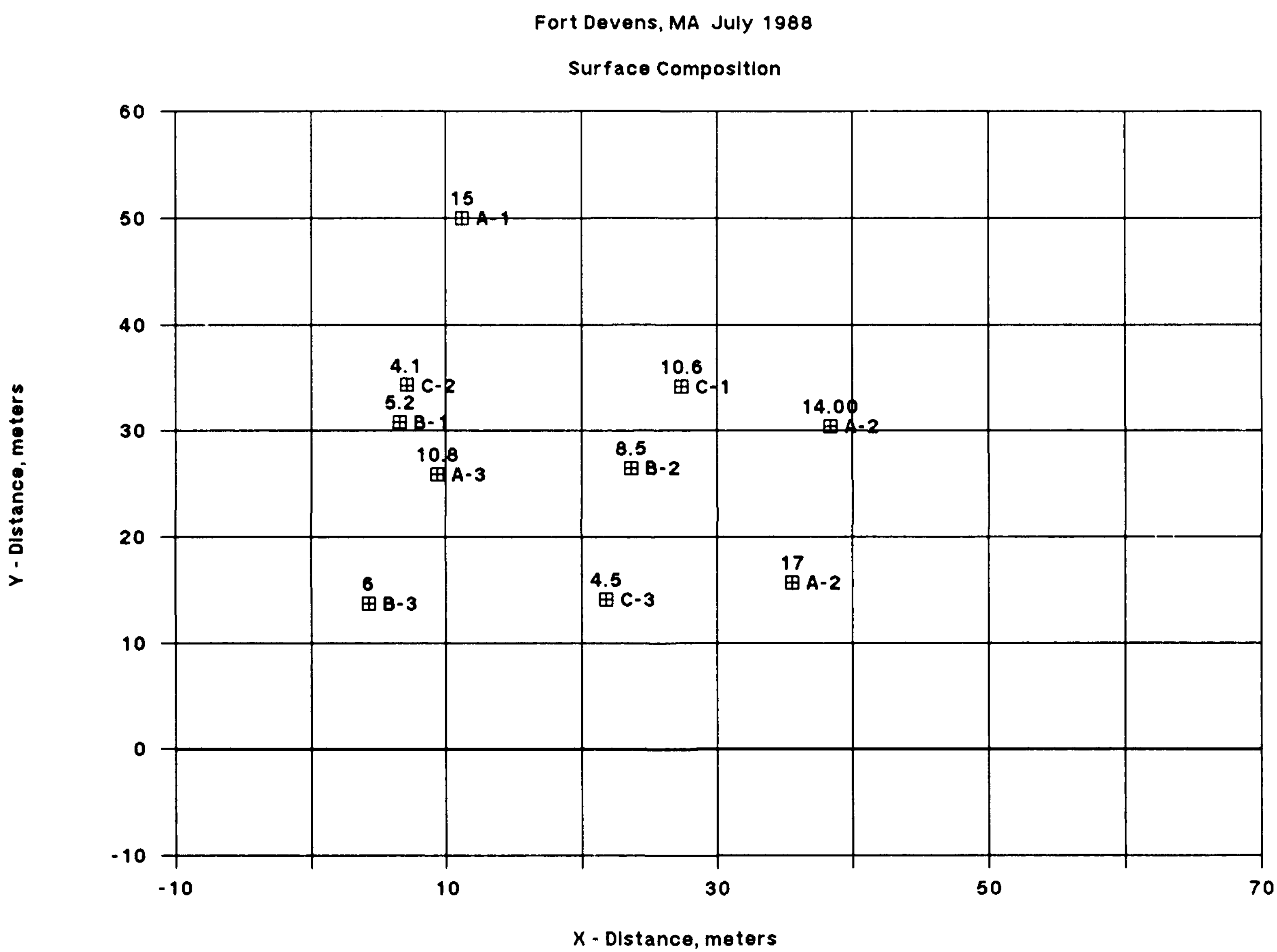
a. Moisture content

Figure 28. Soil parameters measured in the field (Sheet 1 of 3)



b. Density

Figure 28. (Sheet 2 of 3)



c. Sample locations

Figure 28. (Sheet 3 of 3)

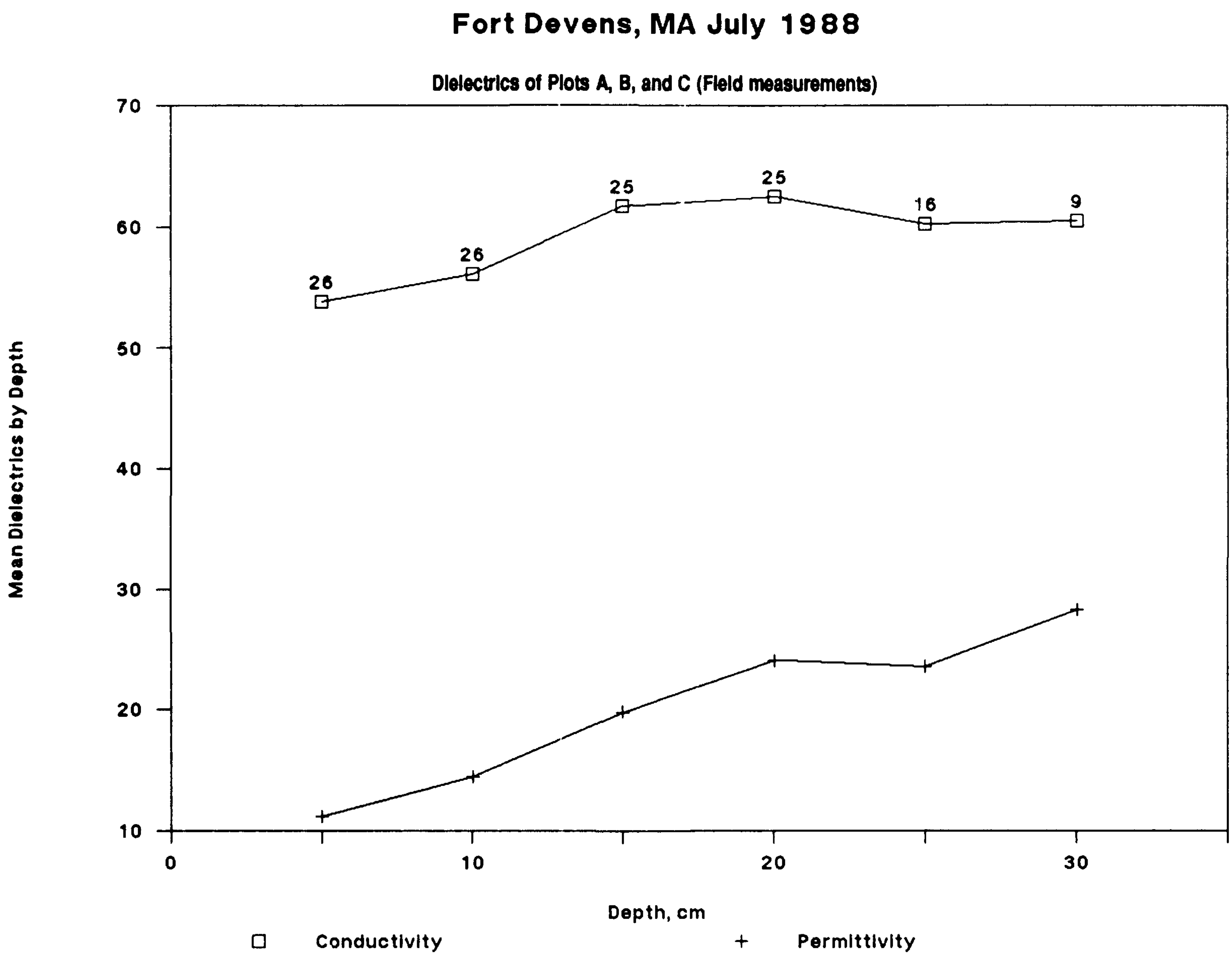
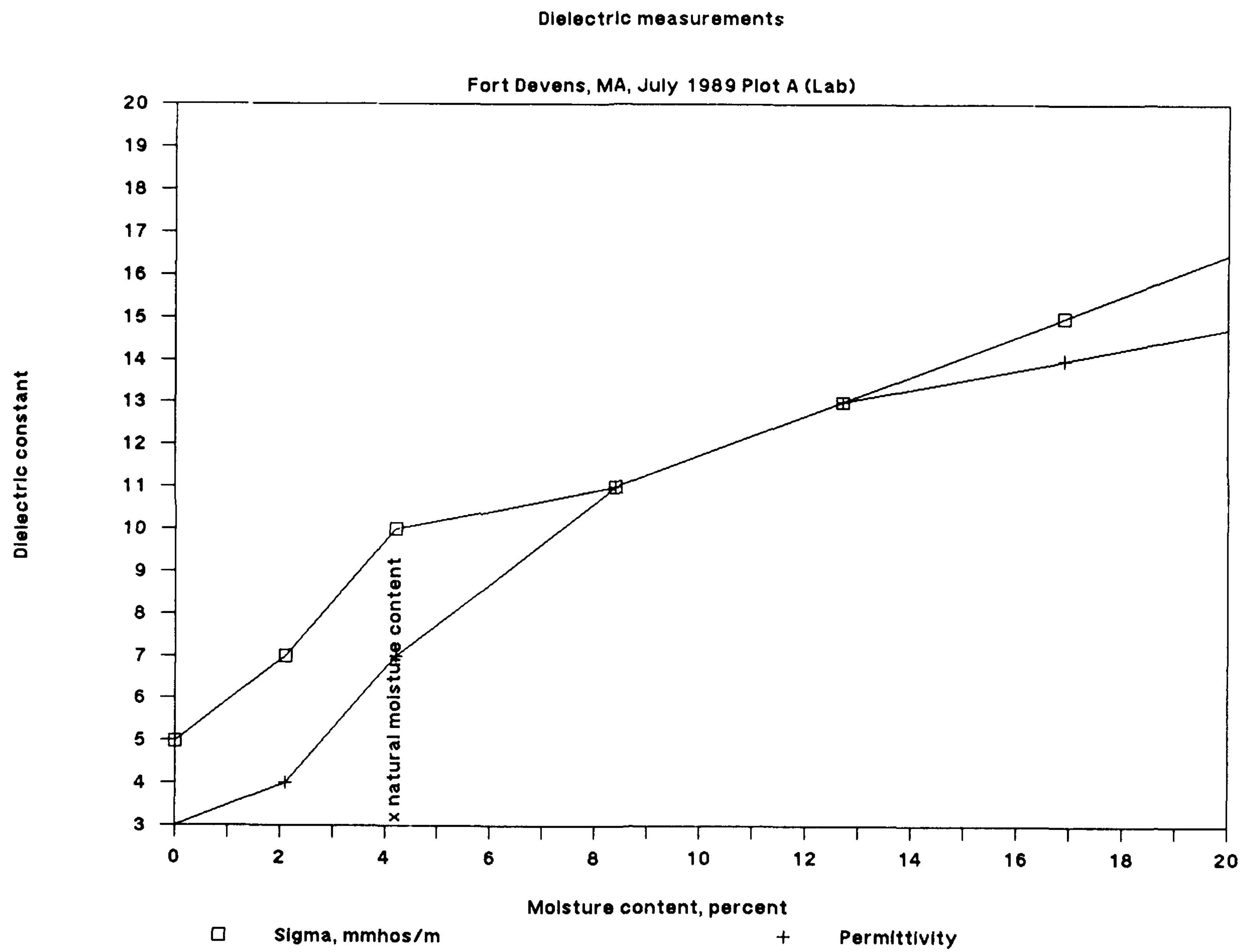
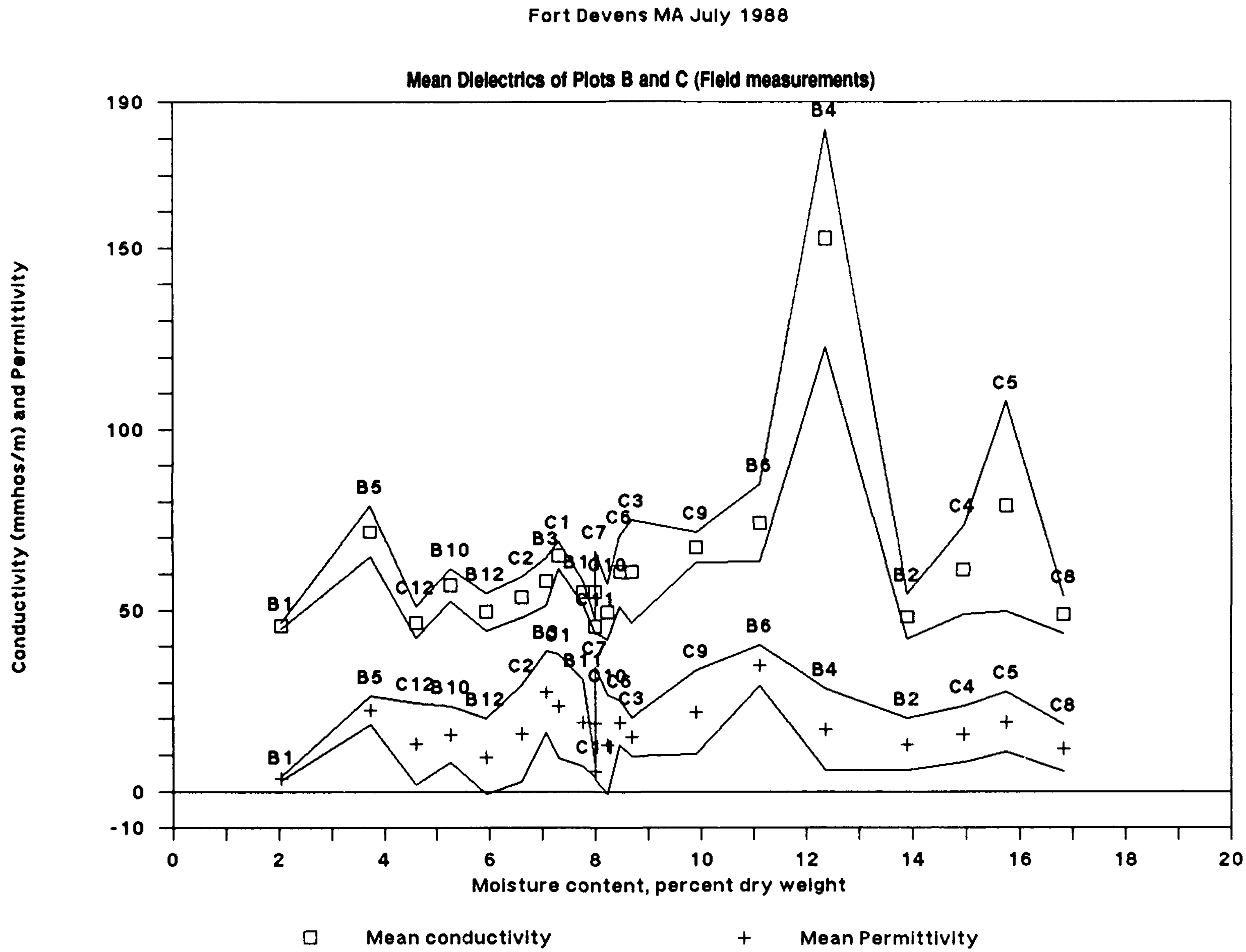


Figure 29. Dielectric values obtained with depth



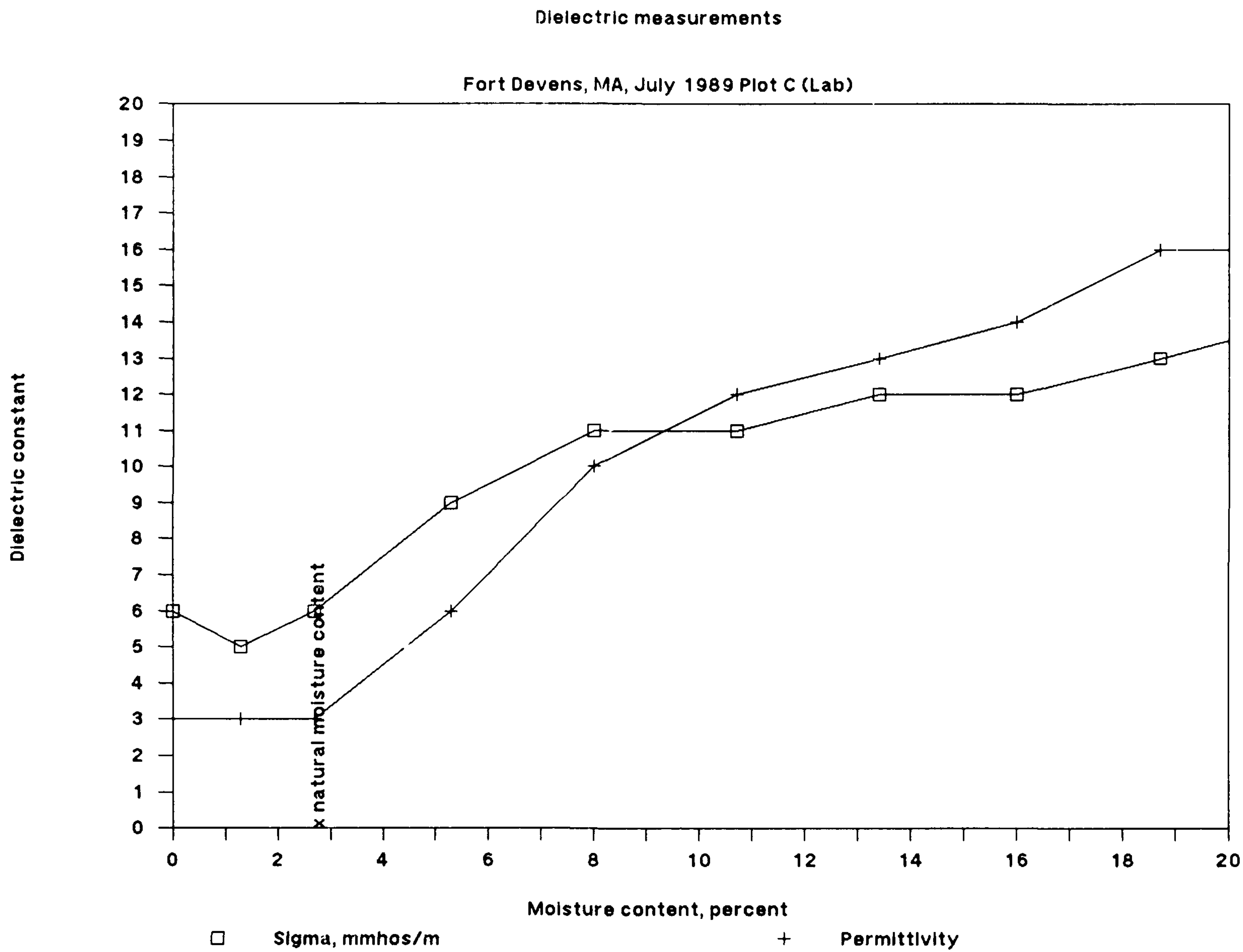
a. Plot A

Figure 30. Dielectrics versus moisture content at Plots A, B, and C (Sheet 1 of 3)



b. Plots B and C

Figure 30. (Sheet 2 of 3)



c. Plot C

Figure 30. (Sheet 3 of 3)

Vegetation

45. Vegetation samples were brought to WES and dried for 24 hr at 200° F; the moisture content was determined for each of the specimens from Plots A and B (Appendix B). Field identifications of species (see Figure 15a) were confirmed at that time by another botanist on the EL staff. As previously stated, Plot C was so sparsely vegetated that vegetation sampling seemed unnecessary early in the characterization effort. However, sparse grasses and forbs had emerged from Plot C by the time of the ADTS overflight and imaging mission (Figure 31).

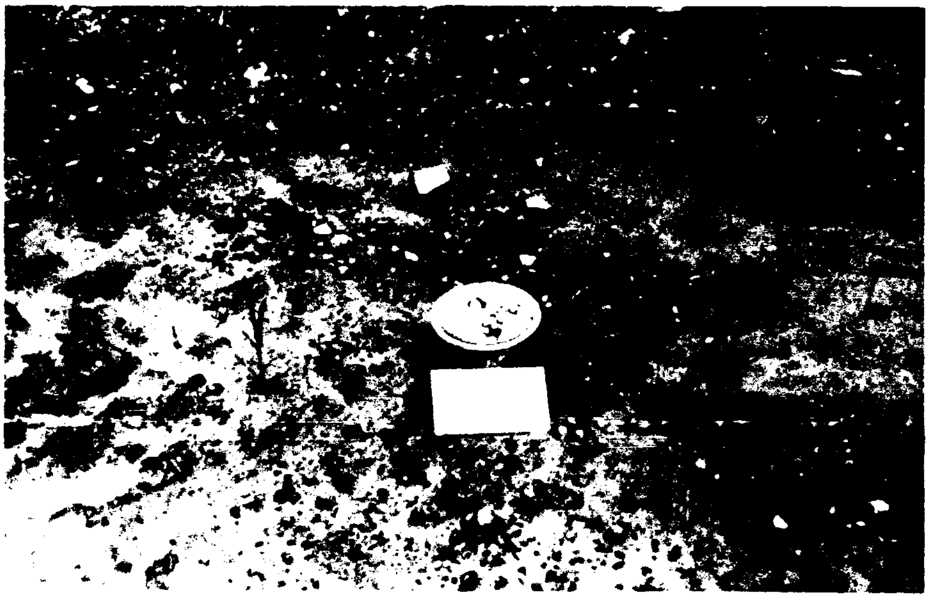


Figure 31. Plot C ground conditions on 20 July 1988

46. The 1-m sampling grid used to sample vegetation in Plot B is shown in Figure 32. Plot A plant parameters were determined on 14 July 1988 using 19 1-m-square samples (from 44,0 to 44,32 and 14,30), and 19 such samples (from 44,38 to 6,38) were used to describe Plot B. On 19 July 1988, Plot A was again sampled, although in a different location (1,0 to 1,10; 1,37 and -2,28.5) for a total of 13 1-m-square samples). Those measurements and the estimates derived from them are given in Appendix B.

47. Moisture in vegetation stands is of particular interest to modelers of scattering and reflection by layered media. Figures 33, 34, and 35 show the respective masses, numbers, and volumes by individual species (extrapolated to the whole plot of 38 by 44 m). Apparent discrepancies are due to some of the plant types not being represented in the water content calculation

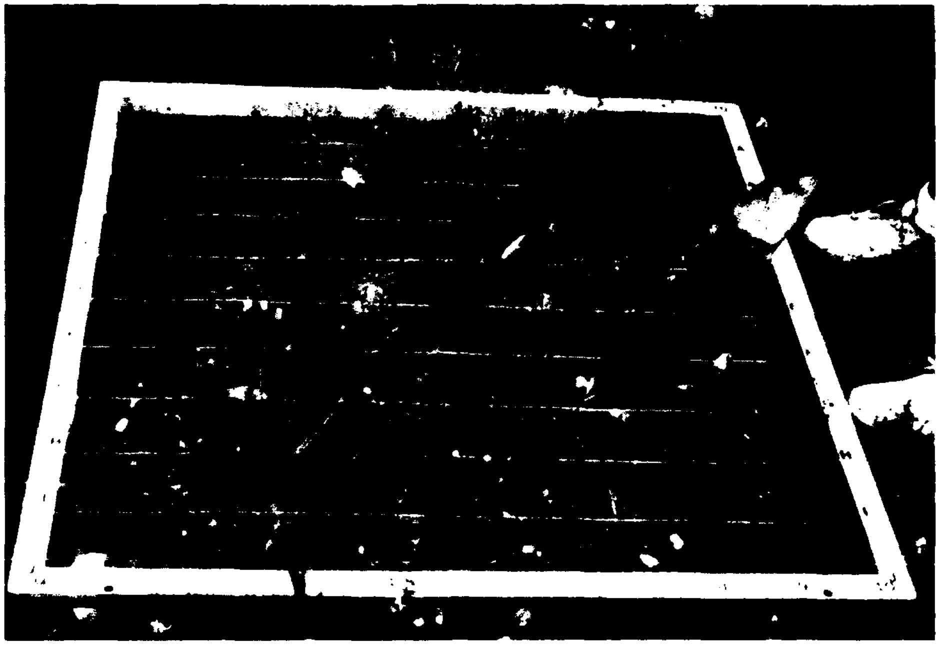


Figure 32. Sampling grid (1-m square) used for sampling vegetation

because samples degraded in transport or because suitable samples were not collected. Relative concentration of water by plant part is shown in Figure 36. Height of typical individuals of each species considered in each of Plots A and B is represented in Figure 37. Figure 38a displays an estimate of cumulative plant and water volume as they are included in successive layers 10 cm high normal to the soil surface. Figure 38b shows the empirical relationship of the plant volumes and masses of Plots A and B to the water volumes of those plants. The correlation coefficient of 0.953 is highly significant. These relationships would probably not obtain very early or very late in the growing season. These estimates are valid only for New England in midsummer, when most of the annual plants are at their most turgid (the wheat is excepted since it was apparently planted for harvest in late spring or early summer). The volume estimates used included only nonzero values. Figure 39c shows leaf area indexes (LAIs) obtained using Fort Devens solar loading measurements compared with similar values found in the literature.

Meteorology

48. Meteorological data recorded with the WES microloggers onsite include the time period when the radar imagery was obtained (Figure 39). Solar sensors were placed both in the open and beneath vegetation in an attempt to link LAI and solar energy intercepted in the fashion of Ulaby

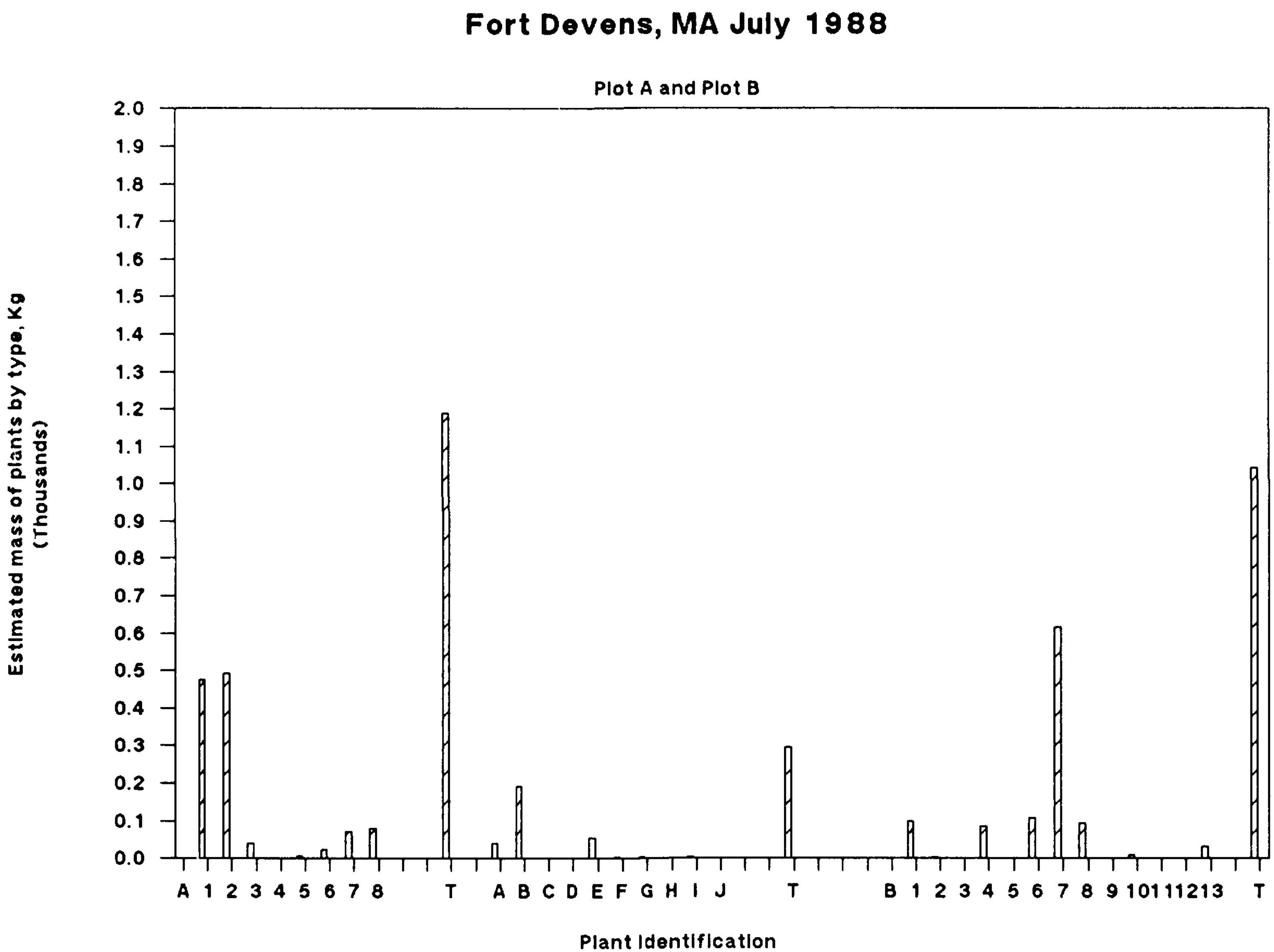


Figure 33. Mass estimates of vegetation at Plots A and B
(See Figure 15 for legend to plant identities)

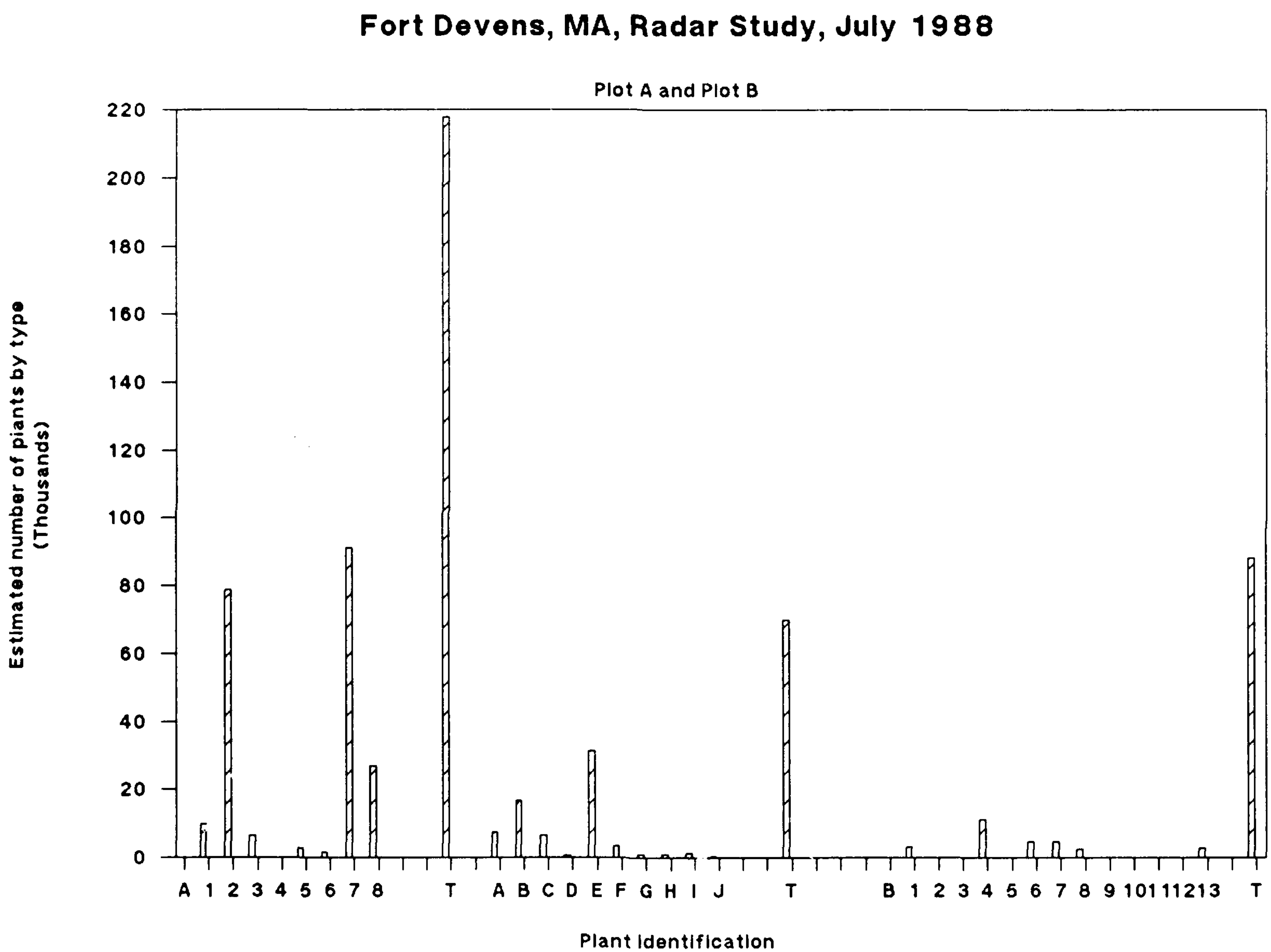


Figure 34. Number estimates of vegetation at Plots A and B

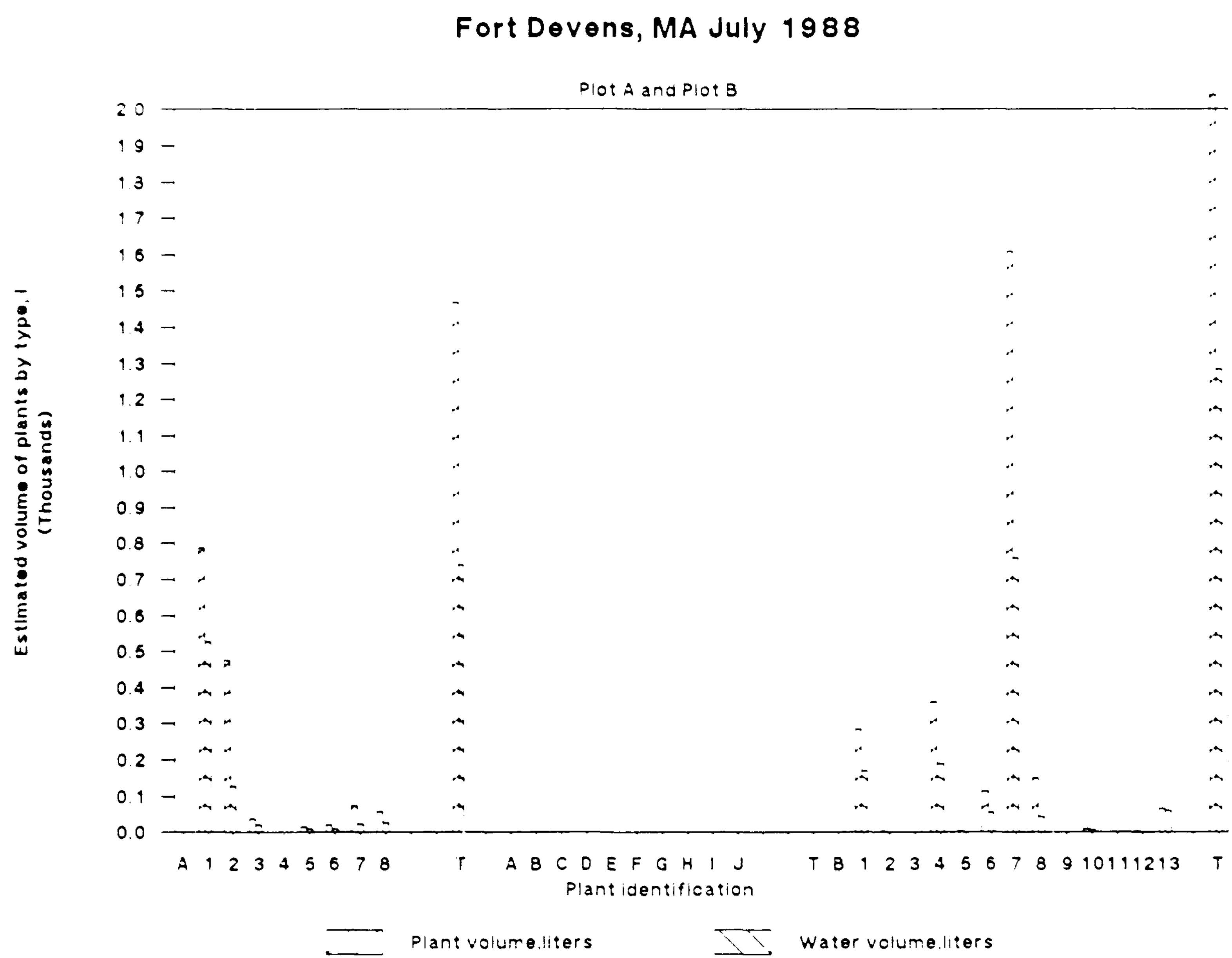


Figure 35. Volume estimates of vegetation sampled at Plots A and B

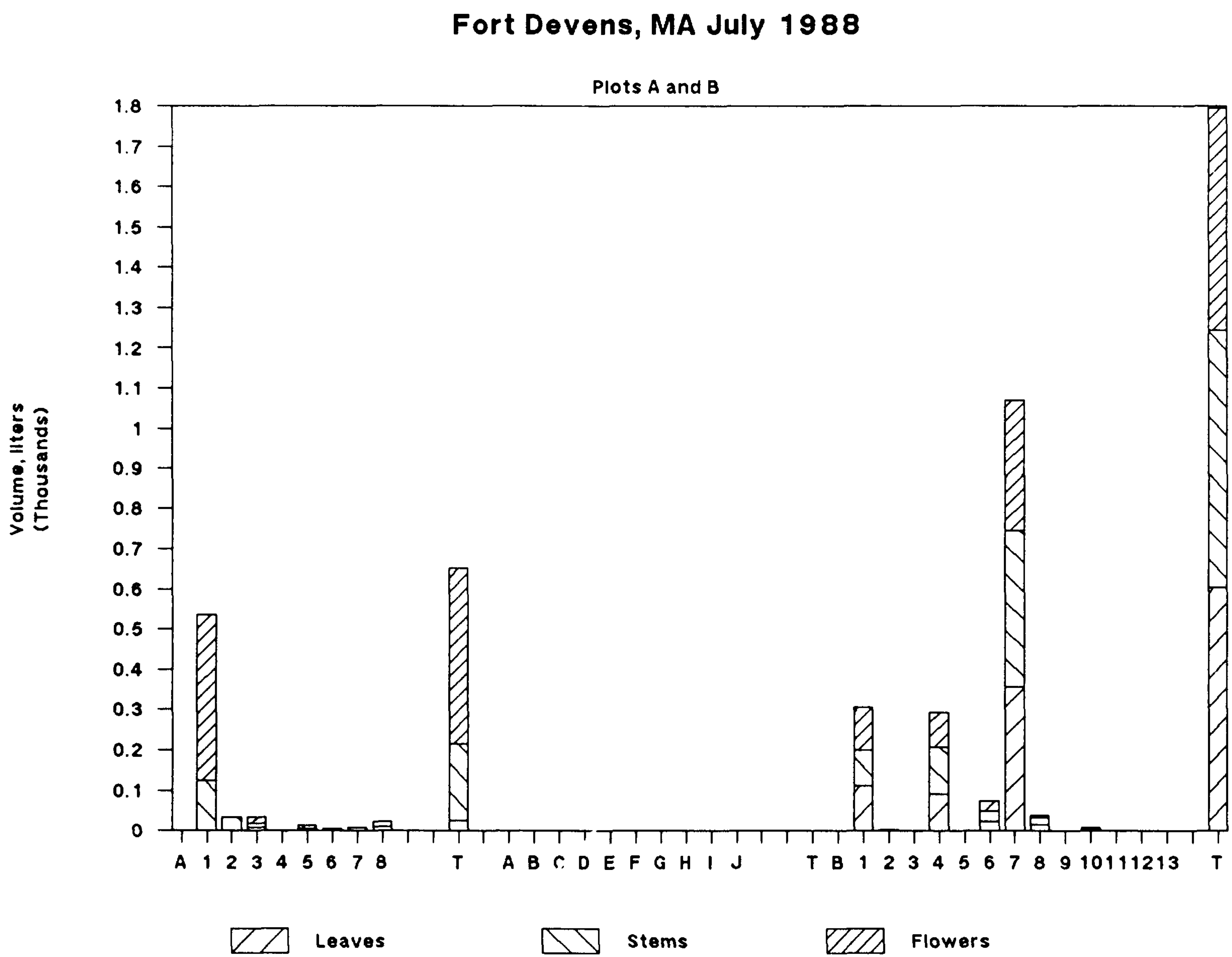


Figure 36. Distribution of water by plant part in Plots A and B

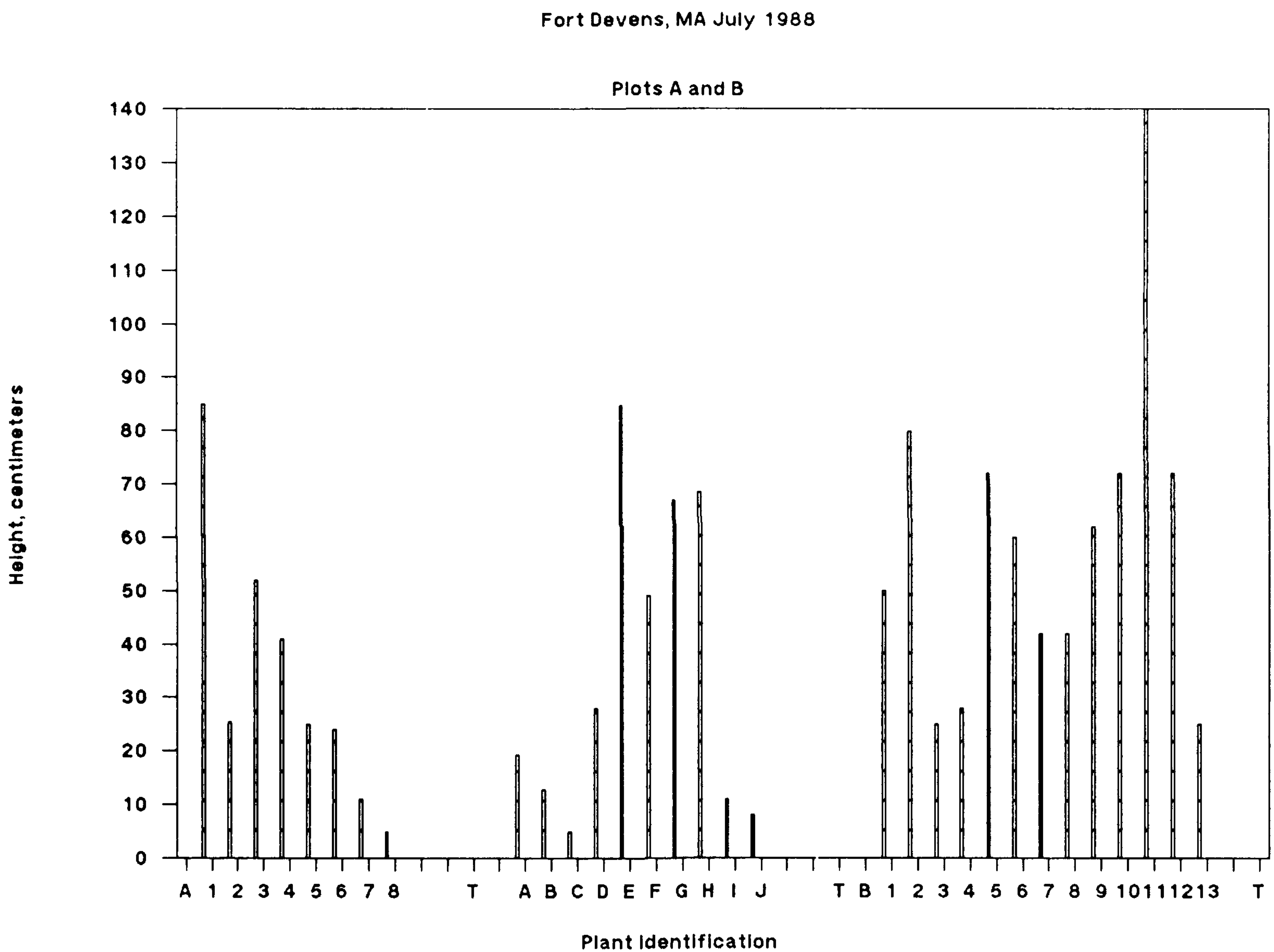
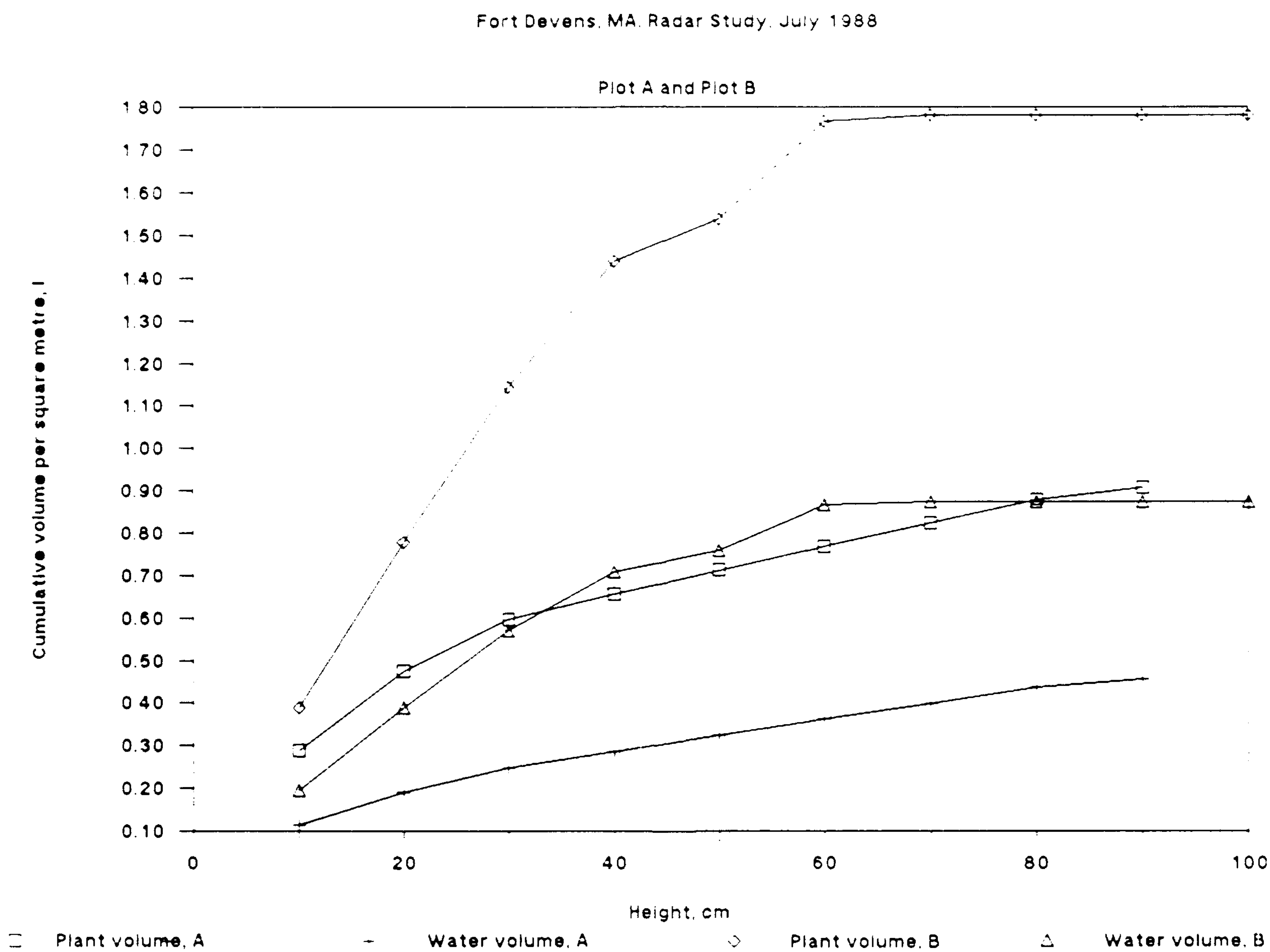
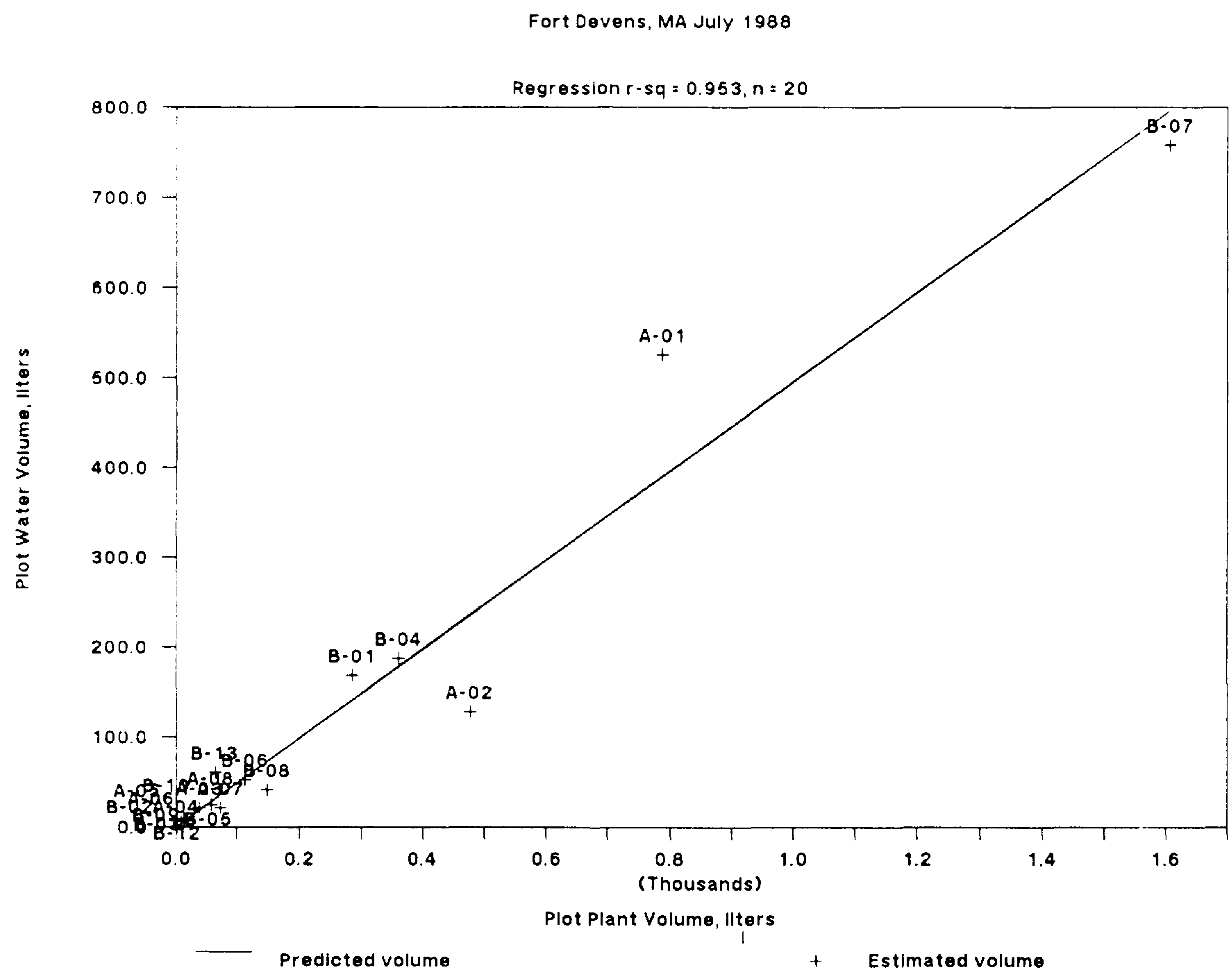


Figure 37. Height of respective plant types in Plots A and B



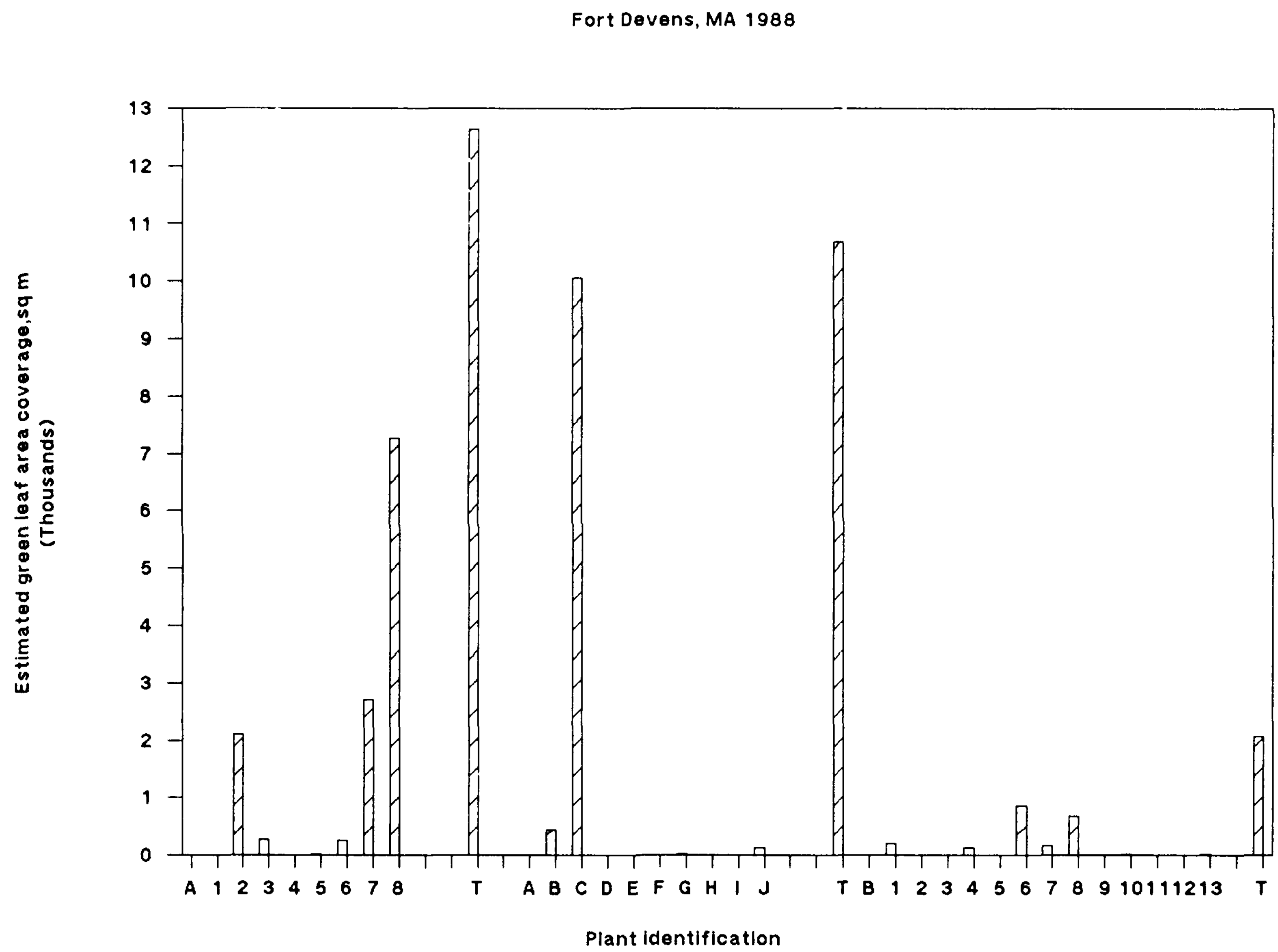
a. Estimate of cumulative water volume as a function of height

Figure 38. Estimates of plant parameters (Sheet 1 of 3)



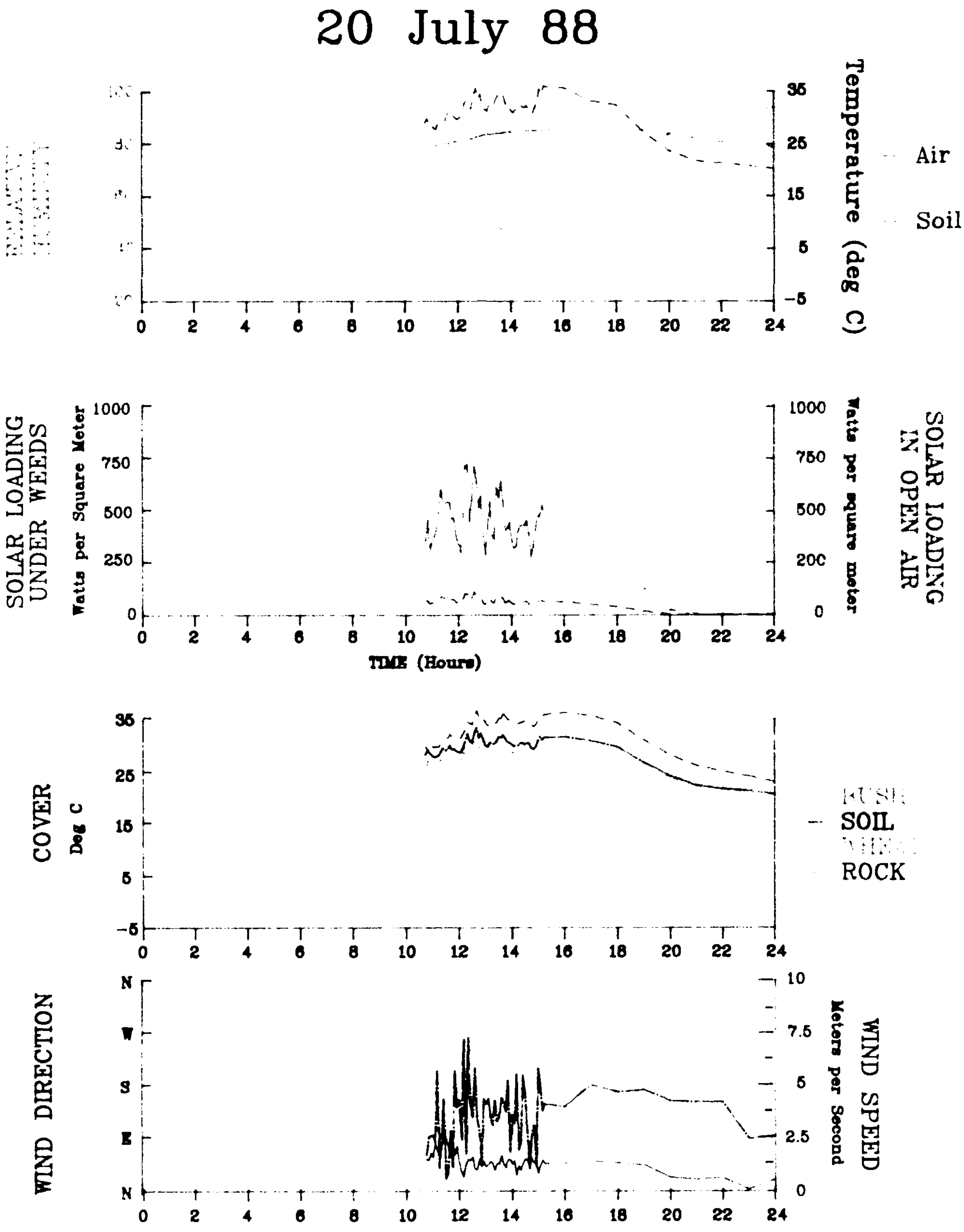
b. Relationship of plant volume to water volume in plot

Figure 38. (Sheet 2 of 3)



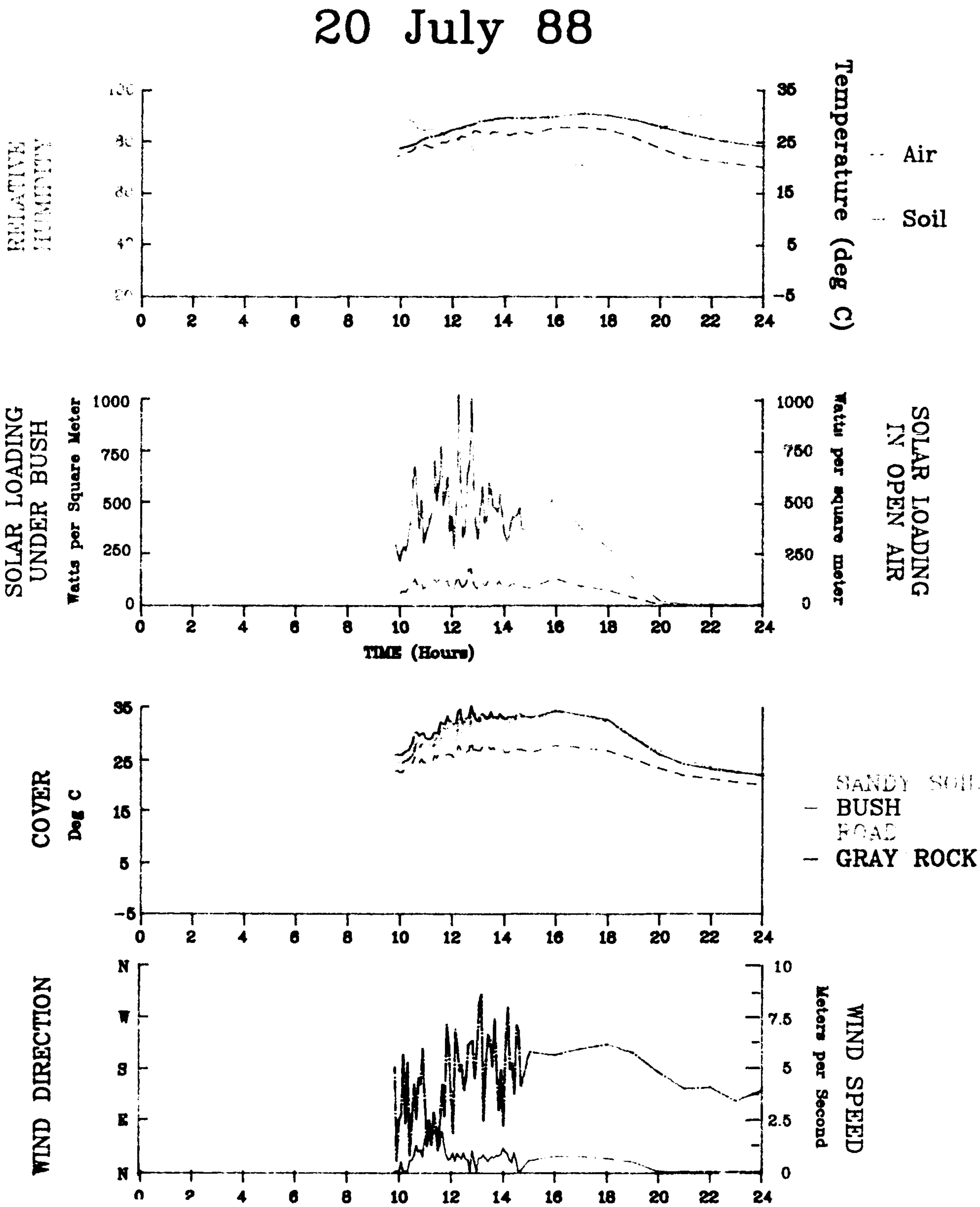
c. Estimate of green leaf area

Figure 38. (Sheet 3 of 3)



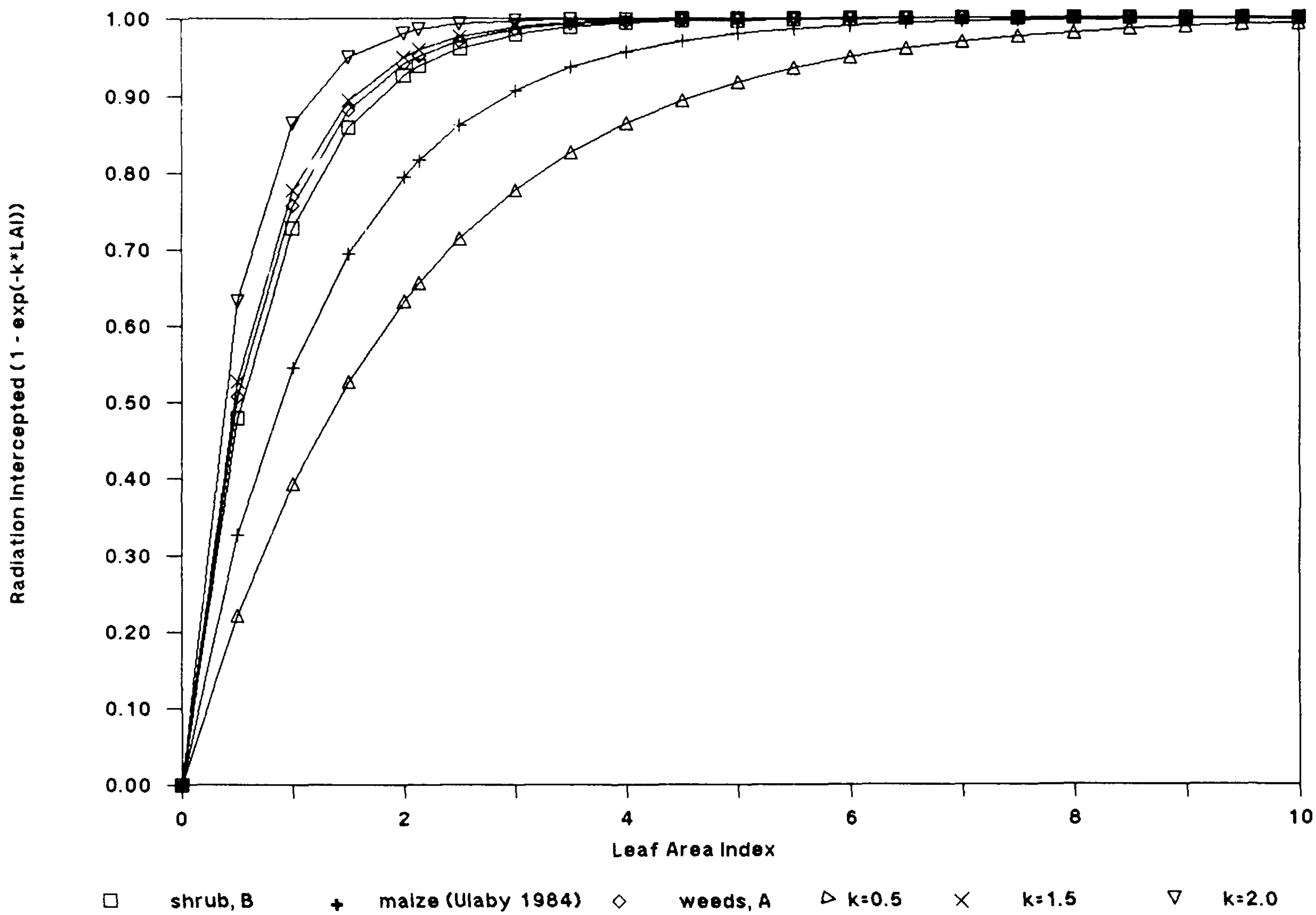
a. Record of meteorological parameters at Plot A

Figure 39. Record of meteorological parameters (Sheet 1 of 3)



b. Record of meteorological parameters at Plots B and C

Figure 39 (Sheet 2 of 3)



c. Leaf-Area-Index based on solar loading measurements at Fort Devens compared with values found in the literature

Figure 39. (Sheet 3 of 3)

et al. (1984). These comparisons and analyses are presented in Figure 39c, even though the data are scanty (2 points of measured solar loading) coincident with the radar overflight. The digital data collected during the overflight are presented in Appendix C.

PART IV: MINE PLACEMENT AND RADAR OVERFLIGHT

49. Mines were emplaced in each of the plots shortly before the scheduied MIT/LL ADTS overflight at 1300 hr on 20 July 1988. Sixteen M-19's were placed in Plot A (Figure 21a), 16 M15(M20) were placed in Plot B (Figure 21b), and 14 M75 were placed as shown in Plot C (Figure 21c). The MIT/LL personnel placed trihedral corner reflectors in the positions indicated in Figure 40 prior to the radar-imaging mission. The characters (beginning "LL") on the right of points of the sketch refer to MIT/LL's nomenclature denoting each reflector. Each reflector has specific calibration details that are used when processing the radar data collected from a scene in which the reflectors appear. Each depression angle flown requires a specific adjustment for each reflector. Due to unforeseen conditions related to the aircraft navigation restrictions and to the performance of the radar, MIT/LL chose to perform only one pass at one depression angle (45 deg).

50. At the MIT/LL Lexington facility on the day following the airborne radar data collection, Mr. John Henry of MIT/LL showed the WES data collection party an image produced from the data collected. Figure 41 is a much-degraded copy of that image with the background suppressed such that only the trihedral corner reflectors of Plots B and C are readily visible as four bright spots in the image. Positions of the reflectors may be compared with the sketch in Figure 40, or in Figure 21, which is drawn to scale.

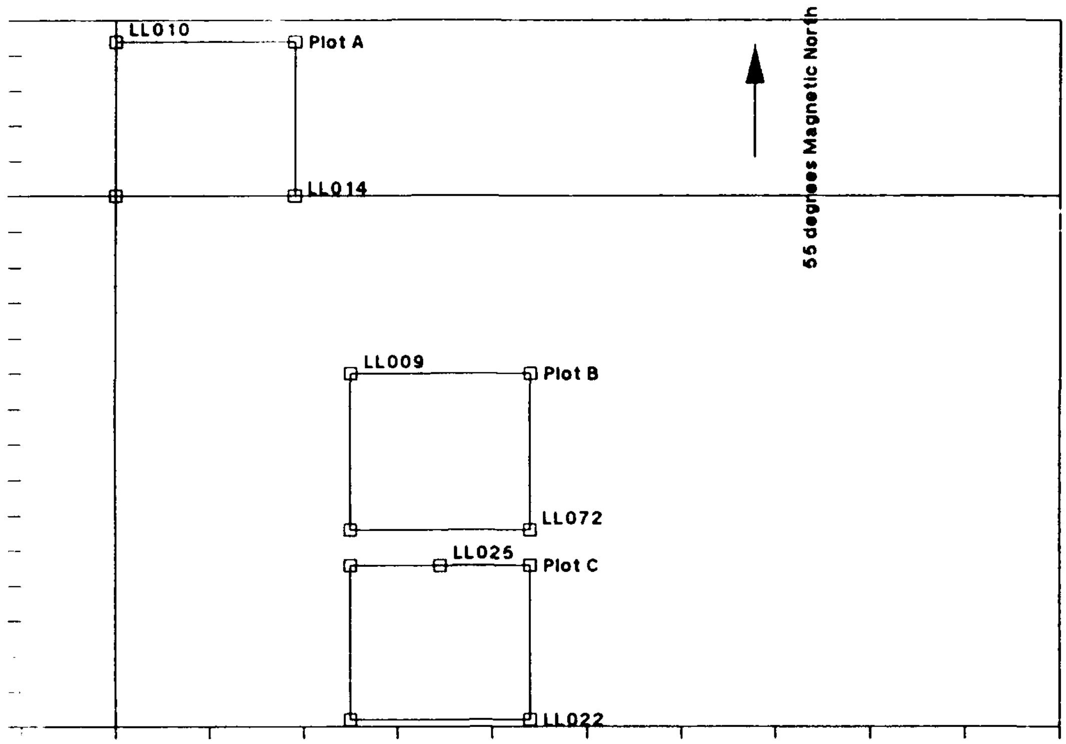


Figure 40. Location of trihedral corner reflectors (not to scale)

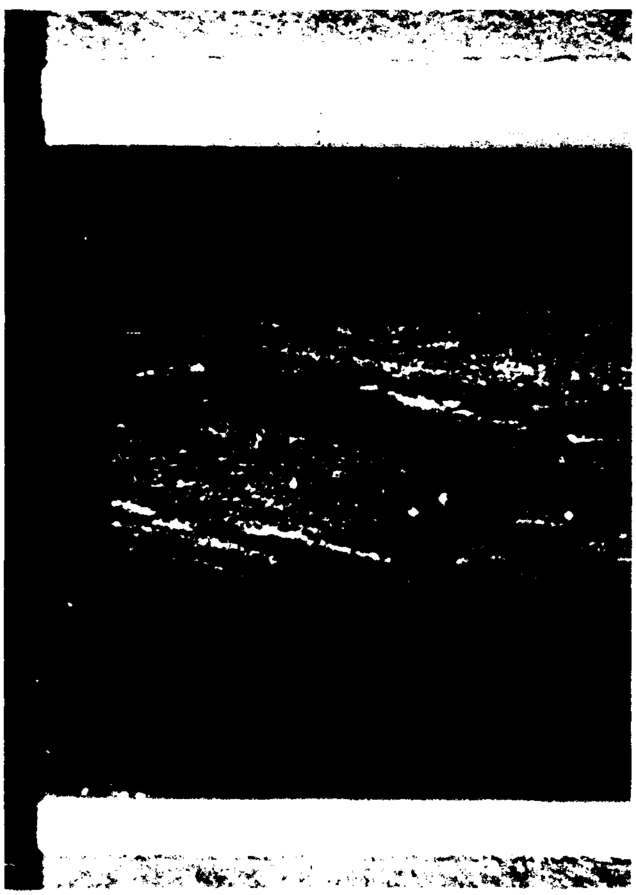


Figure 41. Degraded preliminary image of Plots B and C on 20 July 1988

PART V: ANALYSIS

Surface Geometry

51. As stated in Part III, both macro- and microgeometry measurements were conducted within Range 6A, Fort Devens. A complete listing of x, y, and z readings taken defining the geometry of the three plots and their immediate surrounds has been given in Appendix A. (Units are in metres. The units used in the microgeometry subplots are in centimetres.)

Macrogeometry

52. Differences among the average elevations of Plots A (80920E 7387N), B (80859E 6927N), and C (80814E 6889N) may be detectable in the radar returns. Appendix C shows basic statistics of the elevations encountered. In testing for significant differences among the variances (population variances A = 0.373 , B = 0.349 , C = 0.600 , given in Appendix C), the variance ratios between the respective elevation populations of Plots A and B are as follows (by convention the larger variance being compared is the numerator):

A,B	F = 0.373/0.349 = 1.068
A,C	F = 0.600/0.373 = 1.608
B,C	F = 0.600/0.349 = 1.719

These differences are all highly significant ($F_{tabular\ 0.01} = 1.00$). A tabulation of the statistics computed to test for difference between the means (when equal variance cannot be assumed) appears below:

Plot	Mean	Degrees of Freedom	Standard Deviation	Standard Error of the Mean	tan θ	θ°	d	Tabular value, d 1%	Tabular value, d 5%
A,B	99.01,98.92	384,683	0.611,0.590	0.0312,0.0226	0.0385	2.2	2.33*	2.576	1.960
A,C	99.01,97.88	384,428	0.611,0.773	0.0312,0.0374	0.0487	2.8	23.20**	2.576	1.960
B,C	98.92,97.88	683,428	0.590,0.773	0.0226,0.0374	0.0437	2.5	23.79**	2.576	1.960

* Significant at 5 percent.
** Significant at 1 percent (highly significant).

where $\tan \theta = s_1/s_2$ and degrees of freedom are all "infinite" by definition because of the large populations; e.g., $N_A = 385$, $N_B = 683$, and $N_C = 429$; d = difference between means divided by the square root of the sum of the variances of the sample means (Neville and Kennedy 1968). It can be concluded that the elevations measured at Plots A and B have arithmetic means that are not significantly different at the 1-percent level but are significantly different at the 5-percent level, (assuming unequal variances). At the 5-percent level, all three plot means are significantly different from each other. Further statistics computed concerning the elevations measured at each of the three plots reveal that none are normally distributed (Table A2).

Microgeometry

53. Three microgeometry subplots were placed arbitrarily in each of the three main plots (A, B, and C). Their locations with respect to each enclosing plot have been given in Figure 25. Horizontal measurements on a 10-cm-square grid and vertical differences as small as 0.1 cm were recorded within each 1-m-square plot, for a total of 100 elevation measurements for each of the nine microgeometry subplots. (These measured values can be found in Appendix A.) F-values were calculated for each microgeometry subplot within each plot to compare them in the manner in which the 38- by 44-m plots were compared, thus:

A2,A1	F = 0.850/0.270 = 3.148*
A1,A3	F = 0.270/0.109 = 2.477*
A2,A3	F = 0.850/0.109 = 7.798*
B1,B2	F = 25.33/7.937 = 3.192*
B3,B1	F = 37.44/25.33 = 1.478**
B3,B2	F = 37.44/7.937 = 4.717*
C1,C2	F = 20.45/5.218 = 3.918*
C1,C3	F = 20.45/15.88 = 1.287 (not significant)
C3,C2	F = 15.88/5.218 = 3.044*

* Significant at 0.01 level (highly significant).
** Significant at 0.05 level.

Micro Tabular Plot	Mean	Degrees of Freedom	Standard	Standard Error of the Mean	Tan		Value, d		
					θ	θ°	d	1%	5%
A1,A2	10.668,09218	99,99	0.519,0.922	0.052,0.092	0.563	29.8	135.4*	1.960	2.576
A1,A3	10.668,10.648	99,99	0.519,0.330	0.052,0.033	1.575	57.5	5.284*		
A2,A3	12.184,10.648	99,99	0.922,0.330	0.092,0.033	70.32	70.3	160.2*		
B1,B2	18.810,25.478	99,99	5.033,2.817	0.503,0.282	1.787	60.7	20.0*		
B1,B3	18.810,16.379	99,99	5.033,6.199	0.503,0.620	0.823	39.4	3.87*		
B2,B3	25.478,16.379	99,99	2.817,6.119	0.282,0.612	0.460	24.7	20.0*		
C1,C2	14.702,21.119	99,99	4.522,2.284	0.452,0.228	1.979	63.2	11.1*		
C1,C3	14.702,20.566	99,99	4.522,3.986	0.452,0.399	1.135	48.6	1.24NS		
C2,C3	21.119,20.566	99,99	2.284,3.986	0.228,0.399	0.573	29.8	0.22NS		

* Significant at 0.01 level (highly significant).

** Significant at 0.05 level.

Surface Composition

As is the case of the plot surface geometry variances, testing for the differences in mean microelevations requires a test that considers the unequal variances between most of the plots.

54. Appendix C summarize the measurements made in this study having to do with surface composition. The surface material of Plot A consisted of sand with some fines and gravel. It was not entirely covered with vegetation but rather had significant areas that were unvegetated. The surfaces of Plots B and C were composed of gravelly, sandy subsoil from which the finer grained overburden had been mechanically removed and the remaining soil leveled to provide areas for tank maneuvers of training troops. In Plot B, particularly, rocks of a sufficient size perhaps to exceed the unit resolution of the ADTS radar system were scattered within the plot area. Moreover, significant bodies of standing water were present in Plot B. These features are displayed in Figure 21.

Vegetation

55. A summary of vegetation data measured or estimated is shown in Appendix B. Values resulting from direct measurements are noted with an asterisk (*). Other values appearing are estimated using the measured values.

56. Both Plots A and B were rather sparsely vegetated with low herbaceous vegetation, with the exception of the wheat stand in Plot A and the cattails around the water bodies and occasional shrub (*?Elaeagnus* sp.) in Plot B. Figure 38a indicates that an expected volume of water to be encountered in a typical 1-sq-m sample in Plot A should not exceed 0.5 ℓ, while a comparable value at Plot B would b 0.85 ℓ. The height (thickness of the vegetation layer) in Plot A is about 0.9 m while height in Plot B is approximately 1.4 m. Estimated plant volume per square metre in Plot A is 0.9 ℓ, while that of Plot B is less than 1.8 ℓ. Assuming a cube 1 m on a side, the total contains 1,000 ℓ of volume. Thus, a square metre in Plot A could be expected to contain 0.09 percent of vegetation volume above the soil surface, 56 percent of which would be water (in midsummer). Plot B could be expected to be 0.18-percent vegetation in a cubic metre volume, with 47-percent water. Since the ADTS has a nominal footprint of 1 sq ft, the "cylinder" traveled through the vegetation layer by the radar is 0.093 cu m (pi * r - sq * h , or 1 sq ft * 1 m). Plot A vegetation encountered would be about 0.000084 cu m (0.084 ℓ); Plot B would present 0.00017 cu m (0.17 ℓ).

57. As stated previously, Plot C was essentially bare sand and gravel until quite late in the characterization effort, when a few plants emerged.

Meteorology

58. Two micrometeorology stations with microloggers were deployed at Fort Devens to record on the day of the ADTS overflight. One was placed near Plot A, as shown in Figure 21a, and the other was placed at a location between Plot B and Plot C as shown in Figure 21b. Records of the micrometeorology of Plot A and the area between Plots B and C are shown in Figures 38a and 38b. Comparison of the temperature records of the two locations reveals that fluctuations of air temperature were more pronounced near Plot A than at the station location between Plots B and C. Examination of the overall site layout in Figure 2 shows that Plots B and C were in more sheltered positions than

Plot A; not only is Plot A at a higher average elevation, but it is also free of forested perimeter on the north and west sides. Measurements of relative humidity show that parameter for Plot A varying more widely than in the other location between Plots A and B. Solar loading in open air is greater in the Plots B and C location than in that of Plot A, but the rest of the measured temperatures of typical features in the target areas show no marked differences. This higher loading value can also be attributed to the more sheltered location.

PART VI: SUMMARY

59. In conjunction with MIT/LL, the WES team planned and executed a field characterization effort designed to furnish the data and information necessary to support the interpretation of products obtained by an airborne radar imaging mission. Not only were three different types of small mines precisely located relative to established benchmarks, but the surface topography, surface composition, vegetation, and micrometeorology were also characterized. This effort was executed with sufficient precision so that modelers might be able to characterize the "clutter" surrounding the objects (targets) imaged. Three 38- by 44-m plots were characterized by recording elevation differences as small as 1 cm for each of the three plots in its entirety and 0.1 cm for three 1-m subplots within each of the larger plots. Roughness measurements at a scale likely to influence the radar returns were calculated. Soil composition was determined, and the locations of the samples are shown in reference to the plot coordinates. Principal soil types were also sampled for moisture content, specific gravity, and grain size distribution; dielectric measurements of permittivity and conductivity to 30 cm in depth were made around the perimeters of each of the three plots. Physical and floristic attributes of the vegetation communities present were determined using both field and laboratory methods.

60. Presently, EL, WES, is processing the magnetic tapes of the July Fort Devens mission flown when the data described in this report were collected. These two data sources will be used to complement each other in developing algorithms with the potential of contributing to methods allowing detection/recognition of antitank mines, a high priority of the US Army.

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APPENDIX A

SURVEYED SURFACE GEOMETRY POINTS
FORT DEVENS, MA, JULY 1988

Table A1

Surveyed Points, Plot A

Untranslated			Transl(0,0) = 80920E 7387N		
x	y	z	X	T	N
-71.966	-25.845	98.053	6.353	17.11	1
-70.329	-26.113	98.15	7.99	16.842	2
-73.184	-21.563	98.133	5.135	21.392	3
-70.143	-21.451	98.308	8.176	21.504	4
-73.239	-16.523	98.237	5.08	26.432	5
-70.099	-16.263	98.391	8.22	26.692	6
-73.353	-11.591	98.293	4.966	31.364	7
-70.117	-11.474	98.449	8.202	31.481	8
-72.528	-11.7	98.385	5.791	31.255	9
-72.659	-11.286	98.299	5.66	31.669	10
-72.742	-10.871	98.4	5.577	32.084	11
-72.17	-11.407	98.405	6.149	31.548	12
-72.116	-11.066	98.307	6.203	31.889	13
-72.172	-10.749	98.426	6.147	32.206	14
-71.851	-10.947	98.36	6.468	32.008	15
-73.206	-6.535	98.466	5.113	36.42	16
-70.086	-6.267	98.515	8.233	36.688	17
-73.207	-1.527	98.52	5.112	41.428	18
-70.132	-1.456	98.63	8.187	41.499	19
-73.247	3.452	98.628	5.072	46.407	20
-70.167	3.337	98.717	8.152	46.292	21
-73.238	8.457	98.729	5.081	51.412	22
-70.213	8.342	98.823	8.106	51.297	23
-73.183	13.485	98.836	5.136	56.44	24
-70.228	13.448	98.967	8.091	56.403	25
-73.317	17.422	98.897	5.002	60.377	26
-70.246	17.433	99.009	8.073	60.388	27
-72.945	14.904	98.941	5.374	57.859	28
-74.503	9.063	98.725	3.816	52.018	29
-76.286	8.915	98.703	2.033	51.87	30
-77.826	6.86	98.638	0.493	49.815	31
-73.96	4.878	98.693	4.359	47.833	32
-88.319	4.943	98.56	-10	47.898	33
-72.138	4.715	98.711	6.181	47.67	34
-78.768	0.809	98.364	-0.449	43.764	35
-70.975	-5.513	98.542	7.344	37.442	36
-76.41	-6.389	98.358	1.909	36.566	37
-71.054	-10.77	98.424	7.265	32.185	38
-76.712	-8.271	98.312	1.607	34.684	39
-74.015	-12.968	98.192	4.304	29.987	40
-74.534	-11.727	98.253	3.785	31.228	41
-74.86	-14.166	98.199	3.459	28.789	42
-76.682	-15.757	97.941	1.637	27.198	43
-76.802	-15.49	98.112	1.517	27.465	44
-76.579	-16.089	98.07	1.74	26.866	45
-75.042	-14.098	98.274	3.277	28.857	46
-79.833	-17.848	97.908	-1.514	25.107	47
-74.78	-15.739	98.259	3.539	27.216	48
-74.316	-24.229	98.149	4.003	18.726	49
-73.477	-23.247	98.088	4.842	19.708	50
-74.001	-29.163	97.792	4.318	13.792	51

(Continued)

(Sheet 1 of 8)

Table A1 (Continued)

Untranslated			Transl(0,0) = 80920E 7387N		
X	Y	Z	X	Y	N
-69.847	-34.84	97.725	8.472	8.115	52
-84.116	-27.547	97.234	-5.797	15.408	53
-82.382	-21.166	97.539	-4.063	21.789	54
-81.579	-13.561	97.77	-3.26	29.394	55
-83.004	-6.646	97.865	-4.685	36.309	56
-85.689	1.908	97.968	-7.37	44.863	57
-83.755	7.333	98.194	-5.436	50.288	58
-77.232	14.606	98.603	1.087	57.561	59
-74.454	23.612	98.827	3.865	66.567	60
-60.325	18.403	99.192	17.994	61.358	61
-61.171	18.09	98.806	17.148	61.045	62
-61.634	20.781	99.097	16.685	63.736	63
-62.305	20.315	98.781	16.014	63.27	64
-62.974	19.872	98.727	15.345	62.827	65
-63.364	20.076	98.997	14.955	63.031	66
-62.938	19.387	98.979	15.381	62.342	67
-63.75	19.373	98.958	14.569	62.328	68
-64.376	19.777	98.795	13.943	62.732	69
-64.428	20.357	98.987	13.891	63.312	70
-64.545	19.257	98.984	13.774	62.212	71
-63.82	19.742	98.965	14.499	62.697	72
-65.073	19.786	99.042	13.246	62.741	73
-59.448	22.149	99.317	18.871	65.104	74
-68.354	31.326	99.203	9.965	74.281	75
-60.369	31.373	99.442	17.95	74.328	76
-64.826	49.865	100.199	13.493	92.82	77
-60.463	54.775	100.124	17.856	97.73	78
-18.268	11.255	101.36	60.051	54.21	79
-47.756	20.768	99.709	30.563	63.723	80
-14.793	10.993	101.081	63.526	53.948	81
-33.544	15.043	100.05	44.775	57.998	82
5.336	5.047	101.347	83.655	48.002	83
-23.809	-6.935	100.098	54.51	36.02	84
-36.112	20.498	100.125	42.207	63.453	85
-7.327	5.667	101.272	70.992	48.622	86
-17.973	-9.458	100.151	60.346	33.497	87
-34.949	17.066	99.946	43.37	60.021	88
-46.146	-49.233	98.168	32.173	-6.278	89
-35.181	16.858	99.841	43.138	59.813	90
-41.01	-51.485	98.343	37.309	-8.53	91
-35.254	16.372	99.947	43.065	59.327	92
-32.897	11.462	100.032	45.422	54.417	93
-32.619	11.45	99.951	45.7	54.405	94
-32.134	11.513	100.105	46.185	54.468	95
-34.612	12.567	99.899	43.707	55.522	96
-34.865	12.265	99.778	43.454	55.22	97
-35.13	12.051	99.888	43.189	55.006	98
-32.155	6.314	100.016	46.164	49.269	99
-34.468	8.237	99.925	43.851	51.192	100
-31.798	6.172	99.885	46.521	49.127	101
-31.47	6.043	100.057	46.849	48.998	102
-34.842	6.122	99.822	43.477	49.077	103
-34.617	6	99.851	43.702	48.955	104
-34.932	0.124	99.774	43.387	43.079	105
-28.954	-4.248	100.085	49.365	38.707	106

(Continued)

(Sheet 2 of 8)

Table A1 (Continued)

Untranslated			Transl(0,0) = 80920E 7387N		
x	y	z	X	Y	N
-30.612	-3.009	100.047	47.707	39.946	107
-32.063	-15.727	99.781	46.256	27.228	108
-29.249	-17.929	99.818	49.07	25.026	109
-35.117	-20.502	99.624	43.202	22.453	110
-33.72	-27.39	99.261	44.599	15.565	111
-33.997	-27.169	99.431	44.322	15.786	112
-38.323	-27.453	99.337	39.996	15.502	113
-38.154	-34.916	99.073	40.165	8.039	114
-40.598	-32.02	99.144	37.721	10.935	115
-43.71	-39.016	98.594	34.609	3.939	116
-49.778	-50.885	97.796	28.541	-7.93	117
-47.929	-52.955	97.967	30.39	-10	118
-53.677	-47.737	97.619	24.642	-4.782	119
-53.025	-47.198	97.807	25.294	-4.243	120
-48.925	-37.506	98.461	29.394	5.449	121
-55.321	-41.225	98.341	22.998	1.73	122
-48.996	-31.533	98.729	29.323	11.422	123
-55.811	-39.779	98.38	22.508	3.176	124
-55.088	-30.382	98.665	23.231	12.573	125
-61.895	-36.278	98.381	16.424	6.677	126
-61.774	-37.342	98.263	16.545	5.613	127
-63.025	-32.99	98.448	15.294	9.965	128
-70.373	-35.708	97.673	7.946	7.247	129
-84.168	-30.981	97.148	-5.849	11.974	130
-72.864	-24.987	98.021	5.455	17.968	131
-72.743	-23.368	98.097	5.576	19.587	132
-72.756	-23.372	98.096	5.563	19.583	133
-71.612	-20.754	98.263	6.707	22.201	134
-65.216	-26.465	98.462	13.103	16.49	135
-65.226	-21.471	98.453	13.093	21.484	136
-67.262	-26.353	98.344	11.057	16.602	137
-67.431	-25.978	98.427	10.888	16.977	138
-67.716	-25.642	98.362	10.603	17.313	139
-68.051	-26.424	98.379	10.268	16.531	140
-68.714	-26.261	98.3	9.605	16.694	141
-65.222	-16.944	98.509	13.097	26.011	142
-66.313	-25.443	98.419	12.006	17.512	143
-66.529	-25.089	98.49	11.79	17.866	144
-66.815	-24.546	98.41	11.504	18.409	145
-65.401	-24.356	98.513	12.918	18.599	146
-65.155	-11.862	98.574	13.164	31.093	147
-65.192	-6.738	98.655	13.127	36.217	148
-65.233	-1.792	98.749	13.086	41.163	149
-65.308	3.876	98.899	13.011	46.831	150
-65.288	7.545	99.041	13.031	50.5	151
-65.286	12.937	99.088	13.033	55.892	152
-65.341	17.385	99.05	12.978	60.34	153
-69.052	0.23	98.757	9.267	43.185	154
-68.86	-2.06	98.663	9.459	40.895	155
-67.814	-2.559	98.668	10.505	40.396	156
-67.807	-4.718	98.645	10.512	38.237	157
-68.102	-7.803	98.587	10.217	35.152	158
-67.921	-18.176	98.503	10.398	24.779	159
-65.486	-12.032	98.589	12.833	30.923	160
-65.91	-12.373	98.58	12.409	30.582	161

(Continued)

(Sheet 3 of 8)

Table A1 (Continued)

Untranslated			Transl(0,0) = 80920E 7387N		
x	y	z	X	Y	N
-68.207	-25.661	98.322	10.112	17.294	162
-67.096	-14.215	98.525	11.223	28.74	163
-66.161	-13.922	98.545	12.158	29.033	164
-65.899	-14.566	98.551	12.42	28.389	165
-65.817	-16.621	98.504	12.502	26.334	166
-67.26	-21.537	98.415	11.059	21.418	167
-67.746	-22.868	98.417	10.573	20.087	168
-69.113	-20.501	98.358	9.206	22.454	169
-69.608	-18.693	98.375	8.711	24.262	170
-60.213	-26.418	98.533	18.106	16.537	171
-60.234	-26.055	98.569	18.085	16.9	172
-60.268	-24.52	98.61	18.051	18.435	173
-60.232	-25.741	98.602	18.087	17.214	174
-60.385	-23.844	98.561	17.934	19.111	175
-60.317	-23.14	98.621	18.002	19.815	176
-60.197	-21.715	98.638	18.122	21.24	177
-60.325	-16.776	98.605	17.994	26.179	178
-60.391	-11.784	98.699	17.928	31.171	179
-60.413	-6.827	98.825	17.906	36.128	180
-60.373	-1.824	98.909	17.946	41.131	181
-60.432	-2.156	98.938	17.887	40.799	182
-60.572	-1.195	98.98	17.747	41.76	183
-60.416	3.156	99.082	17.903	46.111	184
-60.374	8.12	99.139	17.945	51.075	185
-60.289	13.129	99.108	18.03	56.084	186
-60.296	11.959	99.208	18.023	54.914	187
-60.411	14.273	99.165	17.908	57.228	188
-60.284	16.285	98.992	18.035	59.24	189
-60.274	17.31	99.001	18.045	60.265	190
-60.768	17.349	98.854	17.551	60.304	191
-61.312	17.344	99.011	17.007	60.299	192
-61.213	14.701	99.074	17.106	57.656	193
-61.781	15.37	98.946	16.538	58.325	194
-62.485	15.407	99.058	15.834	58.362	195
-62.451	17.393	98.897	15.868	60.348	196
-62.836	17.369	98.792	15.483	60.324	197
-63.392	17.349	98.964	14.927	60.304	198
-62.868	15.191	99.081	15.451	58.146	199
-62.909	14.062	99.103	15.41	57.017	200
-64.902	-4.735	98.74	13.417	38.22	201
-63.735	-11.284	98.711	14.584	31.671	202
-64.041	-14.372	98.616	14.278	28.583	203
-64.529	-17.452	98.533	13.79	25.503	204
-65.883	-16.599	98.507	12.436	26.356	205
-61.535	2.833	99.019	16.784	45.788	206
-61.177	11.199	99.172	17.142	54.154	207
-62.11	13.472	99.087	16.209	56.427	208
-58.785	-26.406	98.574	19.534	16.549	209
-58.022	-26.368	98.659	20.297	16.587	210
-55.488	-26.365	98.675	22.831	16.59	211
-55.557	-25.629	98.688	22.762	17.326	212
-58.759	-24.672	98.62	19.56	18.283	213
-56.672	-25.359	98.694	21.647	17.596	214
-56.589	-25.177	98.757	21.73	17.778	215
-56.443	-24.499	98.634	21.876	18.456	216

(Continued)

(Sheet 4 of 8)

Table A1 (Continued)

Translated			Transl(0,0) = 80920E 7387N		
x	y	z	X	Y	N
-56.308	-23.793	98.78	22.011	19.162	217
-58.748	-24.345	98.592	19.571	18.61	218
-55.413	-22.087	98.731	22.906	20.868	219
-58.819	-23.66	98.575	19.5	19.295	220
-58.834	-23.179	98.669	19.485	19.776	221
-55.438	-17.114	98.837	22.881	25.841	222
-55.418	-12.191	98.861	22.901	30.764	223
-55.483	-7.201	98.96	22.836	35.754	224
-55.356	-2.194	99.056	22.963	40.761	225
-58.511	-0.982	99.056	19.808	41.973	226
-58.768	-0.483	99.02	19.551	42.472	227
-59.16	-0.044	99.059	19.159	42.911	228
-55.32	0.16	99.107	22.999	43.115	229
-56.671	1.704	99.12	21.648	44.659	230
-56.802	1.988	99.073	21.517	44.943	231
-57.017	2.248	99.116	21.302	45.203	232
-55.238	2.547	99.032	23.081	45.502	233
-56.455	3.082	99.093	21.864	46.037	234
-56.271	3.216	99.044	22.048	46.171	235
-56.126	3.295	99.062	22.193	46.25	236
-55.117	7.73	99.191	23.202	50.685	237
-56.822	8.528	99.185	21.497	51.483	238
-57.181	9.287	99.147	21.138	52.242	239
-57.602	10.013	99.24	20.717	52.968	240
-54.976	12.684	99.261	23.343	55.639	241
-58.009	12.576	99.22	20.31	55.531	242
-57.899	13.349	99.126	20.42	56.304	243
-57.693	13.881	99.207	20.626	56.836	244
-58.168	14.845	99.205	20.151	57.8	245
-58.738	14.113	99.071	19.581	57.068	246
-59.189	13.501	99.159	19.13	56.456	247
-55.247	17.319	99.385	23.072	60.274	248
-59.68	17.224	99.186	18.639	60.179	249
-57.907	10.273	99.344	20.412	53.228	250
-60.321	0.967	99.115	17.998	43.922	251
-57.846	-6.099	98.959	20.473	36.856	252
-57.887	-11.752	98.824	20.432	31.203	253
-58.975	-17.468	98.698	19.344	25.487	254
-56.25	-19.045	98.823	22.069	23.91	255
-57.431	-21.273	98.719	20.888	21.682	256
-55.353	-18.576	98.887	22.966	24.379	257
-59.405	-12.905	98.709	18.914	30.05	258
-56.779	-14.266	98.777	21.54	28.689	259
-58.526	-6.572	98.886	19.793	36.383	260
-58.205	-3.368	98.991	20.114	39.587	261
-56.109	-3.149	99.004	22.21	39.806	262
-59.581	0.164	99.034	18.738	43.119	263
-58.063	3.193	99.091	20.256	46.148	264
-54.434	-26.38	98.698	23.885	16.575	265
-54.076	-26.389	98.66	24.243	16.566	266
-53.001	-26.372	98.699	25.318	16.583	267
-52.487	-26.38	98.782	25.832	16.575	268
-55.375	-24.345	98.748	22.944	18.61	269
-55.402	-24.863	98.656	22.917	18.092	270
-50.112	-26.395	98.789	28.207	16.56	271

(Continued)

(Sheet 5 of 8)

Table A1 (Continued)

Translated			Transl(0,0) = 80920E 7387N		
x	y	z	X	Y	N
-51.273	-24.333	98.918	27.046	18.622	272
-50.242	-20.563	98.974	28.077	22.392	273
-52.558	-24.276	98.736	25.761	18.679	274
-51.588	-23.601	98.9	26.731	19.354	275
-53.304	-21.107	98.95	24.515	21.848	276
-53.107	-21.059	98.84	25.212	21.896	277
-54.305	-22.274	98.785	24.014	20.681	278
-54.718	-20.944	98.786	23.601	22.011	279
-52.909	-19.563	98.924	25.41	23.392	280
-51.408	-16.344	99.023	26.911	26.611	281
-50.118	-11.679	99.125	28.201	31.276	282
-53.499	-14.131	99.016	24.82	28.824	283
-53.704	-10.994	99.074	24.615	31.961	284
-53.666	-9.753	98.969	24.653	33.202	285
-52.068	-6.53	99.151	26.251	36.425	286
-52.417	-4.292	99.197	25.902	38.663	287
-53.084	-2.902	99.239	25.235	40.053	288
-49.988	-1.706	99.32	28.331	41.249	289
-52.806	0.079	99.212	25.513	43.034	290
-49.851	2.028	99.335	28.468	44.983	291
-52.025	2.702	99.284	26.294	45.657	292
-54.841	2.713	98.979	23.478	45.668	293
-49.871	8.295	99.396	28.448	51.25	294
-54.768	3.285	99.061	23.551	46.24	295
-53.995	3.504	99.094	24.324	46.459	296
-54.157	3.2	99.015	24.162	46.155	297
-53.778	10.706	99.317	24.541	53.661	298
-52.838	5.041	99.223	25.481	47.996	299
-52.796	5.161	99.145	25.523	48.116	300
-52.872	5.724	99.173	25.447	48.679	301
-52.846	5.919	99.25	25.473	48.874	302
-49.796	13.198	99.482	28.523	56.153	303
-52.449	16.776	99.479	25.87	59.731	304
-49.602	17.32	99.597	28.717	60.275	305
-45.297	17.334	99.676	33.022	60.289	306
-45.58	11.732	99.61	32.739	54.687	307
-46.022	10.55	99.577	32.297	53.505	308
-47.176	4.802	99.481	31.143	47.757	309
-47.174	4.593	99.445	31.145	47.548	310
-47.243	4.436	99.5	31.076	47.391	311
-45.65	4.845	99.556	32.669	47.8	312
-45.675	4.334	99.494	32.644	47.289	313
-45.634	4.026	99.527	32.685	46.983	314
-49.494	2.375	99.443	28.825	45.33	315
-46.125	-0.139	99.488	32.194	42.816	316
-49.462	0.161	99.451	28.857	43.116	317
-45.209	-2.166	99.457	33.11	40.789	318
-48.224	-2.125	99.393	30.095	40.83	319
-46.409	-6.938	99.376	31.91	36.017	320
-49.534	-5.195	99.292	28.785	37.76	321
-47.508	-10.632	99.261	30.811	32.323	322
-49.812	-6.094	99.169	28.507	36.861	323
-45.349	-12.431	99.33	32.97	30.524	324
-47.325	-16.781	99.146	30.994	26.174	325
-48.357	-19.019	99.095	29.962	23.936	326

(Continued)

Table A1 (Continued)

Translated			Transl(0,0) = 80920E 7387N		
x	y	z	X	Y	N
-47.614	-18.611	99.185	30.705	24.344	327
-47.748	-19.865	99.13	30.571	23.09	328
-47.247	-19.502	99.054	31.072	23.453	329
-46.658	-22.539	99.245	31.661	20.416	330
-48.737	-23.19	99.11	29.582	19.765	331
-47.716	-20.402	99.129	30.603	22.553	332
-45.227	-26.325	99.08	33.092	16.63	333
-47.679	-26.416	98.921	30.64	16.539	334
-40.324	-26.373	99.28	37.995	16.582	335
-44.179	-24.523	99.192	34.14	18.432	336
-40.351	-17.103	99.395	37.968	25.852	337
-42.259	-12.25	99.463	36.06	30.705	338
-42.7	-7.208	99.499	35.619	35.747	339
-40.619	-2.359	99.653	37.7	40.596	340
-41.941	0.355	99.586	36.378	43.31	341
-45.099	0.438	99.562	33.22	43.393	342
-41.596	4.292	99.641	36.723	47.247	343
-41.779	12.265	99.7	36.54	55.22	344
-40.497	9.343	99.66	37.822	52.298	345
-40.353	15.51	99.684	37.966	58.465	346
-45.011	14.674	99.719	33.308	57.629	347
-40.28	17.311	99.752	38.039	60.266	348
-43.962	15.604	99.779	34.357	58.559	349
-37.665	17.341	99.811	40.654	60.296	350
-37.539	17.352	99.748	40.78	60.307	351
-37.069	17.35	99.728	41.25	60.305	352
-36.916	17.357	99.799	41.403	60.312	353
-35.795	17.347	99.91	42.524	60.302	354
-35.532	17.354	99.843	42.787	60.309	355
-35.36	17.339	99.861	42.959	60.294	356
-35.312	16.736	99.882	43.007	59.691	357
-35.356	16.426	99.918	42.963	59.381	358
-36.612	15.684	99.694	41.707	58.639	359
-36.841	15.535	99.82	41.478	58.49	360
-35.379	12.693	99.863	42.94	55.648	361
-35.341	12.924	99.767	42.978	55.879	362
-35.333	13.62	99.789	42.986	56.575	363
-35.291	13.971	99.861	43.028	56.926	364
-38.711	13.561	99.698	39.608	56.516	365
-37.523	15.717	99.72	40.796	58.672	366
-37.553	15.82	99.645	40.766	58.775	367
-37.767	15.976	99.735	40.552	58.931	368
-37.973	15.68	99.718	40.346	58.635	369
-37.754	15.609	99.644	40.565	58.564	370
-37.698	15.5	99.716	40.621	58.455	371
-39.022	5.709	99.701	39.297	48.664	372
-37.497	0.978	99.735	40.822	43.933	373
-35.294	2.807	99.763	43.025	45.762	374
-38.435	-0.345	99.74	39.884	42.61	375
-38.543	-0.553	99.688	39.776	42.402	376
-38.86	-0.614	99.73	39.459	42.341	377
-38.72	-5.239	99.73	39.599	37.716	378
-39.865	-6.905	99.567	38.454	36.05	379
-35.314	-13.473	99.605	43.005	29.482	380
-36.217	-6.322	99.789	42.102	36.633	381

(Continued)

(Sheet 7 of 8)

Table A1 (Concluded)

Translated			Transl(0,0) = 80920E 7387N		
x	y	z	X	Y	N
-35.247	-6.528	99.775	43.072	36.427	382
-35.253	-21.533	99.639	43.066	21.422	383
-37.098	-26.36	99.456	41.22[illegible]	[illegible].595	384
-38.705	-26.41	99.373	39.61	[illegible]6.545	385

(Sheet 8 of 8)

Table A2

Surveyed Points, Plot B

Untranslated			Transl(0,0) = 80859E 6927N		
x	y	z	X	Y	N
-1.771	60.791	98.993	37.959	-0.107	1
4.802	61.703	99.087	44.532	0.805	2
5.74	61.509	99.173	45.47	0.611	3
4.49	63.392	99.181	44.22	2.494	4
5.571	63.918	99.199	45.301	3.02	5
5.267	67.269	99.312	44.997	6.371	6
7.969	64.886	99.063	47.699	3.988	7
4.537	71.057	99.13	44.267	10.159	8
-1.388	74.907	99.142	38.342	14.009	9
1.516	74.774	99.202	41.246	13.876	10
3.727	72.755	99.196	43.457	11.857	11
3.447	77.46	99.2	43.177	16.562	12
-1.508	81.571	99.152	38.222	20.673	13
3.852	71.19	99.245	43.582	10.292	14
5.527	71.622	99.248	45.257	10.724	15
4.523	73.898	99.293	44.253	13	16
4.454	77.976	99.721	44.184	17.078	17
4.414	77.237	99.587	44.144	16.339	18
5.839	84.112	99.841	45.569	23.214	19
-1.557	86.047	99.396	38.173	25.149	20
5.627	92.738	100.145	45.357	31.84	21
4.841	93.426	100.423	44.571	32.528	22
-1.615	94.939	99.995	38.115	34.041	23
4.421	100.845	100.995	44.151	39.947	24
0.626	102.406	100.552	40.356	41.508	25
0.946	99.422	100.519	40.676	38.524	26
-0.175	99.475	100.52	39.555	38.577	27
1.351	99.167	100.573	41.081	38.269	28
5.736	105.486	101.872	45.466	44.588	29
1.791	109.919	102.256	41.521	49.021	30
-0.261	107.674	101.471	39.469	46.776	31
-1.757	104.934	100.658	37.973	44.036	32
-1.267	105.123	100.795	38.463	44.225	33
-3.329	106.665	100.972	36.401	45.767	34
-4.576	108.859	101.153	35.154	47.961	35
-8.497	110.502	100.768	31.233	49.604	36
-8.894	110.425	100.466	30.836	49.527	37
-9.131	104.949	100.092	30.599	44.051	38
-13.91	108.624	99.582	25.82	47.726	39
-14.598	110.987	100.24	25.132	50.089	40
-20.657	110.738	99.554	19.073	49.84	41
-20.077	108.076	99.922	19.653	47.178	42
-21.251	107.978	99.855	18.479	47.08	43
-23.427	104.897	99.016	16.303	43.999	44
-26.806	112.744	99.224	12.924	51.846	45
-33.222	112.161	98.985	6.508	51.263	46
-36.514	105.093	98.438	3.216	44.195	47
-37.177	105.045	98.2	2.553	44.147	48
-37.744	104.94	98.375	1.986	44.042	49
-38.15	106.57	98.498	1.58	45.672	50
-37.709	106.667	98.406	2.021	45.769	51
-37.31	106.751	98.423	2.42	45.853	52
-40.073	112.227	98.88	-0.343	51.329	53
-46.018	111.978	98.532	-6.288	51.08	54
-54.269	110.395	98.372	-14.539	49.497	55
-52.243	103.853	98.164	-12.513	42.955	56
-46.192	104	98.124	-6.462	43.102	57

(Continued)

(Sheet 1 of 12)

Table A2 (Continued)

Untranslated			Transl(0,0) = 80859E 6927N		
x	y	z	X	Y	N
-45.13	103.51	98.289	-5.4	42.612	58
-43.943	104.196	98.139	-4.213	43.298	59
-43.342	104.328	98.449	-3.612	43.43	60
-40.963	104.783	98.572	-1.233	43.885	61
-39.771	104.803	98.308	-0.041	43.905	62
-39.825	102.334	98.328	-0.095	41.436	63
-43.054	101.255	98.335	-3.324	40.357	64
-43.968	101.105	98.087	-4.238	40.207	65
-44.768	100.81	98.274	-5.038	39.912	66
-49.496	99.052	97.971	-9.766	38.154	67
-43.539	98.601	98.155	-3.809	37.703	68
-42.695	98.952	98.502	-2.965	38.054	69
-41.729	99.658	98.241	-1.999	38.76	70
-40.987	100.128	98.737	-1.257	39.23	71
-39.797	97.34	98.461	-0.067	36.442	72
-40.578	97.365	98.659	-0.848	36.467	73
-41.507	97.339	98.325	-1.777	36.441	74
-42.027	96.479	98.523	-2.297	35.581	75
-42.484	96.141	98.273	-2.754	35.243	76
-47.276	93.619	98.003	-7.546	32.721	77
-49.326	90.386	97.953	-9.596	29.488	78
-48.665	80.701	98.191	-8.935	19.803	79
-39.805	78.582	98.397	-0.075	17.684	80
-39.814	70.233	97.75	-0.084	9.335	81
-48.293	67.989	97.437	-8.563	7.091	82
-46.673	67.754	97.715	-6.943	6.856	83
-45.956	67.82	97.665	-6.226	6.922	84
-46.909	67.164	97.45	-7.179	6.266	85
-47.747	60.248	97.054	-8.017	-0.65	86
-1.782	104.777	100.604	37.948	43.879	87
-1.855	104	100.688	37.875	43.102	88
-1.76	100.684	100.103	37.97	39.786	89
-2.893	98.343	100.129	36.837	37.445	90
-2.851	96.933	99.79	36.879	36.035	91
-2.991	103.405	100.539	36.739	42.507	92
-3.25	100.386	99.845	36.48	39.488	93
-3.974	100.765	99.821	35.756	39.867	94
-4.452	101.674	100.199	35.278	40.776	95
-3.627	103.737	100.44	36.103	42.839	96
-2.889	103.721	100.421	36.841	42.823	97
-5.044	101.884	100.26	34.686	40.986	98
-7.035	104.595	100.028	32.695	43.697	99
-8.151	100.828	100.014	31.579	39.93	100
-8.735	104.168	100.284	30.995	43.27	101
-9.114	102.313	99.81	30.616	41.415	102
-10.501	103.595	99.769	29.229	42.697	103
-11.984	103.201	99.594	27.746	42.303	104
-11.005	104.339	99.968	28.725	43.441	105
-10.937	101.204	99.522	28.793	40.306	106
-12.721	102.634	99.696	27.009	41.736	107
-14.59	101.978	99.135	25.14	41.08	108
-12.641	100.652	99.209	27.089	39.754	109
-13.811	104.418	99.496	25.919	43.52	110
-16.159	103.979	99.057	23.571	43.081	111
-16.384	102.083	99.05	23.346	41.185	112
-17.24	104.891	99.063	22.49	43.993	113
-14.168	100.723	99.154	25.562	39.825	114
-15.921	102.964	99.151	23.809	42.066	115
-15.805	100.673	99.1	23.925	39.775	116
-15.217	100.889	99.258	24.513	39.991	117

(Continued)

(Sheet 2 of 12)

Table A2 (Continued)

Untranslated			Transl(0,0) = 80859E 6927N		
x	y	z	X	Y	N
-16.562	100.578	99.336	23.168	39.68	118
-17.86	100.717	98.982	21.87	39.819	119
-17.632	100.549	99.015	22.098	39.651	120
-17.451	103.253	99.037	22.279	42.355	121
-18.254	102.239	98.988	21.476	41.341	122
-17.204	101.746	98.913	22.526	40.848	123
-18.405	102.201	99.014	21.325	41.303	124
-18.463	103.417	98.827	21.267	42.519	125
-19.18	100.564	98.868	20.55	39.666	126
-19.599	100.697	98.985	20.131	39.799	127
-20.238	100.538	98.769	19.492	39.64	128
-19.584	102.061	98.708	20.146	41.163	129
-20.024	102.931	98.889	19.706	42.033	130
-20.029	104.924	99.164	19.701	44.026	131
-20.642	105.131	99.393	19.088	44.233	132
-21.38	105.206	99.202	18.35	44.308	133
-21.337	103.135	98.804	18.393	42.237	134
-21.824	104.035	99.061	17.906	43.137	135
-22.582	105.025	99.007	17.148	44.127	136
-20.803	99.798	98.741	18.927	38.9	137
-20.868	100.708	98.831	18.862	39.81	138
-22.46	102.029	98.743	17.27	41.131	139
-22.795	99.623	98.745	16.935	38.725	140
-21.496	98.877	98.722	18.234	37.979	141
-23.645	101.557	98.814	16.085	40.659	142
-24.047	102.372	99.007	15.683	41.474	143
-25.415	104.874	99.046	14.315	43.976	144
-24.812	100.717	98.763	14.918	39.819	145
-24.954	101.448	99.008	14.776	40.55	146
-26.363	103.075	98.765	13.367	42.177	147
-28.462	104.667	98.919	11.268	43.769	148
-29.318	101.696	98.813	10.412	40.798	149
-31.287	103.499	98.76	8.443	42.601	150
-31.105	102.221	99.197	8.625	41.323	151
-32.509	98.256	98.667	7.221	37.358	152
-34.045	99.775	98.609	5.685	38.877	153
-32.584	99.8	98.992	7.146	38.902	154
-28.602	101.223	98.784	11.128	40.325	155
-28.915	100.945	98.93	10.815	40.047	156
-29.141	100.595	98.778	10.589	39.697	157
-27.488	99.656	98.974	12.242	38.758	158
-29.153	98.541	98.951	10.577	37.643	159
-29.103	98.083	98.7	10.627	37.185	160
-27.608	99.239	98.759	12.122	38.341	161
-34.103	101.402	98.61	5.627	40.504	162
-32.858	102.851	98.733	6.872	41.953	163
-36.221	104.242	98.442	3.509	43.344	164
-36.757	104.514	98.198	2.973	43.616	165
-37.275	104.519	98.212	2.455	43.621	166
-37.62	104.648	98.391	2.11	43.75	167
-34.401	96.916	98.879	5.329	36.018	168
-33.871	96.924	98.728	5.859	36.026	169
-33.239	97.107	98.848	6.491	36.209	170
-39.714	104.8	98.312	0.016	43.902	171
-39.702	103.699	98.09	0.028	42.801	172
-38.611	102.191	98.324	1.119	41.293	173
-37.331	96.453	98.616	2.399	35.555	174
-36.86	96.525	98.596	2.87	35.627	175
-39.696	96.016	98.384	0.034	35.118	176
-36.016	97.279	98.613	3.714	36.381	177

(Continued)

(Sheet 3 of 12)

Table A2 (Continued)

Untranslated			Transl(0,0) = 80859E 6927N		
x	y	z	X	Y	N
-34.885	97.851	98.707	4.845	36.953	178
-34.453	97.059	98.851	5.277	36.161	179
-34.067	95.97	98.793	5.663	35.072	180
-35.908	96.601	98.666	3.822	35.703	181
-37.949	95.915	98.391	1.781	35.017	182
-37.901	96.836	98.558	1.829	35.938	183
-39.356	97.699	98.539	0.374	36.801	184
-38.786	97.558	98.543	0.944	36.66	185
-39.519	98.992	98.526	0.211	38.094	186
-39.665	98.738	98.434	0.065	37.84	187
-32.353	96.359	98.788	7.377	35.461	188
-32.178	96.427	98.704	7.552	35.529	189
-31.331	96.45	98.754	8.399	35.552	190
-32.238	97.807	98.608	7.492	36.909	191
-35.799	92.68	98.424	3.931	31.782	192
-35.181	92.864	98.603	4.549	31.966	193
-34.987	90.796	98.465	4.743	29.898	194
-34.158	90.982	98.747	5.572	30.084	195
-30.479	96.598	98.864	9.251	35.7	196
-30.382	97.381	98.834	9.348	36.483	197
-30.655	98.128	98.603	9.075	37.23	198
-27.49	98.006	98.699	12.24	37.108	199
-29.481	95.544	98.735	10.249	34.646	200
-24.518	92.006	98.758	15.212	31.108	201
-22.383	93.987	98.694	17.347	33.089	202
-26.005	95.211	98.61	13.725	34.313	203
-28.336	96.466	98.726	11.394	35.568	204
-29.093	98.631	98.955	10.637	37.733	205
-27.61	99.687	98.976	12.12	38.789	206
-27.362	99.372	98.807	12.368	38.474	207
-30.846	95.703	98.791	8.884	34.805	208
-30.223	95.473	98.741	9.507	34.575	209
-29.794	95.324	98.851	9.936	34.426	210
-26.757	98.858	99.021	12.973	37.96	211
-26.37	99.16	98.809	13.36	38.262	212
-26.057	99.494	98.832	13.673	38.596	213
-25.822	99.613	99.104	13.908	38.715	214
-23.99	98.193	98.695	15.74	37.295	215
-23.358	97.918	98.613	16.372	37.02	216
-22.96	98.257	98.63	16.77	37.359	217
-24.073	99.844	98.591	15.657	38.946	218
-24.581	100.057	98.675	15.149	39.159	219
-19.152	91.063	98.983	20.578	30.165	220
-18.804	91.144	98.891	20.926	30.246	221
-18.192	91.342	98.899	21.538	30.444	222
-16.695	88.438	98.916	23.035	27.54	223
-16.591	87.092	98.754	23.139	26.194	224
-16.852	86.423	98.909	22.878	25.525	225
-23.646	96.078	98.957	16.084	35.18	226
-22.782	96.628	98.933	16.948	35.73	227
-21.602	97.021	98.935	18.128	36.123	228
-20.931	97.528	98.939	18.799	36.63	229
-19.625	95.687	98.64	20.105	34.789	230
-17.564	95.592	98.854	22.166	34.694	231
-18.164	97.325	98.783	21.566	36.427	232
-18.407	98.904	98.986	21.323	38.006	233
-16.731	100.095	99.169	22.999	39.197	234
-19.871	99.452	98.86	19.859	38.554	235
-16.361	100.119	99.3	23.369	39.221	236
-15.837	100.028	99.109	23.893	39.13	237

(Continued)

(Sheet 4 of 12)

Table A2 (Continued)

Untranslated			Transl(0,0) = 80859E 6927N		
x	y	z	X	Y	N
-17.019	98.817	99.045	22.711	37.919	238
-15.123	98.843	99.152	24.607	37.945	239
-15.531	98.558	99.072	24.199	37.66	240
-13.898	97.758	99.12	25.832	36.86	241
-14.318	94.815	99.054	25.412	33.917	242
-14.135	95.323	99.319	25.595	34.425	243
-14.688	97.64	99.281	25.042	36.742	244
-13.271	96.299	99.471	26.459	35.401	245
-10.246	95.785	99.319	29.484	34.887	246
-12.133	98.243	99.216	27.597	37.35	247
-11.545	97.498	99.512	28.185	36.6	248
-10.497	97.249	99.327	29.233	36.351	249
-10.541	99.526	99.67	29.189	38.628	250
-6.86	100.603	100.065	32.87	39.705	251
-5.627	100.103	99.658	34.103	39.205	252
-6.335	100.321	99.979	33.395	39.423	253
-8.198	96.013	99.352	31.532	35.115	254
-7.294	95.541	99.329	32.436	34.643	255
-6.904	95.572	99.479	32.826	34.674	256
-6.228	95.654	99.438	33.502	34.756	257
-5.755	95.653	99.636	33.975	34.755	258
-5.566	96.529	99.51	34.164	35.631	259
-6.796	97.222	99.559	32.934	36.324	260
-5.067	94.709	99.657	34.663	33.811	261
-4.888	98.445	99.703	34.842	37.547	262
-1.668	95.691	99.871	38.062	34.793	263
-1.753	95.626	99.864	37.977	34.728	264
-1.784	94.321	100.028	37.946	33.423	265
-2.698	93.657	99.743	37.032	32.759	266
-3.646	94.445	99.532	36.084	33.547	267
-2.124	93.457	99.765	37.606	32.559	268
-3.707	92.425	99.62	36.023	31.527	269
-2.75	91.894	100.03	36.98	30.996	270
-1.898	93.108	99.999	37.832	32.21	271
-2.232	90.859	99.753	37.498	29.961	272
-4.762	91.182	99.544	34.968	30.284	273
-4.5	90.499	99.827	35.23	29.601	274
-3.062	95.401	99.809	36.668	34.503	275
-5.695	91.75	99.657	34.035	30.852	276
-4.719	92.58	99.658	35.011	31.682	277
-5.386	92.578	99.452	34.344	31.68	278
-7.395	93.13	99.517	32.335	32.232	279
-8.194	92.92	99.515	31.536	32.022	280
-8.751	93.639	99.288	30.979	32.741	281
-9.967	93.915	99.27	29.763	33.017	282
-7.859	90.521	99.274	31.871	29.623	283
-9.813	94.704	99.463	29.917	33.806	284
-8.942	94.738	99.316	30.788	33.84	285
-10.872	95.124	99.269	28.858	34.226	286
-8.662	90.793	99.355	31.068	29.895	287
-9.716	90.906	99.252	30.014	30.008	288
-10.36	90.996	98.942	29.37	30.098	289
-11.639	93.725	99.204	28.091	32.827	290
-10.896	93.241	99.315	28.834	32.343	291
-13.207	92.732	99.176	26.523	31.834	292
-12.196	90.711	98.871	27.534	29.813	293
-11.658	92.23	98.963	28.072	31.332	294
-13.654	93.013	99.12	26.076	32.115	295
-13.636	92.05	98.852	26.094	31.152	296
-12.191	89.702	98.778	27.539	28.804	297

(Continued)

(Sheet 5 of 12)

Table A2 (Continued)

Untranslated			Transl(0,0) = 80859E 6927N		
X	Y	Z	X	Y	N
-12.74	89.386	98.94	26.99	28.488	298
-14.83	90.765	98.728	24.9	29.867	299
-15.447	90.342	98.713	24.283	29.444	300
-13.757	87.573	98.693	25.973	26.675	301
-16.272	90.581	98.959	23.458	29.683	302
-14.304	91.329	99.004	25.426	30.431	303
-16.501	92.233	98.979	23.229	31.335	304
-20.028	92.855	98.724	19.702	31.957	305
-23.501	91.608	98.79	16.229	30.71	306
-17.958	87.603	98.889	21.772	26.705	307
-21.575	85.757	98.948	18.155	24.859	308
-21.378	91.121	99.646	18.352	30.223	309
-20.214	88.712	99.607	19.516	27.814	310
-19.185	89.566	99.201	20.545	28.668	311
-28.662	93.091	98.805	11.068	32.193	312
-28.467	91.903	99.034	11.263	31.005	313
-28.311	92.037	98.808	11.419	31.139	314
-27.892	92.337	98.67	11.838	31.439	315
-31.068	93.105	98.946	8.662	32.207	316
-27.654	87.1	98.905	12.076	26.202	317
-28.942	90.803	99.435	10.788	29.905	318
-27.035	88.327	99.01	12.695	27.429	319
-25.546	89.518	99.735	14.184	28.62	320
-24.6	87.166	98.722	15.13	26.268	321
-30.072	89.649	98.812	9.658	28.751	322
-26.825	87.17	98.622	12.905	26.272	323
-37.09	95.755	98.521	2.64	34.857	324
-37.098	95.764	98.522	2.632	34.866	325
-34.039	90.67	98.793	5.691	29.772	326
-40.368	96.587	98.397	-0.638	35.689	327
-37.79	95.415	98.342	1.94	34.517	328
-39.121	92.092	98.207	0.609	31.194	329
-39.678	91.659	98.513	0.052	30.761	330
-36.568	93.089	98.305	3.162	32.191	331
-37.01	92.76	98.39	2.72	31.862	332
-37.237	92.368	98.251	2.493	31.47	333
-38.457	90.132	98.462	1.273	29.234	334
-37.64	91.726	98.459	2.09	30.828	335
-35.746	90.673	98.48	3.984	29.775	336
-37.968	85.946	98.543	1.762	25.048	337
-37.241	87.696	98.564	2.489	26.798	338
-36.444	87.263	98.751	3.286	26.365	339
-37.313	85.983	98.722	2.417	25.085	340
-36.624	85.138	98.756	3.106	24.24	341
-36.671	84.102	98.52	3.059	23.204	342
-35.526	85.604	98.468	4.204	24.706	343
-33.8	88.501	98.498	5.93	27.603	344
-35.247	83.88	98.51	4.483	22.982	345
-34.355	88.838	98.731	5.375	27.94	346
-32.649	85.164	98.511	7.081	24.266	347
-35.105	88.096	98.753	4.625	27.198	348
-34.189	85.233	98.79	5.541	24.335	349
-34.55	86.779	98.456	5.18	25.881	350
-36.301	88.87	98.672	3.429	27.972	351
-35.107	89.517	98.738	4.623	28.619	352
-32.371	85.92	98.541	7.359	25.022	353
-31.137	85.933	98.863	8.593	25.035	354
-30.638	86.089	98.805	9.092	25.191	355
-33.789	90.106	98.7	5.941	29.208	356
-28.051	85.832	98.753	11.679	24.934	357

(Continued)

(Sheet 6 of 12)

Table A2 (Continued)

Untranslated			Transl (0,0) = 80859E 6927N		
x	y	z	X	Y	N
-25.87	85.859	98.561	13.86	24.961	358
-24.114	85.869	98.817	15.616	24.971	359
-14.842	85.887	98.962	24.888	24.989	360
-14.306	85.85	98.718	25.424	24.952	361
-13.594	85.847	98.944	26.136	24.949	362
-11.836	86.174	98.829	27.894	25.276	363
-11.609	86.868	99.144	28.121	25.97	364
-12.531	89.203	98.956	27.199	28.305	365
-10.805	86.566	98.948	28.925	25.668	366
-11.439	89.709	98.907	28.291	28.811	367
-10.069	86.879	99.123	29.661	25.981	368
-9.921	89.847	99.137	29.809	28.949	369
-8.934	87.991	99.435	30.796	27.093	370
-8.792	88.75	99.232	30.938	27.852	371
-8.117	88.23	99.551	31.613	27.332	372
-8.099	87.897	99.426	31.631	26.999	373
-8.056	85.717	99.27	31.674	24.819	374
-7.574	90.353	99.331	32.156	29.455	375
-6.272	86.009	99.61	33.458	25.111	376
-5.71	90.046	99.683	34.02	29.148	377
-5.452	85.736	99.365	34.278	24.838	378
-4.35	90.109	99.83	35.38	29.211	379
-2.264	88.131	99.683	37.466	27.233	380
-3.501	89.819	99.748	36.229	28.921	381
-2.085	89.063	99.941	37.645	28.165	382
-2.241	90.419	99.769	37.489	29.521	383
-1.988	90.125	99.853	37.742	29.227	384
-2.801	89.406	99.972	36.929	28.508	385
-3.038	85.923	99.51	36.692	25.025	386
-2.738	85.811	99.364	36.992	24.913	387
-1.713	85.741	99.384	38.017	24.843	388
-1.663	86.887	99.447	38.067	25.989	389
-2.326	85.277	99.418	37.404	24.379	390
-2.529	83.888	99.385	37.201	22.99	391
-1.885	80.868	99.205	37.845	19.97	392
-2.51	80.812	99.119	37.22	19.914	393
-3.64	75.474	99.095	36.09	14.576	394
-1.88	77.331	99.15	37.85	16.433	395
-2.82	82.777	99.436	36.91	21.879	396
-3.85	81.959	99.605	35.88	21.061	397
-5.205	80.604	99.491	34.525	19.706	398
-4.96	84.408	99.448	34.77	23.51	399
-6.505	84.341	99.292	33.225	23.443	400
-5.506	83.678	99.561	34.224	22.78	401
-7.416	84.997	99.506	32.314	24.099	402
-10.454	85.307	98.924	29.276	24.409	403
-8.556	82.888	98.997	31.174	21.99	404
-9.019	82.753	99.052	30.711	21.855	405
-9.185	81.903	98.941	30.545	21.005	406
-9.897	82.332	98.714	29.833	21.434	407
-11.471	84.986	98.681	28.259	24.088	408
-10.36	82.265	98.799	29.37	21.367	409
-10.767	83.708	98.861	28.963	22.81	410
-10.547	81.193	98.888	29.183	20.295	411
-10.326	80.558	98.828	29.404	19.66	412
-12.66	85.133	98.716	27.07	24.235	413
-11.12	81.538	98.709	28.61	20.64	414
-12.156	81.557	98.739	27.574	20.659	415
-14.312	83.524	98.64	25.418	22.626	416
-13.626	84.156	98.878	26.104	23.258	417

(Continued)

(Sheet 7 of 12)

Table A2 (Continued)

Untranslated			Transl(0,0) = 80859E 6927N		
x	y	z	X	Y	N
-13.617	85.617	98.919	26.113	24.719	418
-14.31	85.611	98.78	25.42	24.713	419
-14.924	85.639	98.969	24.806	24.741	420
-14.601	83.285	98.898	25.129	22.387	421
-15.062	83.282	98.745	24.668	22.384	422
-15.922	82.6	98.933	23.808	21.702	423
-16.341	81.601	98.97	23.389	20.703	424
-16.084	80.847	98.802	23.646	19.949	425
-17.185	85.1	98.67	22.545	24.202	426
-17.757	85.138	98.713	21.973	24.24	427
-18.105	85.217	98.624	21.625	24.319	428
-18.646	85.22	98.833	21.084	24.322	429
-17.975	83.648	98.964	21.755	22.75	430
-17.887	82.935	98.766	21.843	22.037	431
-17.558	81.115	98.806	22.172	20.217	432
-17.217	81.108	98.979	22.513	20.21	433
-17.852	82.373	98.928	21.878	21.475	434
-20.722	84.49	98.728	19.008	23.592	435
-22.232	85.382	99.04	17.498	24.484	436
-18.314	80.938	99.059	21.416	20.04	437
-26.087	84.608	98.741	13.643	23.71	438
-20.634	80.858	98.841	19.096	19.96	439
-20.176	80.996	98.95	19.554	20.098	440
-21.465	80.965	98.945	18.265	20.067	441
-21.677	82.725	98.952	18.053	21.827	442
-22.074	82.554	98.837	17.656	21.656	443
-23.341	82.244	99.003	16.389	21.346	444
-23.202	84.286	98.88	16.528	23.388	445
-23.772	81.972	98.857	15.958	21.074	446
-24.764	82.687	98.58	14.966	21.789	447
-26.212	84.068	98.728	13.518	23.17	448
-24.317	81.744	98.985	15.413	20.846	449
-28.049	85.345	98.714	11.681	24.447	450
-28.247	85.116	98.815	11.483	24.218	451
-25.634	81.987	98.956	14.096	21.089	452
-29.981	85.285	98.936	9.749	24.387	453
-32.663	85.438	98.477	7.067	24.54	454
-35.15	83.338	98.474	4.58	22.44	455
-30.751	80.902	98.912	8.979	20.004	456
-35.885	81.004	98.459	3.845	20.106	457
-36.157	81.011	98.557	3.573	20.113	458
-39.728	80.797	98.396	0.002	19.899	459
-39.454	80.241	98.305	0.276	19.343	460
-38.841	79.409	98.259	0.889	18.511	461
-38.201	79.989	98.417	1.529	19.091	462
-37.912	79.147	98.588	1.818	18.249	463
-38.319	78.523	98.576	1.411	17.625	464
-39.536	78.973	98.447	0.194	18.075	465
-37.84	78.429	98.428	1.89	17.531	466
-39.731	75.743	98.083	-0.001	14.845	467
-35.159	76.145	98.358	4.571	15.247	468
-34.175	75.53	98.43	5.555	14.632	469
-34.447	75.936	98.617	5.283	15.038	470
-33.412	75.776	98.538	6.318	14.878	471
-33.295	76.054	98.426	6.435	15.156	472
-32.564	76.977	98.582	7.166	16.079	473
-32.673	76.522	98.643	7.057	15.624	474
-32.763	76.141	98.475	6.967	15.243	475
-31.491	75.866	98.538	8.239	14.968	476
-31.855	76.113	98.635	7.875	15.215	477

(Continued)

Table A2 (Continued)

Untranslated			Transl(0,0) = 80859E 6927N		
x	y	z	X	Y	N
0.2	76.082	98.602	9.53	15.184	478
-30.011	75.986	98.675	9.719	15.088	479
-29.611	76.024	98.557	10.119	15.126	480
-28.723	76.006	98.728	11.007	15.108	481
-27.637	76.011	98.625	12.093	15.113	482
-26.909	77.002	98.781	12.821	16.104	483
-28.888	80.406	98.879	10.842	19.508	484
-28.441	80.523	98.733	11.289	19.625	485
-26.12	75.935	98.715	13.61	15.037	486
-27.918	80.631	98.801	11.812	19.733	487
-24.317	75.846	98.953	15.413	14.948	488
-23.295	76.724	99.066	16.435	15.826	489
-23.396	78.046	98.863	16.334	17.148	490
-21.257	75.564	98.782	18.473	14.666	491
-21.835	76.874	99.058	17.895	15.976	492
-22.395	78.403	99.088	17.335	17.505	493
-19.417	75.656	98.75	20.313	14.758	494
-21.769	78.713	98.786	17.961	17.815	495
-20.433	77.814	99.01	19.297	16.916	496
-22.342	80.637	98.933	17.388	19.739	497
-22.876	80.594	98.764	16.854	19.696	498
-19.896	78.494	98.841	19.834	17.596	499
-19.384	78.979	98.987	20.346	18.081	500
-19.576	80.276	98.859	20.154	19.378	501
-17.322	80.361	99.036	22.408	19.463	502
-14.696	75.749	98.781	25.034	14.851	503
-13.879	75.936	98.918	25.851	15.038	504
-12.846	76.473	99.004	26.884	15.575	505
-12.11	78.745	98.79	27.62	17.847	506
-11.564	78.413	99.012	28.166	17.515	507
-12.503	75.616	98.756	27.227	14.718	508
-11.04	76.725	98.842	28.69	15.827	509
-10.603	79.151	98.813	29.127	18.253	510
-8.893	80.312	99.065	30.837	19.414	511
-9.901	75.76	99.162	29.829	14.862	512
-8.048	75.806	99.171	31.682	14.908	513
-7.604	75.781	99.073	32.126	14.883	514
-6.764	79.937	99.147	32.966	19.039	515
-5.302	80.404	99.476	34.428	19.506	516
-4.12	79.85	99.168	35.61	18.952	517
-1.857	75.913	99.144	37.873	15.015	518
-1.849	70.72	99.228	37.881	9.822	519
-4.023	70.731	99.076	35.707	9.833	520
-5.262	70.728	99.239	34.468	9.83	521
-6.274	70.916	98.918	33.456	10.018	522
-6.063	74.574	98.946	33.667	13.676	523
-8.14	72.726	98.877	31.59	11.828	524
-9.413	74.254	98.929	30.317	13.356	525
-8.251	74.003	98.931	31.479	13.105	526
-9.405	73.12	98.888	30.325	12.222	527
-8.932	73.547	98.711	30.798	12.649	528
-10.391	70.823	98.921	29.339	9.925	529
-12.175	70.988	98.735	27.555	10.09	530
-11.498	72.071	98.834	28.232	11.173	531
-13.272	71.667	99.018	26.458	10.769	532
-12.189	71.947	99.02	27.541	11.049	533
-13.312	70.901	98.813	26.418	10.003	534
-11.697	74.448	99.129	28.033	13.55	535
-14.875	71.946	98.85	24.855	11.048	536
-13.755	74.303	98.788	25.975	13.405	537

(Continued)

(Sheet 9 of 12)

Table A2 (Continued)

Untranslated			Transl(0,0) = 80859E 6927N		
X	Y	Z	X	Y	N
-15.513	72.651	98.548	24.217	11.753	538
-13.583	72.507	99.059	26.147	11.609	539
-16.267	71.41	98.614	23.463	10.512	540
-15.367	73.578	98.858	24.363	12.68	541
-17.877	71.46	98.514	21.853	10.562	542
-17.05	70.89	98.727	22.68	9.992	543
-13.948	74.915	98.933	25.782	14.017	544
-19.046	71.85	98.858	20.684	10.952	545
-16.795	74.935	98.792	22.935	14.037	546
-17.494	74.939	98.678	22.236	14.041	547
-20.896	71.228	98.772	18.834	10.33	548
-19.293	73.555	98.832	20.437	12.657	549
-21.351	72.24	98.941	18.379	11.342	550
-21.336	75.104	98.757	18.394	14.206	551
-21.561	73.354	98.65	18.169	12.456	552
-21.783	75.191	98.882	17.947	14.293	553
-23.439	74.78	98.765	16.291	13.882	554
-22.733	75.432	98.847	16.997	14.534	555
-23.174	75.181	98.998	16.556	14.283	556
-22.76	72.383	98.615	16.97	11.485	557
-24.2	74.793	98.809	15.53	13.895	558
-24.022	71.771	98.652	15.708	10.873	559
-25.027	75.179	98.729	14.703	14.281	560
-23.22	71.312	98.775	16.51	10.414	561
-25.389	74.716	98.873	14.341	13.818	562
-26.39	71.085	98.784	13.34	10.187	563
-26.964	70.964	98.617	12.766	10.066	564
-26.996	74.95	98.621	12.734	14.052	565
-27.481	74.446	98.803	12.249	13.548	566
-26.482	72.965	98.679	13.248	12.067	567
-30.212	70.949	98.551	9.518	10.051	568
-29.398	73.784	98.605	10.332	12.886	569
-29.223	73.89	98.7	10.507	12.992	570
-28.864	74.021	98.56	10.866	13.123	571
-33.294	72.219	98.267	6.436	11.321	572
-33.227	73.146	98.526	6.503	12.248	573
-29.527	75.552	98.562	10.203	14.654	574
-30.346	75.462	98.712	9.384	14.564	575
-31.398	75.401	98.525	8.332	14.503	576
-34.993	73.55	98.229	4.737	12.652	577
-35.325	73.974	98.435	4.405	13.076	578
-35.802	75.483	98.321	3.928	14.585	579
-36.202	73.99	98.314	3.528	13.092	580
-36.111	75.321	98.439	3.619	14.423	581
-36.388	75.35	98.343	3.342	14.452	582
-36.611	73.926	98.219	3.119	13.028	583
-35.971	74.828	98.271	3.759	13.93	584
-38.413	71.548	98.003	1.317	10.65	585
-38.619	72.691	97.896	1.111	11.793	586
-37.976	73.321	98.106	1.754	12.423	587
-39.699	70.834	97.791	0.031	9.936	588
-39.721	66.104	97.647	0.009	5.206	589
-33.785	68.263	98.058	5.945	7.365	590
-38.34	68.249	97.857	1.39	7.351	591
-37.497	68.095	97.921	2.233	7.197	592
-32.134	66.012	97.992	7.596	5.114	593
-33.503	69.026	98.235	6.227	8.128	594
-29.914	66.812	98.42	9.816	5.914	595
-29.85	70.685	98.585	9.88	9.787	596
-29.412	70.181	98.71	10.318	9.283	597

(Continued)

(Sheet 10 of 12)

Table A2 (Continued)

Untranslated			Transl(0,0) = 80859E 6927N		
X	Y	Z	X	Y	N
-28.892	69.766	98.736	10.838	8.868	598
-29.11	66.799	98.198	10.62	5.901	599
-28.406	69.647	98.588	11.324	8.749	600
-27.741	66.445	98.331	11.989	5.547	601
-27.821	66.744	98.503	11.909	5.846	602
-27.716	70.562	98.602	12.014	9.664	603
-27.855	67.203	98.356	11.875	6.305	604
-26.999	68.392	98.73	12.731	7.494	605
-26.288	67.577	98.466	13.442	6.679	606
-26.309	67.279	98.605	13.421	6.381	607
-27.272	70.399	98.82	12.458	9.501	608
-26.694	70.503	98.646	13.036	9.605	609
-20.634	70.294	98.752	19.096	9.396	610
-19.277	68.676	98.557	20.453	7.778	611
-22.572	68.246	98.613	17.158	7.348	612
-22.046	67.934	98.422	17.684	7.036	613
-21.918	67.399	98.517	17.812	6.501	614
-20.872	68.548	98.581	18.858	7.65	615
-20.785	68.869	98.471	18.945	7.971	616
-20.133	68.613	98.642	19.597	7.715	617
-19.95	67.468	98.475	19.78	6.57	618
-21.883	65.491	98.141	17.847	4.593	619
-20.853	63.476	98.817	18.877	2.578	620
-22.282	62.101	98.58	17.448	1.203	621
-23.897	63.963	98.003	15.833	3.065	622
-25.688	64.229	97.948	14.042	3.331	623
-26.338	65.538	98.387	13.392	4.64	624
-26.962	62.476	98.247	12.768	1.578	625
-25.903	62.065	97.867	13.827	1.167	626
-24.367	60.881	98.404	15.363	-0.017	627
-26.373	60.867	97.778	13.357	-0.031	628
-27.51	61.163	98.15	12.22	0.265	629
-29.068	61.067	97.823	10.662	0.169	630
-32.26	60.979	97.722	7.47	0.081	631
-39.73	60.898	97.379	0	0	632
-39.655	65.798	97.632	0.075	4.9	633
-18.413	64.94	98.945	21.317	4.042	634
-19.916	63.447	98.841	19.814	2.549	635
-21.88	61.082	98.744	17.85	0.184	636
-20.911	63.044	99.055	18.819	2.146	637
-21.786	63.445	98.888	17.944	2.547	638
-20.111	63.019	99.569	19.619	2.121	639
-18.365	69.612	98.409	21.365	8.714	640
-16.877	69.828	98.526	22.853	8.93	641
-14.758	69.991	98.717	24.972	9.093	642
-16.966	65.93	98.754	22.764	5.032	643
-16.416	66.024	98.905	23.314	5.126	644
-15.332	66.022	98.689	24.398	5.124	645
-15.723	64.013	98.657	24.007	3.115	646
-13.081	70.575	98.756	26.649	9.677	647
-11.297	69.153	98.686	28.433	8.255	648
-10.661	64.717	98.661	29.069	3.819	649
-13.109	65.774	99.263	26.621	4.876	650
-9.56	70.531	98.824	30.17	9.633	651
-10.849	66.083	98.656	28.881	5.185	652
-10.125	65.911	98.972	29.605	5.013	653
-9.556	65.965	98.779	30.174	5.067	654
-8.909	70.457	98.963	30.821	9.559	655
-1.838	65.846	99.011	37.892	4.948	656
-5.799	69.68	99.189	33.931	8.782	657

(Continued)

(Sheet 11 of 12)

Table A2 (Concluded)

Untranslated			Transl(0,0) = 80859E 6927N		
x	y	z	X	Y	N
-5.653	69.007	99.067	34.077	8.109	658
-4.853	69.744	99.082	34.877	8.846	659
-5.085	70.422	99.286	34.645	9.524	660
-5.72	70.318	99.029	34.01	9.42	661
-18.518	61.472	98.886	21.212	0.574	662
-16.723	60.81	93.883	23.007	-0.088	663
-14.899	61.953	98.846	24.831	1.055	664
-14.832	61.676	98.975	24.898	0.778	665
-14.755	61.425	98.884	24.975	0.527	666
-13.871	62.371	98.965	25.859	1.473	667
-14.005	63.044	98.654	25.725	2.146	668
-13.082	62.954	98.936	26.648	2.056	669
-12.909	62.409	98.769	26.821	1.511	670
-9.931	65.[illegible]7	98.743	29.799	4.429	671
-9.94	64.851	98.705	29.79	3.953	672
-9.793	64.296	98.856	29.937	3.398	673
-8.511	61.049	98.83	31.219	0.151	674
-7.248	60.992	98.799	32.482	0.094	675
-6.108	60.958	98.872	33.622	0.06	676
-3.92	60.892	98.841	35.81	-0.006	677
-3.225	60.938	98.824	36.505	0.04	678
-2.302	60.939	99.043	37.428	0.041	679
-1.898	60.806	99.076	37.832	-0.092	680
-3.585	64.191	98.759	36.145	3.293	681
-122.362	59.979	95.738	-82.632	-0.919	682
0	0	97.536	39.73	-60.898	683

(Sheet 12 of 12)

Table A3

Survey Points, Plot C

Untranslated			Transl(0,0) = 80814E 6889N		
x	y	z	X	Y	N
-1.836	50.693	98.758	52.892	47.562	1
-1.831	49.868	98.836	52.897	46.737	2
-1.452	49.485	98.765	53.276	46.354	3
-0.637	49.504	98.779	54.091	46.373	4
-1.445	49.886	98.875	53.283	46.755	5
0.54	49.204	98.975	55.268	46.073	6
1.062	48.976	98.991	55.79	45.845	7
0.997	48.643	98.898	55.725	45.512	8
1.444	48.74	98.922	56.172	45.609	9
1.32	49.12	98.932	56.048	45.989	10
0.689	49.662	98.858	55.417	46.531	11
0.076	49.25	98.82	54.804	46.119	12
0.275	48.855	98.846	55.003	45.724	13
4.758	48.868	98.931	59.486	45.737	14
5.134	48.179	98.927	59.862	45.048	15
6.763	48.081	99.015	61.491	44.95	16
7.504	50.213	98.959	62.232	47.082	17
7.02	49.627	99.189	61.748	46.496	18
5.37	48.888	99.126	60.098	45.757	19
6.887	48.736	99.188	61.615	45.605	20
8.761	50.821	99.355	63.489	47.69	21
0.612	45.74	98.846	55.34	42.609	22
0.454	45.533	98.889	55.182	42.402	23
0.245	45.409	98.788	54.973	42.278	24
-0.197	45.491	98.79	54.531	42.36	25
-0.529	45.415	98.91	54.199	42.284	26
-0.529	45.411	98.91	54.199	42.28	27
-0.842	45.319	98.732	53.886	42.188	28
-1.042	44.964	98.817	53.686	41.833	29
-0.965	44.673	98.75	53.763	41.542	30
-0.281	44.688	98.779	54.447	41.557	31
-0.398	45.076	98.896	54.33	41.945	32
0.322	44.771	98.761	55.05	41.64	33
0.555	44.816	98.866	55.283	41.685	34
0.866	44.697	98.788	55.594	41.566	35
2.572	42.463	99.017	57.3	39.332	36
-0.354	43.984	98.681	54.374	40.853	37
-0.748	43.701	98.692	53.98	40.57	38
-0.706	43.992	98.788	54.022	40.861	39
-0.74	44.229	98.732	53.988	41.098	40
-1.405	43.814	98.756	53.323	40.683	41
-1.987	42.455	98.643	52.741	39.324	42
-1.067	42.389	98.641	53.661	39.258	43
-1.542	42.025	98.802	53.186	38.894	44
-1.283	41.829	98.705	53.445	38.698	45
-0.989	41.751	98.799	53.739	38.62	46
-0.934	42.253	98.668	53.794	39.122	47
-0.641	41.711	98.653	54.087	38.58	48
-1.423	41.347	98.743	53.305	38.216	49
-1.506	40.428	98.671	53.222	37.297	50
0.318	34.343	98.716	55.046	31.212	51
2.444	34.815	98.669	57.172	31.684	52
2.654	34.488	98.572	57.382	31.357	53
3.242	33.118	98.587	57.97	29.987	54
3.784	31.967	98.836	58.512	28.836	55
5.101	33.757	98.986	59.829	30.626	56
5.252	34.342	98.702	59.98	31.211	57

(Continued)

(Sheet 1 of 8)

Table A3 (Continued)

Untranslated			Transl(0,0) = 80814E 6889N		
x	y	z	X	Y	N
5.25	35.465	98.955	59.978	32.334	58
0.518	29.653	98.427	55.246	26.522	59
0.832	29.192	98.235	55.56	26.061	60
1.057	28.906	98.435	55.785	25.775	61
-1.364	29.348	98.341	53.364	26.217	62
-1.71	26.81	98.218	53.018	23.679	63
6.586	27.019	98.975	61.314	23.888	64
7.028	27.792	99.219	61.756	24.661	65
6.375	16.143	98.678	61.103	13.012	66
-1.734	14.21	97.858	52.994	11.079	67
4.53	7.832	98.076	59.258	4.701	68
-1.789	6.827	97.692	52.939	3.696	69
-8.044	-2.178	96.968	46.684	-5.309	70
-39.783	6.834	95.972	14.945	3.703	71
-40.284	-6.869	95.782	14.444	-10	72
-54.728	0.89	95.646	0	-2.241	73
-39.959	19.011	96.287	14.769	15.88	74
-49.55	28.846	96.374	5.178	25.715	75
-43.14	24.209	96.261	11.588	21.078	76
-48.34	32.411	96.469	6.388	29.28	77
-39.867	26.822	96.574	14.861	23.691	78
-50.983	49.737	97.041	3.745	46.606	79
-39.811	42.67	97.189	14.917	39.539	80
-49.304	58.256	96.939	5.424	55.125	81
-49.073	58.466	97.107	5.655	55.335	82
-49.006	58.682	96.961	5.722	55.551	83
-39.601	50.895	97.269	15.127	47.764	84
-39.401	51.047	97.347	15.327	47.916	85
-39.035	51.209	97.243	15.693	48.078	86
-39.759	60.771	97.336	14.969	57.64	87
-32.239	56.493	97.635	22.489	53.362	88
-27.114	51.211	97.783	27.614	48.08	89
-27.637	59.344	98.105	27.091	56.213	90
-27.8	59.84	97.781	26.928	56.709	91
-27.756	60.479	98.093	26.972	57.348	92
-24.821	60.576	98.45	29.907	57.445	93
-21.039	60.202	98.769	33.689	57.071	94
-15.977	51.46	98.641	38.751	48.329	95
-9.119	60.535	98.774	45.609	57.404	96
-6.989	57.617	98.985	47.739	54.486	97
-1.585	60.792	98.954	53.143	57.661	98
8.413	59.103	98.985	63.141	55.972	99
-2.621	50.768	98.624	52.107	47.637	100
-3.383	50.801	98.76	51.345	47.67	101
-5.095	47.229	98.785	49.633	44.098	102
-4.618	47.322	98.731	50.11	44.191	103
-4.046	47.255	98.773	50.682	44.124	104
-3.259	47.204	98.708	51.469	44.073	105
-11.015	50.677	98.741	43.713	47.546	106
-5.816	47.263	98.847	48.912	44.132	107
-6.206	47.725	98.737	48.522	44.594	108
-6.904	47.442	98.829	47.824	44.311	109
-11.445	50.119	98.82	43.283	46.988	110
-11.64	50.07	98.732	43.088	46.939	111
-8.576	47.414	98.79	46.152	44.283	112
-9.141	47.373	99.017	45.587	44.242	113
-9.561	47.336	98.835	45.167	44.205	114
-13.464	47.219	98.704	41.264	44.088	115
-13.798	48.137	98.752	40.93	45.006	116
-14.258	47.523	98.58	40.47	44.392	117

(Continued)

(Sheet 2 of 8)

Table A3 (Continued)

Untranslated			Transl(0,0) = 80814E 6889N		
x	y	z	X	Y	N
-14.289	47.04	98.735	40.439	43.909	118
-15.02	47.781	98.777	39.708	44.65	119
-15.336	47.814	98.648	39.392	44.683	120
-18.639	50.943	98.486	36.089	47.812	121
-21.018	47.575	98.208	33.71	44.444	122
-20.719	47.779	98.156	34.009	44.648	123
-21.511	47.336	98.086	33.217	44.205	124
-22.337	49.451	98.048	32.391	46.32	125
-22.596	49.406	98.16	32.132	46.275	126
-22.936	49.258	98.004	31.792	46.127	127
-23.09	47.077	98.03	31.638	43.946	128
-24.002	47.312	97.862	30.726	44.181	129
-23.854	48.245	97.93	30.874	45.114	130
-23.147	47.933	97.891	31.581	44.802	131
-29.306	50.57	97.501	25.422	47.439	132
-27.842	47.164	97.536	26.886	44.033	133
-33.565	50.551	97.401	21.163	47.42	134
-33.101	46.975	97.45	21.627	43.844	135
-32.868	47.092	97.372	21.86	43.961	136
-33.56	46.944	97.378	21.168	43.813	137
-35.679	49.459	97.23	19.049	46.328	138
-35.856	49.29	97.316	18.872	46.159	139
-36.417	49.072	97.237	18.311	45.941	140
-38.376	50.66	97.258	16.352	47.529	141
-38.787	50.474	97.398	15.941	47.343	142
-39.119	50.098	97.231	15.609	46.967	143
-37.951	48.984	97.223	16.777	45.853	144
-37.716	49.164	97.282	17.012	46.033	145
-37.59	49.297	97.231	17.138	46.166	146
-39.633	46.883	97.115	15.095	43.752	147
-36.877	42.361	97.166	17.851	39.23	148
-35.075	46.141	97.225	19.653	43.01	149
-34.943	46.268	97.285	19.785	43.137	150
-34.641	46.396	97.235	20.087	43.265	151
-32.426	44.706	97.322	22.302	41.575	152
-32.813	44.185	97.367	21.915	41.054	153
-33.306	43.715	97.267	21.422	40.584	154
-31.991	42.307	97.285	22.737	39.176	155
-31.69	42.405	97.419	23.038	39.274	156
-31.475	42.595	97.36	23.253	39.464	157
-30.035	42.846	97.388	24.693	39.715	158
-22.374	29.801	97.156	32.354	26.67	159
-22.108	29.851	97.259	32.62	26.72	160
-21.867	29.94	97.181	32.861	26.809	161
-29.6	44.82	97.393	25.128	41.689	162
-17.293	45.735	98.418	37.435	42.604	163
-15.317	46.746	98.632	39.411	43.615	164
-11.467	42.325	98.582	43.261	39.194	165
-9.053	46.756	98.908	45.675	43.625	166
-8.852	46.855	98.985	45.876	43.724	167
-8.223	46.938	98.718	46.505	43.807	168
-8.117	46.572	98.959	46.611	43.441	169
-5.379	42.094	98.687	49.349	38.963	170
-5.745	43.382	99.095	48.983	40.251	171
-6.864	44.151	99.049	47.864	41.02	172
-5.456	44.328	98.933	49.272	41.197	173
-4.522	44.235	98.697	50.206	41.104	174
-2.955	43.274	98.669	51.773	40.143	175
-3.703	43.41	98.858	51.025	40.279	176
-3.674	42.799	98.65	51.054	39.668	177

(Continued)

(Sheet 3 of 8)

Table A3 (Continued)

Untranslated			Transl(0,0) = 80814E 6889N		
x	y	z	X	Y	N
-1.958	42.42	98.637	52.77	39.289	178
-2.058	42.243	98.713	52.67	39.112	179
-2.299	42.122	98.821	52.429	38.991	180
-2.447	42.177	98.712	52.281	39.046	181
-2.621	42.526	98.569	52.107	39.395	182
-2.121	40.675	98.67	52.607	37.544	183
-2.229	39.654	98.812	52.499	36.523	184
-2.312	39.254	98.647	52.416	36.123	185
-2.992	40.163	98.618	51.736	37.032	186
-2.689	41.791	98.658	52.039	38.66	187
-2.944	41.656	98.771	51.784	38.525	188
-3.374	41.751	98.632	51.354	38.62	189
-3.713	41.77	98.623	51.015	38.639	190
-3.961	41.881	98.691	50.767	38.75	191
-3.975	41.885	98.691	50.753	38.754	192
-4.551	41.961	98.579	50.177	38.83	193
-5.052	41.412	98.613	49.676	38.281	194
-5.259	41.347	98.758	49.469	38.216	195
-4.947	38.995	98.625	49.781	35.864	196
-4.754	38.971	98.483	49.974	35.84	197
-3.901	38.831	98.492	50.827	35.7	198
-3.392	38.581	98.606	51.336	35.45	199
-3.385	38.488	98.59	51.343	35.357	200
-3.84	36.967	98.446	50.888	33.836	201
-4.755	36.877	98.423	49.973	33.746	202
-4.951	39.014	98.622	49.777	35.883	203
-5.753	41.841	98.758	48.975	38.71	204
-7.026	37.9	98.666	47.702	34.769	205
-6.977	39.73	98.61	47.751	36.599	206
-8.21	39.439	98.399	46.518	36.308	207
-8.697	39.641	98.554	46.031	36.51	208
-9.224	39.455	98.474	45.504	36.324	209
-10.069	40.613	98.481	44.659	37.482	210
-9.685	40.786	98.58	45.043	37.655	211
-9.448	41	98.489	45.28	37.869	212
-10.511	36.932	98.259	44.217	33.801	213
-17.171	40.484	98.064	37.557	37.353	214
-23.08	37.222	97.474	31.648	34.091	215
-29.127	41.666	97.443	25.601	38.535	216
-28.692	41.782	97.416	26.036	38.651	217
-26.89	37.323	97.356	27.838	34.192	218
-33.652	36.688	97.109	21.076	33.557	219
-39.712	36.837	96.967	15.016	33.706	220
-39.739	39.752	97.098	14.989	36.621	221
-2.759	35.169	98.482	51.969	32.038	222
-3.891	36.148	98.456	50.837	33.017	223
-6.18	32.12	98.246	48.548	28.989	224
-5.903	32.093	98.181	48.825	28.962	225
-5.462	32.093	98.298	49.266	28.962	226
-4.823	33.377	98.35	49.905	30.246	227
-5.198	33.472	98.278	49.53	30.341	228
-5.457	33.588	98.327	49.271	30.457	229
-10.557	36.758	98.232	44.171	33.627	230
-10.483	36.492	98.154	44.245	33.361	231
-10.366	36.109	98.168	44.362	32.978	232
-10.282	35.888	98.239	44.446	32.757	233
-11.321	35.595	98.097	43.407	32.464	234
-11.326	35.719	98.053	43.402	32.588	235
-11.487	36.507	98.119	43.241	33.376	236
-11.738	36.882	98.189	42.99	33.751	237

(Continued)

(Sheet 4 of 8)

Table A3 (Continued)

Untranslated			Transl(0,0) = 80814E 6889N		
x	y	z	X	Y	N
-13.468	36.865	98.034	41.26	33.734	238
-13.125	34.98	97.872	41.603	31.849	239
-13.733	31.912	97.747	40.995	28.781	240
-27.401	32.148	97.023	27.327	29.017	241
-30.269	32.228	96.989	24.459	29.097	242
-34.1	37.265	97.086	20.628	34.134	243
-33.676	32.059	97.013	21.052	28.928	244
-37.185	37.296	97.092	17.543	34.165	245
-39.768	31.856	96.795	14.96	28.725	246
-39.704	36.959	96.956	15.024	33.828	247
-1.916	26.878	98.19	52.812	23.747	248
-8.194	27.016	97.933	46.534	23.885	249
-6.857	29.722	98.102	47.871	26.591	250
-6.999	30.048	98.036	47.729	26.917	251
-7.109	30.432	98.042	47.619	27.301	252
-7.321	31.028	98.137	47.407	27.897	253
-9.72	28.901	97.898	45.008	25.77	254
-9.716	28.649	97.84	45.012	25.518	255
-9.412	28.265	97.91	45.316	25.134	256
-8.972	28.66	97.948	45.756	25.529	257
-14.043	27.358	97.474	40.685	24.227	258
-14.061	27.47	97.399	40.667	24.339	259
-14.129	27.67	97.419	40.599	24.539	260
-14.163	27.756	97.329	40.565	24.625	261
-14.329	28.06	97.348	40.399	24.929	262
-14.401	28.188	97.493	40.327	25.057	263
-14.697	29.145	97.591	40.031	26.014	264
-16.378	31.511	97.568	38.35	28.38	265
-9.779	27.141	97.878	44.949	24.01	266
-10.395	27.52	97.857	44.333	24.389	267
-11.077	27.107	97.773	43.651	23.976	268
-10.245	27.451	97.791	44.483	24.32	269
-16.904	26.701	97.273	37.824	23.57	270
-16.898	26.821	97.189	37.83	23.69	271
-17.208	27.398	97.156	37.52	24.267	272
-17.311	27.649	97.278	37.417	24.518	273
-15.867	28.985	97.548	38.861	25.854	274
-19.13	27.141	97.093	35.598	24.01	275
-19.207	27.397	97.203	35.521	24.266	276
-19.194	27.691	97.19	35.534	24.56	277
-19.401	27.818	97.116	35.327	24.687	278
-22.636	31.889	97.254	32.092	28.758	279
-26.789	28.141	96.969	27.939	25.01	280
-30.417	32.691	96.989	24.311	29.56	281
-31.815	27.625	96.912	22.913	24.494	282
-39.678	26.881	96.563	15.05	23.75	283
-3.25	24.198	98.232	51.478	21.067	284
-2.901	23.756	98.105	51.827	20.625	285
-2.748	23.653	98.182	51.98	20.522	286
-4.859	22.143	98.07	49.869	19.012	287
-4.426	21.983	98.003	50.302	18.852	288
-4.106	21.988	98.143	50.622	18.857	289
-3.226	25.257	98.243	51.502	22.126	290
-3.684	25.437	98.136	51.044	22.306	291
-3.895	25.48	98.204	50.833	22.349	292
-4.992	24.084	98.118	49.736	20.953	293
-4.802	23.944	97.995	49.926	20.813	294
-4.561	23.678	98.142	50.167	20.547	295
-6.561	22.182	97.878	48.167	19.051	296
-6.943	22.389	97.87	47.785	19.258	297

(Continued)

(Sheet 5 of 8)

Table A3 (Continued)

Untranslated			Transl(0,0) = 80814E 6889N		
x	y	z	X	Y	N
-6.853	22.238	97.793	47.875	19.107	298
-7.265	22.284	97.836	47.463	19.153	299
-7.253	22.195	97.778	47.475	19.064	300
-7.59	22.909	97.88	47.138	19.778	301
-7.558	22.731	97.799	47.17	19.6	302
-7.959	22.395	97.708	46.769	19.264	303
-8.373	22.282	97.788	46.355	19.151	304
-8.147	22.283	97.695	46.581	19.152	305
-10.246	23.161	97.67	44.482	20.03	306
-10.164	22.926	97.502	44.564	19.795	307
-10.012	22.43	97.468	44.716	19.299	308
-10.292	22.421	97.558	44.436	19.29	309
-11.947	24.536	97.772	42.781	21.405	310
-13.48	26.577	97.571	41.248	23.446	311
-13.629	26.766	97.492	41.099	23.635	312
-19.205	26.158	97.081	35.523	23.027	313
-19.391	25.984	97.244	35.337	22.853	314
-19.727	25.837	97.057	35.001	22.706	315
-16.046	20.977	97.264	38.682	17.846	316
-16.09	20.728	97.218	38.638	17.597	317
-16.183	20.877	97.378	38.545	17.746	318
-16.537	20.664	97.194	38.191	17.533	319
-25.424	22.139	96.885	29.304	19.008	320
-24.016	27.393	96.961	30.712	24.262	321
-31.555	27.414	96.868	23.173	24.283	322
-31.526	25.508	96.806	23.202	22.377	323
-31.272	25.367	96.692	23.456	22.236	324
-31.256	22.583	96.586	23.472	19.452	325
-39.784	21.856	96.336	14.944	18.725	326
-1.946	21.792	98.206	52.782	18.661	327
-1.957	20.25	98.229	52.771	17.119	328
-1.953	19.869	98.17	52.775	16.738	329
-1.937	16.88	97.992	52.791	13.749	330
-4.174	21.865	98.093	50.554	18.734	331
-4.277	21.952	97.968	50.451	18.821	332
-4.703	22.031	97.988	50.025	18.9	333
-4.804	22.13	98.05	49.924	18.999	334
-6.76	20.95	97.654	47.968	17.819	335
-6.812	20.491	97.766	47.916	17.36	336
-8.365	20.73	97.665	46.363	17.599	337
-8.235	20.37	97.508	46.493	17.239	338
-8.182	20.487	97.536	46.546	17.356	339
-7.941	20.085	97.641	46.787	16.954	340
-8.062	20.077	97.716	46.666	16.946	341
-8.276	19.94	97.568	46.452	16.809	342
-4.216	19.844	97.988	50.512	16.713	343
-4.065	19.509	97.909	50.663	16.378	344
-3.984	19.266	97.979	50.744	16.135	345
-4.665	18.636	97.902	50.063	15.505	346
-4.821	18.846	97.78	49.907	15.715	347
-4.982	18.54	97.77	49.746	15.409	348
-4.987	19.217	97.938	49.741	16.086	349
-5.462	19.112	97.783	49.266	15.981	350
-6.052	18.371	97.594	48.676	15.24	351
-6.09	17.996	97.712	48.638	14.865	352
-5.903	17.616	97.732	48.825	14.485	353
-5.829	17.327	97.61	48.899	14.196	354
-5.757	17.119	97.687	48.971	13.988	355
-7.62	21.849	97.766	47.108	18.718	356
-8.37	21.734	97.6	46.358	18.603	357

(Continued)

(Sheet 6 of 8)

Table A3 (Continued)

Untranslated			Transl(0,0) = 80814E 6889N		
x	y	z	X	Y	N
-8.797	21.934	97.705	45.931	18.803	358
-8.875	21.234	97.51	45.853	18.103	359
-8.604	20.958	97.627	46.124	17.827	360
-10.3	22.18	97.481	44.428	19.049	361
-13.265	17.206	97.218	41.463	14.075	362
-22.152	17.103	96.862	32.576	13.972	363
-29.609	18.939	96.907	25.119	15.808	364
-28.692	17.204	96.702	26.036	14.073	365
-28.002	21.914	96.693	26.726	18.783	366
-30.362	17.206	96.467	24.366	14.075	367
-34.853	17.243	96.334	19.875	14.112	368
-33.583	22.251	96.526	21.145	19.12	369
-39.736	16.945	96.212	14.992	13.814	370
-1.877	16.736	97.998	52.851	13.605	371
-1.94	12.067	97.799	52.788	8.936	372
-2.174	12.042	97.775	52.554	8.911	373
-2.046	12.09	97.849	52.682	8.959	374
-3.281	15.888	97.806	51.447	12.757	375
-3.458	15.858	97.741	51.27	12.727	376
-6.142	16.493	97.703	48.586	13.362	377
-6.449	16.395	97.589	48.279	13.264	378
-5.561	14.318	97.631	49.167	11.187	379
-5.547	14.162	97.573	49.181	11.031	380
-5.879	13.476	97.544	48.849	10.345	381
-6.078	13.386	97.626	48.65	10.255	382
-6.291	13.417	97.569	48.437	10.286	383
-7.767	15.921	97.558	46.961	12.79	384
-6.519	14.05	97.504	48.209	10.919	385
-12.715	12.145	97.286	42.013	9.014	386
-13.012	14.111	97.186	41.716	10.98	387
-13.901	13.766	97.279	40.827	10.635	388
-14.757	17.004	97.207	39.971	13.873	389
-19.73	12.037	96.916	34.998	8.906	390
-20.081	13.319	96.937	34.647	10.188	391
-20.19	13.705	96.837	34.538	10.574	392
-20.252	14.194	96.932	34.476	11.063	393
-20.663	14.815	96.789	34.065	11.684	394
-20.926	15.241	96.962	33.802	12.11	395
-21.876	16.199	96.853	32.852	13.068	396
-22.2	14.505	96.834	32.528	11.374	397
-22.08	14.326	96.689	32.648	11.195	398
-21.602	14.619	96.884	33.126	11.488	399
-21.651	16.333	96.866	33.077	13.202	400
-22.028	16.379	96.751	32.7	13.248	401
-23.473	12.06	96.7	31.255	8.929	402
-22.864	16.876	96.833	31.864	13.745	403
-24.393	16.588	96.653	30.335	13.457	404
-29.628	12.008	96.394	25.1	8.877	405
-31.094	16.929	96.436	23.634	13.798	406
-39.741	11.946	96.061	14.987	8.815	407
-35.925	17.2	96.249	18.803	14.069	408
-36.053	14.78	96.315	18.675	11.649	409
-39.773	6.909	95.977	14.955	3.778	410
-37.529	7.281	96.015	17.199	4.15	411
-32.491	11.918	96.281	22.237	8.787	412
-25.332	12.044	96.565	29.396	8.913	413
-25.129	6.936	96.555	29.599	3.805	414
-20.472	11.873	96.902	34.256	8.742	415
-18.975	11.979	96.984	35.753	8.848	416
-13.743	11.857	97.26	40.985	8.726	417

(Continued)

(Sheet 7 of 8)

Table A3 (Concluded)

Untranslated			Transl(0,0) = 80814E 6889N		
x	y	z	X	Y	N
-13.002	6.939	97.245	41.726	3.808	418
-12.066	13.19	97.261	42.662	10.059	419
-11.897	13.152	97.315	42.831	10.021	420
-11.676	13.177	97.266	43.052	10.046	421
-8.842	6.945	97.433	45.886	3.814	422
-8.632	6.951	97.517	46.096	3.82	423
-8.397	7.108	97.436	46.331	3.977	424
-10.322	10.324	97.597	44.406	7.193	425
-9.225	8.214	97.551	45.503	5.083	426
-1.842	6.924	97.689	52.886	3.793	427
-1.898	11.872	97.767	52.83	8.741	428

(Sheet 8 of 8)

Table A4

Microgeometry, Plot A, cm

Location	10	20	30	40	50	60	70	80	90	100
A1	40.203	30.155	99.538	(x,y,z)						
a	11.0	10.5	11.0	10.7	9.8	10.9	10.7	10.5	10.5	10.7
b	10.4	10.6	10.3	9.3	9.5	10.5	10.3	10.3	10.2	11.0
c	10.7	10.5	10.2	10.2	10.1	10.2	10.1	10.3	9.5	10.0
d	10.3	10.6	10.6	10.6	10.4	10.4	10.4	10.5	10.2	10.0
e	10.2	11.0	10.7	10.8	10.7	10.7	10.3	10.4	9.8	10.0
f	11.4	11.3	11.0	10.8	10.8	10.7	10.5	10.3	10.3	9.8
g	11.3	11.5	11.4	10.7	10.8	11.0	10.8	10.8	10.5	10.4
h	11.5	11.5	11.2	11.0	10.5	10.8	10.8	10.8	10.8	10.5
i	11.5	12.0	11.5	11.5	11.2	11.2	11.0	10.8	10.8	10.0
j	12.4	11.5	11.5	11.0	11.0	10.8	10.8	10.8	10.4	10.5
Mean	11.1	11.1	10.9	10.7	10.5	10.7	10.6	10.6	10.3	10.3
Std	0.7	0.5	0.5	0.6	0.5	0.3	0.3	0.2	0.4	0.4
A2	17.946	40.367	98.955							
a	12.8	12.5	12.7	13.0	13.2	14.5	14.0	13.5	13.7	14.5
b	12.2	12.2	12.4	12.5	12.5	13.2	14.5	13.2	13.5	13.7
c	12.5	12.7	12.0	12.0	12.0	12.5	13.0	13.0	13.0	13.3
d	12.6	12.5	12.2	12.0	11.8	11.0	12.0	12.8	13.5	13.2
e	12.5	12.7	12.2	12.5	11.8	12.2	10.8	12.5	13.0	12.8
f	12.5	12.5	11.8	12.0	11.5	10.5	11.0	12.0	12.5	12.5
g	12.5	12.0	11.5	11.0	11.0	10.8	11.2	11.8	12.5	12.5
h	12.2	12.0	11.2	11.0	11.2	11.0	12.0	12.3	12.5	12.0
i	12.2	11.0	10.8	10.0	10.8	12.0	12.5	12.3	12.0	11.8
j	11.5	10.8	10.5	10.5	11.0	12.5	12.5	12.0	10.8	11.0
Mean	12.350	12.090	11.730	11.650	11.680	12.020	12.350	12.540	12.700	12.730
Std	0.338	0.643	0.680	0.923	0.712	1.180	1.166	0.537	0.817	0.955
A3	37.102	59.891	99.653							
a	10.3	10.2	10.0	10.2	10.5	10.5	10.7	10.8	10.8	10.8
b	10.2	10.0	10.0	10.1	9.8	10.0	10.3	10.8	10.8	10.8
c	10.0	10.2	10.0	10.2	10.2	10.5	10.4	10.8	10.8	10.8
d	10.5	10.6	10.5	10.5	10.5	10.6	10.7	11.0	11.0	11.0
e	11.0	10.8	10.5	10.5	10.5	10.6	10.8	11.0	11.0	11.0
f	11.0	11.0	10.5	10.2	10.5	10.5	10.8	11.0	11.0	11.0
g	10.8	10.8	10.8	10.5	10.3	10.8	10.8	11.0	10.8	10.5
h	11.0	10.8	11.0	9.5	10.5	10.7	10.8	10.8	10.8	10.8
i	11.2	11.0	11.0	11.0	10.8	11.0	11.0	10.8	10.8	10.5
j	10.8	10.8	10.7	11.0	10.8	10.8	11.0	10.8	10.8	10.8
Mean	10.7	10.6	10.5	10.4	10.4	10.6	10.7	10.9	10.9	10.8
Std	0.4	0.3	0.4	0.4	0.3	0.3	0.2	0.1	0.1	0.2

Table A5

Microgeometry, Plot B, cm

Location	10	20	30	40	50	60	70	80	90	100
B1	16.231	26.734	98.916							
a	22.9	19.4	17.6	16.1	15.2	14.8	14.9	15.1	13.5	13.5
b	20.0	20.5	18.2	17.8	15.5	15.8	15.6	14.5	14.3	14.2
c	22.3	23.1	24.1	19.8	17.2	14.4	15.9	14.6	14.6	14.4
d	25.0	24.1	23.8	22.8	18.6	16.9	14.8	12.8	13.0	13.9
e	26.1	24.8	24.6	23.2	21.5	18.5	14.8	12.3	11.7	11.6
f	27.5	24.9	23.3	22.5	21.8	18.9	15.6	13.3	10.3	9.7
g	29.1	25.3	23.3	24.4	21.5	20.4	18.9	13.2	9.8	7.4
h	27.8	26.2	24.1	23.2	21.2	20.1	20.2	15.8	11.4	8.9
i	26.8	26.6	24.4	23.0	21.0	20.2	19.9	17.5	14.4	12.1
j	26.8	24.9	24.2	24.3	21.8	20.4	19.9	17.5	17.4	14.3
Mean	25.4	24.0	22.8	21.7	19.5	18.0	17.1	14.7	12.9	12.0
Std	2.7	2.2	2.5	2.7	2.5	2.3	2.2	1.8	2.3	2.4
B2	4.808	10.511	98.153				4.808	10.510	98.153	
a	26.4	28.6	29.0	28.4	27.8	25.0	23.3	19.9	19.4	19.9
b	25.4	28.0	27.9	28.0	27.3	26.6	23.9	21.7	20.4	19.9
c	26.0	28.0	28.0	27.6	27.4	25.8	25.1	22.5	23.7	21.0
d	25.3	27.2	28.0	28.1	27.3	26.7	23.8	24.3	22.8	22.1
e	25.8	27.0	28.8	28.2	27.7	26.7	24.5	23.4	22.5	22.5
f	25.2	26.9	28.0	28.5	28.4	27.6	25.1	23.7	22.7	22.6
g	25.0	26.8	28.2	28.8	28.5	27.0	26.8	21.9	21.0	22.5
h	23.8	25.2	28.1	29.1	28.9	28.1	26.8	21.2	18.4	22.0
i	23.9	25.4	27.8	29.2	28.8	28.0	27.0	23.2	20.9	22.4
j	26.0	26.9	28.9	29.5	28.5	27.4	26.7	22.6	21.8	21.5
Mean	25.3	27.0	28.3	28.5	28.1	26.9	25.3	22.4	21.4	21.6
Std	0.8	1.0	0.4	0.6	0.6	0.9	1.4	1.2	1.6	1.0
B3	25.206	12.203	98.728							
a	36.0	33.4	31.1	24.1	20.7	18.9	20.1	19.6	20.2	19.3
b	35.3	30.5	25.8	19.7	17.8	18.7	18.8	19.4	19.0	17.6
c	32.4	22.1	19.4	17.3	17.1	17.5	17.8	18.0	16.3	16.5
d	20.2	17.9	17.2	17.5	17.5	16.6	15.4	13.6	15.4	13.4
e	16.4	16.4	17.5	17.4	17.4	16.3	14.5	11.2	10.6	10.7
f	16.9	17.4	17.7	18.0	15.6	13.0	11.8	8.2	8.0	9.6
g	17.8	17.4	17.9	16.0	15.5	12.0	12.3	8.5	6.7	8.0
h	19.2	18.1	17.4	15.3	15.9	14.2	10.6	6.0	5.4	7.7
i	19.9	18.2	16.6	16.6	16.8	14.4	9.8	4.8	5.6	8.3
j	20.1	19.2	18.3	17.9	16.3	13.5	9.1	5.2	6.1	9.6
Mean	23.4	21.1	19.9	18.0	17.1	15.5	14.0	11.5	11.3	12.1
Std	7.4	5.7	4.5	2.3	1.4	2.3	3.7	5.6	5.5	4.1

Table A6

Microgeometry, Plot C, cm

Location	10	20	30	40	50	60	70	80	90	100
C1	37.632	39.609	98.145							
a	16.2	13.3	11.7	8.5	11.5	13.0	14.1	12.1	11.2	8.4
b	16.4	15.7	13.4	11.0	8.8	9.5	12.2	11.8	10.7	8.9
c	18.0	16.1	15.9	13.2	9.8	8.2	8.8	11.1	11.1	10.2
d	19.4	18.5	17.5	14.4	12.5	10.2	8.4	9.0	7.7	10.6
e	19.1	18.7	18.0	15.1	13.5	12.1	9.5	7.6	6.6	9.3
f	20.0	18.9	18.0	17.6	16.0	14.3	12.3	10.1	9.5	9.0
g	21.5	20.1	19.0	17.9	16.8	15.4	14.0	12.9	10.4	9.5
h	22.4	21.7	20.3	19.5	17.3	17.4	15.1	13.6	12.9	11.5
i	24.1	22.7	22.6	20.5	18.8	17.1	16.1	14.7	13.2	12.6
j	25.1	24.1	23.8	22.4	19.9	19.2	16.8	15.7	14.6	12.7
Mean	20.2	19.0	18.0	16.0	14.5	13.6	12.7	11.9	10.8	10.3
Std	2.9	3.2	3.6	4.1	3.6	3.5	2.9	2.4	2.3	1.5
C2	28.422	12.165	96.547							
a	18.5	18.5	18.5	18.0	18.0	17.3	17.2	16.0	16.5	17.8
b	18.2	18.5	19.0	17.5	17.5	18.9	18.0	18.9	18.0	18.7
c	18.0	18.7	19.6	19.0	19.9	19.5	19.7	19.8	19.0	19.4
d	18.5	20.5	20.5	20.9	20.3	20.5	19.4	20.3	21.2	20.4
e	22.3	22.0	21.9	21.9	21.2	22.2	21.5	22.0	21.5	21.3
f	24.4	23.8	23.2	23.0	22.8	23.0	22.3	22.1	21.0	19.9
g	24.0	24.0	23.4	23.7	23.3	23.0	21.4	20.5	19.7	18.7
h	24.6	24.3	23.9	24.0	23.0	22.3	20.8	21.2	20.0	20.3
i	24.4	25.0	24.5	23.0	23.6	22.3	23.2	22.9	21.9	21.9
j	24.6	25.5	24.4	23.8	24.0	23.8	23.0	22.5	21.0	22.6
Mean	21.8	22.1	21.9	21.5	21.4	21.3	20.7	20.6	20.0	20.1
Std	2.9	2.7	2.2	2.4	2.2	2.0	1.9	2.0	1.6	1.4
C3	43.342	23.173	97.625							
a	24.9	24.9	25.1	23.5	22.5	20.9	19.0	15.3	14.9	13.9
b	24.5	26.3	25.1	23.8	22.1	21.3	17.2	17.6	14.7	14.0
c	26.0	26.8	25.3	23.7	22.2	21.2	18.4	17.0	14.7	14.4
d	27.6	26.0	23.5	20.3	21.0	20.0	17.8	15.0	13.0	14.0
e	28.5	27.4	21.9	20.5	20.3	19.0	17.3	15.9	19.2	16.0
f	27.2	23.4	22.9	22.0	22.6	22.4	19.7	20.6	19.3	17.0
g	26.5	26.5	25.1	22.0	22.9	22.2	18.9	17.8	15.5	15.0
h	27.8	25.5	23.5	22.2	19.9	18.7	17.3	16.7	15.4	15.0
i	26.4	25.2	22.8	20.9	18.9	18.1	17.3	16.7	17.0	15.0
j	26.3	22.0	22.8	20.7	18.6	18.7	18.2	18.9	19.0	16.2
Mean	26.6	25.4	23.8	22.0	21.1	20.3	18.1	17.2	16.3	15.1
Std	1.2	1.6	1.2	1.3	1.5	1.5	0.8	1.6	2.1	1.0

APPENDIX B
VEGETATION DATA

Table B1

Moisture Content of Vegetation Samples from Plots A, B, and C*

Plant	14 July 1988 Leaves	14 July 1988 Stems	14 July 1988 Flowers	14 July 1988 Total	26 July 1988 Leaves	26 July 1988 Stems	26 July 1988 Flowers	26 July 1988 Total
A-01		16.1	16.3	32.4		15.9	15.6	31.5
A-02		26.6		26.6		25.8		25.8
A-03	26.8	20.8	18.1	65.7	26.1	20.0	17.5	63.6
A-04	17.7	19.5	20.0	57.2	16.6	19.0	19.5	55.1
A-05	15.7	15.6	15.7	47.0	15.8	15.4	15.6	46.8
A-06	19.5	19.6		39.1	13.7	19.0		37.7
A-07		36.8		36.8		35.8		35.8
A-08	24.3	17.4		41.7	23.5	16.6		40.1
B-01	14.8	20.8	17.0	52.6	15.2	20.4	17.3	52.9
B-02	45.2	74.1	24.0	143.3	38.2	72.3	23.2	133.7
B-03	48.9	45.7	19.8	114.4	48.4	44.4	19.2	112.0
B-04	18.6	16.5	18.8	53.9	18.2	15.9	18.6	52.7
B-05	0.0	36.2	16.4	52.6	0.0	35.2	16.4	51.6
B-06	20.5	25.2	20.0	65.7	19.7	26.4	19.4	65.5
B-07	32.4	65.3	42.0	139.7	31.4	63.5	40.8	135.7
B-08	19.6	24.5	26.0	70.1	19.0	23.4	25.1	67.5
B-09	36.8	27.8	0.0	64.6	35.8	26.8	0.0	62.6
B-10	22.5	17.3	0.0	39.8	21.9	15.9	0.0	37.8
B-11	51.2	123.1	54.8	229.1	49.5	121.7	56.3	227.5
B-12	13.4	17.0	13.8	44.2	14.1	17.4	14.3	45.8

(Continued)

* Fort Devens, MA, MIT/LL Radar Study.

(Sheet 1 of 8)

Table B1 (Continued)

Plant	Wet Weight Less Bag and Tag (11.76 g)				Transportation Loss			
	Leaves	Stems	Flowers	Total	Leaves	Stems	Flowers	Total
A-01		4.1	3.8	8.0		0.2	0.7	0.9
A-02		14.0		14.0		0.8		0.8
A-03	14.3	8.2	5.7	28.3	0.7	0.8	0.6	2.1
A-04	4.8	7.2	7.7	19.8	1.1	0.5	0.5	2.1
A-05	4.0	3.6	3.8	11.5	-0.1	0.2	0.1	0.2
A-06	6.9	7.2		14.2	0.8	0.6		1.4
A-07		24.0		24.0		1.0		1.0
A-08	11.7	4.8		16.6	0.8	0.8		1.6
B-01	3.4	8.6	5.5	17.6	-0.4	0.4	-0.3	-0.3
B-02	26.4	60.5	11.4	98.4	7.0	1.8	0.8	9.6
B-03	36.6	32.6	7.4	76.7	0.5	1.3	0.6	2.4
B-04	6.4	4.1	6.8	17.4	0.4	0.6	0.2	1.2
B-05	-11.8	23.4	4.6	16.3		1.0		1.0
B-06	7.9	14.6	7.6	30.2	0.8	-1.2	0.6	0.2
B-07	19.6	51.7	29.0	100.4	1.0	1.8	1.2	4.0
B-08	7.2	11.6	13.3	32.2	0.6	1.1	0.9	2.6
B-09	24.0	15.0	-11.8	27.3	1.0	1.0	0.0	2.0
B-10	10.1	4.1	-11.8	2.5	0.6	1.4	0.0	2.0
B-11	37.7		44.5	192.2	1.7	1.4	-1.5	1.6
B-12	2.3	5.6	2.5	10.5	-0.7	-0.4	-0.5	-1.6

(Continued)

Table B1 (Continued)

Plant	Paper Bag Weights, g Leaves	Stems	Flowers	Total	Emptied Plastibag Weights, g Leaves	Stems	Flowers	Total
A-01		64.4	65.6	130.0		12.9	13.4	26.3
A-02		65.8		65.8		13.3		13.3
A-03	64.8	65.8	65.2	195.8	13.7	13.2	13.4	40.3
A-04	65.6	65.3	65.7	196.6	13.3	13.1	13.5	39.9
A-05	65.4	65.3	65.7	196.4	13.2	12.9	13.3	39.4
A-06	65.8	66.0		131.8	13.0	13.0		26.0
A-07		65.3		65.3		13.9		13.9
A-08	65.4	65.3		130.7	13.4	13.0		26.4
B-01	65.5	65.6	65.7	196.8	9.6	9.7	9.5	28.8
B-02	66.1	65.8	65.5	197.4	10.1	14.6	13.9	38.6
B-03	65.5	65.6	65.5	196.6	13.7	13.9	13.7	41.3
B-04	65.6	65.4	65.4	196.4	13.6	9.9	13.6	37.1
B-05		65.5	65.7	131.2		9.9	13.4	23.3
B-06	65.5	65.8	65.6	196.9	13.8	9.6	13.7	37.1
B-07	65.8	65.5	65.6	196.9	13.8	9.9	13.6	37.3
B-08	65.5	66.0		131.5	13.9	15.3	13.7	42.9
B-09	65.6	65.9		131.5	9.7	9.7	0.0	19.4
B-10	65.8	65.5	65.5	196.8	18.9	9.9	0.0	28.8
B-11	65.3	65.5	65.5	196.3	14.1	14.1	13.7	41.9
B-12				0.0	9.7	9.7	9.8	29.2

(Continued)

(Sheet 3 of 8)

Table B1 (Continued)

Plant	Before Drying Paper Bag and Sample Leaves	Flowers	Total	Sample Lost in Transfer Leaves	Stems	Flowers	Total
A-01		68.4	135.9		1.1	1.6	14.5
A-02			78.4		1.5		1.5
A-03	77.2	69.4	219.4	1.9	1.4	1.6	28.5
A-04	69.9	71.8	212.9	1.5	1.3	1.7	28.1
A-05	68.0	68.2	204.2	1.4	1.1	1.5	27.6
A-06	71.6		143.7	1.2	1.2		14.2
A-07			87.2		2.1		2.1
A-08	75.4		144.3	1.6	1.2		14.6
B-01	71.3	73.2	220.8	-2.2	-2.1	-2.3	17.0
B-02	99.7	74.9	297.8	-1.7	2.8	2.1	26.8
B-03	100.1	70.9	266.8	1.9	2.1	1.9	29.5
B-04	70.3	70.5	212.3	1.8	-1.9	1.8	25.3
B-05		68.6	159.5		-1.9	1.6	11.5
B-06	71.5	71.5	223.9	2.0	-2.2	1.9	25.3
B-07	70.9	77.0	227.1	2.0	-1.9	1.8	25.5
B-08	83.3	92.5	289.4	2.1	3.5	1.9	31.1
B-09	91.7	0.0	174.7	-2.1	-2.1		7.6
B-10	135.2	0.0	207.9	7.1	-1.9		17.0
B-11	100.7	108.2	381.6	2.3	2.3	1.9	30.1
B-12	69.9	69.8	212.6	-2.1	-2.1	-2.0	17.4

(Continued)

(Sheet 4 of 8)

Table B1 (Continued)

Plant	Corrected for Unincluded Sample				Total Less Bags	After Drying		Bag + Sample	
	Leaves	Stems	Flowers	Total		Leaves	Stems	Flowers	Total
A-01		68.6	70.0	138.7	8.7		66.2	52.2	118.4
A-02		79.9	0.0	79.9	14.1		73.2	0.0	73.2
A-03	79.1	74.2	71.0	224.4	28.6	66.8	67.1	51.8	185.7
A-04	71.4	72.5	73.5	217.5	20.9	66.7	66.8	52.2	185.7
A-05	69.4	69.1	69.7	208.3	11.9	66.2	66.2	52.4	184.8
A-06	72.8	73.3		146.2	14.4	68.1	66.7		134.8
A-07	0.0	89.3		89.3	24.0		76.9		76.9
A-08	77.0	70.1		147.2	16.5	66.4	65.3		131.7
B-01	69.1	74.2	70.9	214.3	17.5	64.2	66.8	64.4	195.4
B-02	98.0	126.0	77.0	301.1	103.7	71.4	75.3	65.1	211.8
B-03	102.0	97.9	72.8	272.8	76.2	72.5	73.9	64.5	210.9
B-04	72.1	69.6	72.3	214.1	17.7	63.9	64.6	64.5	193.0
B-05	0.0	89.0	70.2	159.3	28.1		82.5	63.9	146.4
B-06	73.5	78.7	73.4	225.7	28.8	64.5	69.7	64.5	198.7
B-07	72.9	77.3	78.8	229.1	32.2	64.5	66.7	67.1	198.3
B-08	85.4	117.1	94.4	297.0	165.5	70.7	79.1	74.9	224.7
B-09	89.6	80.9	0.0	170.6	39.1	72.9	69.5		142.4
B-10	142.3	70.8	0.0	213.2	16.4	75.5	65.7		141.2
B-11	103.0	175.0	110.1	388.2	191.9	72.3	85.4	73.5	231.2
B-12	67.8	70.8	67.8	206.5	206.5	63.8	58.2	64.4	186.4

(Continued)

(Sheet 5 of 8)

Table B1 (Continued)

Plant	Dry Weight-Tare				Weight of Water g			
	Leaves	Stems	Flowers	Total	Leaves	Stems	Flowers	Total
A-01	0.0	4.2	4.4	8.7		1.3	16.2	17.5
A-02	0.0	14.1	0.0	14.1		5.2	0.0	5.2
A-03	14.3	8.4	5.8	28.6	10.4	5.7	17.6	33.7
A-04	5.8	7.2	7.8	20.9	3.2	4.4	19.6	27.2
A-05	4.0	3.8	4.0	11.9	1.8	1.8	15.8	19.4
A-06	7.0	7.3	0.0	14.4	3.5	5.4		8.9
A-07	0.0	24.0	0.0	24.0		10.3		10.3
A-08	11.6	4.8	0.0	16.5	9.0	3.6		12.6
B-01	3.6	8.6	5.2	17.5	7.1	9.5	8.8	25.4
B-02	31.9	60.2	11.5	103.7	28.3	47.9	9.8	86.0
B-03	36.5	32.3	7.3	76.2	27.6	21.9	6.4	55.9
B-04	6.5	4.2	6.9	17.7	6.4	6.9	6.0	19.3
B-05	0.0	23.5	4.5	28.1	0.0	8.4	4.7	13.1
B-06	8.0	12.9	7.8	28.8	7.0	11.2	7.0	25.2
B-07	7.1	11.8	13.2	32.2	6.4	12.5	9.9	28.8
B-08	19.9	51.1	94.4	165.5	12.6	34.5	17.6	64.7
B-09	24.0	15.0	0.0	39.1	18.8	13.5	0.0	32.3
B-10	76.5	5.3	-65.5	16.4	59.7	7.0	0.0	66.7
B-11	37.7	109.5	44.6	191.9	28.4	87.3	34.7	150.4
B-12	67.8	70.8	67.8	206.5	6.1	14.7	5.4	26.2

(Continued)

(Sheet 6 of 8)

Table B1 (Continued)

Plant	Fraction of Total Water			Water Fraction of Dry Weight			
	Leaves	Stems	Flowers	Leaves	Stems	Flowers	Total
A-01	0.000	0.074	0.926		0.307	3.648	2.016
A-02	0.000	1.000	0.000		0.368		0.368
A-03	0.309	0.169	0.522	0.725	0.675	3.014	1.177
A-04	0.118	0.162	0.721	0.548	0.608	2.500	1.300
A-05	0.093	0.093	0.814	0.446	0.469	3.911	1.628
A-06	0.393	0.607	0.000	0.497	0.736		0.619
A-07	0.000	1.000	0.000		0.428		0.428
A-08	0.714	0.286	0.000	0.773			0.765
B-01	0.280	0.374	0.346	1.951	1.100	1.679	1.450
B-02	0.329	0.557	0.114	0.886	0.795	0.849	0.829
B-03	0.494	0.392	0.114	0.755	0.677	0.872	0.733
B-04	0.332	0.358	0.311	0.979	1.627	0.865	1.089
B-05	0.000	0.641	0.359		0.357	1.035	0.467
B-06	0.278	0.444	0.278	0.871	0.866	0.893	0.874
B-07	0.222	0.434	0.344	0.896	1.056	0.748	0.894
B-08	0.195	0.533	0.272	0.632	0.675	0.186	0.391
B-09	0.582	0.418	0.000	0.782	0.898		0.827
B-10	0.895	0.105	0.000	0.780	1.311		4.072
B-11	0.189	0.580	0.231	0.753	0.797	0.777	0.784
B-12	0.233	0.561	0.206	0.090	0.208	0.080	0.127

(Continued)

(Sheet 7 of 8)

Table B1 (Concluded)

Plant	Water Fraction by Wet Weight			Wet Weight Basis
	Leaves	Stems	Flowers	Total
A-01		0.235	0.785	0.668
A-02		0.269		0.269
A-03	0.420	0.403	0.751	0.541
A-04	0.354	0.378	0.714	0.565
A-05	0.308	0.319	0.796	0.619
A-06	0.332	0.424		0.382
A-07		0.300		0.300
A-08	0.436	0.427		0.433
B-01	0.661	0.524	0.627	0.592
B-02	0.470	0.443	0.459	0.453
B-03	0.430	0.404	0.466	0.423
B-04	0.495	0.619	0.464	0.521
B-05		0.263	0.509	0.318
B-06	0.465	0.464	0.472	0.466
B-07	0.473	0.514	0.428	0.472
B-08	0.387	0.403	0.157	0.281
B-09	0.439	0.473		0.453
B-10	0.438	0.567		0.803
B-11	0.429	0.444	0.437	0.439
B-12	0.082	0.172	0.074	0.113

(Sheet 8 of 8)

Table B2

Vegetation Data Collected at Fort Devens, MA, 14-19 July 1988

Common Name	Botanical Name	Plant Id.*	Height, cm	Individual Mass Determination, g Field	Individual Mass Determination, g From spl	Ind. Vol. ml	Total Number Sampled	Sample Total Area m sq	Mean Number per sq m in Entire Sample	Mean Mass per sq m in Entire Sample	Leaf Area per Plant,* sq cm	Crown Width, cm	Area Shaded by Typical Plant, sq cm	Per Plant GLAI
Wheat	*Triticum* sp.	A-01	85	5	5	8	106	18	5.89	28.6	0	1	1	0.00
Grass	Family Gramineae	A-02	25	13	2	2	848	18	47.11	349.6	319	15	177	1.81
Shasta daisy	*Rudbeckia* sp.	A-03	52	11	4	4	72	18	4.00	28.5	504	50	1964	0.26
Black-eyed susan	Family Compositae	A-04	41	19	8	13	1	18	0.06	0.8	409	16	201	2.03
Scirpus	*Scirpus* sp.	A-05	25	2	4	30	32	18	1.76	4.7	73	4	13	5.77
Forb	Undetermined	A-06	24	27	7	6	18	18	1.00	17.1	1806			
Small grass	Family Gramineae	A-07	11	2	0	0	980	18	54.44	50.6	354			
Low forbs	Undetermined	A-08	5	5	2	4	291	18	16.17	56.1	3199			
Bare		A-Bare						18						
Marigold	Undetermined	A-A	19	13			58	13	4.46	58.0		18	254	0.00
Grass	Family Gramineae	A-B	13	27			130	13	10.00	272.0	319	33	855	0.37
Forb	Undetermined	A-C	5	5	2	4	291	13	22.38	107.4	3199	16	201	15.91
Shrub	*Elaeagnus* sp.	A-D	28	5			5	13	0.38	2.0		9	64	0.00
Wheat	*Triticum* sp.	A-E	85	4			243	13	18.69	74.8		5	20	0.00
Eve. primrose	*Oenothera* sp.	A-F	49	2			27	13	2.08	3.1		98	7543	0.00
Br. grass	Family Gramineae	A-G	67	13			7	13	0.54	6.7	354	29	661	0.54
Milkwort	*Polygala* sp.	A-H	69				8	13	0.62	0.0	109	37	1075	0.10
Vine	Undetermined	A-I	11	5			10	13	0.77	3.7		25	491	0.00
Lt. forbs	Undetermined	A-J	8				4	13	0.31	0.0	3199	15	177	18.10
Bare		Bare						13	0.16	0.0				
Daisy fleabane	*Erigeron* sp.	B-01	50	21	40	116	25	13	1.92	58.9	612			
Queen Anne's lace	*Daucus* sp.	B-02	80	113	36	40	20	962	0.02	1.6	575			
Hop clover	*Trifolium* sp.	B-03	25	94	3	70	9	1672	0.01	0.3	330			
Milkwort	*Polygala* sp.	B-04	28	13	3	54	20	3	6.67	50.1	109	20		0.35
Grass	Family Gramineae	B-05	72	26	2	2	20	314	0.06	0.9		42	314	0.00
Buttercup	*Ranunculus* sp.	B-06	60	29	16	30	20	7	2.86	64.3	1806		1385	
Red clover	*Trifolium* sp.	B-07	42	246	12	30	20	7	2.86	368.5	354	36		0.35
Red clover (dead)	*Trifolium* sp.	B-08	42	28	43	70	20	13	1.54	54.8	2607	34	1018	2.87
Succulent	Undetermined	B-09	62	44	97	105	5	1672	.00	0.2	5085		908	
Shrub	*Elaeagnus* sp.	B-10	72	740	740	691	12	1672	0.01	5.3	13629	90		2.14
Cattails	*Typha latifolia*	B-11	140	187	132	240					144		6362	
Black-eyed susan	*Rudbeckia hirta*	B-12	72	12	16	30	0				409			
Scirpus	*Scirpus* sp.	B-13	25	6	14	30	35	20	1.76	18.1	72			

(Continued)

* Values resulting from direct measurement.

(Sheet 1 of 4)

Table B2 (Continued)

Entire Plot (38 by 44 sq m plot) Extrapolation

Common Name	Estimated Individuals In Plot	Corrected for Enclosed Wheat Stand (N=335/m-sq)	Fresh Density	Dry Basis Lab. Determ. of Water Fraction	Wet Basis Fraction Water Content	Estimated Plant Mass kg	Estimated Plant Volume ℓ	Fraction of Total	Estimated Green Leaf Area Cov. sq m	GLAI Plot Gross	By Plant	SRI 1300 hr	k	Dry Dens. g/ml	Water Volume ℓ	Regression Predicted Volume 0.6
Wheat	9846	97653	0.60	2.02	0.67	474	788	0.54	0.0	0.00				0.36	527	440.6
Grass	78770	66201	1.03	0.37	0.27	491	476	0.32	2112.7	1.26	1.81	0.991		0.81	128	266.3
Shasta daisy	6688	5621	1.04	1.18	0.54	40	39	0.03	283.5	0.17	0.26			0.67	21	21.6
Black-eyed susan	93	78	0.65	1.30	0.57	1	2	.00	3.2	.00	2.03			0.41	1	0.9
Scirpus	2949	2478	0.47	1.63	0.62	7	14	0.01	18.0	0.01	5.77			0.29	9	7.9
Forb	1672	1405	1.25	0.62	0.38	24	19	0.01	253.8	0.15				0.90	7	10.8
Small grass	91031	76505	0.97	0.43	0.30	71	73	0.05	2711.4	1.62				0.74	22	41.0
Low forbs	27031	22717	1.37	0.76	0.43	79	58	0.04	7268.1	4.35				0.95	25	32.2
Bare																
	218080.	272659				1187	1469	1.00	12650.68	7.566					740	821
Marigold	7460	6269				82										
Grass	16720	14052				382			448.3	0.27	0.37					
Forb	37427	31455				151			10063.5	6.02	15.91					
Shrub	643	89918				459										
Wheat	31254	26266				105						0.831				
Eve. primrose	3473	2918				4										
Br. grass	900	757				9			26.8	0.02						
Milkwort	1029	865							9.4	0.01	0.10					
Vine	1286	1081				5										
Lt. forbs	514	432							138.3	0.08	18.10					
Bare																
	100705.8	174014				1197			10686	6.391						
Daisy fleabane	3215	3215	0.34	2.47	0.59	99	286	0.11	196.7	0.12				0.22	169	136.3
Queen Anne's lace	35	35	0.91	3.22	0.45	3	3	.00	2.0	.00				0.62	1	1.4
Hop clover	9	9	1.34	2.17	0.42	0	0	.00	0.3	.00				0.94	0	0.2
Milkwort	11147	11147	0.23	2.44	0.52	84	361	0.14	121.1	0.07				0.15	188	172.1
Grass	106	106	0.80	0.57	0.32	1	2	.00	0.0	0.00				0.61	1	0.9
Buttercup	4777	4777	0.95		0.47	108	113	0.04	863.0	0.52				0.65	53	53.7
Red clover	4777	4777	0.38	1.85	0.47	616	1607	0.62	169.3	0.10	0.35			0.26	759	766.5
Red clover (dead)	2572	2572	0.62	2.18	0.28	92	148	0.06	670.6	0.40	2.87			0.48	42	70.6
Succulent	5	5	0.92	1.63	0.45	0	0	.00	2.5	.00				0.63	0	0.2
Shrub	12	12	1.07	1.70	0.80	9	8	.00	16.4	0.01	2.14	0.071	0.034	0.59	7	4.0
Cattails	0	0	0.78	3.75	0.44	0	0	0.00	0.0	0.00				0.54	0	0.0
Black-eyed susan	90	90	0.53	3.26	0.11	1	2	.00	3.7	.00				0.48	0	1.1
Scirpus	2946	2946	0.47	20.15	0.95	30	64	0.02	21.3	0.01				0.24	61	30.6
	29692	29692				1043	2595	1	2067	1.236					1280	

(Continued)

(Sheet 2 of 4)

Table B2 (Continued)

Common Name	Mass, kg /cm ht	Plant Volume (l) /cm ht	Plant Volume (l) ht, cm	Water Volume (l) /cm Height		Average Metre-Square Spot, 1-cm Height Increments: Cumulative Volume, l: Mass	Plant	Water	% of one-m-cubed		Height, cm		Regression Output:		
Wheat	0.0033	0.0055	85.0	0.0037	Plant, A	0.2946	0.2895	0.1156			10.0	Water, A	Constant		0.0
Grass	0.0116	0.0112	25.3	0.0030		0.4601	0.4742	0.1905			20.0		Std Err of Y Est		62.0
Shasta daisy	0.0005	0.0004	52.0	0.0002		0.5630	0.5976	0.2480			30.0		R Squared		0.9
Black-eyed susan	0.0000	0.0000	41.0	0.0000		0.6011	0.6578	0.2876			40.0		No. of Observations		8.0
Scirpus	0.0002	0.0003	25.0	0.0002	Mass, A	0.6345	0.7132	0.3246			50.0		Degrees of Freedom		7.0
Forb	0.0006	0.0005	24.0	0.0002		0.6688	0.7695	0.3622			60.0				
Small grass	0.0039	0.0040	11.0	0.0012		0.7021	0.8250	0.3992			70.0		X Coefficient(s)	0.6	
Low forbs	0.0094	0.0069	5.0	0.0030		0.7355	0.8804	0.4363			80.0		Std Err of Coef.	0.1	
Bare						0.7522	0.9081	0.4548	0.091	0.045	90.0				
												0.496			
Marigold															
Grass															
Forb															
Shrub															
Wheat															
Eve. primrose															
Br. grass															
Milkwort															
Vine															
Lt. forbs															
Bare															
Daisy fleabane	0.0012	0.0034	50.0	0.0020	Plant, B	0.1497	0.3892	0.1950			10.0	Water, B	Constant		0.0
Queen Anne's lace	0.0000	0.0000	80.0	0.0000		0.2994	0.7784	0.3901			20.0		St Err of Y Est		16.3
Hop clover	0.0000	0.0000	25.0	0.0000		0.4419	1.1445	0.5697			30.0		R Squared		1.0
Milkwort	0.0018	0.0077	28.0	0.0040		0.5664	1.4412	0.7099			40.0		No. of Observations		13.0
Grass	0.0000	0.0000	72.0	0.0000		0.6102	1.5379	0.7589			50.0		Degrees of Freedom		12.0
Buttercup	0.0011	0.0011	60.0	0.0005	Mass, B	0.6992	1.7680	0.8676			60.0				
Red clover	0.0088	0.0229	42.0	0.0108		0.7112	1.7807	0.8737			70.0		X Coefficent(s)	0.5	
Red clover (dead)	0.0013	0.0021	42.0	0.0006		0.7116	1.7811	0.8739			80.0		St Err of Coef.	.0	
Succulent	0.0000	0.0000	62.0	0.0000		0.7116	1.7811	0.8739			90.0				
Shrub	0.0001	0.0001	72.0	0.0001		0.7116	1.7811	0.8739	0.178	0.087	100.0				
Cattails	0.0000	0.0000	140.0	0.0000		0.7116	1.7811	0.8739			110.0				
Black-eyed susan	0.0000	0.0000	72.0	0.0000		0.7116	1.7811	0.8739			120.0				
Scirpus	0.0007	0.0015	25.0	0.0015		0.7116	1.7811	0.8739			130.0				
						0.7116	1.7811	0.8739			140.0				
												0.49			

(Continued)

(Sheet 3 of 4)

Table B2 (Concluded)

Common Name	Water Fraction by Wet Weight			Volume, l, in Plot			
	Leaves	Stems	Flowers	Leaves	Stems	Flowers	Total
Wheat		0.23	0.78	0	124	413	537
Grass		0.27		0	34	0	34
Shasta daisy	0.42	0.40	0.75	9	8	16	33
Black-eyed susan	0.35	0.38	0.71	0	0	1	1
Scirpus	0.31	0.32	0.80	3	3	7	13
Forb	0.33	0.42		2	3	0	6
Small grass	0.30		0	7	0	7	
Low forbs	0.44	0.43		11	11	0	22
				25	190	437	652
Marigold							
Grass							
Forb							
Shrub							
Wheat							
Eve. Primrose							
Br. grass							
Milkwort							
Vine							
Lt. forbs							
Daisy fleabane	0.66	0.52	0.63	112	89	106	306
Queen Anne's lace	0.47	0.44	0.46	1	1	1	2
Hopclover	0.43	0.40	0.47	0	0	0	0
Milkwort	0.49	0.62	0.46	92	117	87	296
Grass		0.26	0.51	0	0	0	0
Buttercup	0.47	0.46	0.47	25	24	25	74
Red clover	0.47	0.51	0.43	357	390	325	1071
Red clover	0.39	0.40	0.16	16	17	7	40
Succulent	0.44	0.47		0	0	0	0
Shrub	0.44	0.57		3	4	0	7
Cattails	0.43	0.44	0.44	0	0	0	0
Black-eyed susan	0.08	0.17	0.07	0	0	0	0
Scirpus							
				605	641	550	1796

(Sheet 4 of 4)

Table B3

SITE A MICROLOGGER DATA
TRAINING AREA 6A, FORT DEVENS, MA
20 JULY, 1988

TIME OF SAMPLE	RADIOMETER GREEN BUSH DEGREES C	RADIOMETER GRAY ROCK DEGREES C	RADIOMETER BARE SOIL DEGREES C	RADIOMETER WHEAT HEADS DEGREES C	SOL RADIATION UNDER WEED WATTS/SQ MTR	AIR TEMP DEGREES C	SOIL TEMP AT 10 cm DEGREES C	RELATIVE HUMIDITY PER CENT	SOL RADIATION IN OPEN WATTS/SQ MTR	WIND DIRECTION FROM NORTH	WIND SPEED M/SEC
1045	23.92	29.54	28.30	26.23	58.55	29.07	24.13	61.71	352.20	60.04	1.42
1050	26.20	30.28	29.29	27.29	72.80	30.00	24.24	61.34	450.40	89.50	1.40
1055	25.67	30.01	28.58	26.47	53.64	28.68	24.33	62.62	306.50	92.00	1.72
1100	25.60	29.71	28.12	26.29	56.27	28.71	24.43	64.07	342.20	93.30	1.56
1105	25.53	29.59	27.87	26.17	60.12	27.99	24.52	64.79	370.60	81.30	2.13
1110	25.45	29.69	27.93	26.39	62.47	27.78	24.60	65.18	402.40	205.10	1.90
1115	25.86	29.70	28.13	26.68	71.80	28.65	24.67	64.18	486.10	36.60	1.62
1120	26.18	30.31	28.86	27.27	88.10	28.72	24.75	63.83	593.70	88.40	2.09
1125	26.74	31.22	29.54	27.63	82.70	29.08	24.84	62.15	542.90	136.20	2.37
1130	26.69	31.35	29.17	27.74	82.30	29.14	24.93	62.27	533.90	18.26	2.44
1135	26.92	31.39	29.25	27.58	83.20	30.03	25.03	61.34	535.50	28.52	2.12
1140	27.19	32.07	30.05	28.19	81.00	31.13	25.13	58.90	535.50	100.80	1.62
1145	26.76	31.71	29.29	27.35	72.40	30.01	25.22	59.15	456.10	38.98	2.21
1150	27.05	31.84	29.41	27.71	73.50	30.35	25.32	59.90	460.40	204.70	1.64
1155	26.72	31.55	28.99	27.12	59.84	29.87	25.42	59.78	370.80	141.60	2.05
1200	26.29	31.49	28.75	27.19	57.56	29.77	25.50	60.20	334.40	153.50	1.28
1205	26.24	31.41	28.74	27.27	51.16	29.98	25.57	60.17	299.20	85.20	0.84
1210	26.88	32.18	29.76	28.16	77.00	31.00	25.65	57.27	464.00	258.20	0.60
1215	27.87	33.00	30.93	29.47	102.70	32.74	25.70	54.73	710.00	60.27	1.18
1220	28.70	34.52	32.34	29.66	100.90	33.36	25.77	52.39	716.00	262.50	1.44
1225	27.76	34.15	30.89	28.52	70.20	31.99	25.87	52.44	439.90	148.90	1.38
1230	27.58	33.98	30.50	28.62	82.90	31.65	25.97	54.71	549.40	121.30	1.54
1235	28.86	35.26	32.26	30.53	110.60	34.12	26.07	51.06	718.00	211.30	0.95
1240	29.15	36.69	33.48	30.72	91.10	35.55	26.17	44.47	644.60	123.00	0.98
1245	28.24	35.48	31.50	29.51	78.50	33.58	26.32	47.17	509.80	93.10	1.46
1250	28.60	35.87	32.35	29.84	83.30	34.35	26.43	45.56	566.10	45.74	1.13
1255	27.98	35.12	31.28	28.75	58.48	32.38	26.56	48.90	380.70	156.90	1.32
1300	27.11	34.21	29.95	28.12	48.73	31.44	26.65	52.33	278.40	146.00	1.11
1305	27.03	33.67	29.79	28.13	67.72	31.14	26.72	52.51	411.90	156.00	1.19
1310	27.77	34.34	30.55	29.05	80.40	32.23	26.79	50.81	545.80	124.30	1.33
1315	27.58	34.48	30.62	28.63	60.46	32.20	26.85	50.00	371.40	110.80	1.26
1320	27.35	34.05	30.22	28.65	58.82	31.93	26.91	52.06	349.40	153.70	0.93
1325	28.15	34.38	30.85	29.84	88.60	33.46	26.94	51.09	611.20	117.50	1.23
1330	28.37	35.15	31.66	29.98	81.50	34.20	26.97	46.88	558.60	123.30	1.23
1335	28.74	35.21	31.62	29.94	89.90	33.94	27.02	48.25	638.90	137.40	1.61
1340	28.47	36.01	32.02	29.95	80.20	34.60	27.08	45.46	547.50	152.90	1.21
1345	28.08	35.61	31.43	29.17	59.74	33.52	27.16	47.61	397.80	133.20	1.03
1350	27.56	35.04	30.72	28.69	64.44	31.98	27.22	49.94	410.80	188.40	1.43
1355	27.60	34.84	30.59	29.38	68.77	32.25	27.28	50.57	440.00	63.52	1.42
1400	27.13	34.46	30.24	28.58	57.19	31.25	27.31	50.91	355.60	128.00	1.21
1405	27.22	34.13	29.93	28.40	51.85	30.89	27.36	53.69	312.10	113.10	1.36
1410	27.09	34.02	30.00	28.58	53.84	31.44	27.38	53.54	322.30	200.30	0.67
1415	27.34	34.09	29.94	28.87	63.30	32.11	27.40	51.88	400.80	68.27	1.12
1420	27.57	34.31	30.55	29.22	65.50	32.57	27.39	51.70	423.60	84.70	0.94
1425	27.68	34.48	30.53	29.10	65.08	32.12	27.40	50.63	427.40	196.90	1.24
1430	27.18	34.57	30.27	28.72	64.79	31.91	27.42	50.55	425.40	165.30	1.45
1435	27.63	34.67	30.50	29.09	66.28	32.28	27.45	50.12	451.90	94.90	1.43

(Continued)

Table B3 (Concluded)

TIME OF SAMPLE	RADIOMETER GREEN BUSH DEGREES C	RADIOMETER GRAY ROCK DEGREES C	RADIOMETER BARE SOIL DEGREES C	RADIOMETER WHEAT HEADS DEGREES C	SOL RADIATION UNDER WEED WATTS/SQ MTR	AIR TEMP DEGREES C	SOIL TEMP AT 10 cm DEGREES C	RELATIVE HUMIDITY PER CENT	SOL RADIATION IN OPEN WATTS/SQ MTR	WIND DIRECTION FROM NORTH	WIND SPEED M/SEC
1440	27.40	34.71	30.57	29.07	57.04	31.69	27.46	50.42	389.80	35.45	1.14
1445	26.91	33.93	29.57	28.10	42.03	30.75	27.49	52.51	276.00	99.70	1.49
1450	26.96	33.60	29.27	28.12	46.16	30.82	27.51	54.30	317.40	111.50	1.28
1455	27.40	33.89	29.73	28.74	57.61	31.92	27.52	52.53	399.30	39.36	1.24
1500	27.96	34.56	30.85	29.22	65.57	33.41	27.52	50.45	475.30	208.80	0.77
1505	28.23	35.46	31.78	29.46	66.71	35.46	27.53	46.78	468.10	178.00	1.15
1510	27.85	35.34	31.15	29.32	69.84	34.51	27.55	47.19	522.60	135.20	1.40
1515	28.28	35.94	31.60	29.98	64.22	36.00	27.61	45.76	489.70	147.00	1.23
1600	28.44	36.30	31.78	29.90	63.99	35.70	27.85	44.64	466.20	141.90	1.25
1700	27.43	35.76	30.97	28.91	50.88	33.25	28.17	48.94	351.50	180.30	1.36
1800	26.81	34.30	29.79	28.15	39.19	32.37	28.09	53.59	264.60	168.00	1.27
1900	25.00	30.99	26.79	25.90	19.23	27.28	27.65	67.93	124.00	171.60	1.17
2000	23.15	28.11	24.22	23.82	2.92	23.63	26.89	84.10	20.16	152.70	0.57
2100	21.68	26.09	22.42	22.20	-0.22	21.69	26.09	90.60	1.30	150.70	0.48
2200	21.33	24.96	21.72	21.72	-0.32	21.20	25.38	91.50	0.54	150.60	0.54
2300	20.92	24.02	21.23	21.26	-0.23	20.75	24.81	92.40	0.50	87.00	0.45
0	20.43	22.97	20.69	20.66	-0.27	20.16	24.34	93.70	0.50	91.30	0.46

Table B4

SITE B AND C MICROLOGGER DATA
TRAINING AREA 6A, FORT DEVENS, MA
20 JULY, 1988

TIME OF SAMPLE	RADIOMETER SANDY SOIL DEGREES C	BUSH DEGREES C	RADD DEGREES C	GRAY ROCK DEGREES C	SOL RADIATION IN OPEN WATTS/SQ MTR	AIR TEMP DEGREES C	SOIL TEMP AT 10 cm DEGREES C	RELATIVE HUMIDITY PER CENT	SOL RADIATION UNDER BUSH WATTS/SQ MTR	WIND DIRECTION FROM NORTH	WIND SPEED M/SEC
950	23.98	22.81	26.10	24.45	295.20	22.08	23.54	90.00	68.19	182.30	0.45
955	24.15	22.86	26.21	24.45	250.80	22.27	23.61	89.70	63.53	18.56	0.45
1000	23.99	22.55	26.09	24.27	212.50	22.32	23.73	89.20	57.24	88.60	0.45
1005	24.04	22.58	26.13	24.38	261.30	22.41	23.85	89.00	68.27	98.80	0.47
1010	24.63	23.06	26.49	24.87	283.50	22.62	23.95	88.90	69.82	204.30	0.45
1015	24.74	23.27	26.85	24.92	262.60	22.87	24.07	88.70	69.12	83.90	0.45
1020	25.07	23.57	27.02	25.15	336.70	23.06	24.19	88.40	84.70	190.30	0.45
1025	25.47	23.81	27.75	25.61	398.00	23.24	24.32	88.00	93.40	28.34	0.52
1030	26.01	24.48	28.48	26.14	605.10	23.52	24.48	87.40	113.00	90.80	0.54
1035	27.75	25.66	30.28	28.01	675.80	24.16	24.65	86.40	130.70	152.60	0.77
1040	27.53	24.89	30.29	28.37	491.00	24.24	24.90	84.70	107.60	90.36	1.25
1045	26.96	24.35	29.66	27.54	370.50	24.33	25.17	84.50	93.10	163.40	0.97
1050	27.56	25.15	30.03	28.28	515.90	24.27	25.42	84.30	110.90	153.10	1.03
1055	27.18	24.56	30.21	27.94	298.10	24.40	25.61	84.30	83.60	215.40	0.73
1100	26.86	24.38	29.28	27.61	344.50	24.21	25.78	84.40	90.60	117.80	1.55
1105	26.81	24.60	29.02	27.72	375.30	24.02	25.91	84.70	94.40	44.09	1.83
1110	26.86	24.50	28.99	27.83	423.00	23.88	26.00	84.80	100.70	90.10	2.00
1115	26.96	24.75	29.37	27.77	450.50	23.94	26.07	84.90	96.90	46.89	1.57
1120	28.06	25.81	30.59	28.99	702.00	24.15	26.12	84.90	127.80	103.30	1.87
1125	27.98	25.49	30.18	29.31	506.50	24.31	26.23	84.80	114.20	81.50	2.03
1130	28.63	26.04	30.75	29.95	590.20	24.61	26.37	84.60	123.60	37.35	1.12
1135	29.40	26.23	32.39	30.86	772.00	24.89	26.52	83.10	141.50	86.90	1.22
1140	29.21	25.79	32.03	31.16	481.70	24.88	26.69	82.40	119.00	152.20	1.94
1145	29.07	25.99	32.04	30.82	543.60	24.88	26.89	82.60	119.40	97.00	1.24
1150	29.66	26.17	33.53	31.29	621.60	25.19	27.04	82.20	123.70	258.80	0.77
1155	29.35	26.09	32.51	30.96	358.80	25.41	27.20	81.70	95.10	221.30	0.56
1200	29.18	26.01	32.50	31.01	432.10	25.44	27.35	81.30	104.50	130.40	0.62
1205	28.49	25.51	31.85	30.46	266.40	25.18	27.47	81.40	81.30	65.36	0.89
1210	29.02	26.17	32.14	30.68	470.40	25.35	27.54	81.30	113.00	249.80	0.51
1215	31.09	27.75	34.51	32.61	1027.00	25.76	27.59	81.10	150.10	214.60	0.87
1220	31.31	27.35	34.77	33.16	598.70	26.13	27.69	79.70	110.90	175.70	0.72
1225	29.81	25.98	32.49	31.83	322.80	25.99	27.90	78.90	89.40	187.10	0.60
1230	29.66	26.14	32.38	31.36	359.30	25.98	28.07	79.00	100.80	141.00	0.90
1235	29.79	26.63	33.33	31.49	624.60	25.99	28.19	79.00	113.70	164.50	0.60
1240	30.51	26.84	33.27	32.10	676.30	26.24	28.25	78.40	180.20	221.50	0.55
1245	32.69	28.69	35.58	34.71	1002.00	26.77	28.35	78.10	182.40	226.30	0.45
1250	31.81	26.99	33.98	34.11	583.70	27.15	28.52	74.80	117.70	228.80	1.03
1255	31.26	26.97	32.96	33.32	387.60	27.16	28.76	74.40	93.20	162.80	0.47
1300	30.52	26.84	32.57	32.77	317.40	27.01	28.97	73.90	85.10	214.40	0.45
1305	30.44	26.75	33.47	32.53	463.10	26.71	29.08	73.50	106.40	295.00	0.65
1310	31.16	27.47	33.97	33.16	576.60	26.70	29.13	74.00	119.60	310.70	0.65
1315	30.84	26.96	33.60	33.17	394.60	26.62	29.18	73.40	99.60	88.10	0.81
1320	30.53	26.76	33.10	32.77	405.60	26.57	29.25	73.90	98.10	183.40	0.67
1325	31.27	27.53	33.36	33.37	592.60	26.54	29.29	73.20	122.20	239.60	0.49
1330	31.37	27.07	34.33	33.52	549.80	26.96	29.33	73.80	117.40	230.40	0.63
1335	30.95	27.38	33.21	33.39	477.40	26.86	29.40	72.60	115.00	183.70	0.74
1340	31.02	26.82	33.33	33.17	467.30	26.86	29.45	72.30	107.50	268.60	0.65

(Continued)

Table B4 (Concluded)

TIME OF SAMPLE	RADIOMETER SANDY SOIL DEGREES C	BUSH DEGREES C	RADO DEGREES C	GRAY ROCK DEGREES C	SOL RADIATION IN OPEN WATTS/SQ MTR	AIR TEMP DEGREES C	SOIL TEMP AT 10 cm DEGREES C	RELATIVE HUMIDITY PER CENT	SOL RADIATION UNDER BUSH WATTS/SQ MTR	WIND DIRECTION FROM NORTH	WIND SPEED M/SEC
1345	30.83	26.82	33.10	33.17	449.80	26.89	29.51	73.40	102.50	178.40	0.77
1350	30.99	27.26	33.95	33.55	547.10	26.76	29.54	73.20	118.10	107.20	0.77
1355	31.05	27.34	33.19	33.53	443.00	26.77	29.58	73.10	103.90	177.60	0.83
1400	30.28	26.59	33.06	32.97	348.20	26.61	29.63	73.30	88.80	79.80	1.15
1405	29.79	26.39	32.93	32.40	307.60	26.35	29.66	73.80	81.90	226.20	0.97
1410	29.79	26.36	33.28	32.14	317.70	26.23	29.65	74.60	85.60	287.40	0.87
1415	30.14	26.85	33.21	32.34	400.60	26.40	29.61	74.90	99.60	179.70	0.56
1420	30.30	27.06	33.32	32.46	427.80	26.55	29.58	74.30	104.80	189.10	0.46
1425	30.22	26.84	33.04	32.67	420.80	26.57	29.56	73.60	102.20	134.90	0.92
1430	30.48	27.03	33.83	32.80	439.20	26.75	29.56	74.10	102.10	255.90	0.54
1435	30.82	26.92	34.31	33.01	475.60	26.94	29.57	73.10	108.30	246.40	0.45
1440	30.55	26.98	33.54	33.15	367.10	27.02	29.60	72.50	88.50	146.50	0.45
1500	29.63	26.36	33.21	32.24	358.20	26.55	29.61	73.00	83.80	208.90	0.52
1600	31.74	27.77	34.32	34.60	530.80	27.80	29.88	70.40	130.70	203.40	0.72
1700	31.17	27.27	33.57	33.60	371.40	27.84	30.53	70.70	91.90	214.60	0.72
1800	29.83	26.64	32.73	32.21	282.10	27.35	30.16	73.40	74.60	222.50	0.63
1900	27.16	25.02	29.17	29.25	125.70	25.86	29.31	77.20	37.75	208.00	0.47
2000	24.69	23.28	25.98	26.75	18.66	23.79	28.02	84.80	5.64	174.20	0.45
2100	23.03	21.81	24.02	24.83	0.57	21.92	26.65	89.80	0.85	145.50	0.45
2200	22.17	21.25	23.17	23.70	-0.07	21.35	25.60	90.80	0.63	147.80	0.45
2300	21.52	20.60	22.49	22.72	-0.18	20.69	24.81	91.70	0.53	123.40	0.45
0	21.00	20.06	21.99	21.87	-0.14	20.13	24.17	92.90	0.58	140.10	0.45

APPENDIX C

BASIC STATISTICS OF THE ELEVATION DATA COLLECTED FOR PLOTS A, B, AND C

Variable Name: z N = 385

Fort Devens Radar Study, July 1988, Plot A

Arithmetic mean = 99.010249351

Sample std. dev. = 0.611460636
Sample variance = 0.37388411
Coefficient of variation = 0.61757307%

Population std. dev. = 0.610666015
Population variance = 0.372912982
Coefficient of variation = 0.616770505%

Standard error of the mean = 0.03116292

Minimum = 97.148
Maximum = 101.36

Sum = 38118.946000002
Sum of squares = 3774309.9199425
Deviation SS = 143.5714981

1st moment = 0
2nd moment = 0.37291298197886
3rd moment = 0.0775026
Moment coefficient of skewness = 0.34033374954173
4th moment = .55815
Moment coefficient of kurtosis = 4.0136169693957

Normal distribution goodness of fit test:

The hypothesis that the population is normal of mean 99.010249350655 and std. dev. 0.61146063612966 can be rejected at the 95% confidence level

CHI square = 22.584, D.F. = 5, P = 4.048E-04

Variable Name: z N = 683

Fort Devens, MA, July 1988, Plot B

Arithmetic mean = 98.924427526

Sample std. dev. = 0.590930169

Sample variance = 0.349198465

Coefficient of variation = 0.597355157%

Population std. dev. = 0.590497412 = rms

Population variance = 0.348687194

Coefficient of variation = 0.596917694%

Standard error of the mean = 0.22611315

Minimum = 95.738

Maximum = 102.256

Sum = 67565.383999997

Sum of squares = 6684105.0861015

Deviation SS = 238.1533532

1st moment = 0

2nd moment = 0.34868719350334

3rd moment = 0.1873528

Moment coefficient of skewness = 0.90992624700967

4th moment = 0.94045

Moment coefficient of kurtosis = 7.7350605333042

Normal distribution goodness of fit test:

The hypothesis that the population is normal of mean 98.924427525618 and std. dev. 0.59093016935004 can be rejected at the 95% confidence level

CHI square = 112.022, D.F. = 5, P = 4.486E-07

Variable Name: z N = 429

Fort Devens, MA, Radar Study, July 1988, Plot C

Arithmetic mean = 97.880006993

Sample std. dev. = 0.774060007
Sample variance = 0.599168895
Coefficient of variation = 0.790825452%

Population std. dev. = 0.773157313 = rms
Population variance = 0.597772231
Coefficient of variation = 0.789903206%

Standard error of the mean = 0.037371969

Minimum = 95.646
Maximum = 99.355

Sum = 41990.522999999
Sum of squares = 4110289.1291668
Deviation SS = 256.444287

1st moment = 0
2nd moment = 0.59777223072012
3rd moment = -0.1393495
Moment coefficient of skewness = -0.30151006232996
4th moment = 0.81
Moment coefficient of kurtosis = 2.2668017878511

Normal distribution goodness of fit test:

The hypothesis that the population is normal of mean 97.880006993004 and std. dev. 0.77406000724142 can be rejected at the 95% confidence level

CHI square = 32.967, D.F. = 5, P = 3.371E-06

Frequency Distributions

Header Data for: C:PLOTA LABEL: plotaxyz
Number of cases: 385 Number of variables: 4

Variable: 3. z

Fort Devens, MA, July 1988, Plot A

Class Limits		Frequency	Percent	Cumulative Frequency	Cumulative Percent
97.00 <	97.20	1	.26	1	.26
97.20 <	97.40	1	.26	2	.52
97.40 <	97.60	1	.26	3	.78
97.60 <	97.80	6	1.56	9	2.34
97.80 <	98.00	6	1.56	15	3.90
98.00 <	98.20	14	3.64	29	7.53
98.20 <	98.40	27	7.01	56	14.55
98.40 <	98.60	40	10.39	96	24.94
98.60 <	98.80	55	14.29	151	39.22
98.80 <	99.00	41	10.65	192	49.87
99.00 <	99.20	66	17.14	258	67.01
99.20 <	99.40	30	7.79	288	74.81
99.40 <	99.60	22	5.71	310	80.52
99.60 <	99.80	39	10.13	349	90.65
99.80 <	100.00	20	5.19	369	95.84
100.00 <	100.20	12	3.12	381	98.96
100.20 <	100.40	0	.00	381	98.96
100.40 <	100.60	0	.00	381	98.96
100.60 <	100.80	0	.00	381	98.96
100.80 <	101.00	0	.00	381	98.96
101.00 <	101.20	1	.26	382	99.22
101.20 <	101.40	3	.78	385	100.00
	Total	385	100.00		

(Continued)

Fort Devens, MA, July 1988, Plot A (Continued)

Class Limits			Frequency	
97.00	<	97.20	1	
97.20	<	97.40	1	
97.40	<	97.60	1	
97.60	<	97.80	6	==
97.80	<	98.00	6	==
98.00	<	98.20	14	======
98.20	<	98.40	27	===========
98.40	<	98.60	40	=================
98.60	<	98.80	55	========================
98.80	<	99.00	41	==================
99.00	<	99.20	66	=============================
99.20	<	99.40	30	=============
99.40	<	99.60	22	=========
99.60	<	99.80	39	=================
99.80	<	100.00	20	========
100.00	<	100.20	12	=====
100.20	<	100.40	0	
100.40	<	100.60	0	
100.60	<	100.80	0	
100.80	<	101.00	0	
101.00	<	101.20	1	

Frequency Distributions

Header Data for: C:PLOTB LABEL: plotbxyz
Number of cases: 683 Number of variables: 4

Variable: 3. z

Fort Devens, MA, July, 1988 Plot B

Class Limits		Frequency	Percent	Cumulative Frequency	Cumulative Percent
95.00 <	95.20	0	0.00	0	0.00
95.20 <	95.40	0	0.00	0	0.00
95.40 <	95.60	0	0.00	0	0.00
95.60 <	95.80	1	0.15	1	0.15
95.80 <	96.00	0	0.00	1	0.15
96.00 <	96.20	0	0.00	1	0.15
96.20 <	96.40	0	0.00	1	0.15
96.40 <	96.60	0	0.00	1	0.15
96.60 <	96.80	0	0.00	1	0.15
96.80 <	97.00	0	0.00	1	0.15
97.00 <	97.20	1	0.15	2	0.29
97.20 <	97.40	1	0.15	3	0.44
97.40 <	97.60	3	0.44	6	0.88
97.60 <	97.80	8	1.17	14	2.05
97.80 <	98.00	9	1.32	23	3.37
98.00 <	98.20	17	2.49	40	5.86
98.20 <	98.40	40	5.86	80	11.71
98.40 <	98.60	77	11.27	157	22.99
98.60 <	98.80	149	21.82	306	44.80
98.80 <	99.00	148	21.67	454	66.47
99.00 <	99.20	78	11.42	532	77.89
99.20 <	99.40	44	6.44	576	84.33
99.40 <	99.60	32	4.69	608	89.02
99.60 <	99.80	24	3.51	632	92.53
99.80 <	100.00	18	2.64	650	95.17
100.00 <	100.20	10	1.46	660	96.63
100.20 <	100.40	3	0.44	663	97.07
100.40 <	100.60	9	1.32	672	98.39
100.60 <	100.80	5	0.73	677	99.12
100.80 <	101.00	2	0.29	679	99.41
101.00 <	101.20	1	0.15	680	99.56
101.20 <	101.40	0	0.00	680	99.56
101.40 <	101.60	1	0.15	681	99.71
101.60 <	101.80	0	0.00	681	99.71
101.80 <	102.00	1	0.15	682	99.85
102.00 <	102.20	0	0.00	682	99.85
102.20 <	102.40	1	0.15	683	100.00
	Total	683	100.00		

(Continued)

Fort Devens, MA, July 1988, Plot B (Continued)

Class Limits		Frequency	
95.00 <	95.20	0	
95.20 <	95.40	0	
95.40 <	95.60	0	
95.60 <	95.80	1	
95.80 <	96.00	0	
96.00 <	96.20	0	
96.20 <	96.40	0	
96.40 <	96.60	0	
96.60 <	96.80	0	
96.80 <	97.00	0	
97.00 <	97.20	1	
97.20 <	97.40	1	
97.40 <	97.60	3	
97.60 <	97.80	8	=
97.80 <	98.00	9	=
98.00 <	98.20	17	===
98.20 <	98.40	40	=======
98.40 <	98.60	77	==============
98.60 <	98.80	149	=============================
98.80 <	99.00	148	============================
99.00 <	99.20	78	===============
99.20 <	99.40	44	========
99.40 <	99.60	32	======
99.60 <	99.80	24	====
99.80 <	100.00	18	===
100.00 <	100.20	10	=
100.20 <	100.40	3	
100.40 <	100.60	9	=
100.60 <	100.80	5	
100.80 <	101.00	2	
101.00 <	101.20	1	
101.20 <	101.40	0	
101.40 <	101.60	1	
101.60 <	101.80	0	
101.80 <	102.00	1	
102.00 <	102.20	0	
102.20 <	102.40	1	

Frequency Distributions

Header Data for: C:PLOTFIXC LABEL:
Number of cases: 429 Number of variables: 1

Variable: 1. z

Fort Devens, MA, July 1988, Plot C

=====CLASS LIMITS====		FREQUENCY	PERCENT	....CUMULATIVE... FREQUENCY	PERCENT
95.00 <	95.20	0	.00	0	.00
95.20 <	95.40	0	.00	0	.00
95.40 <	95.60	0	.00	0	.00
95.60 <	95.80	2	.47	2	.47
95.80 <	96.00	2	.47	4	.93
96.00 <	96.20	2	.47	6	1.40
96.20 <	96.40	10	2.33	16	3.73
96.40 <	96.60	9	2.10	25	5.83
96.60 <	96.80	9	2.10	34	7.93
96.80 <	97.00	27	6.29	61	14.22
97.00 <	97.20	22	5.13	83	19.35
97.20 <	97.40	47	10.96	130	30.30
97.40 <	97.60	37	8.62	167	38.93
97.60 <	97.80	39	9.09	206	48.02
97.80 <	98.00	28	6.53	234	54.55
98.00 <	98.20	34	7.93	268	62.47
98.20 <	98.40	18	4.20	286	66.67
98.40 <	98.60	23	5.36	309	72.03
98.60 <	98.80	71	16.55	380	88.58
98.80 <	99.00	39	9.09	419	97.67
99.00 <	99.20	8	1.86	427	99.53
99.20 <	99.40	2	.47	429	100.00
	TOTAL	429	100.00		

Fort Devens, MA, July 1988, Plot C (Continued)

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=====CLASS LIMITS====  FREQUENCY .............................
   95.00 <     95.20         0 |
   95.20 <     95.40         0 |
   95.40 <     95.60         0 |
   95.60 <     95.80         2 |
   95.80 <     96.00         2 |
   96.00 <     96.20         2 |
   96.20 <     96.40        10 |====
   96.40 <     96.60         9 |===
   96.60 <     96.80         9 |===
   96.80 <     97.00        27 |===========
   97.00 <     97.20        22 |========
   97.20 <     97.40        47 |===================
   97.40 <     97.60        37 |===============
   97.60 <     97.80        39 |===============
   97.80 <     98.00        28 |===========
   98.00 <     98.20        34 |=============
   98.20 <     98.40        18 |=======
   98.40 <     98.60        23 |=========
   98.60 <     98.80        71 |=============================
   98.80 <     99.00        39 |===============
   99.00 <     99.20         8 |===
   99.20 <     99.40         2 |
```

Fort Devens, MA, July 1988, Dielectric Measurements

Id.	Depth, cm.	Moisture Cont. %	Sigma	Epsilon	Conduct. mean	Permit. mean	Conduct. s.d.	Permit. s.d.
A1	5.00		58.70	40.41	59.01	39.32	3.12	8.02
A1	10.00		54.03	27.21				
A1	15.00		61.69	39.88				
A1	20.00		61.63	49.76				
A2	5.00		55.75	21.71	55.39	32.77	2.93	7.49
A2	10.00		51.46	34.22				
A2	15.00		54.66	32.37				
A2	20.00		59.67	42.76				
A3	5.00		46.55	17.42	51.39	28.84	2.87	6.65
A3	10.00		54.01	33.68				
A3	15.00		52.79	31.34				
A3	20.00		52.19	32.93				
A5	5.00		52.83	18.85	55.63	36.36	3.27	16.53
A5	10.00		51.92	22.38				
A5	15.00		59.01	45.17				
A5	20.00		58.74	59.03				
A6	5.00		51.68	21.21	47.65	33.20	14.64	7.83
A6	10.00		54.10	26.59				
A6	15.00		58.11	38.13				
A6	20.00		55.70	40.92				
A6	25.00		18.67	39.13				
B1	5.00	2.00	44.97	2.82	45.63	3.61	0.86	0.59
B1	10.00		45.77	3.29				
B1	15.00		45.78	3.30				
B1	20.00		46.56	3.76				
B1	25.00		46.57	3.78				
B1	30.00		44.13	4.70				
B2	5.00	13.50	49.74	4.50	48.11	12.86	6.20	7.16
B2	10.00		53.94	14.93				
B2	15.00		44.50	9.25				
B2	20.00		37.97	10.05				
B2	25.00		54.41	25.55				
B3	5.00	6.90	50.62	13.37	57.97	27.28	6.59	11.26
B3	10.00		56.68	27.51				
B3	15.00		66.61	40.96				

(Continued)

(Sheet 1 of 4)

Fort Devens, MA, July 1988, Dielectric Measurements (Continued)

Id.	Depth, cm.	Moisture Cont. %	Sigma	Epsilon	Conduct. mean	Permit. mean	Conduct. s.d.	Permit. s.d.
B4	5.00	12.00	115.56	6.59	152.54	16.98	29.97	11.24
B4	10.00		133.02	5.46				
B4	15.00		191.94	24.43				
B4	20.00		169.62	31.44				
B5	5.00	3.60	60.48	16.87	71.71	22.35	7.02	3.81
B5	10.00		71.07	20.86				
B5	15.00		77.57	24.96				
B5	20.00		77.73	26.70				
B6	5.00	11.00	63.64	37.37	74.06	34.82	10.63	5.55
B6	10.00		66.25	25.54				
B6	15.00		75.53	36.17				
B6	20.00		90.81	40.19				
B10	5.00	5.00	55.04	8.72	56.88	15.73	4.43	7.76
B10	10.00		50.53	6.81				
B10	15.00		52.69	10.19				
B10	20.00		59.15	17.73				
B10	25.00		61.66	23.46				
B10	30.00		62.23	27.49				
B11	5.00	7.60	49.28	4.57	54.83	18.88	3.31	11.90
B11	10.00		51.91	7.85				
B11	15.00		54.99	12.41				
B11	20.00		58.10	19.69				
B11	25.00		58.53	34.42				
B11	30.00		56.19	34.33				
B12	5.00	5.60	46.14	2.64	49.55	9.60	5.16	10.39
B12	10.00		46.12	3.83				
B12	15.00		47.63	4.80				
B12	20.00		48.14	6.51				
B12	25.00		59.74	30.23				
C1	5.00	7.50	63.40	4.18	65.16	23.49	3.69	14.24
C1	10.00		60.29	8.13				
C1	15.00		69.97	33.41				
C1	20.00		63.26	35.74				
C1	25.00		68.90	35.99				
C2	5.00	6.40	48.79	3.71	53.60	15.99	5.62	13.33
C2	10.00		49.32	5.48				
C2	15.00		51.44	7.07				
C2	20.00		49.62	10.93				
C2	25.00		58.85	30.86				
C2	30.00		63.60	37.86				

(Continued)

(Sheet 2 of 4)

Fort Devens, MA, July 1988, Dielectric Measurements (Continued)

Id.	Depth, cm.	Moisture Cont. %	Sigma	Epsilon	Conduct. mean	Permit. mean	Conduct. s.d.	Permit. s.d.
C3	5.00	8.50	53.00	3.75	60.73	15.07	14.09	5.28
C3	10.00		48.01	3.21				
C3	15.00		49.13	8.54				
C3	20.00		49.71	13.36				
C3	25.00		55.71	19.97				
C3	30.00		84.86	21.63				
C4	5.00	14.50	49.75	9.09	61.16	15.63	12.27	7.70
C4	10.00		52.58	11.91				
C4	15.00		57.57	12.77				
C4	20.00		61.59	28.75				
C4	25.00		84.32					
C5	5.00	15.30	52.12	7.61	78.71	19.15	28.91	3.30
C5	10.00		63.04	11.65				
C5	15.00		67.34	20.89				
C5	20.00		76.74	26.74				
C5	25.00		134.33	28.87				
C6	5.00	8.30	51.50	10.76	60.62	18.94	9.70	6.28
C6	10.00		54.85	18.06				
C6	15.00		59.42	18.50				
C6	20.00		76.70	28.43				
C7	5.00	7.80	45.64	8.72	54.91	18.74	11.36	15.48
C7	10.00		45.63	8.74				
C7	15.00		48.13	9.10				
C7	20.00		48.74	9.67				
C7	25.00		65.46	27.55				
C7	30.00		66.90	42.81				
C8	5.00	16.30	41.73	5.47	48.67	11.82	5.20	6.44
C8	10.00		45.55	6.87				
C8	15.00		47.96	11.00				
C8	20.00		51.00	12.02				
C8	25.00		57.13	29.74				
C9	5.00	9.60	60.19	7.54	67.35	21.82	4.15	11.48
C9	10.00		69.35	25.53				
C9	15.00		70.27	15.85				
C9	20.00		69.58	38.37				
C10	5.00	8.10	42.02	3.74	49.41	12.85	7.63	13.63
C10	10.00		43.54	4.68				
C10	15.00		49.17	12.23				
C10	20.00		49.63	5.42				

(Continued)

(Sheet 3 of 4)

Fort Devens, MA, July 1988, Dielectric Measurements (Concluded)

Id.	Depth, cm.	Moisture Cont. %	Sigma	Epsilon	Conduct. mean	Permit. mean	Conduct. s.d.	Permit. s.d.
C10	25.00		46.78	8.35				
C10	30.00		65.33	42.66				
C11	5.00	7.80	46.74	4.22	45.52	5.39	1.98	1.46
C11	10.00		41.26	3.28				
C11	15.00		45.89	4.94				
C11	20.00		47.37	5.92				
C11	25.00		46.13	7.84				
C11	30.00		45.74	6.13				
C12	5.00	4.40	43.54	4.68	46.57	13.11	4.31	11.24
C12	10.00		44.44	8.03				
C12	15.00		44.45	8.05				
C12	20.00		44.09	6.34				
C12	25.00		46.97	14.18				
C12	30.00		55.90	37.36				

(Sheet 4 of 4)

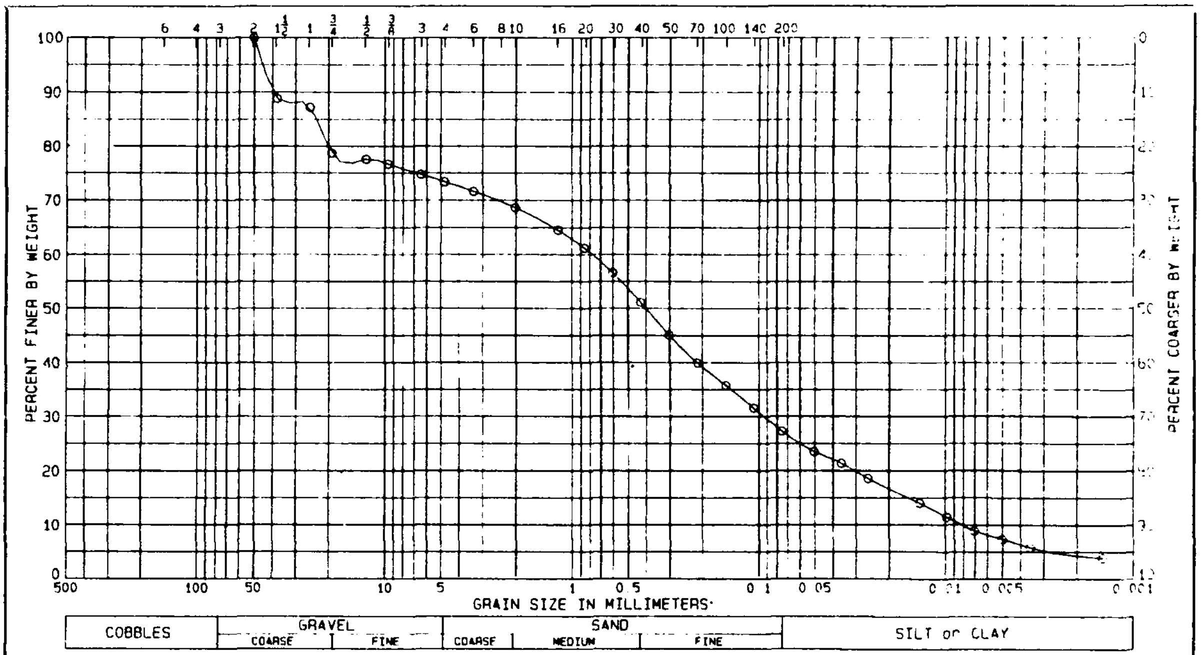
Fort Devens, MA, Range 6A, Surface Composition

Sample Id.	Visual Soil Type	Speedy Moisture %	Date	Gross weight Ring + Sample, g	Ring Weight, g	Ring vol = 302.6 Wet Density g/cc	Dry Density g/cc
A-2		17	14 July	687.5	163.9	1.73	1.48
A3		22.5		667.9	153.8	1.70	1.39
B-1 (notcatt.)		2		679.9	163.9	1.71	1.67
B-1 (cattails)		11.8		651.3	153.8	1.64	1.47
B1bulk							
B2bulk							
B3bulk							
B4bulk							
B5bulk							
C-1 -		2.7					
C-2 - Bulk		8					
C-3 - Smpls		5.1					
C-4 -		3					
A-1	Sand/clay	15	20 July	488.4	153.8	1.11	0.96
A-2		14.00		683.7	163.9	1.72	1.51
A-3		10.8		673.6	153.8	1.72	1.55
B-1	Sand	5.2		618.7	153.8	1.54	1.46
B-2	Sand	8.5		682.3	163.9	1.71	1.58
B-3	Sand	6		677.2	163.9	1.70	1.60
C-1	Clay	10.6		725.1	153.8	1.89	1.71
C-2	Sand	4.1		697.3	163.9	1.76	1.69
C-3	Sand	4.5		683.9	153.8	1.75	1.68

Laboratory Characterization of Surface Soils

Fort Devens, MA, Range 6A, July 1988

Corresp Field Data	Sample ID	ID Classification	Liquid Limit	Plastic Limit	Plasticity Index	Specific Gravity
*	A-1	Clayey sand (SC) brown, trace of gravel	37	22	15	2.60
*	A-2	Gravelly silty sand (SM) gray	Nonplastic			2.68
*	B-1	Gravelly silty sand (SM) gray	Nonplastic			2.68
	B-2	Gravelly silty sand (SM) gray	15	14	1	2.70
*	B-3	Gravelly sandy Clay (CL) gray	26	18	8	2.72
	B-4	Silty sand (SM) Brown, with gravel	Nonplastic			2.67
	B-5	Sandy clay (CL) gray, with gravel	25	15	10	2.73
*	C-1	Sand (SW-SM) gray, with gravel	Nonplastic			2.70
*	C-2	Silty sand (SM) gray, with gravel	Nonplastic			2.67
*	C-3	Gravelly silty sand (SM) gray	Nonplastic			2.69
*	C-4	Silty sand (SM) gray	Nonplastic			2.71



LL 15	PL 14	PI 1	GS 2.70	NAT W. %	

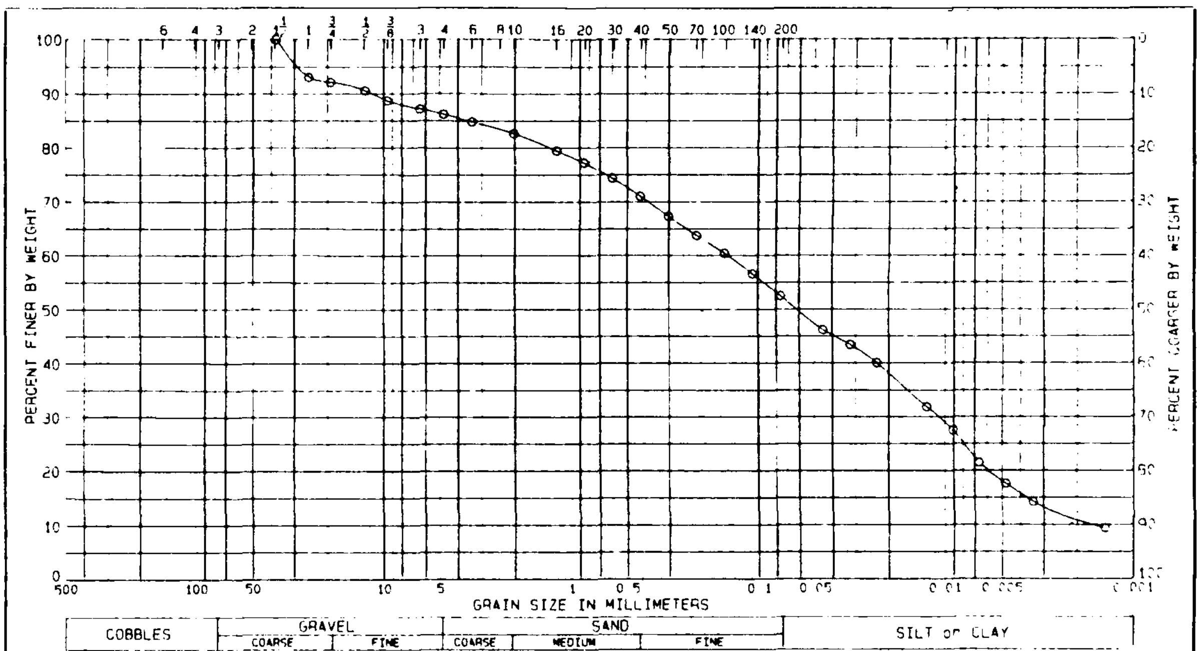
CLASSIFICATION
GRAVELLY SILTY SAND (SM) GRAY

PROJECT MIT/LL RADAR STUDY

BORING NO B-2 SAMPLE NO 1

DEPTH/ELEV 0-10 DATE 01 SEP 86

GRADATION CURVE



LL 26	PL 18	PI 8	GS 2.72	NAT W. %	

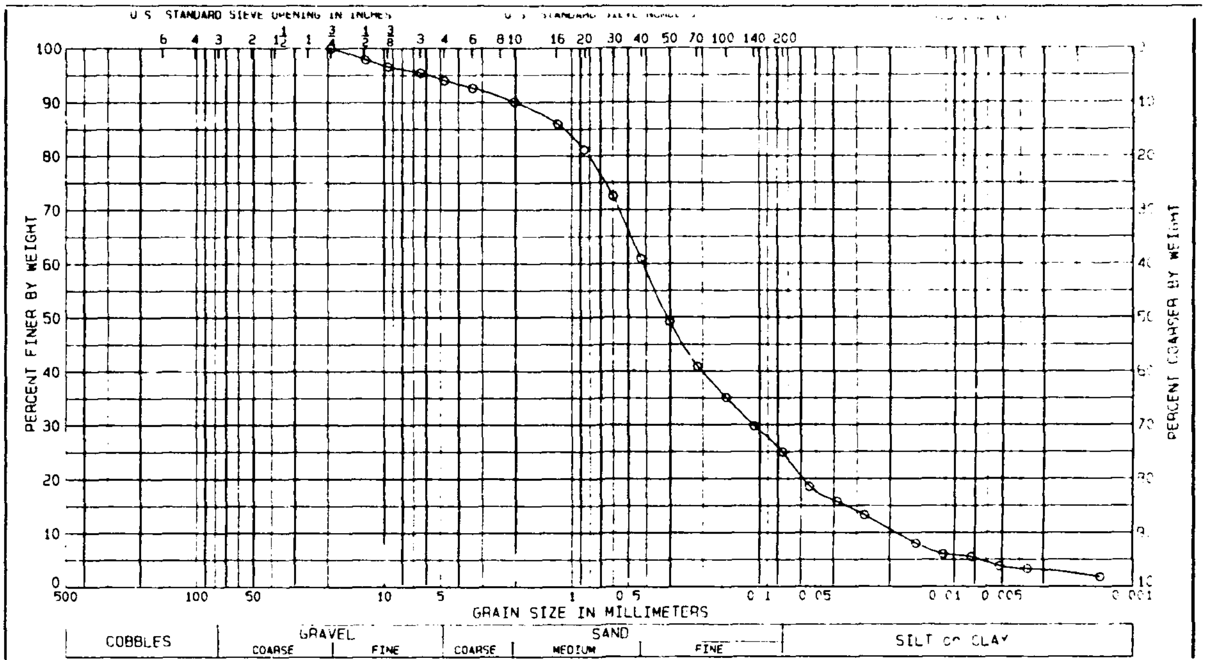
CLASSIFICATION
GRAVELLY SANDY CLAY (CL) GRAY

PROJECT MIT/LL RADAR STUDY

BORING NO B-3 SAMPLE NO 1

DEPTH/ELEV 0-10 DATE 01 SEP 86

GRADATION CURVE



LL NP | PL | PI | GS 2.67 | NAT W. %

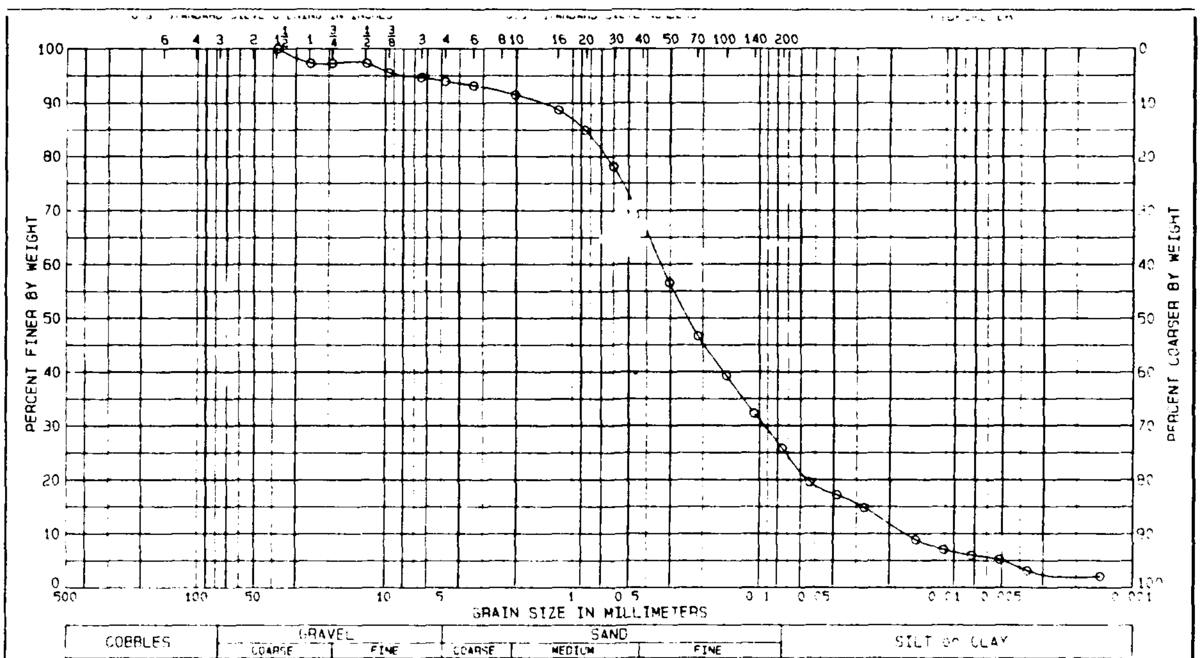
CLASSIFICATION
SILTY SAND (SM) BROWN, WITH GRAVEL

GRADATION CURVE

PROJECT MIT/LL RADAR STUDY

BORING NO B-4 SAMPLE NO 1

DEPTH/ELEV 0-10 DATE 01 SEP 88



LL NP | PL | PI | GS 2.67 | NAT W. %

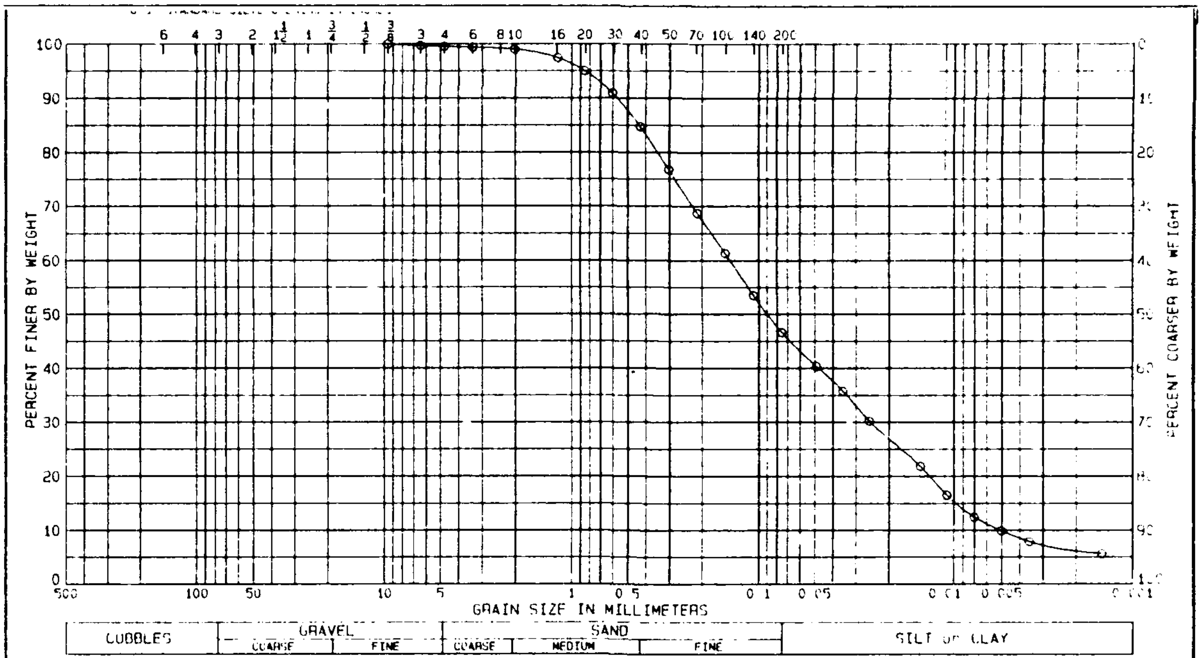
CLASSIFICATION
SILTY SAND (SM) GRAY, WITH GRAVEL

GRADATION CURVE

PROJECT MIT/LL RADAR STUDY

BORING NO C-2 SAMPLE NO 1

DEPTH/ELEV 0-10 DATE 01 SEP 88



LL NP	PL	PI	GS 2.71	NAT W, %	

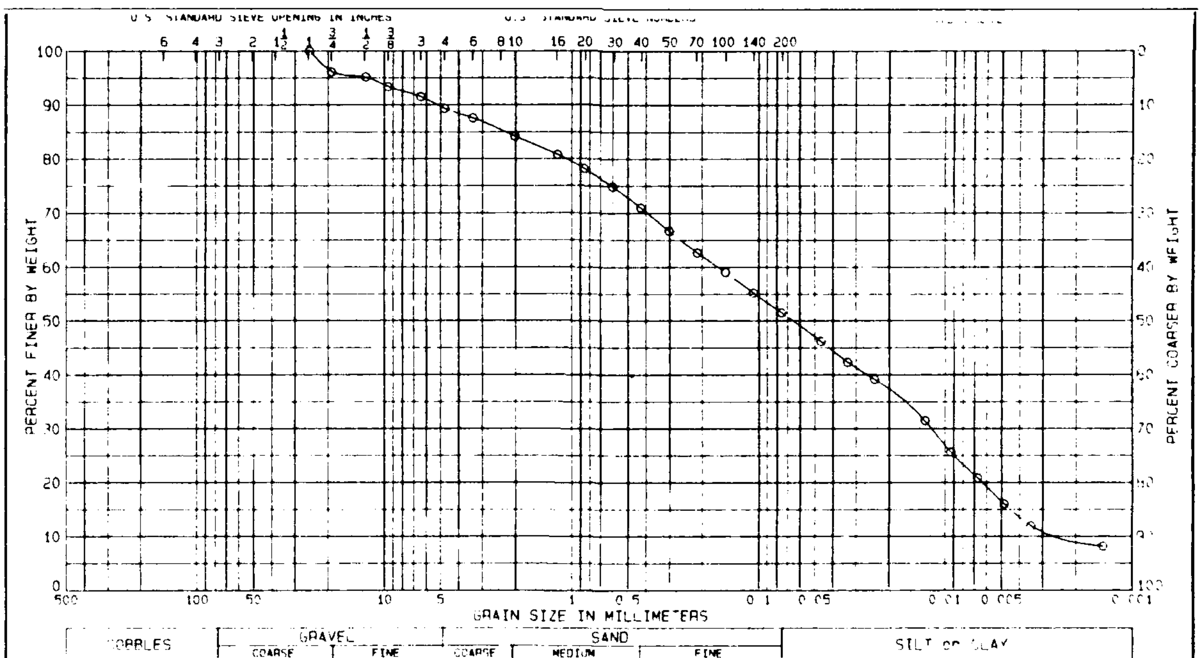
CLASSIFICATION
SILTY SAND (SM) GRAY

PROJECT MIT/LL RADAR STUDY

BORING NO C-4 SAMPLE NO 1

DEPTH/ELEV 0-10 DATE 01 SEP 88

GRADATION CURVE



LL 25	PL 15	PI 10	GS 2.73	NAT W, %	

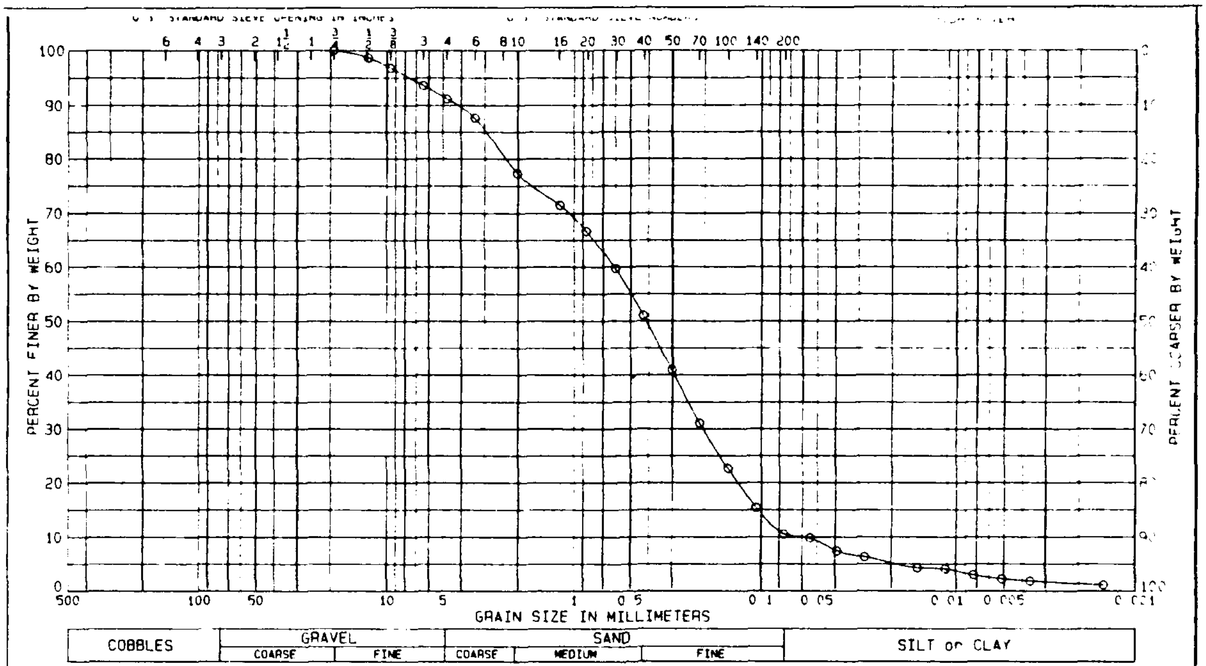
CLASSIFICATION
SANDY CLAY (CL) GRAY, WITH GRAVEL

PROJECT MIT/LL RADAR STUDY

BORING NO B-5 SAMPLE NO 1

DEPTH/ELEV 0-10 DATE 01 SEP 88

GRADATION CURVE



LL NP	PL	PI	GS 2.70	NAT W. %	

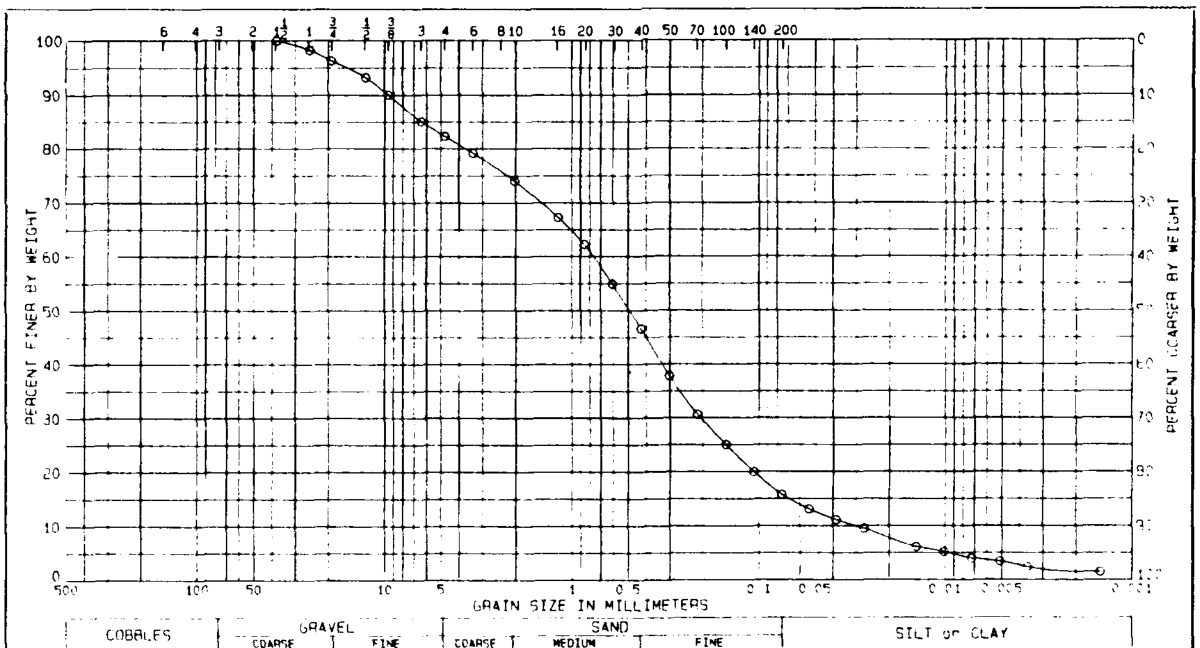
CLASSIFICATION
SAND (SW-SM) GRAY, WITH GRAVEL

GRADATION CURVE

PROJECT MIT/LL RADAR STUDY

BORING NO C-1 SAMPLE NO 1

DEPTH/ELEV 0-10 DATE 01 SEP 88



LL NP	PL	PI	GS 2 69	NAT W. %	

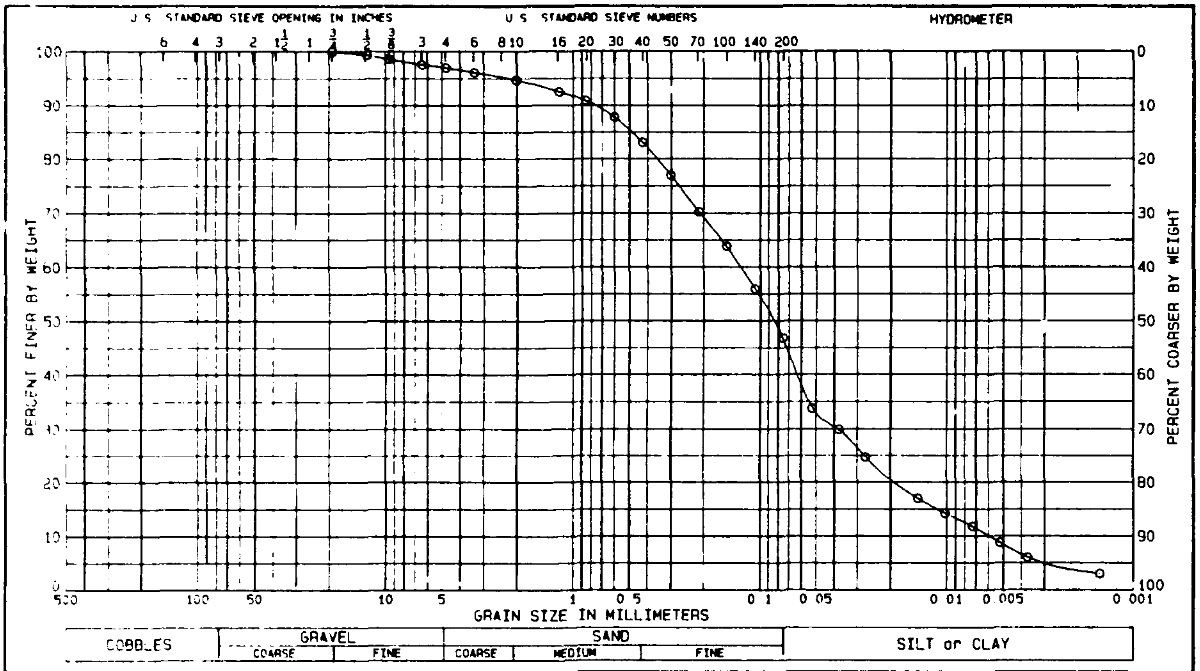
CLASSIFICATION
GRAVELLY SILTY SAND (SM) GRAY

GRADATION CURVE

PROJECT MIT/LL RADAR STUDY

BORING NO C-3 SAMPLE NO 1

DEPTH/ELEV 0-10 DATE 01 SEP 89



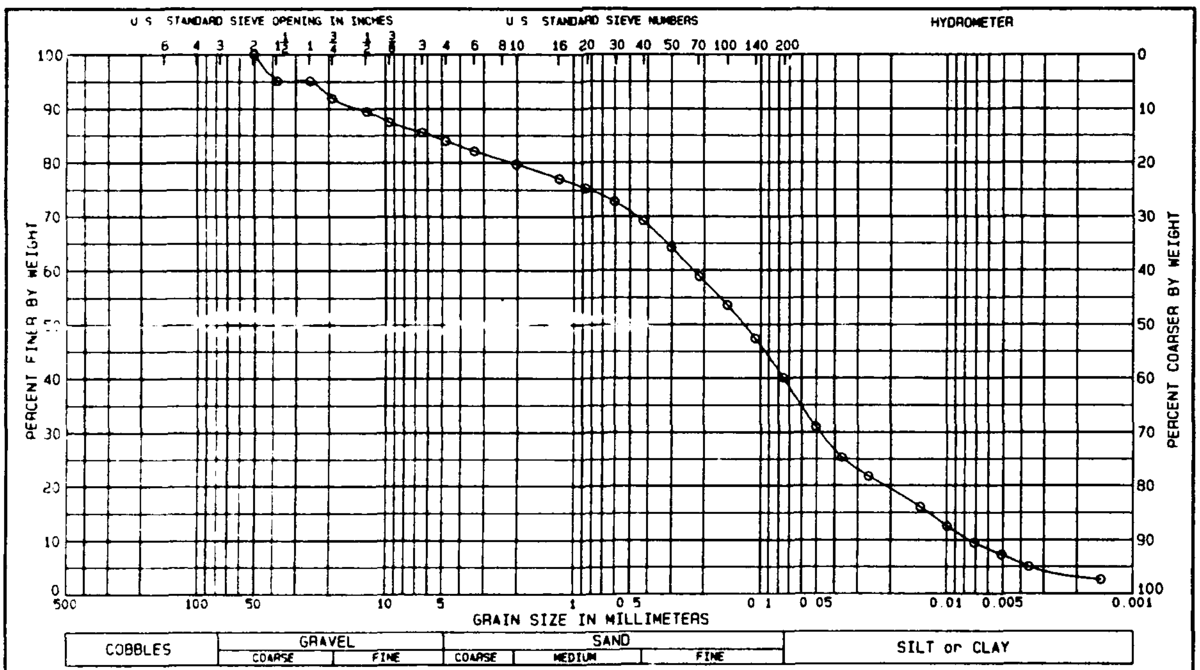
LL 37	PL 22	PI 15	GS 2 60	NAT W, %	

CLASSIFICATION
CLAYEY SAND (SC) BROWN, TRACE OF GRAVEL

PROJECT MIT/LL RADAR STUDY

BORING NO. A SAMPLE NO. 1
DEPTH/ELEV 0-10 DATE 01 SEP 88

GRADATION CURVE



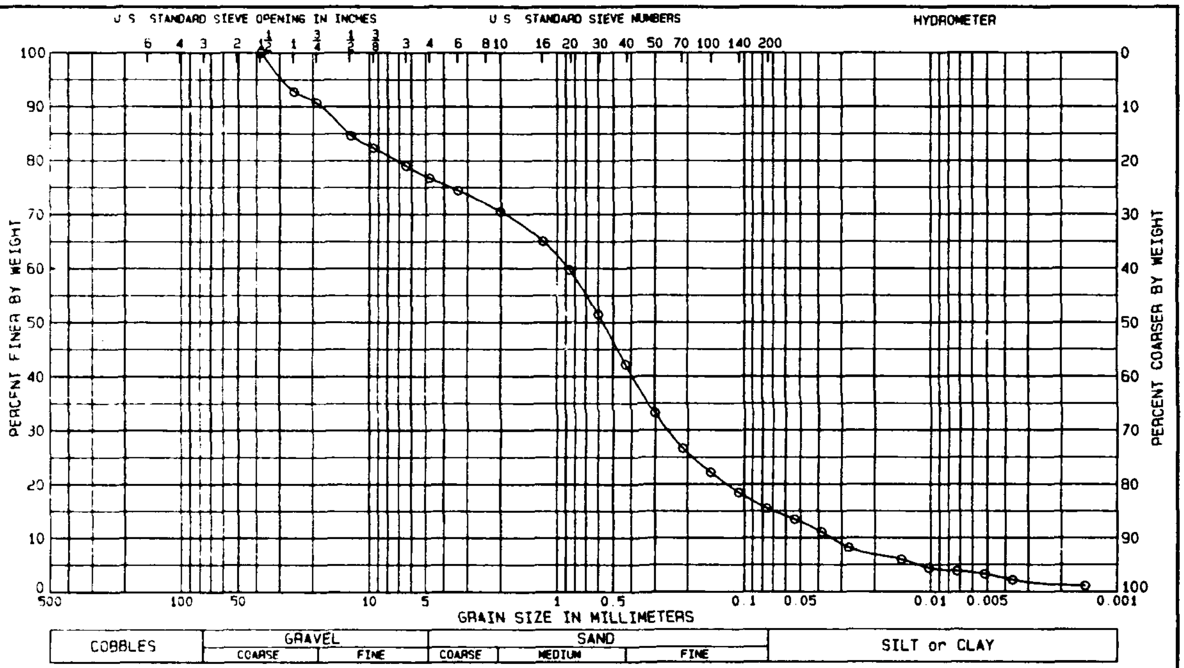
LL NP	PL	PI	GS 2 68	NAT W, %	

CLASSIFICATION
GRAVELLY SILTY SAND (SM) GRAY

PROJECT MIT/LL RADAR STUDY

BORING NO. A-2 SAMPLE NO. 1
DEPTH/ELEV 0-10 DATE 01 SEP 88

GRADATION CURVE



LL NP	PL	PI	GS 2.68	NAT W, %	

CLASSIFICATION
GRAVELLY SILTY SAND (SM) GRAY

PROJECT MIT/LL RADAR STUDY

BORING NO. B-1 SAMPLE NO. 1

DEPTH/ELEV 0-10 DATE 01 SEP 88

GRADATION CURVE

APPENDIX D

RADAR CROSS-SECTION REPORT, MASSACHUSETTS INSTITUTE OF TECHNOLOGY, LINCOLN LABORATORY

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

LINCOLN LABORATORY

LEXINGTON, MASSACHUSETTS 02173-0073

23 September 1988 47C-1443

Area Code 617
863-5500

Ms. Katherine Long
Waterways Experiment Station
P.O. Box 631
Vicksburg, MS 39180

Dear Ms. Long:

Per your request, radar cross-section measurements of the three targets you sent us have been completed. These measurements were taken at 35 GHz using our short-range scatterometer, the "Flashlight Radar." Data were taken in linear basis and then mathematically transformed to circular basis. All measurements have been polarimetrically calibrated.

The three targets ranged from the smallest (Target 1) to the largest (Target 3). The latter was measured at two orientations; in one orientation the radar boresight was slightly off broadside to one of the target's flat sides, and in the other orientation the radar was aimed approximately 45 degrees off broadside. All three objects were measured at the three requested depression angles of 5, 9, and 45 degrees.

The attached radar cross-section (RCS) report details the measurement results. The data are in decibels referred to a square meter (dBsm). The target RCS is calculated at the range where the reflected power in all four polarization channels is maximum (the "peak span" of the polarization scattering matrix). For the linear basis case, the four magnitudes are arranged:

HH HV

VH VV ,

where HV means "transmit horizontal polarization, receive vertical polarization," etc.

For the circular basis, the measurements correspond to the magnitudes of:

RR RL

LR LL ,

where RL means "transmit right circular polarization, receive left circular polarization," etc.

Also listed in the RCS report are the complex values. Note that in a few instances the cross-polarized channels do not exactly agree; this is usually attributable to the very small cross-sections being measured, near the instrument's noise floor.

To aid in the interpretation of these results, four graphs are attached. These present the target RCS versus downlook angle for all six magnitudes, three each in the linear and the circular bases.

Figure 1 shows the RCS values for Target 1, the smallest object of the three. It demonstrates that the target is of relatively small radar cross section, with typical co-pol values averaging approximately -20 dBsm. It is an odd-bounce object with very low linear cross-polarization.

Figure 2 plots the RCS values for Target 2. As might be surmised by its greater bulk, this object is of larger cross section than Target 1, averaging about -10 dBsm. Again it has little linear cross-pol. Note, however, that Target 2 is primarily odd-bounce at the 5 and 9 degree depression angles, while at the 45 degree angle it becomes an even-bounce reflector. In addition, the HH linear response dominates at the three measurement angles.

Figure 3 shows the RCS values for Target 3, oriented slightly off broadside from one of its flat sides. At 9 and 45 degrees the object has a very low average cross-section, below -20 dBsm. At 5 degrees the returns are primarily co-polarized odd-bounce, while at 45 degrees the LL return dominates. Figure 4 illustrates that a 45 degree rotation of the target does little to change its RCS properties; it still retains its low cross-section above 5 degrees. However, it now returns about as much energy in the even-bounce channel as in the odd-bounce channel for the 9 and 45 degree depression angles.

Finally, I have appended a sketch of the measurement set-up, and also a copy of our paper on the Flashlight Radar for your reference. Note that for these measurements an unfocused antenna was used instead of the one in the paper. The unfocused antenna was used to illuminate the entire target and thus measure its total radar cross section.

If you have questions about these measurements or require further information, please contact me at the number below.

Sincerely,

Richard L. Ferranti

Richard L. Ferranti
Staff Member
Battlefield Surveillance
(617) 981-3454

RLF/mh
Attachments

tgldeg5

Linear basis, dB peak-span

-22.034	-41.098	HH	HV
-41.098	-16.405	VH	VV

Circular basis, dB peak-span

-27.698	-18.795	RR	RL
-18.795	-28.785	LR	LL

tgt2 5 degrees

Linear basis, dB peak-span

-16.694	-60.000
-60.000	-12.241

Circular basis, dB peak-span

-15.308	-19.485
-19.485	-15.308

tgt3 5 degrees: slightly off broadside

Linear basis, dB peak-span

-15.062	-35.585
-41.098	-15.696

Circular basis, dB peak-span

-33.590	-15.442
-15.313	-43.709

tgt3 5 degrees: 45 degree rotation

Linear basis, dB peak-span

-14.197	-41.098
-35.585	-14.853

Circular basis, dB peak-span

-32.239	-14.419
-14.639	-60.000

user2:[irving.flash.udata]tgts

tgldeg5
Linear basis, complex peak-span

```
 -0.063 +j(   0.047)     -0.008 +j(   0.000)
 -0.008 +j(   0.000)     -0.133 +j(   0.070)
```

Circular basis, complex peak-span

```
  0.035 +j(  -0.020)     -0.059 +j(  -0.098)
 -0.059 +j(  -0.098)     -0.035 +j(   0.004)
```

tgt2 5 degrees
Linear basis, complex peak-span

```
  0.086 +j(   0.117)      0.000 +j(   0.000)
  0.000 +j(   0.000)     -0.242 +j(   0.023)
```

Circular basis, complex peak-span

```
  0.164 +j(   0.047)     -0.070 +j(  -0.078)
 -0.070 +j(  -0.078)     -0.164 +j(  -0.047)
```

tgt3 5 degrees: slightly off broadside
Linear basis, complex peak-span

```
  0.063 +j(  -0.164)      0.000 +j(  -0.016)
  0.000 +j(  -0.008)      0.047 +j(  -0.156)
```

Circular basis, complex peak-span

```
  0.020 +j(  -0.004)      0.160 +j(   0.051)
  0.160 +j(   0.059)      0.004 +j(   0.004)
```

tgt3 5 degrees: 45 degree rotation
Linear basis, complex peak-span

```
  0.125 +j(  -0.148)      0.000 +j(  -0.008)
  0.000 +j(  -0.016)      0.102 +j(  -0.148)
```

Circular basis, complex peak-span

0.023 +j(0.000)	0.148 +j(0.117)
0.148 +j(0.109)	0.000 +j(0.000)

user2:[irving.flash.udata]tgts2

tgt1 9 degrees.
Linear basis, dB peak-span

-12.731	-41.098
-41.098	-15.062

Circular basis, dB peak-span

-25.424	-13.983
-13.983	-26.999

tgt2 9 degrees
Linear basis, dB peak-span

-10.306	-35.585
-34.671	-20.908

Circular basis, dB peak-span

-18.398	-13.952
-14.246	-20.016

tgt3 9 degrees: slightly off broadside
Linear basis, dB peak-span

-26.398	-35.585
-35.585	-27.945

Circular basis, dB peak-span

-37.911	-27.137
-27.137	-33.752

tgt3 9 degrees: 45 degree rotation
Linear basis, dB peak-span

-41.098	-60.000
-60.000	-27.945

Circular basis, dB peak-span

-35.585	-32.239
-32.239	-35.585

tgt1 9 degrees.
Linear basis, complex peak-span

```
-0.227 +j(  -0.039)      0.008 +j(   0.000)
 0.008 +j(   0.000)     -0.148 +j(  -0.094)
```

Circular basis, complex peak-span

```
-0.039 +j(   0.035)      0.066 +j(  -0.188)
 0.066 +j(  -0.188)      0.039 +j(  -0.020)
```

tgt2 9 degrees
Linear basis, complex peak-span

```
-0.266 +j(  -0.148)     -0.016 +j(   0.000)
-0.016 +j(   0.008)     -0.070 +j(  -0.055)
```

Circular basis, complex peak-span

```
-0.102 +j(  -0.063)      0.102 +j(  -0.172)
 0.102 +j(  -0.164)      0.094 +j(   0.031)
```

tgt3 9 degrees: slightly off broadside
Linear basis, complex peak-span

```
 0.000 +j(  -0.047)      0.016 +j(   0.000)
 0.016 +j(   0.000)      0.000 +j(  -0.039)
```

Circular basis, complex peak-span

```
 0.000 +j(   0.012)      0.043 +j(   0.000)
 0.043 +j(   0.000)      0.000 +j(   0.020)
```

tgt3 9 degrees: 45 degree rotation
Linear basis, complex peak-span

```
 0.000 +j(  -0.008)      0.000 +j(   0.000)
 0.000 +j(   0.000)      0.000 +j(  -0.039)
```

Circular basis, complex peak-span

0.000 +j(0.016)	0.023 +j(0.000)
0.023 +j(0.000)	0.000 +j(-0.016)

user2:[irving.flash.udata]tgts3

tgt1 45 degrees
Linear basis, dB peak-span

-18.949	-41.098
-41.098	-18.529

Circular basis, dB peak-span

-19.929	-22.923
-24.347	-20.900

tgt 2 45 degrees
Linear basis, dB peak-span

-5.139	-25.950
-26.641	-10.565

Circular basis, dB peak-span

-8.743	-15.379
-15.896	-6.758

tgt 3 45 degrees: off broadside
Linear basis, dB peak-span

-21.784	-23.878
-23.878	-19.680

Circular basis, dB peak-span

-32.125	-29.764
-29.764	-16.437

tgt3 45 degrees: 45 degree rotation
Linear basis, dB peak-span

-18.380	-29.574
-29.829	-24.999

Circular basis, dB peak-span

-24.421	-24.203
-23.195	-21.137

RCS report

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tgtl 45 degrees
Linear basis, complex peak-span

0.047 +j(0.102)	0.000 +j(-0.008)
0.008 +j(0.000)	-0.117 +j(0.008)

Circular basis, complex peak-span

0.086 +j(0.051)	-0.059 +j(-0.039)
-0.051 +j(-0.031)	-0.078 +j(-0.043)

tgt 2 45 degrees
Linear basis, complex peak-span

0.078 +j(-0.547)	0.047 +j(0.016)
0.039 +j(0.023)	-0.180 +j(0.234)

Circular basis, complex peak-span

0.109 +j(-0.348)	0.160 +j(-0.055)
0.152 +j(-0.047)	-0.148 +j(0.434)

tgt 3 45 degrees: off broadside
Linear basis, complex peak-span

0.039 +j(-0.070)	0.063 +j(0.008)
0.063 +j(0.008)	0.016 +j(0.102)

Circular basis, complex peak-span

0.004 +j(-0.023)	-0.016 +j(0.027)
-0.016 +j(0.027)	-0.020 +j(0.148)

tgt3 45 degrees: 45 degree rotation
Linear basis, complex peak-span

-0.117 +j(0.023)	-0.031 +j(0.008)
-0.031 +j(0.000)	-0.008 +j(-0.055)

Circular basis, complex peak-span

-0.059 +j(0.008)	0.016 +j(-0.059)
0.016 +j(-0.066)	0.051 +j(-0.070)

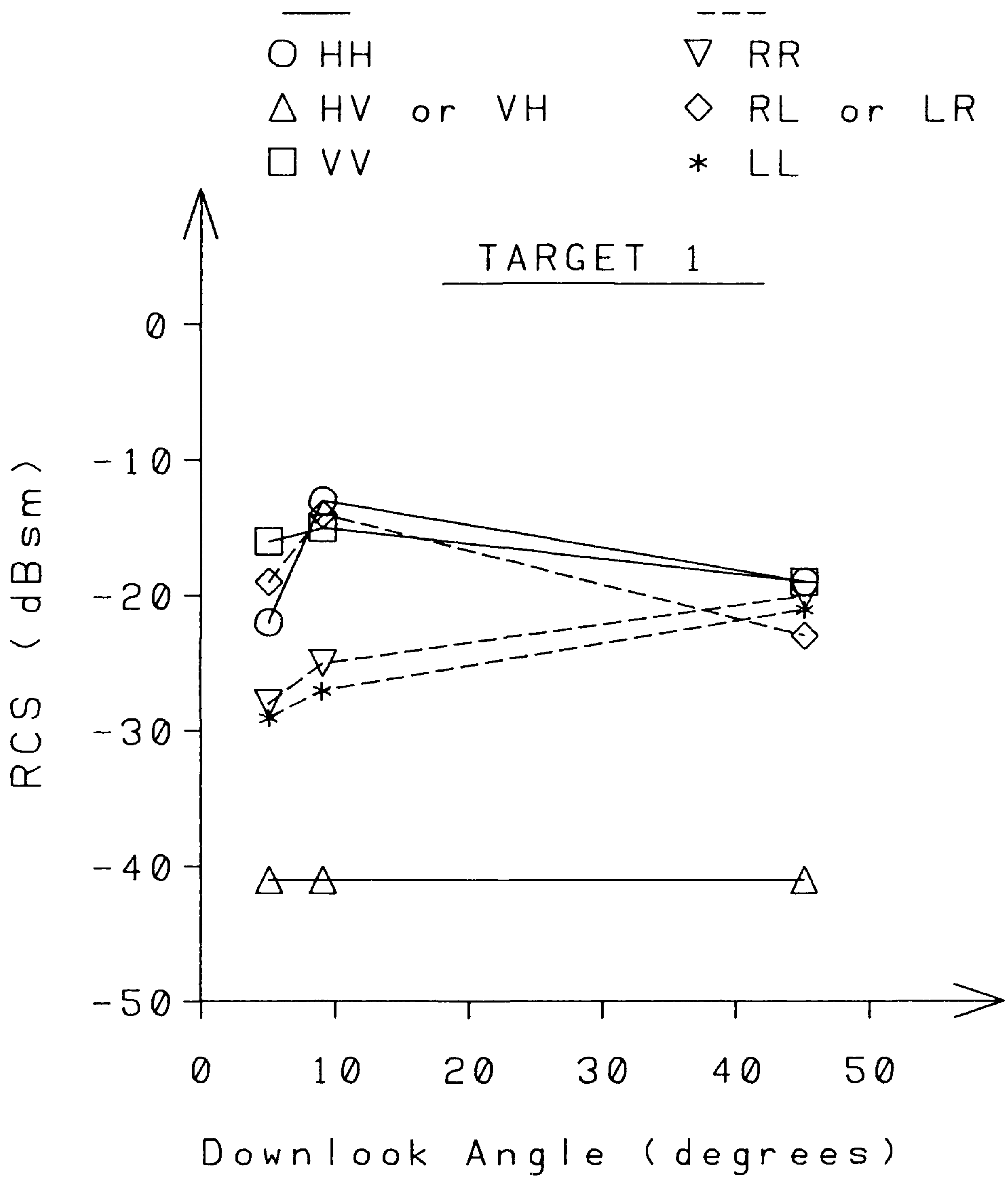

Figure 1: Target 1 RCS Magnitudes

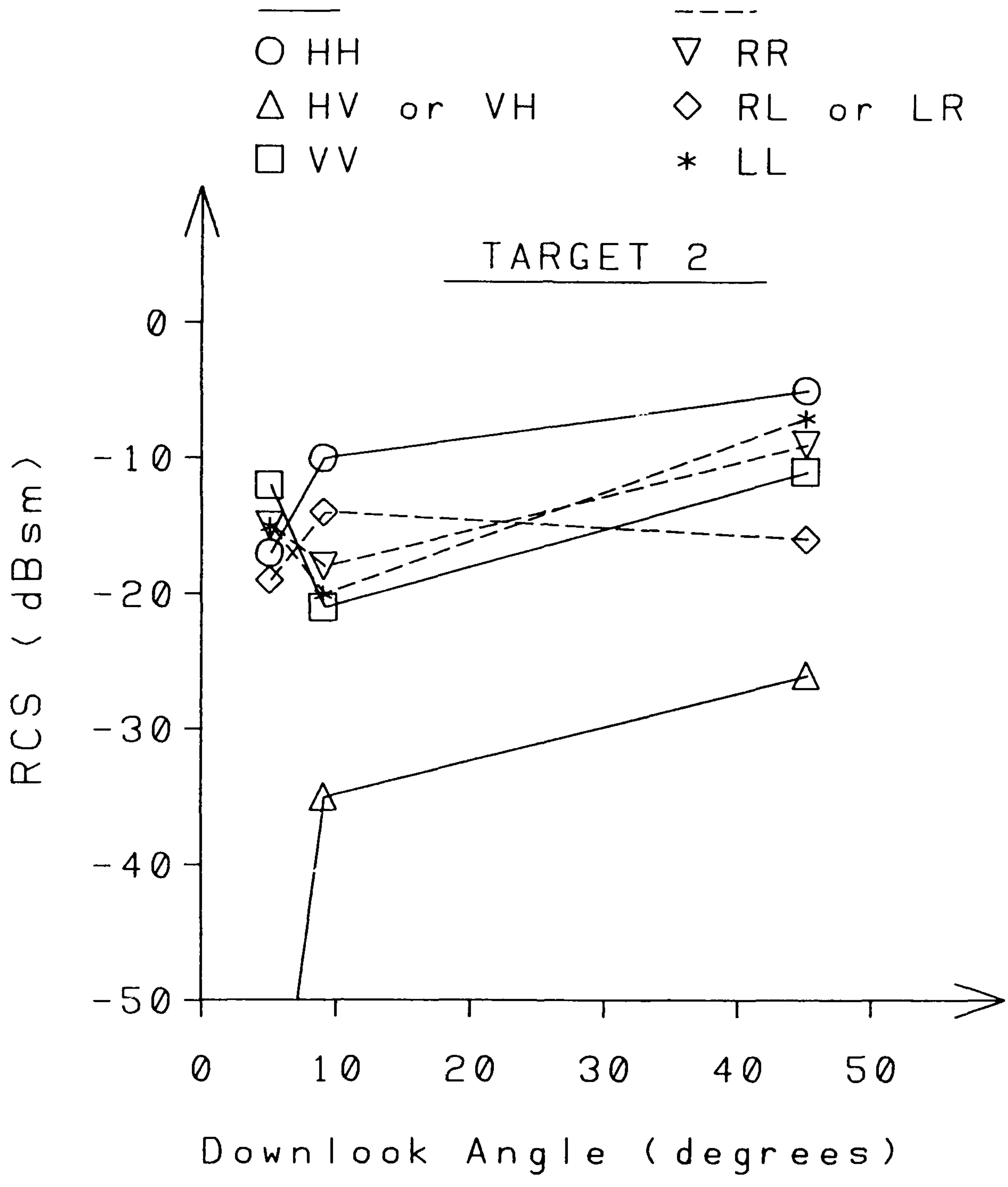

Figure 2: Target 2 RCS Magnitudes

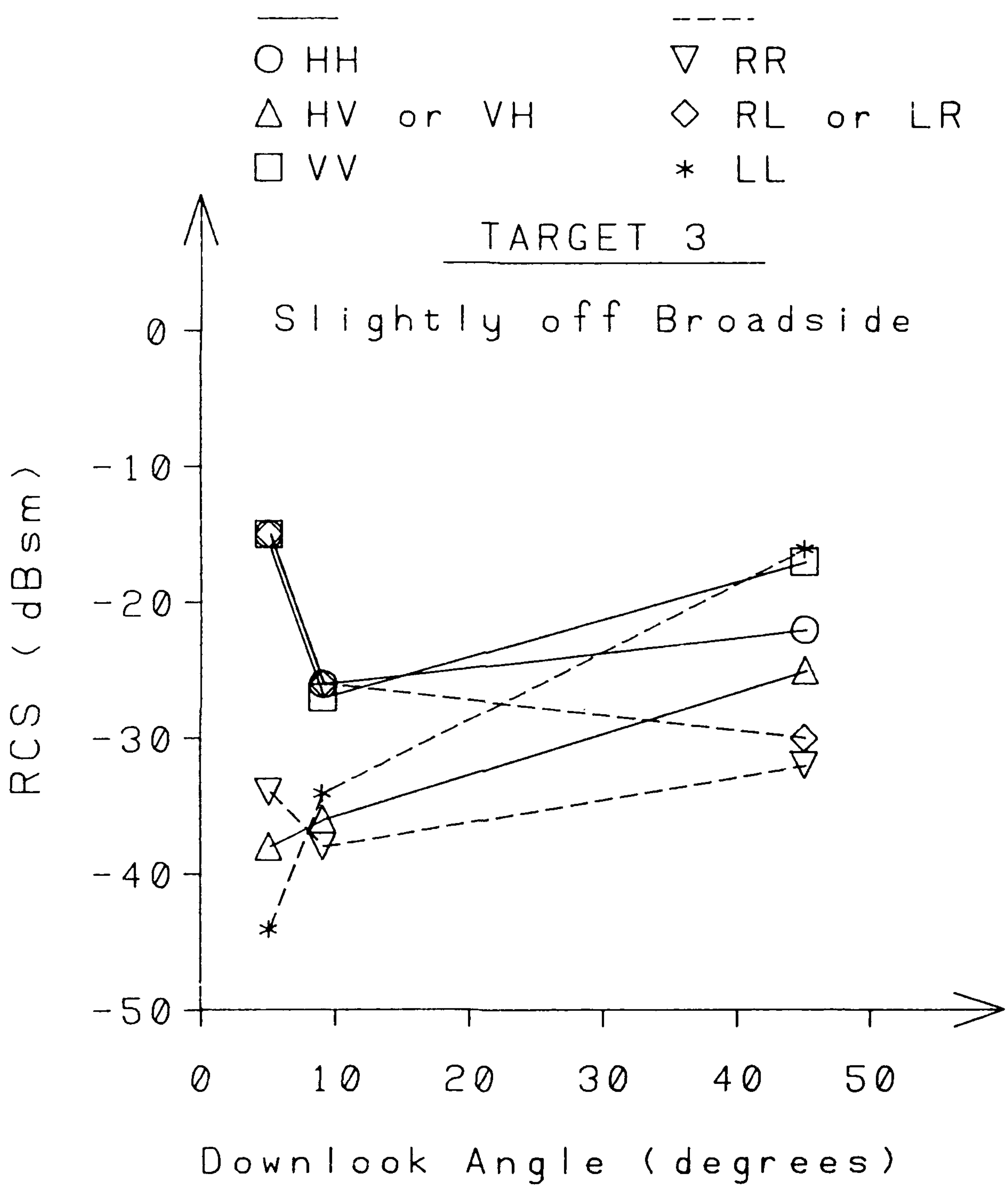

Figure 3: Target 3 RCS Magnitudes, slightly off broadside

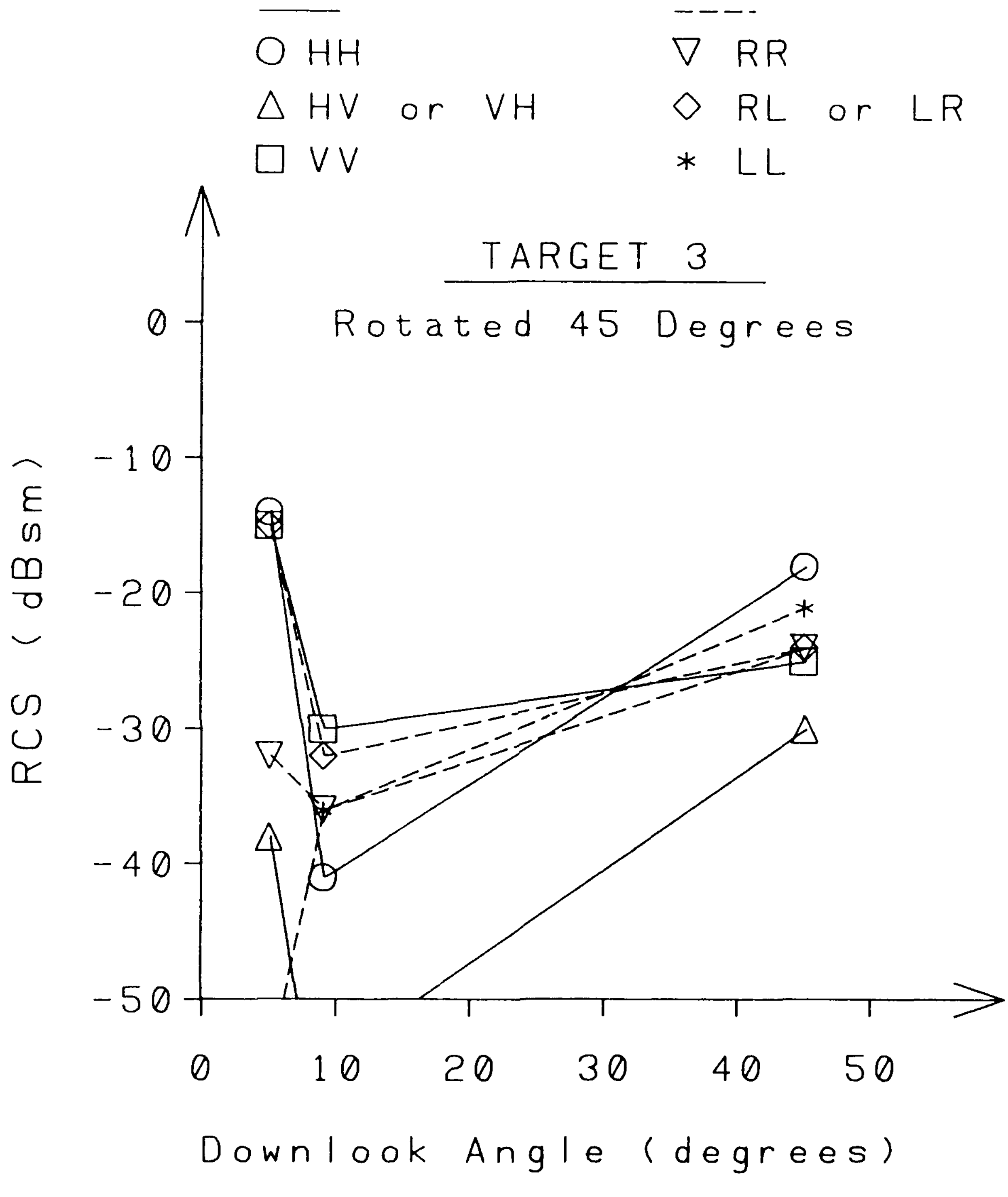

Figure 4: Target 3 RCS Magnitudes, rotated 45 degrees

MEASUREMENT SET-UP