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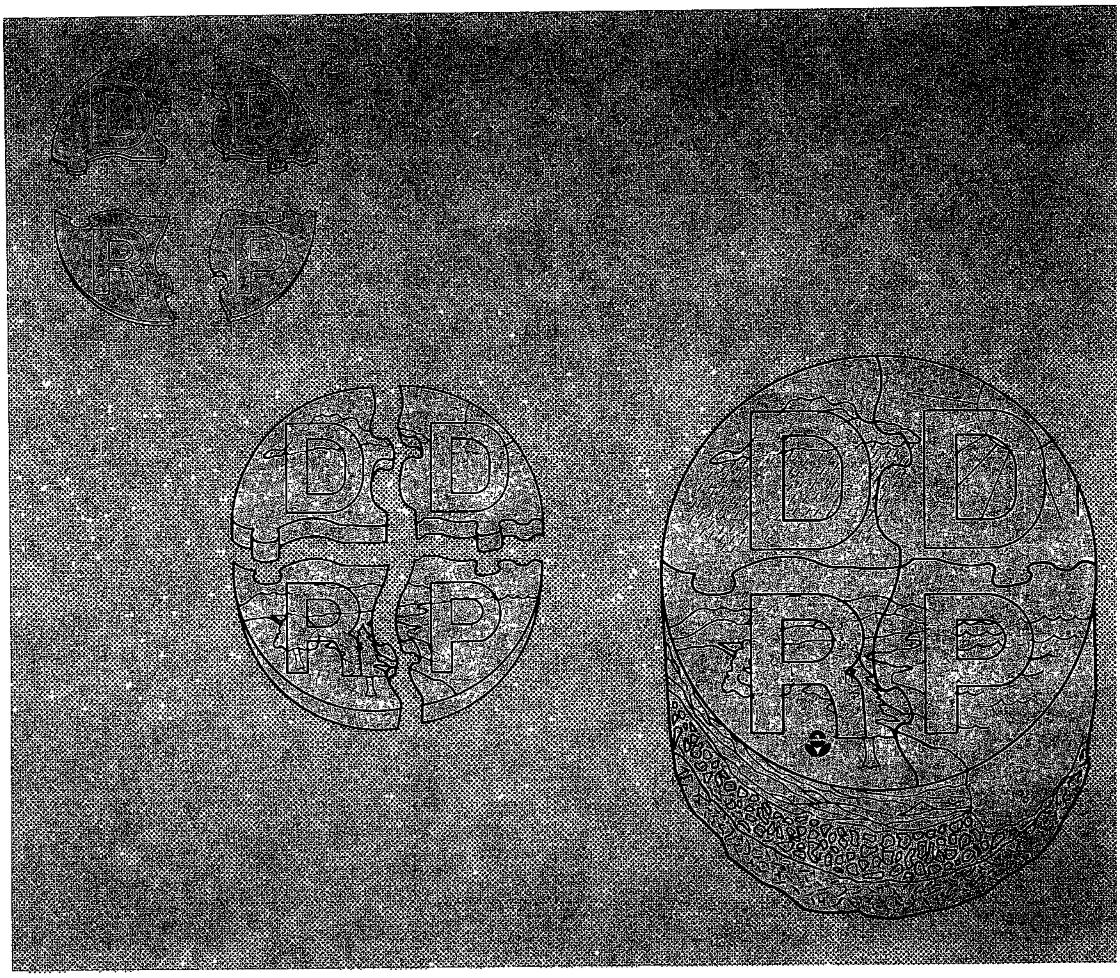
Volume I. Sampling



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Direct/Delayed Response Project: Field Operations and Quality Assurance Report for Soil Sampling and Preparation in the Northeastern United States
Volume I: Sampling

by

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A Contribution to the
National Acid Precipitation Assessment Program

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Notice

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This document is one volume of a set which fully describes the Direct/Delayed Response Project, Northeast and Southeast soil surveys. The complete document set includes the major data reports, quality assurance plans, analytical methods manuals, field operations reports, and quality assurance reports. Similar sets are being produced for each Aquatic Effects Research Program component project. Colored covers, artwork, and the use of the project name in the document title serve to identify each companion document. The proper citation of this document remains:

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Abstract

The Direct/Delayed Response Project is designed to address the concern over potential acidification of surface waters by atmospheric deposition within the United States. The Northeastern soil survey was conducted during the autumn of 1985 as a synoptic physical and chemical survey to characterize watersheds located in a region of the United States believed to be susceptible to the effects of acidic deposition. This document describes the planning activities and summarizes field operations and quality assurance/quality control activities associated with soil sampling activities of the Northeastern soil survey.

Prior to the regional soil survey, a pilot study was conducted to develop and test site location protocols and field sampling procedures and to assess logistical constraints associated with implementing these procedures. Twenty-five soil series and 51 pedons were sampled in New York, Maine, and Virginia. From this study, a sampling site selection algorithm was developed to select soil and vegetation classes for sampling activities in the Northeastern region. A total of 306 pedons were described and sampled in the Northeastern soil survey.

In general, soil sampling activities during the survey proceeded as planned. Pertinent observations, problems, and concerns are discussed in this report and recommendations are made for modification and improvements. These recommendations may be valuable to planners of similar projects.

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List of Abbreviations

DDRP	Direct/Delayed Response Project
DQO	Data quality objective
ELS	Eastern Lake Survey
EMSL-LV	Environmental Monitoring Systems Laboratory-Las Vegas, Nevada
EPA	U.S. Environmental Protection Agency
ERL-C	Environmental Research Laboratory-Corvallis, Oregon
FD	Field duplicate
GIS	Geographic Information System
NADSS	National Acid Deposition Soil Survey
NAPAP	National Acid Precipitation Assessment Program
NCSS	National Cooperative Soil Survey
NSWS	National Surface Water Survey
ORNL	Oak Ridge National Laboratory
QA	Quality assurance
QAMS	Quality Assurance Management Staff
QC	Quality control
RCC	Regional Correlator/Coordinator
SAF	Society of American Foresters
SCS	Soil Conservation Service

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Section 1

Introduction

Background

The Direct/Delayed Response Project (DDRP) is an integral part of the acidic deposition research program of the U.S. Environmental Protection Agency (EPA). The EPA program is conducted under the federally mandated National Acid Precipitation Assessment Program (NAPAP) which addresses the concern over potential acidification of surface waters by atmospheric deposition within the United States. DDRP is administered by the EPA Environmental Research Laboratory, Corvallis, Oregon (ERL-C).

The overall purpose of DDRP is to characacterize geographic regions of the United States by predicting the long-term response of watersheds and surface waters to acidic deposition. Two regions were selected for study because of their apparent history of sensitivity to acidic deposition: the Northeastern region of the United States and the southwestern portion of the Blue Ridge Province. Based on the results of previous surface water surveys conducted by EPA and on data from DDRP, each watershed system in these two regions will be assigned one of the following three classifications. Each category is defined according to the time scale in which the system is assumed to reach steady-state conditions at current levels of acidic deposition:

- Direct Response - Watersheds with surface waters that are either presently acidic (alkalinity is less than 0) or will become acidic within a few (3 to 4) mean water residence times (less than 10 years).
- Delayed Response - Watersheds in which surface waters will become acidic after a period of from a few mean water residence times to several decades (within 10 to 100 years).
- Capacity Protected - Watersheds in which surface waters will not become acidic for centuries to millennia.

Two specific objectives of the DDRP regional soil surveys are as follows:

- To characterize the variability of the physical, chemical, and mineralogical properties of soils sampled in watersheds in the regions of concern.
- To define other descriptive watershed characteristics, e.g., vegetation type and depth to bedrock, of the regions of concern.

Data from the DDRP research will be collected and analyzed at three levels:

- Level I - System description and statistical analysis.
- Level II - Single factor response-time estimates.
- Level III - Dynamic systems modeling.

Field and laboratory data collected in the aquatic, soil, and vegetation surveys will comprise the system description in Level I. Next, these data will be used in Level II to develop single factor estimates of the response time of watershed properties, e.g., sulfate adsorption capacity, to acidic deposition. Finally, the detailed data from special interest watersheds will be used in Level III to calibrate three dynamic simulation models, MAGIC (Cosby et al., 1984), ILWAS (Chen et al., 1984), and

Trickle-Down (Schnoor et al., 1984), that predict regional ecosystem response to acidic deposition. The response-time estimates developed in Level II will be used in these calibrated simulation models to predict regional responses to acidic deposition.

Soil and Vegetation Surveys

DDRP is comprised of three component survey activities: soil mapping, vegetation mapping, and soil sampling. The soil mapping and vegetation mapping tasks were the responsibility of ERL-C. The soil sampling was conducted as a cooperative effort of two EPA laboratories under the management of the technical director at ERL-C. The soil sampling task leader at ERL-C had overall responsibility for the soil sampling including quality assurance/quality control (QA/QC) for the site selection and profile descriptions. Logistical support and sampling, preparation, and analytical QA/QC support were provided by the EPA Environmental Monitoring Systems Laboratory located in Las Vegas, Nevada (EMSL-LV).

Quality Assurance/Quality Control

A QA/QC program was developed to assure the validity of the profile description and sampling efforts of the DDRP Soil Survey. The integrity of the sampling activities affects the ultimate quality of data derived from the physical, chemical, and mineralogical analyses of the samples. The QA/QC program was designed to assess data quality so that potential users of the data may determine if the data meet their project needs.

In addition, the QA/QC program was designed to assure that the data are comparable. To achieve comparability, soils were described and sampled according to documented protocols (see Appendix A), although special interest watersheds were sampled using slightly modified protocols. Laboratory analyses were conducted according to documented protocols (Cappo et al., 1987).

Field Operations Documentation

This report documents field operations during sampling activities in the Northeastern Soil Survey, and evaluates compliance with the protocols provided to the sampling crews. Deviations from the protocols are documented, data for profile descriptions are reviewed, and an evaluation is made of the potential effect of these deviations on the validity of the sampling and the integrity of the samples. In addition, this report recommends modifications to the sampling protocols that should be considered for future surveys.

This report was primarily developed from the following sources of information:

- Documents referenced in this report.
- Sampling log books.
- Field data forms.
- Photographic slides of each pedon sampled.
- Audit reports by QA/QC staff.
- Sample receipt log books.
- Project reports to EPA management.
- Interviews of project participants.
- Notes from the meeting held at the close of the sampling and preparation activities.

The Northeastern Soil Survey

The Northeastern Soil Survey included the states of Maine, New York, New Hampshire, Pennsylvania, Connecticut, Rhode Island, Vermont, and Massachusetts. In New York and Massachusetts, special interest watersheds were sampled as part of this survey. The design of the soil survey is presented schematically in Figure 1.

Mapping of Soils and Vegetation

Soil mapping and vegetation mapping were conducted in accordance with the protocols described in Lammers et al. (in preparation). Mapping was conducted primarily by Soil Conservation Service (SCS) soil scientists under interagency agreements between EPA and the U.S. Department of Agriculture (USDA). In some states, SCS subcontracted cooperators at land-grant universities and private

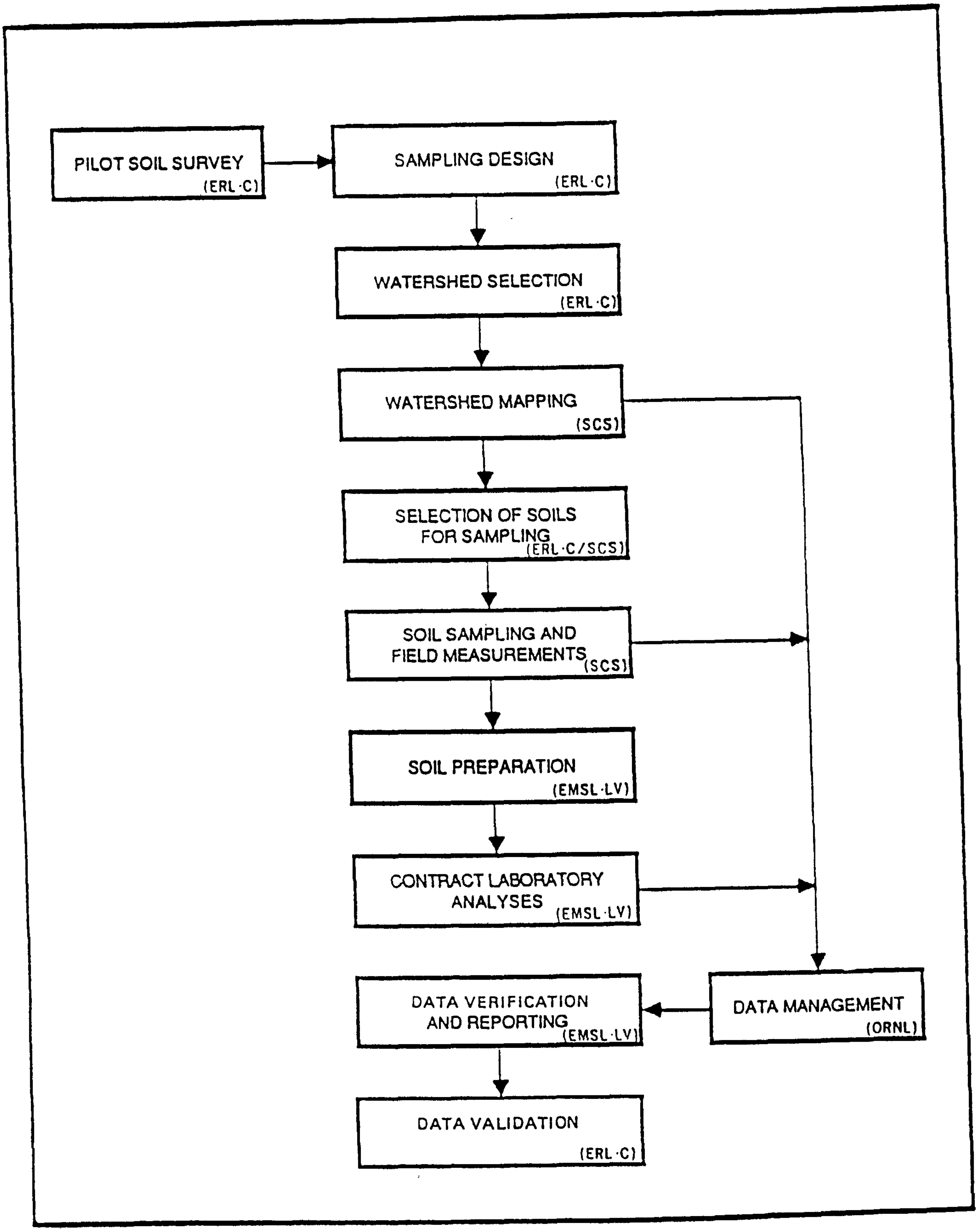

Figure 1. Design for the Direct/Delayed Response Project Soil Survey.

consultants, and temporarily hired other individuals for staffing the sampling crews.

Survey of the Surface Water

The National Surface Water Survey (NSWS) is a NAPAP program designed and implemented by EPA to conduct a chemical survey of lakes and streams located in regions of the Eastern United States believed to be susceptible to the effects of acidic deposition. Phase I of this program included the Eastern Lakes Survey (ELS), conducted in the fall of 1984. Of the 1,763 lakes visited during the survey, 1,612 were sampled. Chemical characterizations were performed on 2,399 samples from these lakes. Sampling was not undertaken if lakes were ice covered or thermally stratified, the specific conductance of the water exceeded 1,500 μS/cm, or landing conditions for the sampling helicopters were hazardous.

Pilot Soil Survey

Concurrent with ELS in 1984, a pilot soil survey was conducted in Maine and New York in the northeastern region and in Virginia in the southeastern region. The pilot study provided information for planning and designing the Northeastern Soil Survey. Complete details of the pilot survey are provided in Chapter 3 of the DDRP Action Plan/Implementation Protocol (U.S. EPA, 1985) and in Reuss and Walthall (1987).

Watershed Selection for the Soil Survey

The 773 watersheds included in the northeastern region of the ELS were used to determine possible watersheds to be sampled in the Northeastern Soil Survey. A stratification model based on alkalinity was used to examine physical and chemical data from the ELS and to set boundaries for the strata. Lakes were grouped into three strata, defining 149 possible low alkalinity watersheds for mapping and Soil Sampling activities for the Northeastern Soil Survey. The watershed selection method is detailed in chapters 2, 3, and 4 of the DDRP Action Plan/Implementation Protocol (U.S. EPA, 1985).

Soil Mapping and Development Sampling Classes

The objective of the soil mapping was to identify soil types occurring within the watersheds, so that similar soils could be grouped into sampling classes. Mapping for the Northeastern Soil Survey was conducted from April through July, 1985. The protocols used in mapping are detailed in Chapter 7 of the DDRP Action Plan/Implementation Protocol (U.S. EPA, 1985). A separate field operations report discusses mapping activities in the northeastern region (Lammers et al., in preparation).

Initial criteria for the development of the sampling classes were as follows:

- Group similar soils so that the variability within a sampling class is less than the variability between sampling classes.
- Restrict the number of sampling classes that have limited occurrence in the watersheds studies, i.e., that occur only in less than 5 percent of the watersheds.
- Restrict the number of sampling classes having a total mapping area of less than 200 acres, i.e., 83 hectares (ha) or about 0.1 percent of the overall area mapped in the region.

The final step was to identify sampling classes in specific watersheds for sampling. The sampling classes were selected to satisfy the following criteria:

- Characterize all sampling classes at similar levels of precision.
- Include the variation in soil characteristics over the watersheds selected for sampling.
- Include the variation in soil characteristics over the clusters developed from the ELS data.

The definition of sampling classes was accomplished at the soil correlation and sampling class selection workshops at Saranac

Lake, New York, July 9 through 11, 1985, and at Corvallis, Oregon, July 16 through 18, 1985. The procedures developed to satisfy the sampling objectives are presented in the QA plan (Bartz et al., 1987) and are detailed in the Definition of Soil Sampling Classes and Selection of Sampling Sites for the Northeast (U.S. EPA, 1986).

Computer Program for Selection of Sampling Sites

The algorithm for watershed and sampling site selection was applied using a personal computer programmed to obtain a list of possible sampling classes for each watershed. The subsequent steps were performed manually by ERL-C staff.

A watershed map with soil mapping units delineated by sampling class was used in conjunction with a 1-ha by 1-ha mylar grid overlay. Random coordinates were generated by a computer program, and located on the grid. If the resulting point did not fall within a soil mapping unit containing the sampling class chosen for that watershed, then another random coordinate point was chosen using the program. If the point fell on a mapping unit that was a soil complex, a random procedure was used to ensure that the probability of accepting the point was approximately equal to the proportion of the sampling class within the complex (see Appendix A, Section 2.5.2, Step 4).

This process was repeated until five random points located within mapping units containing the correct sampling class were designated in the watershed. The points were numbered 1 through 5, in the order of selection, and plotted on the base map. In addition, a vegetation class associated with the sampling class was defined for each point. Copies of the resulting maps and lists of the assigned sampling and vegetation classes were then given to the SCS for site selection purposes.

The method for sampling site selection as described above presented problems when applied to sampling classes that occur as a long, narrow component on the landscape. For these sampling classes, fifty or more random coordinates were often generated before five points were located within the area of the sampling class. Therefore, a second selection method was developed by ERL-C statisticians to reduce the time required to choose five points while satisfying the requirements for a random selection. This second method involved the following steps: (1) overlaying the 1-ha by 1-ha mylar dot grid on the watershed map; (2) numbering all points that fell into mapping units contained in the selected sampling class consecutively from 1 to n; (3) defining the appropriate random number window size which was dependent on the number of points in the sampling class delineations; and, (4) selecting sampling sites 1 through 5 using a five-digit random number table.

For cases in which complexes were under consideration for sampling, an additional keep/reject criterion was applied. Usually the final two, or occasionally three, digits were used for the selection process. However, in complexes, using the occurrence of the sampling class within the sampling unit to the nearest 10 percent as an index, the sampling point was incorporated as a selected site only if the occurrence was greater than or equal to the first digit of the random number. Therefore, the point was rejected as a sampling site when the occurrence was less than the random number with 0 representing 10, because only the major soils were sampled.

Field Selection of Sampling Locations

The sampling crews used the watershed base map and the protocol presented in the field manual (Appendix A) to locate the sampling locations. This system assured a high probability for locating a point within the correct sampling class and vegetation class.

Routine soil sampling conducted by the SCS characterizes soils on the landscape by using descriptive soil series characteristics based on a non-random, highly selective sampling design. The DDRP Soil Survey differs from this routine in that it is based on the random selection of sampling locations within a region of concern. This experimental design, i.e., random sampling of soil pedons, allows derivation of statistically valid inferences concerning watershed responses to acidic deposition. These data can then be applied in the Level III modeling effort.

To fulfill the data requirements for calibration of the acid deposition response models, sampling sites in special interest watersheds were not selected randomly. Instead, the sampling crew was sent to a specified point and instructed to sample a soil that was intended to represent the specific watershed or portion of the watershed from which it was obtained.

Coordination of Sampling Activities

Weekly conference calls between SCS and EPA staff were used to discuss and resolve matters involving sampling protocols and site location difficulties, as well as to review the status of sampling operations and to identify access difficulties, e.g., the need for a helicopter or pontoon plane to access a watershed. In addition, the conference calls also provided regular communication to ensure that all SCS staff were informed of protocol modifications and issues of concern. Major issues resulting from these discussions were documented in the DDRP team reports by the soil sampling task leader.

Exit Meeting

Following soil sampling activities in the northeastern region, an exit meeting was held January 6 through 7, 1986, in Las Vegas, Nevada. Meeting participants included SCS staff from Connecticut, Maine, Massachusetts, New Hampshire, New York, and Pennsylvania; representatives from the sampling crews; ERL-C and EMSL-LV DDRP staff; representatives from Northrop Services, Inc. (technical and support staff for ERL-C), Lockheed Engineering and Sciences Company, (technical and support staff for EMSL-LV), Oak Ridge National Laboratory (ORNL), and the Northeast National Technical Center; and a representative of the Tennessee SCS state office staff (providing Southern Blue Ridge Province representation).

Section 2

Field Operations

Preparation for Field Operations

EMSL-LV was responsible for contracting preparation laboratories, procuring equipment and supplies, and developing sampling protocols prior to the initiation of soil sampling activities. The approach to these tasks is summarized in the following sections.

Preparation Laboratories

Preparation laboratory staff were responsible for storing samples received from the sampling crews, preparing soils for analysis (i.e., drying, sieving, and shipping samples to the analytical laboratories), determining the percentage of rock fragments, testing for the presence of carbonate, and determining the bulk density of clod samples. In addition, preparation laboratory staff initially distributed field equipment and supplies, received requests from the sampling crews for additional equipment and supplies, and inventoried the equipment returned by the sampling crews at the end of the sampling effort.

Four preparation laboratories were contracted by EMSL-LV to provide the services summarized above. The laboratory locations and states assigned to each laboratory are provided below:

Preparation Laboratory	*State Assignments*
University of Massachusetts Stockbridge Hall Amherst, Massachusetts	MA, VT, NH
University of Connecticut Plant Science Department Soil Characterization Laboratory Storrs, Connecticut	CT, RI
University of Maine Department of Soil Science Orono, Maine	ME
Cornell University Department of Agronomy Ithaca, New York	NY, PA

Procurement of Equipment and Supplies

A detailed listing of equipment and supplies is presented in Section 8.0 of Appendix A. Most of the materials were provided by EPA, although SCS personnel used their own equipment and supplies in some cases.

Most equipment and supplies were procured under the direction of EMSL-LV. Cost estimates were obtained from at least three suppliers. The overall cost, shipping charges, and delivery of the purchase within the required time frame were considered prior to the initiation of a support contractor purchase request for each item. For some specialty supplies, e.g., clod storage boxes, a sole source justification was required.

EMSL-LV was responsible for shipping equipment and supplies to the preparation laboratories via air courier, and the preparation laboratory personnel distributed the materials to the sampling crews. Other equipment was supplied directly to SCS personnel by ERL-C.

Protocol Development

A detailed manual was developed to emphasize and modify SCS National Cooperative Soil Survey procedures for accomplishing the objectives of the soil survey. This document includes procedures for sampling, describing, and preparing soils (see Appendix A).

Sampling procedures for the special interest watersheds were modified by ERL-C and provided directly to the sampling crew assigned to special interest watersheds. These modifications were necessary because of the intended use of the data for model testing and calibration. Protocol modifications for site selection of the special interest watersheds resulted in the collection of representative, but not random, samples.

The intensity of horizon sampling was also modified for the special interest watersheds, as follows. Horizons in the pedon normally were subdivided for sampling if they were greater than 20 cm (8 inches) in thickness. In no case should sampling intervals have exceeded 20 cm (8 inches) in thickness, regardless of the perceived uniformity of the horizon or its position within the pedon. Although in some cases it may have been necessary to deviate from these guidelines, sampling crews were encouraged to follow them as carefully as possible, because a primary objective of the special interest watershed study was to intensively sample the pedons for within-profile variations. The ideal sample would have contained all soil materials from the horizon within the pedon, but in actuality this was not a practical measure.

Sampling Crew Training

EPA personnel involved in the sampling effort, SCS personnel, and others contracted by the SCS participated in a sampling workshop in Orono, Maine, from August 7 through 8, 1985. The purpose of the workshop was to review the sampling protocols, to review the field data forms and codes used for pedon description, and to participate in a field exercise following the specified protocols. Two soils were sampled: a typical Northern forest soil (Spodosol) and a wet, bog soil (Histosol). Sampling crew identification numbers and the preparation laboratory to which each crew was to submit samples were assigned during the workshop. Questions pertaining to protocols, particularly sample labeling, were discussed. Some protocols were revised as a result of this workshop. A revised field sampling manual was prepared to incorporate the appropriate modifications that were discussed at this workshop, and the manual was sent to the sampling crews on September 18, 1985. Sampling was underway at that time.

The New York and Maine sampling crews spent additional days training in the field as a group before sampling was initiated. This allowed the crews within a state to develop consistent methods and to review the protocols, particularly for labeling samples and using the field data form codes.

Crew Assignment for Special Interest Watershed Sampling

Special interest watersheds in New York (Woods Lake, Clear Pond, and Panther Lake) and Massachusetts (Caldwell Creek) were sampled by the members of the New Hampshire sampling crew (NH01). This crew was assigned the designations NY04 in New York and MA03 in Massachusetts to differentiate it from the routine sampling crews.

Changes to Sampling Protocols

Prior to the initiation of sampling, the field manual was reviewed by the sampling crews and SCS state staff. Procedures were field tested during the first few weeks of sampling, and some modifications were suggested. This review subsequently resulted in editorial changes and two major protocol modifications for using the field data forms (DDRP Team Report No. 3, September 20, 1985):

- The field data form required entry of latitude-longitude. There was some confusion whether this referred to the latitude-longitude for the lake on the watershed or to the latitude-longitude of the sampling site. The sampling crews were instructed via the SCS to enter the latitude-longitude of the sampling site.

- For some thick soil horizons, separate samples were obtained from the upper and lower portions. Originally the protocol was interpreted that both samples were to be given the same sample code, and were to be distinguished by an additional code (U or L) on the sample label. This protocol was clarified such that the sample code was recognized as the identification of a unique sample, i.e., the sample code identified a separate sample rather than a specific horizon. Therefore, each portion of the thick horizon was assigned a different sample code, and the sample code for two samples would appear on different lines of the field data form.

In addition, two minor changes in protocol were adopted (DDRP Team Report No. 1, September 9, 1985):

- Because sampling to a depth of 150 cm was impractical in C horizons composed of dense, compact till, the crews were instructed to sample near the top of the horizon and to verify, e.g., by a soil core, that the horizon was unchanged to 150 cm.
- Original protocol had required photographs of soil profiles to be taken with either a macro or wide-angle lens. This requirement was changed to specify a wide-angle lens only.

As mentioned above, a revised field sampling manual (Appendix A) incorporating the appropriate changes from the sampling workshop (Appendix B) was sent to the sampling crews on September 18, 1985 (DDRP Team Report Number 3, September 20, 1985).

Soil Sampling

Soil sampling operations cover a wide range of activities including site selection, pit excavation, photographic documentation, pedon description, and soil sampling. Sampling protocols are described in Appendix A. The following sections discuss problems and concerns associated with the implementation of the required sampling protocols. Recommendations are also presented to modify and improve the protocols for use in future regional soil surveys.

Sampling activities were initiated during the week of August 12, 1985, in Maine; the week of August 19, 1985, in New York; and the week of August 26, 1985, in Massachusetts, New Hampshire, Connecticut, and Pennsylvania (DDRP Team Report No. 1, September 9, 1985). All 306 routine pedons had been sampled by November 15, 1985. This met the target date for completion of sampling. A summary of soil sampling activities is provided in Table 1.

The special interest watersheds were sampled during the fall: from October 26 through November 2, 1985, in New York; and from November 15 through 18, 1985, in Massachusetts.

It should be noted that soil sampling activities were begun during unusually dry conditions. Then, cyclonic activity, accentuated by Hurricane Gloria, resulted in excessive rainfall within a short time period during the week of September 23, 1985. Locally, this caused treefalls and road washouts restricting site access and precluding sampling for several weeks.

Site Selection

One of the initial responsibilities of the sampling crew leader was to assess sampling site locations. The watershed maps provided by ERL-C were reviewed to determine the physical accessibility of each site and whether it was located on private or public land.

Table 1. Summary of Routine Soil Sampling during 1985

States	Number of Pedons		Dates of Sampling	
	Designated	Sampled	Initial	Final[a]
Connecticut, Rhode Island	26	23	8/26	10/29
Massachusetts, Vermont	58	54	8/26	10/7
Maine	86	83	8/12	10/30
New Hampshire	30	30	8/26	10/8
New York	88	85	8/19	11/1
Pennsylvania	31	31	8/26	11/7
TOTAL	319	306	8/26	11/7

[a] Determined from a review of sampling log books.

On one watershed, sampling sites had to be reassigned. In this case, only the upperreaches of the South Lake watershed in New York were originally mapped. When sampling site locations were assigned, it was unclear as to whether the whole watershed or only the mapped subcatchment was to be considered for sampling. When the rest of the watershed was mapped, new sampling sites were selected; however, the newly mapped area did not contain any soils of the desired sampling class. Therefore, the newly selected sites were located in the upper reaches of the South Lake watershed as originally assigned (DDRP Team Report No. 5, October 3, 1985).

Site Restrictions

Physical Inaccessibility--

Sites were defined as physically inaccessible if all alternatives for approaching the area were eliminated or if the site were under water. Most sampling points were physically accessible. Pontoon helicopters and fixed-wing aircraft support were available for difficult sites, but could not be used within the wilderness areas of the Adirondacks. If a lake were of sufficient size and presented no discernable obstacles, pontoon planes were landed on the lake. No information was available regarding the use of fixed-wing aircraft for access to specific sites. Helicopters were reserved as a vehicular option for watersheds containing smaller lakes. Helicopters were used for access to the following three watersheds in New York:

- Cheney Pond (watershed identification 1A3-042).
- North Branch Lake (1A2-042).
- South Lake (1A3-065).

There were no identifiable problems associated with this operation.

Access Denied--

In some cases sites were not sampled because access was denied by private landowners. Early in the survey it was suggested that an official letter to the landowners on EPA letterhead (see Appendix C) would be helpful to explain why access was necessary and to assure landowners that the sampling crews were representing the EPA in a national environmental research program. Subsequently, sampling crew leaders reported that the letter was helpful in gaining access and permission to obtain samples on privately owned land.

In Pennsylvania it was found that many sites were located on private land. Accordingly, Pennsylvania SCS staff determined ownership and requested access for all sites before the initiation of sampling in that state. However, access was often granted for only two or three of the selected starting points for the assigned sampling class on a watershed. This consequently limited the number of potential starting points available for site selection.

In other states, access was requested just before the sampling crews prepared to sample each watershed. Four pedons were eliminated because access was denied for all sites which met the predetermined soil and vegetation criteria (see Table 2).

Inappropriate Site Conditions--

Occasionally a pedon was eliminated from the list of selected pedons because of unfavorable conditions observed at the site. These conditions included flooded sites and highly disturbed areas, e.g., parking lots or housing developments built on fill. These locations were considered inappropriate for the DDRP regional characterization of soils (see Table 2).

Vegetation Class Considerations--

Vegetation classes were determined from data obtained during the watershed mapping. Vegetation classes recorded during this mapping activity were identified using Society of American Foresters (SAF) cover types (Eyre, 1980); however, vegetation classes specified for the soil survey were based on an aggregation of SAF cover types (see Appendix A, Section 2.1). In some cases the cover types selected from the mapping could not be found at the site during sampling. Discrepancies were attributed to the method used to group mapping units into sampling classes, mapping error, or vegetative changes at the site between the time of mapping and sampling. Table 3 provides a list of all identified sites that were sampled under a cover type other

Table 2. Pedons Disqualified from Sampling[a]

Watershed ID	Watershed Name	State	Sampling Class	Reason	Pedon Type[b]
1C2-048	Cranberry Pond	NY	I21	Access denied	R,P
1C2-048	Cranberry Pond	NY	I21	Access denied	R
1D1-031	Kings Pond	MA	H3	Seasonal flooding	R
1D1-068	Little Sandy Pond	MA	H3	Access denied	R,P
1D2-049	Spring Grove Pond	RI	E6	Disturbed soil	R,P
1D2-093	Ashland Reservoir	MA	I40	Routine pedon not requested	P
1D3-033	No name	CT	E6	Disturbed soil	R
1E1-061	Little Seavy Lake	ME	I38	Access denied	R
1E1-077	Long Pond	ME	S01	Wrong sampling class	R
1E1-123	First Pond	ME	I38	Flooded by beaver	R

[a] Modified from DDRP Team Report No. 8, October 31, 1985.
[b] Pedon type: R = routine, P = paired.

Table 3. Pedons Sampled under a Vegetation Class Different from that Specified

Watershed ID	Watershed Name	State	Sampling Class	Vegetation Class Requested	Vegetation Class Sampled
1A3-048	Grass Pond	NY	I2	Open, wetland	Conifer
1B3-052	No Name	NY	I25	Open, dry	Mixed hardwood
1C2-050	Moore's Pond	MA	I40	Mixed (Pine-Hemlock)	Conifer
1C2-054	Lake Wampanoag	MA	S01	Hardwood	Mixed
1C3-063	Martin Meadow Pond	NH	I38	Hardwood mapped as conifer	Hardwood
1D3-002	Dyke's Pond	MA	E6	Mixed	Open
1D3-003	Sandy Pond	MA	I41	Open, Wetland	Mixed hardwood
1E2-038	Nelson Pond	ME	S11	Hardwood mapping	Open, logged since

than the vegetation class originally specified. In some instances, permission to alter the specified vegetation class was obtained from ERL-C or EMSL-LV staff prior to sampling. In other instances, the sampling crews sampled the required sampling class, but noted difficulties in locating the appropriate sampling class beneath the specified vegetation type.

It should be noted that the vegetation at a sampling site might be nominally different in terms of percentage from the required vegetation class and still fit the class. This is because the vegetation mapping units were not pure for a given vegetation class, e.g., a conifer class could contain a mixture of up to a 20 percent stand of hardwoods and still meet the criteria for a conifer mapping unit. Sampling crews were instructed to consider vegetation located in the proximity of the site in order to meet suitable sampling criteria. Comments made at the exit meeting indicated that this assessment was not performed consistently by all sampling crews, i.e., some crews considered only the vegetation directly above the point to be sampled.

Effect of Disqualification on the Number of Pedons Sampled for Each Sampling Class--

Of the six sampling classes from which pedons were disqualified (see Table 2), only sampling class I21 appears to be underrepresented with regard to samples with three pedons disqualified and only two pedons sampled. It is likely that not enough samples exist to characterize the variability of this sampling class. Three pedons each were disqualified from sampling classes E6 and H3; however, six pedons were sampled for each sampling class. Two pedons were disqualified from I38, one from I40, and one from S01; the number of pedons sampled for those sampling classes were seven, nine, and seven, respectively.

Protocol Adherence--

A problem was identified at the exit meeting that affected sample class determinations because the crews had varying perceptions of what constituted a sampling class. Some decided, erroneously, that sampling classes were restricted to specific soil series. This interpretation would lead to rejection of pedons that met the broad criteria for a sampling class but not the narrow criteria for a series. The correct approach should be emphasized in the protocols for future surveys by providing a specific definition of "sampling class", a flowchart indicating soils included in the sampling class (see Appendix D), and instructions on the use of the flowchart. It should be stated that series criteria are not an overriding factor for selecting a site within the sampling class.

The site selection protocol was adhered to by all sampling crews except MA01. Protocol deviations by MA01 were noted in the sampling log book entries and QA auditor's report. The primary protocol deviation was failure to observe the 20-foot interval requirement along random transects from the originally specified sampling point to an acceptable sampling point. The following are excerpts from the MA01 sampling log book (pp. 16 and 17) and from an audit report, respectively:

> "There were two points designated within this watershed for the I40 sampling class. They were both in the same map unit. This map unit has several homes and roads within it and two marsh symbols. There is a limited area suitable for sampling, so I decided to locate the sampling site within a wooded, vacant lot."

> "The protocol deviations used by the crew are as follows. The first involved site selection. Protocol was followed--up until pacing the transects at 20-foot intervals. As vegetation was important in the selection, pacing proceeded until the correct vegetation was located."

Additional MA01 logbook entries did not indicate any obvious site selection protocol deviations. The entry corresponding with the audit visit did not detail site selection procedures or provide evidence of the incorrect site selection protocols observed by the auditor.

Often insufficient information was provided in the log books to determine what site selection procedures were used. Conversely, highly detailed site selection discussions were provided in the sampling log books for some pedons. It appears that the auditor did not discuss these protocol deviations with the MA01 sampling crew or mention the importance of randomized site selection.

Recommendations for Site Selection--

In Connecticut, New Hampshire, Rhode Island, and Maine, the SCS state office staff determined the sampling site locations for many pedons. The sampling crews were directed to a flagged location. This procedure enabled the field crew to sample two pedons per day. Sampling crews were also able to label sample bags and fill out a portion of the field data form before arriving at the site. This was not the routine procedure for other states, but it is recommended that this procedure be considered as an option to facilitate sampling.

Sampling Difficulties Relating to Soil Characteristics

Histosols--

In many instances where the sampling class required that a Histosol be sampled, inherent difficulties in description and sampling were encountered. In these wet organic soils, excavating a pedon for description and sampling was not possible. Therefore, samples were obtained using an auger or post-hole digger, and placed on plastic sheets for description.

In one instance, the sampling log book stated that the sampling crew had to remove the organic borings by hand because the material would not remain in the auger. The primary concern in sampling these soils is the possibility of contaminating subsurface samples, because the deeper horizons must necessarily be recovered through the surface horizons. Additional difficulties can occur in reconstructing the soil profile and determining accurate horizon designations and boundaries. Variability in horizon thickness further complicates the collection of discrete, uncontaminated samples.

Wet or Saturated Mineral Soils--

A number of pedons were sampled at locations that were extremely wet or subject to a high water table. These sites included pedons with water seepage that advanced into the bottom of the pit, as well as those with partial or complete saturation of the profile.

A number of measures were implemented for sampling wet soils in order to reduce the likelihood of sample contamination. As discussed in the previous section, boring was one method used to collect wet samples. In less extreme situations, water could be removed from the bottom of the pit by hand bailing or by the use of mechanical and hand pumps. In addition, sampling was initiated at the bottom of the pit and progressed upward in an effort to avoid sample contamination as water rose in the pit. From an assessment of log book comments, all crews seemed cognizant of the need to prevent sample contamination.

The protocols for sampling saturated soils were discussed at the exit meeting. It was agreed that, whenever possible, groundwater should be removed from soil pits before sampling. When no other sampling method is feasible, a bucket auger or post-hole digger can be used to obtain satisfactory soil samples. In future surveys, the use of bucket augers or post-hole diggers should be documented on the field data form and in the log book.

It was recommended that EMSL-LV provide hand pumps to the sampling crews for future surveys. In addition, it was suggested that future field sampling manuals include the following recommendations for draining wet soil pits:

- Dig a sump hole in a corner of the pit away from the face to be described. Bail or pump water from the sump hole as necessary.
- Dig sump holes upstream of the groundwater flow, if the direction can be determined, to intercept or divert the groundwater flow.
- In level areas, dig a number of sump holes around the pit to temporarily intercept the groundwater flow.

It is possible that none of the above suggestions will work in situations where the soil materials are coarse-textured and lateral groundwater movement is rapid. One soil scientist participating in the soil survey stated that collecting uncontaminated samples from high water table soils is an impossible task given the use of standard field sampling equipment such as that employed in this project.

Later during a conference call on December 20, 1985, ERL-C and EMSL-LV staffs agreed that an effort would be made to determine which pedons were sampled using bucket augers or post-hole diggers. In the data base, these pedons would be tagged with a data qualifier "W" to identify samples that may have been contaminated because of the sampling method. Those suspect samples are listed in Table 4, although there may be others that were not identified in the log books or on the field data forms. Samples that may have been contaminated because of other conditions observed during sampling are also listed in Table 4.

Other Problem Soils--

In some cases, soil pits could not be excavated to the required 1.5 m depth. Large rock fragments or dense substrata were often the limiting factor rather than lithic or paralithic bedrock contacts. These situations were evaluated by the sampling crew leader, who determined the feasibility of further manual excavation. The protocols required that all on-site decisions regarding excavation depths be documented on the field data form.

Equipment for Pedon Description and Sampling

The success of pedon excavation and description, photographic documentation, clod sampling, sample storage and transportation, and other field activities was dependent on

Table 4. Pedons with Possible Contamination or Other Characteristics that may Affect Analytical Results

Watershed ID	Watershed Name	State	Sampling Class	Reason for Concern
1A1-012	Whitney Lake	New York	S05	C horizon saturated
1A1-020	Fourth/Bisby Lake	New York	H3	Limed
1A1-064	Mt. Arab Lake	New York	E02	Bucket auger used for 3C
1A2-048	No Name	New York	H2	Auger sample
1A3-043	Unknown	New York	E02	Wet, pH higher than expected
1B1-043	Penn Lake	Pennsylvania	I30	Strip mine
1B1-043	Penn Lake	Pennsylvania	E6	Strip mine
1B3-021	Lil Butler	Pennsylvania	I33	Manure, fertilizer
1B3-032	Wixon Pond	New York	H2	Wet, required laying out to describe
1B3-041[a]	East Stroudsburg Reservoir	Pennsylvania	H2	Bucket auger and post-hole digger used
1B3-051	Barret Pond	New York	H2	Wet, required laying out to describe
1B3-052	No Name	New York	E6	Parking lot, fill
1B3-053	No Name	Pennsylvania	I33	Wet
1B3-056	Riga Lake	Connecticut	H2	Wet, interhorizon contamination, auger and spade used
1B3-062[a]	Bassett	Pennsylvania	I25	Hayfield, limed
1C1-009	Upper Baker Pond	New Hampshire	I37	Sampled Cg2 with bucket auger
1C2-021[a]	Clear Pond	Maine	S12	Auger sample, standing water at 28 cm
1C2-057	Babbidge Reservoir	New Hampshire	E02	Sampled Cg2 with bucket auger
1C2-057	Babbidge Reservoir	New Hampshire	I01	Bucket auger used for lower C (113 to 150 cm)
1C2-057[a]	Babbidge Reservoir	New Hampshire	I01	Sampled Cg and Cg2 with bucket auger
1C2-062	Pemigewasset	New Hampshire	I37	Sampled Cg3 and Cg4 with bucket auger
1C2-062	Pemigewasset	New Hampshire	I38	Sampled Bg and 2Crg with bucket auger
1C3-031	Sadawaga Lake	Vermont	H3	Quaking mat, hand-collected Histosol
1D1-054	Upper Mill Pond	Massachusetts	H3	Post-hole digger from 38 to 150 cm
1D2-093	Ashland Reservoir	Massachusetts	I10	Manure, fertilizer
1D3-020	Little Alum Pond	Massachusetts	I9	Auger used from 125 to 150 cm
1E1-082	Stevens Pond	Maine	S11	Field burned, treated with herbicide (Velpar)
1E2-002	No Name	Maine	I46	Auger used from 108 to 135 cm
1E2-063	Kaler's Pond	Maine	E2	Sampled IICg and IIC with bucket auger

[a] Paired pedon.

the equipment supplied to the trained sampling crews. The immediate availability of equipment to the sampling crews was an important factor. The utility, reliability, durability, and efficiency of the equipment had a major effect on the quality of the sampling. Recommendations of the sampling crews to modify, eliminate, or procure equipment for use in future surveys are discussed below.

Plastic Sample Bags--

Observations were made early in the survey regarding the use of plastic sample bags. The sampling crews noted that when heavy, wet samples were obtained, double-bagging was necessary to avoid bag breakage during transport. Dry samples usually did not require the same precautions and no more than one plastic bag was needed. Some crews routinely double-bagged all samples as a precautionary measure.

Staplers--

Small, hand-held staplers that use standard staples were supplied for securing the plastic bags. Several sampling crews commented that heavy duty staplers with large staples would be more durable in the field, although some crews preferred the small staplers because they were light weight and more convenient for carrying to remote sampling sites. It is recommended that both types of staplers be made available to the sampling crews for future surveys, and then crews can use the type they prefer.

Sharpshooter Shovels--

A number of sampling crews noted that sharpshooter shovels, also known as tile spades, had a short life span when subjected to frequent use. The primary difficulty was that these shovels broke or dented easily.

However, they did appear to be especially effective in pit excavation. For that reason, sampling crews recommended that a number of backup sharpshooters be made available to sampling crews when replacement was necessary.

Styrofoam Coolers--

Samples were typically stored in local cold storage facilities at the end of the day or transported directly to the preparation laboratory. Styrofoam coolers containing gel-pacs were used only when samples could not be placed in cold storage within 24 hours after collection, or when samples could not be transported directly to the preparation laboratories. For the New York crews, sufficient coolers were not always available. To meet this deficiency, 40-gallon plastic garbage pails were substituted when necessary.

Thermometers--

Sampling crews were supplied with thermometers to monitor the temperature in the styrofoam coolers during sample transport and storage. Temperature data were desired to assess the efficiency of the gel-pac cooling system. It was found that the styrofoam coolers in conjunction with the gel-pacs maintained temperatures at or below ambient soil conditions. However, when soils were sampled on very cold days, some crews reported that the samples were colder than the partially thawed gel-pacs, and the samples were responsible for maintaining the temperature in the styrofoam coolers.

Measurement of the internal temperature of the coolers is not recommended for future surveys, provided sample delivery within 24 hours is guaranteed and the coolers are protected from direct sunlight at all times.

Gel-Pacs--

Many gel-pacs initially supplied by EMSL-LV had been used previously in ELS, and leaked electrolyte solution upon thawing. Generally, samples were thought to be protected, because they were contained in plastic bags within cloth sample bags. However, many samples contained angular rock fragments that were capable of puncturing the plastic bags.

Because of the unreliability of the gel-pacs, sampling crews double-bagged the gel-pacs in plastic zip-lock bags to limit the possibility of sample contamination. As the survey progressed, gel-pacs subject to leakage were replaced.

The sampling log books did not identify any samples that had been contaminated by gel-pac leakage. The sample receipt log books kept at the preparation laboratories did not note any problems related to gel-pac leakage.

Photographic Equipment--

Sampling crews were asked to provide 35-mm cameras for photographic documentation. Fast (ASA 400) slide film was recommended for photography in the understory when a flash was not used; however, sampling crews were encouraged to evaluate the quality of the initial slides and subsequently to change film speed or film type, if necessary.

At the exit meeting, the following recommendations were given to improve the quality of the photographic documentation for future surveys.

- EMSL-LV should supply a compact, 35-mm camera with a built-in flash and a wide-angle lens to each sampling crew.
- ASA 400 film should be used, regardless of light conditions.
- A standard metric scale should be used in all pedon and understory photographs.
- A standard gray card for pedon and understory identification should be supplied to all sampling crews. The crew will be responsible for the black lettering.
- Pedon faces that are partially shaded should be photographed when fully shaded to provide uniformly lighted exposures.
- Horizon boundaries should be marked with golf tees to make them more visible in the photographs.

Hand Pumps--

Hand pumps were not supplied by EPA for this survey; however, the experiences with sampling wet soils indicate that hand pumps should be supplied in the future. Sampling crews that used hand pumps indicated that some models deteriorated quickly because of suspended sand and silt in the water being pumped from the soil pit. An appropriate model would be one, e.g., the Beckman Gusher, that does not wear rapidly in the field environment.

Sample Sieving Protocol

In general, sieving at the sampling site to remove rock fragments greater than 20 mm in diameter was implemented successfully. However, two preparation laboratories indicated that samples containing rock fragments greater than 20 mm were processed at the laboratories on several occasions. The sample bags were not labeled with this information, and the information was not entered in the sample receipt log book at the time samples were submitted to the preparation laboratories.

This deviation from protocol has several implications. First, for those samples, the sampling crew's estimate of the volume of rock fragments is suspect. Secondly, it must be presumed that the sampling crew collected a sufficiently large sample so that the amount of fine earth material is representative of the pedon. Finally, the corresponding determination of percentage rock fragments in the 2- to 20-mm fraction, which is performed at the preparation laboratory, is suspect.

Sampling crew NY03 did not sieve samples from the four pedons because the sieve was not taken to the field when those samples were collected. The sampling log book noted that the following samples had not been sieved:

Identification	*Watershed Name*	*Sampling Class*
IB3-052	No Name	E6 (sampled in duplicate)
IB3-052	No Name	I25
AI-003	Nawk Pond	S05

This protocol deviation was not recorded in the sampling log books or on the field data forms of other crews, although another preparation laboratory received some unsieved samples. The personnel at that preparation laboratory commented that unsieved samples could not be identified at the time samples were submitted by the sampling crew. While the unsieved samples were within the plastic bags, large rock fragments were not visible.

For future surveys, the protocols should be written to emphasize that the sampling crew is responsible for noting any unusual sample conditions or protocol deviations in the sampling log book, on the field data form, directly on the sample bags, and in the sample receipt log book. The preparation laboratory should note unsieved samples in the sample processing log book.

Sample Labeling Discrepancies

During the initial days of sampling, a number of samples were mislabeled by the crews. Normally, preparation laboratory personnel were able to identify and correct mislabeled samples at the time the sample code and horizon interval (Label A) data were verified against the corresponding field data form. It was very important that each sampling crew submit the field data forms to the preparation laboratory with the samples, but this was not done consistently. Often the preparation laboratories waited several weeks before receiving the field data forms.

After these initial difficulties were resolved, the frequency of labeling errors decreased with time. Sample labeling errors did not result in any serious identification problems for the preparation laboratory personnel, therefore, no samples will be tagged as suspect in the data base because of mislabeling.

Clod Sampling for Determination of Bulk Density

Sampling crews were instructed to collect three clod samples from each horizon if it were physically possible to obtain them. Sampling crews were instructed to prepare clods by immersing them in a Saran:acetone solution of 1:4 or 1:7 by weight, depending on the stability of the clod. The sampling crews were instructed to record the number of times the clod was dipped into the Saran:acetone mixture. This information was used in the calculation for bulk density. [Please note that the equation for calculating the weight of air-dry Saran as stated on Page 3 of 5, Section 7.0 of Appendix A is incorrect. Refer to Papp and Van Remortel (1987) for the correct equation.]

The clod sampling procedure is complicated by horizon thickness, soil structure and consistence, cohesion/adhesion properties, soil texture, root density, and the field moisture content of the soil. Because clods were not expected to be collected from every horizon, the projected success rate for sampling was 50 percent. EMSL-LV QA staff assessed that the success rate for excavating clods from mineral horizons was 48 percent. Comments by sampling crews indicated that clod sampling was more successful after the soils had been moistened by precipitation associated with Hurricane Gloria.

In one situation, the clods collected were too wet to retain their integrity in the Saran mixture. This information was recorded in the MA02 sampling log book for watershed ID3-020, sampling class I37, but there was no corresponding entry in the sample receipt log book. No other difficulties or unusual situations were recorded concerning clod sampling or the Saran treatment.

The following observations resulted from comments made at the exit meeting and the review of audit reports, field data forms, sampling log books, and sample receipt log books. The Saran:acetone ratios varied between 1:4 and 1:7. The number of Saran coatings varied between one and two, and may not have been reported to the preparation laboratory. The duration of the immersion of clods sampled from one pedon varied from less than 10 seconds to about 80 seconds. It should not be assumed that the coatings of Saran were uniform from clod to clod or from sampling crew to sampling crew.

For future surveys, it is recommended that one standard Saran:acetone solution be used. However, because acetone is volatile, the sampling crew will have to carry a separate container of acetone for maintaining the solution at a nearly constant viscosity. Clods should be immersed in the Saran:acetone solution only once and for a set period of time. If a clod is dipped more than once, this must be recorded on the clod label and in the sampling log book. Also, safety precautions must be taken because acetone is flammable, and both Saran and acetone are carcinogens.

Field Data Forms and Codes for Pedon and Site Descriptions

No major difficulties were encountered in filling out the SCS-developed field data forms. Audit reports indicated that a number of the sampling crews drafted a final version of the field data form derived from a rudimentary version that had been completed on-site. The intended protocol was to use the field data forms to document activities as they occurred in the field, without regard for generating a second, neater copy.

An audit report mentioned one case in which sampling crew ME02 had difficulty completing digits 1 through 17 of the free-form notes, i.e., watershed identification, unit, sampling class, and pedon azimuth. The auditor assisted the crew in completing the information.

Field data forms were reviewed in detail by EMSL-LV staff. Discrepancies on the field data forms were identified by EMSL-LV, and subsequently were corrected by the SCS state staff or by the sampling crews. This confirmation process is detailed in the QA/QC section of this report under the heading "Field Data Form Discrepancies".

The following problems concerning the codes used on the field data forms were discussed during the exit meeting:

- Microrelief-Pattern (P) -- Many sampling crews were not familiar with the microrelief codes, and did not provide this information. For future surveys, this category will not be used.

- Parent Material - Degree of Weathering and Bedding Inclination (W) -- Again, many sampling crews were unfamiliar with this characteristic. For future surveys, this category will not be used.

- Size -- Two different sets of codes were provided for this category, one set on the form, and one set in the manual. It was decided that the codes indicated below would be the most useful for future surveys, and should replace those on the field data form:

Size (Roots, Pores, Concentrations)

M	Micro	2	Medium
M1	Micro and fine	23	Medium and coarse
V1	Very fine	3	Coarse
11	Very fine and fine	4	Very coarse
1	Fine	5	Extremely coarse
12	Fine and Medium	13	Fine to coarse

- pH -- There were no codes provided for the bromocresol green and chlorophenol red indicators. Sampling crews adopted the following abbreviated codes for each indicator:

  Bromocresol Green = BG
  Chlorophenol Red = PR

  These codes will be placed on future field data forms.

- Diagnostic Features -- There was some disagreement regarding whether a lithic contact qualified as a diagnostic feature. Some sampling crews used it as such, while others did not. The consensus suggested that in most cases a lithic contact is not a diagnostic feature, therefore it will not appear on future field data forms.

- Land Use -- A code for cropland abandoned less than 3 years before sampling was recommended as an additional code.

Sampling crews used code descriptions from two sources during the survey, those given in the sampling manual (Appendix A) and those given on the back of the field data forms. As mentioned above, the two sets of codes were not identical. The approximately 10 percent discrepancies between the two sources were rectified by EMSL-LV QA staff during data verification.

The final recommendations for future use of the field data form were the following:

- Coordinate with the SCS to redesign the format of the field data form.

- Allow space on the field data form for all codes and their definitions.

- Add necessary codes and definitions that are currently missing.

- Correct errors in codes and definitions before using them on the revised form.

Entry of Field Data by the Sampling Crews

The use of the SCS-developed software package for data entry from the SCS-SOI-232 form was discussed at the exit meeting. New Hampshire was the only state that used this software package, which generates detailed tabular descriptions. The New Hampshire SCS staff used the printout to verify the data on the field data forms before the forms were mailed to EMSL-LV and ORNL.

Connecticut staff pointed out some shortcomings in the software package. For example, Histosol descriptions could not be generated. Also, some pH values were not accepted by the software, but were valid measurements for that sampling class. It was recommended that the software be revised concurrently with the field data form. For future surveys, it was suggested that information from the field data forms be entered by the SCS state staff. The data could be entered independently by ORNL, and then the two files could be compared as an error checking mechanism. Data entry operations performed by ORNL are discussed in the QA/QC section of this report under the heading "Error Checking Procedures".

Sample Transport and Storage

Samples were required to be placed in cold storage at 4 °C within 24 hours after sampling. As previously mentioned, some sampling crews rented cold storage facilities near the sampling sites and stored samples until delivery to the preparation laboratory could be made at the end of the week.

Overall, this system was found to be efficient. Cold storage near sampling sites was an improvement over the styrofoam cooler/gel-pac system for three reasons:

- Sampling crews did not have to be concerned about refreezing gel-pacs while in the field.

- Sampling crews could consolidate the samples and make one trip to the preparation laboratory each week rather than one trip each day. In many cases, the watersheds were too far from the preparation laboratory to allow samples to be transported there each day.

- Temperatures in cold storage facilities were more stable, and were less affected by ambient air temperatures.

One pedon, watershed identification ID2-025, sampling class I6, was resampled because the temperature of the cold storage facility exceeded the protocol requirement because of a power failure.

Preparation Laboratory Interactions and Responses

All four preparation laboratories were responsive in accommodating the schedules of the sampling crews. This was necessary because a sampling crew often delivered samples to a preparation laboratory following a long field day or at the end of a week. Delivery time often could not be arranged during conventional work hours. In some cases, the sampling crews were given keys to the preparation laboratory and the cold storage facilities. In addition to delivering samples, sampling crew personnel obtained equipment and supplies at the preparation laboratory.

As part of their responsibilities, laboratory personnel were required to check the incoming samples against the listing recorded by the sampling crew in the sample receipt log book. This was done as soon as possible to ensure that sample sets were complete and labels were filled out properly. Occasionally the laboratory staff were able to inventory the samples while a sampling crew member was present to assist in resolving any problems.

Weekly conference calls including ERL-C and EMSL-LV staff and preparation laboratory personnel aided in the distribution of supplies and equipment, resolved issues requiring input from project management, and allowed the laboratory personnel an opportunity to share information. Discussion items from these conference calls were documented in the DDRP team reports by the project officer for the preparation laboratories.

Section 3

Quality Assurance Program

EPA has mandated that the Quality Assurance Management Staff be responsible for providing technical guidelines to ensure that adequate planning and implementation of QA/QC occurs in all EPA-funded programs that involve environmental measurements. In support of this responsibility, data quality objectives (DQOs) are developed as the initial step in the process leading to the preparation of the QA project plan. The QA project plan specifies the policies, organization, objectives, and QA/QC activities needed to achieve the DQOs.

Data Quality Objectives

The application of DQOs increases the likelihood of collecting data that will meet the needs of data users as well as providing for greater efficiency and success in data collection activities. The EPA Quality Assurance Management Staff has defined guidelines and specifications for developing DQOs. The inherent quality of a data set is represented in terms of five characteristics: precision, accuracy, representativeness, completeness, and comparability. Brief explanations of these characteristics follow:

- Precision and accuracy - quantitative measures that characterize the variability and bias inherent in a given data set. Precision is defined by the level of agreement among repeated measurements of the same characteristic. Accuracy is defined by the difference between an estimate based on the data and the true value of the parameter being estimated.

- Representativeness - the degree to which the data collected accurately reflect the population, group, or medium being sampled.

- Completeness - the quantity of data that is successfully collected with respect to that amount intended in the experimental design. A certain percentage of the intended data must be successfully collected for valid conclusions to be made. Completeness of data collection is important because missing data may reduce the precision of estimates or may introduce bias, thereby lowering the level of confidence in the conclusions drawn from the data.

- Comparability - the similarity of data from different sources included in a single data set. Because more than one sampling crew was collecting samples and more than one laboratory was preparing and analyzing the samples, uniform procedures must be used. This ensures that samples are collected in a consistent manner and that data from different laboratories are based on measurements of the same parameter.

Sampling Objectives

The DQOs presented in this section were developed by the ERL-C project staff. That development included the preparation of a detailed DQO document which received external peer review, and was approved by the technical director of the Aquatic Effects Research Program before the initiation of sampling activities.

DQO concepts that had been developed for analytical laboratory operations were difficult to apply to soil sampling activities. DQOs for soil sampling were developed to ensure that field operations, e.g., sampling site location, profile description, and sampling, would be conducted in a consistent manner. These objectives were intended to reduce the error inherent in collecting soils data and to provide an indication of the variability among sampling crews.

The following paragraphs contain information from the QA project plan (Bartz et al., 1987). Also, where the QA project plan differs in conceptual approach, the information from the draft DQO document is presented in brackets. Additional explanations appear in parentheses.

Precision and Accuracy--

The regional correlator/coordinator (RCC) must be a qualified soil scientist with several years experience in soil profile description and soil mapping. The RCC monitors one site per sampling crew [monitors 6 to 10 percent of the sampling units] for adherence to SCS standards, procedures, and sampling protocol modifications, and performs an independent duplicate profile description. At least one site in each state is [3 to 5 percent of the sites are] monitored with the SCS state staff representative while the remaining sites may be monitored independently. The RCC also insures that SCS state staff performs duplicate profile descriptions. During this process, the RCC identifies, discusses, and resolves any significant problems. Written reports are submitted to the sampling task leader at ERL-C within two weeks. The resolution of major problems is reported verbally within two working days.

A representative of the SCS state staff independently describes a minimum of one site per sampling crew [5 to 10 percent of the sample pedons]. These independent pedon descriptions are used to assess the variability in site descriptions among soil scientists. The SCS representative monitors adherence to protocol for site selection, labeling, and sampling. The soil profile is described on the same face of the pit described by the sampling crews. The representative makes the assessment while the crew is describing and sampling the pedons. Written reviews are submitted to the sampling task leader at ERL-C within two weeks. Major problems are reported verbally within two working days.

The QA representative audits each sampling crew at least once [5 percent of the sampling units] to ensure adherence to sampling protocol. Written reports are submitted to the QA manager at EMSL-LV within two weeks. Major problems are reported verbally within two working days. The QA manager is responsible for conveying any major problems to the technical monitor or technical director.

A small percentage of the sampling units is selected randomly by EPA for sampling to determine the within-sampling class variability. These replicate pedons, called paired pedons, are selected before sampling begins. (Note: The paired pedon [see Appendix A, Section 2.7] and the routine pedon from a representative site for each selected sampling class are sampled on the same day by the same field crew. The criteria for the paired pedon are the following:

- Establish sufficient distance between the two sampling locations to avoid disturbing the paired pedon because of the sampling of the routine pedon.
- Use the same sampling class and vegetation class as for the routine pedon.
- Use the same slope position as for the routine pedon.)

Sample pits are located accurately on the soil survey maps, and the pit dimensions and the long azimuth are recorded. The pit face from which samples are removed is recorded, and the location of the pit in the field is flagged or identified so that the site can be revisited. The soil profile is described according to SCS protocols.

One horizon per day is sampled in duplicate by each field crew. (Note: The choice is made at the discretion of the field crew; however, an attempt is made to sample across the range of horizon types. The sample is taken by placing alternate trowelsful of sample into each of two sample bags [see Appendix A, Section 3.5].) One field duplicate is included in each set of samples sent to a preparation laboratory.

Representativeness--

The primary concerns in the selection of sampling sites are: (1) to assess soil characteristics, (2) to integrate information on parent material, internal drainage, soil depth, slope, and vegetative cover, and (3) to determine representative sampling classes. Soils which have been identified in the study regions have been combined into groups, or sampling classes, which are either known to have or are expected to have similar chemical and physical characteristics. Each of the sampling classes can be sampled across a number of watersheds in which they occur. In this approach, a given soil sample does not represent the specific watershed from which it came. Instead it contributes to a set of samples which collectively represents a specific sampling class on all watersheds within the sampling region. The lead soil scientist of the sampling party selects a sampling site representing the designated sampling class and vegetation class within the designated watershed according to the DDRP soil sampling protocols (see Appendix A).

Completeness--

Soil sampling protocols require the sampling of 100 percent of the designated pedons and of the prerequisite number of horizons. If samples are lost, spilled, or mislabeled, it is possible to return to the field and resample the same site. If a sampling site is inaccessible, the reason for excluding the site must be formally documented by the sampling crew.

Comparability--

The use of standard SCS methods, protocols, and forms for the sampling phase provides field and analytical data that are comparable to data generated from SCS investigations and other studies which have utilized these standardized methods.

Fulfillment of Objectives

Precision and Accuracy--

Twenty-six paired pedons were sampled to provide information on variability between morphologically matched pedons. Horizon types were not equally represented by the field duplicates that were sampled. Of the 526 field duplicates, A and E horizons comprised 17 percent; B horizons, 57 percent; C horizons, 16 percent; and organic horizons, 10 percent.

Representativeness--

All pedons sampled were within the range of morphological characteristics as assigned for their respective sampling classes. Validation activities should assess whether or not the sampling classes, as defined by the physical, chemical, and mineralogical data, are separate populations.

Completeness--

A total of 306 pedons were sampled of the 319 pedons initially selected, resulting in 96 percent completeness. Although this does not meet the 100 percent goal, the number of samples collected will provide sufficient data for valid conclusions to be made for all sampling classes with the exception of I21. For this sampling class, three pedons were disqualified from sampling (see Table 2 and discussion on page 11), and only two pedons were sampled. It is likely that sample size is insufficient to characterize the variability of this sampling class.

Comparability--

The comparability of morphological characteristics is discussed in detail under the heading "Review of Profile Descriptions". The comparability of physical, chemical, and mineralogical data obtained from different analytical laboratories under several contracts and method versions will be addressed in forthcoming quality assurance reports.

Quality Assurance Evaluations and Audits

The objective of on-site observations is to assess the quality of sampling activities performed by the sampling crews. Three categories of observations were conducted for the sampling activities by the RCC, SCS state staffs, and EMSL-LV QA auditors. Included in this section are the activities observed, the level of effort for each category, deviations from protocol, difficulties identified, and recommendations for future surveys.

Evaluations by the Regional Correlator/Coordinator

EPA contracted a former SCS soil scientist to serve as the RCC. All sampling crews, except NY02 and ME04, were evaluated. However, the records reviewed for this report indicate that the members of sampling crew ME04 may have been evaluated during on-site visits with the other Maine sampling crews, because crew members were often rotated. Crews sampling the special interest watersheds were evaluated by the RCC during the sampling of routine pedons. The activities of PA01 were evaluated twice by the RCC.

A summary of the level of RCC evaluation activities is presented in Table 5. Although the overall 3.9 percent level of effort did not meet the DQO goal of 6 to 10 percent, the evaluations conducted were not necessarily unproductive. Rather, it seems that the DQO goal was set too high. A more realistic objective would have the RCC evaluate the activities of each sampling crew only once, unless a second evaluation is necessary to observe the implementation of corrective action. The DQO should be revised to reflect this recommendation.

Written reports prepared by the RCC included the following information:

- Watershed name.
- Date of review.
- Watershed identification.
- Sampling class.
- Cover type.
- Soil series name.
- Sampling crew.

The RCC evaluated and briefly described the manner in which the crew located the sampling site, labeled the samples, and adhered to the sampling protocols. The names of sampling crew members and SCS state staff reviewing the site were included in each report. Detailed discussions of protocol questions and suggestions made by the RCC were not provided.

The reports identified only two issues related to protocol. During the evaluation of NH01, the RCC expressed concern that samples might not be cooled adequately before arrival at the preparation laboratory. However, according to the state soil scientist, USDA Forest Service cold storage facilities were used for all samples except those obtained on September 3, 4, and 5, 1985. Those samples were cooled using the gel-pac system (S. Pilgrim, August 3, 1987, personal communication). The other concern was related to sampling site location by CT01. It was determined that all possible pedon sites at the first sampling point were underwater. Therefore, the first location was not sampled, and the sampling crew proceeded to the next sampling point.

It is recommended that the RCC should evaluate only the sampling site location and soil characterization activities and that the evaluations should be performed as early in the survey as possible. This would allow the RCC an opportunity to clarify the protocols with each crew. The clarifications should be written, and after the approval of the sampling task leader and the QA staff, the information

Table 5. Summary of On-Site Evaluations and Audits

State	Routine Pedons Sampled	Evaluations: RCC number	Evaluations: RCC %	Evaluations: SCS State Staff number	Evaluations: SCS State Staff %	Audits: QA Staff number	Audits: QA Staff %
NY	85	3	3.5[a]	5	5.8	3	3.5[b]
NH	30	2	6.6	2	6.6	1	3.3[b]
CT, RI	23	1	4.3[a]	2	8.6	1	4.3[b]
MA, VT	54	2	3.7[a]	3	5.5	2	3.7[b]
ME	83	3	3.6[a]	6	7.2	2	2.4[b]
PA	31	2	6.4	3	9.6	0	0.0[b]
Total	306	13	4.2[a]	21	6.9	9	2.9[b]

[a] Did not meet the DQO lower limit of 6 percent.
[b] Did not meet the DQO lower limit of 5 percent.

should be provided to all crews early enough in the survey to benefit the sampling effort. The RCC should assess the procedural variations among sampling crews, and include the assessment in the final written report. Difficulties and concerns should be discussed andany recommendations for corrective action should be provided. When corrective action is necessary for a given crew, a subsequent evaluation should be made to verify that the corrective action was implemented.

A standard questionnaire should be developed to ensure that all field operations and sampling crews are evaluated according to uniform criteria. The questionnaire also would provide better documentation of areas reviewed during the evaluation.

Evaluations by the Soil Conservation Service State Staff

SCS state staffs were responsible for evaluating the sampling crews in their respective states. It was desirable for these evaluations to be conducted by SCS staff who were not members of the sampling crews so that evaluations would be as objective as possible. In some cases, however, SCS state staff were also sampling crew members.

Written reports were submitted from all states. All crews except ME03 were evaluated by the SCS state staff; however, each member of ME03 was evaluated while serving on other Maine sampling crews. MA03 was evaluated during the sampling of special interest watersheds. Special interest watershed sampling by MA02 was not reviewed independently, but sampling was conducted with a member of the SCS state staff as crew leader.

A summary of the level of SCS evaluation activities is presented in Table 5. The 6.9 percent level of effort was within the DQO goal of 5 to 10 percent. No difficulties were mentioned in the written reports. Most reports were very brief with few details concerning the activities evaluated. Site selection and sampling protocols were not discussed for every crew.

It is recommended that the SCS state staffs be provided with a detailed questionnaire to ensure that all sampling site selection and soil characterization activities are evaluated and that detailed, written documentation is produced. Standard questionnaires are particularly important for these evaluations which, unlike the RCC evaluations, are performed by different individuals. It is important that all sampling crews, within and among states, are evaluated according to uniform criteria to assure the comparability of the evaluations.

Like the RCC evaluations, the SCS state staff evaluations are most useful when performed as early in the survey as possible. The procedural variations among sampling crews should be assessed and included in the written report. Difficulties and concerns should be discussed and any recommendations for corrective action should be provided. In addition, when corrective action is necessary for a given crew, a subsequent evaluation should be made to verify that the corrective action was implemented.

Audits by Quality Assurance Staff

EMSL-LV QA staff audited the activities performed by the sampling crews, primarily to evaluate adherence to sampling protocols. Written audit reports were provided for all sampling crews visited. Audits were not conducted for sampling crews ME03, ME04, and PA01. MA03 was audited during special interest watersheds sampling. MA02 was audited during routine sampling operations.

A summary of the level of audits conducted by QA staff is presented in Table 5. The 2.9 percent level of effort did not meet the DQO goal of 5 percent. Even if all sampling crews had been audited once by the QA staff, the overall level of effort would still fall below the DQO goal of 5 percent. The DQO for auditing activities should be modified so that all sampling crews are audited once at the outset of the soil sampling operations and a second time only if corrective action is necessary. In the future, funding should be arranged to ensure that the audit program is not interrupted by "freezing" of EPA travel funds because the new fiscal year budget has not received Congressional approval.

The audit reports contained a summary of activities and difficulties encountered during the on-site visit. A standard check sheet was also included in each report. A summary report comparing the variability observed among sampling crews within each state and the variability among all sampling crews was not provided.

Concerns identified during the audits include the following:

- One sampling crew deviated from the protocol for site location procedures.
- Samples were possibly contaminated by use of a bucket auger.
- The amounts of time that bulk density clods were immersed in the Saran:acetone solution varied.
- Field data forms were not completed by one sampling crew at the time of soil description and sampling.
- One crew used the sampling log book in the field during the site selection process, but not during soil sampling. Instead, notes were collected in the field, and the log book was completed at the office.

Auditors observed some modifications to the protocols that should be considered for future surveys:

- All members of CT01 participated in the determinations of particle size class and percent rock fragments. A consensus of the group reduced the personal bias of the data.
- A windshield snowbrush was used by CT01 for cleaning sieves and plastic sheets.
- A checklist and outline developed by the New York SCS staff were used in the field by NY02. The checklist (Appendix E) summarized the sampling activities sequentially, and recorded activities as they were performed. The outline (Appendix E) was available for reference as a further explanation of sampling protocols.
- Each member of ME01 was assigned responsibility for specific tasks during the sampling activities which resulted in a well-organized, efficient operation.

Audits should be performed as early in the survey as possible. This would identify initial difficulties and allow for corrections and clarifications to the protocols to be made early in the survey. Clarifications should be approved by the QA staff, and then written and provided to all crews early enough in the survey to be of benefit to the sampling effort. When corrective action is necessary, the activities of the sampling crew should be reaudited to assure that protocols are being followed as specified. Comprehensive documentation of the audits and any corrective actions will assure that a complete assessment of sampling operations is available at the end of the survey.

Reports were written for each audit, but were not submitted to the sampling task leader during sampling. Rather, the reports were submitted to the QA technical monitor, and forwarded to the sampling task leader after the close of the sampling activities.

The soil sampling task leader suggested a modification in the timeframe for the submission of audit reports and the implementation of corrective action. The auditor should bring any deficiencies in the sampling procedures to the QA manager's attention. If a problem is observed that might seriously compromise data quality, the QA manager should send a written report to the sampling task leader or designees within one week, preceded by telephone contact. Routine written reports should be submitted within two weeks.

Review of Log Books

Review of Sampling Log Books

Sampling log books maintained by all crews were reviewed to identify, evaluate, and summarize the following information:

- On-site observations by the RCC, SCS state staff, and QA staff, including documentation of concerns discussed with the evaluator or auditor.
- Difficulties encountered in locating any sampling site.

- Site conditions or soil characteristics that could have an adverse effect on the analytical results.

- Sampling procedures that might affect the quality of the samples collected.

- Difficulties with equipment or supplies.

- Comments regarding adherence to protocol, including any procedural modifications or recommendations for future surveys.

An examination of sampling log books indicated a wide range in the amount of detail recorded, which can be attributed partially to the lack of a specified format for log book entries. It is recommended that several forms be developed as a basis for detailed documentation of daily sampling activities, and be hardbound as a sampling log book for future surveys. Suggested forms are provided in figures 2 through 6.

A title page identifying sampling crew personnel is provided in Figure 2. Several sampling log books contained no record of sampling crew members. A number of suggested formats for summarizing the contents of the sampling log books are provided in Figure 3. A more structured format would ensure that all necessary information is entered in the sampling log books as a better record of field activities. Suggested formats for site location and soil sampling entries are provided in figures 4 and 5, respectively.

The completeness of the photographic record obtained by the sampling crews was difficult to evaluate. A master list of the exposures would have been helpful. A slide key such as that outlined in Figure 6 would provide an easy reference for sampling crews to use in labeling processed slides. A master slide list could be generated by each sampling crew, and could be included in each slide catalog submitted to the project management at the conclusion of the survey.

Sampling log books could also contain the following types of information to further increase their value as reference documents:

- Notes detailing equipment and supply needs.

- Notes on the function and use of field equipment.

- Phone numbers of all sampling crew members, SCS state staff, and others associated with the sampling operations.

- Complete records of the clod sampling procedure, including horizons successfully sampled, the number of clods obtained from each horizon, and reasons clods could not be obtained from unsampled horizons.

Review of Sample Receipt Log Books

Sample receipt log books were reviewed to identify, evaluate, and summarize the following information:

- Condition of samples upon arrival at the preparation laboratory.

- Labeling errors and correction of mislabeled sample numbers.

- Sampling difficulties or protocol deviations identified in sampling log books and documented upon receipt of the sample at the preparation laboratory.

- Level of field duplicates for comparison with DQO goals.

- Level of paired pedon samples for comparison with DQO goals.

The sample receipt log books did not provide all information expected. However, each preparation laboratory may maintain other notebooks containing this information that were not reviewed for this report.

Log Book #1--

Log book #1 followed a column and row format. Set identification, site identification, sample code, condition, and time/date were used as the column headers. A column header for noting the individual who delivered the samples was included for entries between August 21, 1985 and September 19, 1985, but

Field Crew Members: ____________________ Field Crew: __________

____________________ __________

____________________ __________

Field Crew Leader: ____________________

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Routine Staff: ____________________

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Additional
Participants: ____________________

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Notes: ____________________

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Audit Visits: ____________________

____

____

Who:	Date:	Page in Logbook of Notes Taken During Audit
________	________	________
________	________	________
________	________	________

Figure 2. Recommended title page for sampling log books.

Pedon Number	County	Sampling Class	Page	
			Site Selection Notes	Sampling Notes

Lake Name	Lake ID	Location	Page

Set ID	Date Used	Where Used	Page

Figure 3. Recommended index page for sampling log books.

Site Selection

Watershed No.: ____________________ Pedon No.: ____________

Location: ____________________ Lake Name: ____________

______________________________ ______________________

______________________________ ______________________

County: ____________________ Date: ____________

Map: ____________________ Crew ID: ____________

Sampling Class: ____________________

Vegetation Class: ____________________ Additional Participants: ______

______________________________ ______________________

______________________________ ______________________

______________________________ ______________________

______________________________ ______________________

______________________________ ______________________

Site Location Notes: ____

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Point 1: ____

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Figure 4. Recommended format for site location notes.

Soil Sampling

Watershed No.: ____________________ Pedon No.: ____________________

Location: ____________________ Lake Name: ____________________

County: ____________________ Date: ____________________

Map: ____________________ Crew ID: ____________________

Sampling Class: ____________________

Vegetation Class: ____________________ Additional Participants: ____________________

Weather: ____________________

Time of Arrival: ____________________ Time of Departure: ____________________

Samples Collected			
Sample Code	Horizon	Depth	# Clods

Figure 5. Recommended format for sampling notes.

Notes: ____________________

Sample Storage: ____________________

Sample Transport to Prep Lab: ____________________

Figure 5. (Continued).

Film Roll #	Slide #	WS ID	WS Name	Sampling Class	Slide Description

Figure 6. Recommended format for slide key.

was omitted from entries after September 19, 1985. The condition of samples was noted as good for all samples received, and wet samples were indicated. Sample labeling errors were corrected by a line running through the incorrect entry with the correction made above the entry. These corrections were not initialed. No unique conditions or protocol deviations were recorded in the log book. No data for the number of horizons sampled for clods or the number of clods collected were provided.

Log Book #2--

The format of the sample receipt log book submitted by Laboratory #2 followed a column and row organization. Column headers were the following: code, batch number, crew identification, site identification, set identification, date received, received by, delivered by, and comments. A weekly summary of the number of samples received, total number of samples collected, the number of pedons sampled for the week, and the total number of pedons sampled were provided. Mislabeled samples were identified, as were wet samples. Clod samples and horizons from which these were collected were identified in a few cases, but not routinely. Cases where no field duplicate was collected were noted.

Log Book #3--

The log book reviewed for this report was the preparation laboratory's sample processing log book rather than the sample receipt log book. It is a compilation of the sampling labels received by the preparation laboratory. The labels were affixed to the pages of the log book near the left-hand margin of the page. On the right the sample condition, number of sample bags received, sample weight, and percent rock fragments were recorded. Sample labeling errors were corrected in the right margin. The laboratory began recording the date of sample receipt as of September 13, 1985. No unique conditions or protocol deviations were noted in the log book. No data for the number of horizons sampled for clods or the number of clods collected were provided.

Log Book #4--

The log submitted by Laboratory #4 was a computer-generated list of data under the following headings: set identification, sample code, date sample was collected, date and time the sample was received, and initials of the recipient. This log provided no record of the condition of the samples upon receipt at the preparation laboratory, the number of horizons sampled for clods, or the number of clods collected. No mislabeling errors were indicated, although a few lines were crossed out in the lists with no explanation for the changes.

The variability of the information recorded in the sample receipt log books suggests that a standard format would be desirable to ensure that useful sample receipt information is recorded. This documentation includes the date, time, and person delivering the sample in addition to information identifying each sample as a unique entity. All samples delivered to the preparation laboratory should be logged in, including clod samples. A record of field duplicates and paired pedon samples would also be useful for later data summary. A suggested format for sample receipt log books is provided in Figure 7. The many column headers needed to record all necessary data suggest that an 11- by 14-inch notebook would be most useful. Columns must be wide enough to allow data to be entered legibly.

Sampling crews should record directly on the sample bag label any information that may be important in the handling of the sample by the preparation laboratory (e.g., unsieved samples) or that may affect the quality of the sample (e.g., leaking gel-pacs contaminated samples stored in the styrofoam coolers). This information should then be recorded in the sample receipt log book under "Sample Condition".

Collection of Field Duplicates

The number of field duplicates (526) obtained during sampling satisfied the DQO goal, which specified that each sampling crew was to collect one horizon in duplicate on each day of sampling. The level of field duplicate collection was evaluated by the number of pedons sampled per day. Horizon types were not equally represented by the samples collected (see page 21).

To facilitate the evaluation of field duplicate collection, sample receipt log books

									Sample Condition	Additional Notes		
Sample Number	Crew ID	Site ID	Set ID	Date Collected	Date Received	Time Received	Delivered By	Received By	Wet/Dry (W/D) Sieved/Unsieved (S/U) Bag Split (BS) Under Volume (UV)	Number of Clod Samples Collected for Each Horizon Sampled	Field Duplicate?	Paired Pedon?

Figure 7. Recommended format for sample receipt log books.

should record the date of sample collection so that a determination of the number of field duplicates that should have been collected can be made easily. The sample receipt log book at one preparation laboratory did not contain the dates of sample collection, and the log book of another did not record the receipt of any special interest watershed samples.

Review of Profile Descriptions

Paired Pedon Descriptions

The DQO target level for paired pedon description and sampling was 30 paired pedons of the initial 313 pedons to be sampled, or a level of 9.4 percent. Four paired pedons were eliminated from consideration because access was denied or soils were highly disturbed at the sampling location, or, in one instance, because a matching routine pedon was not chosen by the computerized site selection process (see Table 2, page 11). A summary of the 26 paired pedons sampled and their distribution among the states is given in Table 6. Twenty-six paired pedons out of the 306 total pedons sampled resulted in an 8.5 percent level of replication.

Paired pedons are the geostatistical equivalent to field duplicates. The location of the paired pedons is determined using the following criteria:

- Sufficient distance between the routine and replicate pedon must be allowed to avoid disturbance from the excavation of the replicate pedon affecting the sampling of the routine pedon.
- The replicate pedon must satisfy the same sampling and vegetation class requirements as the routine pedon.
- The replicate pedon must occupy the same slope position as the routine pedon.
- Both the replicate and routine pedons must be described and sampled using the same protocols used for all routine pedons.

The objective of paired pedon description and sampling is to gain some indication of the variability of field-observed characteristics and physical and chemical soil properties over short distances. The determination of physical and chemical parameters will yield quantitative data that may be used in statistical comparisons during data validation.

The qualitative components of the paired pedon descriptions were evaluated for this report. Differences in horizon designations and other descriptive parameters, e.g., pH, color, roots, and rock fragments, constitute the basis for comparison in this report. Analysis of profile descriptions for paired pedons may give a different picture of similarity than analysis based on the results of physical and chemical data. Any qualitative differences determined in the comparison of paired pedon descriptions are not intended to be used for any specific purpose other than documenting the variability observed during the Northeastern Soil Survey.

The paired pedon descriptions were systematically reviewed by comparing the field observations of descriptive parameters, such as horizon boundaries, horizon thickness, color, texture, roots, and pH, between the routine and paired pedons. Acceptable ranges of differences for descriptive parameters were included in the comparison. Subsequently, the paired pedons were classified as similar, moderately different, or very different based primarily on the soil morphology, but with consideration of other descriptive parameters. Of the 26 paired pedons compared, 38 percent of the pairs were evaluated as similar, 31 percent were moderately different, and 31 percent were very different.

Paired pedons may be compared with respect to both the correlation of the horizon designations and the correlation of field-measured characteristics of horizons identified for both pedons. When there is little agreement in the horizon designations for the routine and paired pedons, quantitative comparisons of field-measured characteristics are not possible.

An attempt at qualitative comparisons of the characteristics for pedons classified as very similar revealed that no additional information on variables within pedon pairs was gained above that derived by determining the proportion of horizon designations in common

Table 6. Summary of the Qualitative Differences Between Paired Pedons

Watershed ID	Sampling Class	Crew ID	Pedon Comparison	Total Horizons	Horizons Described Differently number	%
			Massachusetts			
1C2-050	I40	MA02	M[a]	10	5	50
1D1-034	I06	MA01	M	9(10)[d]	2(3)[d]	30
1D2-094	I09	MA01	S[b]	5	1	20
1D3-003	I41	MA02	D[c]	5	5	100
			Maine			
1C1-021	S12	ME02	D	8(9)	7(8)	89
1E1-077	S10	ME03	S	8	0	0
1E1-092	I02	ME01	M	6	0	0[e]
1E1-123	I42	ME01	S	7	0	0
1E1-069	S08	ME02	D	6(5)	5(4)	80
1E1-022	S05	ME02	M	9(10)	6(7)	70
			Pennsylvania			
1B3-012	I29	PA01	S	4	0	0
1B3-041	H02	PA01	S	3	0	0
1B3-060	I33	PA01	S	6	0	0
1B3-062	I25	PA01	M	7	0	0[f]
			New Hampshire			
1C2-057	I01	NH01	D	7(6)	5(4)	67
1C3-063	I38	NH01	S	6	0	0
			Rhode Island			
1D1-067	I01	CT01	D	9	6	67
			New York			
1A1-012	E02	NY03	M	6	0	0[g]
1A2-002	S05	NY03	D	8(6)	5(3)	50
1A2-037	S05	NY01	D	7(8)	4(5)	63
1A2-045	S13	NY02	M	7	0	0[h]
1A2-052	S02	NY01	M	9(7)	7(5)	71
1A3-040	I01	NY02	D	8(7)	6(5)	71
1A3-046	E05	NY03	S	4	0	0
1B3-004	I30	NY02	S	6	0	0
1B3-052	E06	NY03	S	5	0	0

[a] Moderately different (M).
[b] Similar (S).
[c] Very different (D).
[d] The number of horizons described for the routine pedon are given first, followed by the number of horizons described for the paired pedon in parentheses.
[e] Horizon thickness, boundary, and pH differed.
[f] Horizon thickness, boundary, and color differed.
[g] Color, pH, degree of weathering, and morphogenesis differed.
[h] Horizon thickness, color, pH, and rock fragments differed.

for those pairs. Even when the paired descriptions were similar,, the field-measured properties, e.g., horizon, thickness, were found to differ considerably. This provided the additional justification for considering the routine and replicate pedons as unmatched pairs.

The qualitative classification of the paired pedons is summarized in Table 6. A comparison of the horizon designations shared by paired pedons is a crude analysis of the integrated sum of differences of all field-measured characteristics. The number of horizons shared by each pair and the number of those described differently within each pair are also provided in Table 6.

The pedons classified as very different were those that exhibited differences in horizon designations between 50 and 100 percent. Generally, the surface horizons of those pedons were more similar than were the subsurface horizons. Differences in horizon designations and characteristics became greater with depth.

Paired pedons that were classified as moderately different were those that differed from each other for up to 78 percent of the total number of horizon designations. In situations where the horizon designations were the same, i.e., 0 percent difference, there were still three or more horizon properties, specifically horizon thickness, depth, boundary, color, or pH, that were variable enough to justify a conclusion that the paired pedons were qualitatively different.

Comparison of paired pedons at the qualitative level appears to be a useful exercise only for describing the inherent natural variability of the sampling classes. The value of this comparison for future surveys can only be determined after the analytical data are complete, and has been analyzed statistically. The low correlation values between the routine and replicate pedons suggests difficulty in sampling qualitatively similar pedons utilizing the sampling design employed in this survey. The lack of qualitative similarity between paired pedons does not necessarily mean these soils are dissimilar for the purposes of this project, because in this project similar soils are defined by sampling classes. In every case, paired pedons fell into the same sampling class, and were identified as the same soil series.

The results of the laboratory analyses for paired pedon samples should be analyzed and reviewed before a final determination of the variability between paired pedons and, thereby, within sampling classes, is assessed. The conclusion that only 38 percent of the paired pedons were rated as similar should be considered when examining the laboratory data. It may also be difficult to quantitatively or qualitatively evaluate the variability of the paired pedons and the sampling classes based on the analytical results only.

In summary, this examination of the field-described characteristics points out the difficulty in matching horizon-for-horizon and the associated field characteristics over the distance of a few meters for soils identified as the same series. Matching data for all pedons within a sampling class over the entire region is expected to be even more difficult. The paired pedons are true field duplicates, but the examination of the data should be considered a validation activity. Paired pedons should be included in future surveys to describe the variability of soils within a sampling class over a distance of a few meters.

Independent Pedon Descriptions

In addition to the RCC and SCS state staff evaluations previously discussed, independent pedon descriptions occasionally were made (see Table 7). These were compared with the sampling crews' pedon descriptions. A total of 23 independent descriptions were made by either the RCC and the sampling crew or by the sampling crew and the SCS state staff, and in five cases both evaluators made independent descriptions of the same pedons.

The purpose of performing independent pedon descriptions is to provide a basis for qualitatively evaluating the variability that occurs when two or more soil scientists describe the same pedon. Although the standards and guidelines routinely used by the SCS are often based on precisely defined terms, the consistency in application is not always perfect. A certain degree of subjectivity is inherent in this process, creating some variability between individuals making observations on the same soils. For example, the color of one horizon may be described in three different ways by as many describers. The precision of comparing a soil sample with a Munsell color chip is primarily influenced by the amount of sunlight present, the moisture content of the sample, and the ability of the describer to distinguish hue, value, and chroma differences.

Independent pedon descriptions are useful for comparing notes on measuring subjective field characteristics, such as horizon boundaries, soil texture, or color. Usually, horizon designations are determined by evaluating a range of physical characteristics and interpreting their relationship to soil development. Independent pedon descriptions are comparable only where the describers focus on the same face or portion of the pedon.

Independent pedon descriptions made by two describers are summarized in Table 7. The horizon designations for each pedon description were evaluated with respect to all field-measured variables recorded on the field

Table 7. Summary of Independent Pedon Descriptions Evaluated

Watershed ID	Sampling Class	Describers: Crew ID	Evaluator: RCC	Evaluator: SCS	Horizons Described Differently: Total	Horizons Described Differently: number	Horizons Described Differently: %
1A2-052	S02	NY01	x	-	11	3[a]	27
1D3-044	I40	NY01	-	x	8	0[b]	0
1A3-040	I01	NY02	-	x	7(8)	2[b,c]	29
1A2-002	S05	NY03	-	x	7(8)	0[b,c]	0
1A2-054	S14	NY02	x	x	-	-	-
1A2-012	E2	NY03	x	x	-	-	-
1E2-049	S13	ME01	x	x	-	-	-
1E3-042	S13	ME02	-	x	7(6)	1[b,c]	14
1E2-038[d]	S13	ME04	-	x	-	7	0
1E1-054	S14	ME02	-	x	8(7)	1[b]	13
1E2-069	S18	ME02	-	x	5(4)	1[b,c,e]	20
1E2-007	S02	ME02	-	x	9	1[b,c]	11
1E1-074	E5	ME03	x	-	5	0[b,e]	0
1E1-062	I2	ME02	x	-	7(8)	3[b,f]	43
1B2-028	I33	PA01	-	x	8	0	0
1B3-041	I29	PA01	-	x	6	0	0
1B3-053	I25	PA01	x	x	-	-	-
1B3-053	I33	PA01	x	-	7(5)	4	57
1C3-031	-	-	x	x	-	-	-
1D2-094	I41	MA01	-	x	9	0[b]	0
1D3-020	I5	MA02	-	x	5	0[b,f]	0
1D1-031	E3	MA01	x	-	-	-	-
1D3-053	-	-	-	-	9	2[b,c]	22
1D1-034	E3	MA01	-	x	9(10)	5[a]	56
1B3-056	H2	CT01	x	-	4	0[g]	0
1D3-033	I10	CT01	-	x	-	-	-
1D3-025	I06	CT01	-	x	8	0	0
1D3-025	-	-	-	-	6	0	0
1C2-037	I05	NH01	x	x	-	-	-
1C2-037	I09	NH01	x	-	8(7)	1[h,i]	13
1C2-057	E02	NH01	-	x	6(5)	5[b,e,i]	83

[a] Horizon designations.
[b] Soil color.
[c] Field-observed pH.
[d] Horizon designations were determined by both describers together.
[e] Texture.
[f] Structure.
[g] Lithologic discontinuity.
[h] Horizon thickness.
[i] Horizon boundary.

data forms, according to the same procedure used for paired pedon descriptions. Soil colors were the most often noted differences between the descriptions. These may be related to variability in the describers' vision or actual color variability in the samples. Soil pH differences may have been due to differences between soil samples or the types of pH reagent, as well as differences in perception of the pH color charts.

Unless it was certain that the descriptions were made within a specific, delineated area of the exposed soil profile, independent pedon description comparisons were only qualitative. It was not possible to conduct a more detailed comparison of the field descriptions because only one pedon (watershed ID 1A1-012) seemed to have been described by all three describers for a specific portion of the pedon.

It is recommended that the protocols for future surveys specifically indicate that all independent pedon descriptions must be performed in the same portion of the pedon. The pedon should be marked to clearly delineate the profile for description. If descriptions are not performed in the same locations, it should be clearly noted on the field data form. Independent pedon description comparisons yield little useful information unless the exact portion of the same profile is described.

It is also recommended that the independent field descriptions be reviewed among all participants while still in the field so that differences and discrepancies can be discussed and documented at that time for the benefit of the data users. The objective is not to reach a consensus on the best description, but is to provide an exchange of information concerning the inherent variability among describers and the characterization of soil development features.

Data Entry and Management

This section describes the software, procedures, and QA/QC measures used during the development of the computerized data base. Data entry protocols included visual scanning of the data forms, computer entry, entry checking, and editing. The specific software, procedures, and checks varied according to data type and also evolved through time because of adjustments in the data collection protocols, reporting forms, available computer software and equipment, and personnel.

Soil Mapping Data Files

During the spring and summer of 1985, SCS soil scientists mapped 145 watersheds in eight northeastern states. Transects were made on the mapped watersheds to determine mapping unit composition. SCS state staffs prepared watershed attribute maps that delineated soil types, vegetation cover types, bedrock geology, and depth to bedrock at a scale of 1:24,000. Bedrock geology delineations were derived from existing geological maps. The other maps were derived from data collected as part of this project.

Preliminary map legends and mapping unit descriptions were prepared by SCS state staffs using existing soil surveys, topographic maps, and aerial photography. After mapping was completed, the provisional legends and mapping unit descriptions were correlated at a workshop held in Saranac Lake, New York, in July 1985. Using data from field transects, the workshop participants applied a consistent mapping unit nomenclature and composition from state to state. Most of the mapping units were described as consociations or complexes of soil series, although a few mapping units were defined as consociations or complexes at a higher taxonomic category e.g., Great Group.

Each mapping unit description form included the mapping unit name, slope, landscape position, landform, parent material, depth to bedrock, taxonomic classification, and inclusions of unnamed soils occurring in the mapping unit. The map legends and mapping unit description forms were scanned for legibility, completeness, and accuracy. Any discrepancies were resolved through communication with the SCS state staffs.

Following the workshop, both ERL-C and ORNL entered the watershed map attributes and mapping unit description data into their respective computer systems. Data entry at ORNL was performed by an in-house data entry center and the resulting files were transferred to SAS files (SAS Institute Inc., 1987) on the IBM 3033 system. ERL-C input the data using dBase III software on an IBM personal computer. The ERL-C files were transferred to ORNL in an ASCII format, were uploaded to SAS files on the IBM 3033 system, and the two entries were compared for discrepancies. Transect data were computerized by an in-house data entry center using a double entry procedure, and were uploaded to SAS files on an IBM 3033 system.

Discrepancies in watershed attributes were resolved through legend corrections and some remapping by the SCS state staffs, and the revised data were entered into the data base. ERL-C used the ARC-INFO geographic information system (GIS) to digitize the watershed attribute files. Then ERL-C compared the updated watershed attribute data with the digitized watershed attribute data, and resolved any inconsistencies. Finally, the GIS-derived mapping unit areas were adopted as the most reliable.

The mapping unit data were separated into three files: mapping unit legend file, mapping unit composition file, and mapping unit component file. The mapping unit legend file contains data pertaining to the identification of the mapping unit, including the symbol, name, and physiographic information. The mapping unit component file contains data on each named soil or inclusion, such as slope, drainage class, and taxonomic classification. The mapping unit composition file contains the percentage of individual components found in each mapping unit. The reasons for splitting the data into three files were to reduce the amount of redundant information stored in a single file and to facilitate the review and comparison of the mapping unit components.

ERL-C sent listings of the computerized mapping unit files to the SCS state staffs for review and resolution of apparent inconsistencies. Several iterations of updates were entered into the SAS files at ORNL. The corrections were entered into a change file which contained the record identifier, the variable name, the old value, and the new value. The change file was then compared with each record in the data base. Only when all three items matched an observation in the data base was the new value inserted. This method of updating the data base virtually eliminated the possibility of adjusting the wrong observation or variable.

After the updates were made, ORNL generated frequency tables of the coded variables and compared these tables with lists of valid codes. The frequency tables were used to build code translation tables containing the codes and definitions. The code translation tables are stored as SAS format libraries in the data base.

The final step in editing the mapping data files involved the labeling of variables and, where necessary, the modification of variable names and labels to ensure consistency among the data files. The complete contents of the mapping files are given in Turner et al. (1987).

Soil Sampling Data Files

Each sampling location and soil profile were described in conjunction with soil sampling. During the training workshop at the University of Maine-Orono, the sampling crews were instructed in uniform procedures for describing the soils and recording data on the field data forms.

Upon completion of sampling in the fall of 1985, copies of the data forms were sent to ORNL, ERL-C, and EMSL-LV. At ORNL, the forms were scanned visually for completeness, legibility, and the validity of code entries. ORNL personnel noted any missing, illegible, or suspect data.

Following resolution, the data were computerized at ORNL by an in-house data entry center using double entry procedures and were then transferred to SAS files on the IBM 3033 computer system. The data were entered as two linked files. The base file, designated 232 BO, contains one record for each pedon. Data pertinent to the entire pedon such as identifier, date sampled, location, taxonomic classification, and physiographic information, are stored in this file. These data were taken from the first page of the field data form. The horizon file, designated 232 HO, contains the horizon characteristics, such as horizon depth, thickness, color, structure, and other specific horizon features. These data were reported on pages 2 through 4 of the field data form.

The EMSL-LV staff developed and implemented procedures to evaluate the data recorded on the field data forms (Bartz et al., 1987). Following receipt of the field data forms, EMLV-LV examined the forms for suspect data and sent a list of discrepancies to the SCS state offices for resolution. SCS returned the confirmed or corrected data. These data were entered into a change file, and were integrated into the data base.

ORNL generated frequency tables of coded variables and compared them against a list of valid codes. Invalid or suspect codes were identified and sent to EMSL-LV for resolution. This resulted in another round of updates which were incorporated into the data base.

As with the mapping data, labels were assigned to all field variables and, where necessary, variable names and labels were modified to ensure consistency among the various data files. The complete contents of the field data files are discussed in Turner et al. (1987).

Section 4

Recommendations and Conclusions

Recommendations have been provided throughout this report to resolve issues and concerns stemming from the Northeastern Soil Survey sampling operations. These recommendations are summarized in this section to aid in the design of future surveys. Although the detailed discussions provided in the text of this report are not reproduced in this section, the appropriate sections are referenced, and the recommendations are presented in the order of occurrence in the text. A summary assessing the overall quality of the soil sampling operations concludes this report.

Recommendations

Site Selection

- As an alternative to site selection by the sampling crew, SCS state staff could identify and flag sampling site locations before soil sampling. Then sampling crews could be sent to sites that have been previously evaluated to meet soil and vegetation class requirements.

Sampling Difficulties

- If possible, groundwater should be removed from saturated soils before sampling. This could be accomplished by digging a sump pit upstream of groundwater flow or by digging a number of sump holes around the pit.

- Methods for draining wet soil pits include digging a sump hole in a corner of the pit away from the face to be sampled or using a mechanical pump.

- Bucket augers or post-hole diggers should be used to collect soil samples only if no other sampling technique is feasible. The use of bucket augers or post-hole diggers should be documented on the field data form.

- Adequate time should be taken to carefully sample each pedon. All necessary sampling equipment should be available for use on-site.

- Sampling should not be performed during severely inclement weather if it can be avoided.

- Data from samples obtained via bucket augers or post-hole diggers should be tagged with "W" in the data base.

Equipment

- Extra sharpshooter shovels should be procured as replacements for those damaged during pit excavation.

- Monitoring the temperatures of styrofoam coolers should not be necessary in future surveys.

- A 35-mm camera with a flash unit and wide-angle lens should be provided to each sampling crew.

- ASA-400 film provided the highest quality of exposures during the sampling period.

- A standard scale for soil depth demarcations should be used in all pedon photographs.

- A standard card to identify pedons should appear in all photographs.

- Pedon faces should be photographed either in complete sunlight or complete shade, using a flash unit where necessary.

- Horizon boundaries should be marked with golf tees for greater visibility in the photographs.

- Hand pumps should be supplied to all sampling crews.

Sample Sieving

- Sampling crews should note any protocol deviations (e.g., unsieved soils) in the sampling log books and directly on the sample labels to ensure that the preparation laboratory receives this information.

- Preparation laboratory personnel should note any unusual sample conditions or protocol deviations in the sampling receipt log books.

Clod Sampling for Determination of Bulk Density

- Greater consideration should be given to the use of a standard Saran:acetone mixture for the coating of clods. Information on the viscosity of the solution and the dipping procedure should be noted in the sampling log books.

Field Data Forms and Codes

- Codes to be eliminated from future versions of the field data form include the following:

  - Micro-relief - pattern (P).

  - Parent material - degree of weathering and bedding inclination (W).

  - Diagnostic features - lithic subgroups (L).

- Codes selected to characterize size are the following:

Size (Roots, Pores, Concentrations)

M	Micro	2	Medium
M1	Micro and fine	23	Medium and coarse
V1	Very fine	3	Coarse
11	Very fine and fine	4	Very coarse
1	Fine	5	Extremely coarse
12	Fine and medium	13	Fine to coarse

- Codes to be added to future versions of the field data form include:

  - Field-measured properties - Soil pH:

    BG = bromocresol green
    PR = chlorophenol red

  - Land use - cropland abandoned less than 3 years.

- Recommendations for future use of field data forms include:

  - Assist the SCS in redesigning the format of the computerized SCS-SOI-232 field data form.

  - Allow ample space on the field data form for all codes and their definitions.

  - Add, correct, or delete codes and their definitions, as necessary.

- Use the SCS-developed software package to enter field data into the computer. Revisions of the data entry package should be concurrent with revisions of the field data form.

Regional Correlator/Coordinator Evaluations

- The RCC should evaluate all sampling crews at least once, as early as possible in the soil sampling period. Follow-up reviews should be conducted where necessary.

- A standard format should be developed for written evaluations performed by the RCC.

- Variation among sampling crews within and among states should be evaluated.

Soil Conservation Service State Staff Evaluations

- All crews should be evaluated at least once, as early as possible in the soil sampling period. Follow-up reviews should be conducted where necessary.

- SCS state staffs should be provided with a specific evaluation form to ensure that detailed, written documentation of each site visit is provided.

- Site selection and soil description methods within and among each state's crews should be evaluated.

Quality Assurance Staff Audits

- All sampling crews should be audited as early as possible in the sampling operations.

- Before leaving the sampling site, the auditor should inform the sampling crew of discrepancies identified during an audit.

- Detailed audit reports should be submitted to the sampling task leader within two weeks following the completion of the audit. If major audit discrepancies are noted, telephone contact should be made within two days following the completion of the audit.

- A summary report should be provided comparing the variability observed among sampling crews, both within and among the states.

- Where the quality of certain samples is seriously questioned, the suspect pedon should be resampled. The new set of samples should be analyzed and the corresponding data output compared to that from the original samples.

- Audit reports should contain enough detail to fully document the areas evaluated. Issues identified during the audit should be listed and their resolution described. Follow-up reviews to ensure protocol adherence should also be provided.

- The QA staff representative should ensure that each sampling crew is audited, and that evaluations by the RCC and SCS state staffs are made.

- Information from audit reports and evaluations should be used to assess the ability of contract bidders, e.g., private consultants, to accomplish sampling under strict specifications, before the awarding of sampling contracts.

Sampling Log Books

- Several formats for documentation of field information by the sampling crews were presented as examples (see figures 2 through 6). A preprinted sampling log book in standardized format should be provided to each sampling crew.

- Sampling log books should contain information concerning:

  - Visits by RCC, SCS state staff, and QA auditors, including documentation of issues and concerns discussed.

  - Difficulties encountered in site location activities.

  - Difficulties encountered during soil sampling operations.

  - Irregular site conditions or characteristics that could have an adverse effect on the resulting analytical data.

  - Sampling activities that could have an adverse effect on the quality of samples collected.

- Documentation of equipment deficiencies.

- Comments concerning protocol adherence or modification.

- Comparisons of paired pedon descriptions, noting similarities and differences.

- Phone numbers of the preparation laboratory, the SCS state staff, and others associated with the DDRP Soil Survey.

- A record of clod samples collected, including documentation when clod samples were not collected.

Sample Receipt Log Books

- Each sampling crew should record sample information upon delivery of the samples to the preparation laboratory, and the laboratory personnel should verify the information as soon as possible. A suggested format containing the necessary information to assess sample condition and initiate sample tracking is provided in Figure 6.

Independent Pedon Descriptions

- The protocols should require that all independent pedon descriptions are made along the same profile face.

- All independent pedon descriptions should be reviewed among the participants while still in the field, in order to provide a comparison of variability among the describers.

Conclusions

Generally, soil sampling activities proceeded as planned within the expected time frame. The sampling methods and quality assurance activities developed for use in the Northeastern Soil Survey sampling activities ensured the collection of soil samples of known and documented quality. The coordination of sampling activities among the many participants was a large-scale, complex task that was successfully performed as originally conceived with a minimum of unanticipated difficulties and modifications. A number of conclusions and recommendations have been made in this report to assist planners of similar projects.

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Appendix A

Sampling and Preparation Laboratory Protocols for the Direct/Delayed Response Project Soil Survey

The following protocols were used by the sampling crews and the preparation laboratory personnel participating in the Northeastern DDRP Soil Survey. The draft manual was revised using the information obtained from the sampling and preparation laboratory training workshop held on August 7 and 8, 1985. The draft did not undergo external review and was not formally released by EPA. It is presented here without editorial correction. Note that various Soil Conservation Service documents were used in the preparation of this draft; however, because no editorial corrections have been made, those documents are not cited.

Field Sampling Manual for the National Acid Deposition Soil Survey

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1.0 Introduction

1.1 Scope

This field sampling manual is written to guide personnel involved in the collection of soil samples for the U.S. Environmental Protection Agency's (EPA) Direct/Delayed Response Project (DDRP) Soil Survey. All field and laboratory personnel must be trained by a field manager or another person knowledgeable in the procedures and protocols detailed in this manual. The scope of the field sampling manual covers field operations, shipping of samples from the preparation laboratory to the analytical laboratory, and sample receipt by the analytical laboratory.

This manual is a companion to the [laboratory] methods manual for the National Acid Deposition Soil Survey (NADSS) and the quality assurance plan for the National Acid Deposition Soil Survey (NADSS). There is some repetition among the manuals which is necessary to maintain continuity and to document concisely the methodology of the soil survey.

The basic goals of the NADSS procedures are to collect representative samples without contamination, to preserve sample integrity for analysis, and to analyze samples correctly. Analytical methods have been chosen that offer the best balance between precision, accuracy, sensitivity, and the needs of the data user.

The overall objective of NADSS is to predict the long-term response of watersheds and surface waters to acidic deposition. Based on this research, each watershed system will be classified according to the time scale in which it will reach an acidic steady state, given current levels of deposition. Three classes of watershed systems are defined:

> *Direct response systems:* Watersheds with surface waters that either are presently acidic (alkalinity <0), or will become acidic within a few (3 to 4) mean water residence times (<10 years). NOTE: Most lakes in the northeast have relatively short residence times, i.e., less than 2 to 4 years.
>
> *Delayed response systems:* Watersheds in which surface waters will become acidic in the time frame of a few mean residence times to several decades (10 to 100 years).
>
> *Capacity protected systems:* Watersheds in which surface waters will not become acidic for centuries to millennia.

The objective of this manual is to define the means by which to characterize and sample soil mapping units using U.S. Department of Agriculture-Soil Conservation Service (USDA-SCS) descriptive techniques.

1.2 Personnel

1.2.1 Field Sampling Crews

The field sampling crews will consist of soil scientists experienced in the National Cooperative Soil Survey. Crews will be numbered consecutively beginning with 01. For example, if Maine has three crews, they will be ME01, ME02, and ME03. These crews will be responsible for selecting the pedon location, sampling the soil, and describing the profile. The field crew leader will have ultimate responsibility for each crew's daily activities, such as placement of the pedon within each sample class, correct labeling of sample bags and forms, and prompt shipment of samples.

1.2.2 Regional Coordinator/Correlator

The Regional Coordinator/Correlator (RCC) will monitor six to ten percent of the sampling units to ensure adherence to SCS standards and field sampling protocol. Three to five percent of the sites will be monitored in conjunction with the monitoring responsibilities of the SCS staff of each state. The remaining sites will be monitored independently of the state SCS staff. Monitoring will include a review of profile descriptions and selection of sites for sampling. The RCC will be a qualified soil correlator with many years of experience with soil profile description and soil mapping. He will also ensure that the SCS State Office Staff perform duplicate profile descriptions. In this process, he will review these descriptions and point out potential problems.

1.2.3 Quality Assurance/Quality Control Representative

The quality assurance/quality control (QA/QC) representative will review five percent of the sampling units to ensure adherence to sampling protocol as specified in this manual.

1.2.4 SCS State Office Staff

Members of the SCS State Office Staff will independently describe five to ten percent of the sample pedons and site descriptions and will monitor field sampling protocol. At least one site per state will be audited by the RCC representative. The use of duplicate profiles, determined prior to sampling, will assess variability in site description and sampling techniques between soil scientists and will check adequacy of site selection and labeling. This process requires that the staff perform their assessment while the crew is describing and sampling the pedons. NOTE: Reviews by the RCC, QA/QC representative, and the SCS State Office Staff should be documented and all reports should be submitted to the EPA-Las Vegas QA Manager.

1.2.5 Soil Preparation Laboratory

Four soil preparation laboratories will participate in NADSS. These laboratories include the Cornell University Characterization Laboratory at Ithaca, New York, the University of Maine Soils Laboratory at Orono, Maine, the University of Connecticut Soil Testing Laboratory at Storrs, Connecticut, and the University of Massachusetts Soil Testing Laboratory at Amherst, Massachusetts.

Small bags, data forms, labels, audit samples, shipping containers, and other equipment will be shipped to these soil preparation laboratories by EPA-Las Vegas. The field soil scientists will use these laboratories as sample drop-off points and supply pick-up points.

1.2.6 Analytical Laboratories

Routine and QA samples will be shipped in batches to each analytical laboratory from the preparation laboratory. Each batch will consist of a maximum of 39 routine samples and field duplicates, 2 audit samples, and a preparation laboratory duplicate.

2.0 Site Selection

2.1 Watershed Selection

Because the objectives of DDRP are focused on making regional inferences, it was critical that the 150 watersheds selected for mapping of soils and watershed characteristics constitute a representative sample of the region. The 773 watersheds included in Region I of the National Surface Water Survey (NSWS) provided an excellent starting point from which to draw a subsample of 150 for the northeastern portion of DDRP, because: (1) the NSWS lakes were selected according to a rigorous probability sampling method (stratified by five subregions and three alkalinity classes within each subregion), and (2) water-chemistry information was available from NSWS for these lakes.

The 150 watersheds to be studied in DDRP also are part of the Phase II lake-monitoring program of NSWS that will provide a data set that contains both water-chemistry and watershed information. Therefore, the procedure used to select these watershed incorporated criteria relevant to both DDRP and NSWS. The procedure consisted of five steps, which are summarized as follows:

Step 1: Lakes of low interest (too shallow, highly enriched, capacity protected, polluted by local activities, or physically disturbed) were excluded.

Step 2: Lakes too large to be sampled (>200 ha) were excluded.

Step 3: A cluster analysis was performed on a set of chemical and physical variables to group the remaining 510 lakes into three clusters of lakes with similar characteristics.

Step 4: A subsample of 60 lakes was selected from each cluster, then the three subsamples were weighted to represent the overall population of lakes in the northeast.

Step 5: Lakes with watersheds too large to be mapped at the required level of detail (watersheds >300 ha) were excluded from the subsamples.

This procedure identified 148 lakes and watersheds, spread across the three clusters. Note that the three groups differ primarily in their alkalinities, pH levels, and calcium concentrations. To maintain the ability to regionalize conclusions drawn on the sample of 148 watersheds, the precision of information characterizing each of these watersheds should be comparable, and each cluster should be described at the same level of detail as the others.

2.2 Watershed Mapping

During the spring and summer of 1985, 145 of the 148 watersheds were mapped. The logistics and protocols of the watershed mapping are described in chapters 6 and 7, Volume 5, Appendix B.2 Soil Survey -- Action Plan/Implementation Protocol.

A total of about 440 mapping units were identified in the 150 watersheds. Sampling each of the 440 mapping units would not necessarily be the best way to describe adequately the chemistry of the region's soils. A better procedure is to combine the identified soils into groups, or sampling classes, which are either known or expected to have similar soil-chemical characteristics. Each of these sampling classes can then be sampled across a number of watersheds in which they occur, and the mean characteristics of the sampling class can be computed. These mean values and the variance about the mean can then be used to build "back-up" area- or volume-weighted estimates of each watershed's characteristics.

For this procedure to work, it is critical that a sufficient number of samples are taken (five or more) to characterize the variability of each sampling class. This necessitates aggregating the number of mapping units into a reasonable number of sampling classes, given budgetary constraints. Thus, the central goal is to develop a method of grouping the large number of soils into a reasonable number of sampling classes.

2.3 Sampling Classes

2.3.1 Data Base

The data base contains about 2200 observations that were recorded on the field forms during the soil mapping of 145 watersheds selected as part of the DDRP and the Phase II lakes survey. This information includes:

Taxonomic class (series, subgroup, great group).
Parent material.
- Origin.
- Mode of deposition.

Drainage class.
Slope class.
Slope configuration.
Family texture.
Geomorphic position.
Dominant landform.
Surface stoniness.
Percent inclusions.
Percent complexes.
Estimated depth to bedrock.
Estimated depth to permeable material.

This information was considered in aggregating similar mapping units into sampling classes. The data base also includes the area of each mapping unit, number of occurrences, and percent of the watershed area.

Separate data files also exist for vegetation type, vegetation class, and geology. The data management system, dBase III, runs on an IBM PC-XT microcomputer at the EPA Environmental Research Laboratory in Corvallis, Oregon (ERL-C).

2.3.2 Evaluation of Sampling Classes

A taxonomic approach was used to identify 38 sampling classes as a foundation for aggregating similar mapping units. Taxonomic classification is based on similarities among soil properties. This taxonomic scheme was modified to reflect the major factors influencing soil chemistry.

2.4 Watershed and Sampling Class Selection

2.4.1 Sampling Class Objectives

The primary goal of this part of the sample selection procedure is to determine which sampling classes will be sampled in which watersheds. The sample sites should be selected to meet the following objectives:

Objective 1: To characterize all the sampling classes with similar levels of precision.

Objective 2: To describe the variation in watershed characteristics.

Objective 3: To describe the variation in the acid neutralizing capacity (ANC) clusters developed from the lake survey.

2.4.2 Sampling Class Constraints

To meet these three objectives, a series of constraints was developed based on the allocation of samples to sampling classes and watersheds. The constraints that must be met follow:

Constraint 1: Approximately equal numbers of samples will be taken from each sampling class.

Constraint 2: Approximately two samples will be taken from each watershed.

Constraint 3: Not more than one sample will be taken from each sampling class in each watershed.

Constraint 4: Samples will be selected over the range of ANC clusters within each sampling class.

The method outlined here was developed to randomly select watersheds and sampling classes, within these constraints, using a simple selection algorithm.

2.4.3 Selection Algorithm

The method selection proceeds through a series of stages. Wherever possible, the rationale for the particular approach taken is described and cross-referenced with the objectives and constraints.

The selection method is based on the use of a systematic, weighted, random sample of the watersheds that contain any given sampling class. First, the number of samples to be taken in each sampling class is determined (Constraint 1).

2.4.3.1--

The first task is to construct a matrix of the occurrences of each sampling class in each watershed. This matrix is used to: (1) prepare a list of the watersheds that contain each sampling class, and (2) determine the number of different sampling classes in each watershed.

When the number of watersheds represented in each sampling class has been determined, it is possible to allocate the samples to sampling classes (given Constraint 3).

Using eight samples per sampling class as a base, the following sample allocation occurs. Eight samples will be allocated to each sampling class where there are more than eight watersheds; where there are eight watersheds or less, one sample will be allocated to each watershed.

2.4.3.2--

The next task is to determine which watersheds will be selected within each sampling class. In this process, constraints 2 and 4 are centrally important.

If watersheds are selected randomly within each sampling class, the watersheds that contain a large number of sampling classes will have more samples allocated to them than will the watersheds that have fewer sampling classes. To counteract this effect, and to help approach an approximately equal number of samples per watershed, the watersheds will be weighted (during the random selection procedure) by the inverse of the number of sampling classes that they contain.

For example, if one watershed contains four different sampling classes, it will be exposed to the sample selection procedure four times. Thus, it will be given one quarter of the weight of a watershed that contains only one sampling class. Using this technique, both watersheds have an approximately equal probability of being selected. This scheme will work accurately if there are equal numbers of watersheds considered in each sampling class; the presence of unequal numbers will cause some deviation from the most desirable distribution of samples.

To avoid overemphasizing the very common soils, only one sample will be taken from each watershed that contains only one sampling class. All named soils in a complex soil series are counted as occurrences in their respective sampling classes. For example, a Tunbridge-Lyman soil complex in a watershed mapping unit would be considered as one occurrence of sampling class S12, which contains the Tunbridge series, and one occurrence of sampling class S13, which contains the Lyman series.

The method used to select watersheds within sampling classes will be to sort the watersheds by ANC cluster and then take a systematic, weighted, random sample using the weights described above. This procedure selects a random starting point in the list of watersheds and then selects watersheds at regular intervals from the (weighted) list. This method ensures a selection across the range of ANC clusters.

To ensure that a watershed is not sampled more than once for a given sampling class, the weight assigned should not be larger than the interval used in the systematic sampling. Weights should be scaled down if they exceed the systematic sampling interval.

2.4.3.3--

Once this procedure has been followed for each sampling class, the initial selection of watersheds and sampling classes can be summarized. Three options are possible at this point:

- The weighing factors can be adjusted iteratively until the allocation is acceptable.
- Samples can be arbitrarily moved among watersheds to reach the desired allocation.
- The selection can be accepted as adequate.

If the selection is not considered adequate, the most acceptable solution is to repeat the procedure using adjusted weights. This process could be automated, if necessary, with the weight of a watershed being increased until it receives sufficient samples.

The method of sampling class and watershed selection outlined here is designed to satisfy the objectives and constraints listed in sections 2.4.1 and 2.4.2. Given the nature of the constraints, it is likely that there is no single, perfect solution; however, this method allows the production of an acceptable selection that is a compromise between the demands of the different objectives.

2.5 Final Selection of Sampling Locations

2.5.1 Rationale and Objectives

Soil surveys generally have a holotypic purpose of describing the typical soil series or soil phases found in a watershed. The DDRP is interested in obtaining samples that are integrative or that represent the sampling class in the watershed. This sampling class may contain six or seven similar soils. The sampling purpose is not to describe the characteristics of a specific soil phase, but rather to describe the characteristics of the sampling class. Because all soils within a sampling class are considered similar in soil chemistry, the specific sampling location within a sampling class can be selected at random with respect to the soil series. The procedures described in this section are intended to: (1) characterize the range of variability that occurs within a sampling class, and (2) characterize the soils within a sampling class using similar levels of precision.

Determining the sampling location within the watershed sampling class is a two-step process.

2.5.2 Sampling Site Selection

There are five steps in selecting representative sampling sites within a sampling class:

NOTE: Steps 1 through 5 will be completed by ERL-C. Maps that show the five random points, as discussed in Step 3, will be given to each SCS sampling crew.

Step 1: Prepare a list of all mapping units and the sampling class or classes in which they occur. Most mapping units will occur only in one sampling class; complexes may occur in two or more sampling classes. For each complex, record the proportion of area occupied by each soil series in the complex (from the mapping unit description). This proportion should be average proportion, excluding the area occupied by inclusions.

Step 2: For each watershed, obtain the watershed map and identify the sampling classes selected for that watershed. Mapping-unit delineations for each soil series must be aggregated and identified for each sampling class.

Step 3: Transfer a grid that has a cell size of about 2 acres to a Mylar sheet. Overlay the grid on the watershed map. Select a set of random coordinates (using a computer program) and determine if the point they represent intersects one of the sampling classes selected on that watershed. If the point does not fall within the selected sampling classes, draw another pair of random coordinates. Continue this process until five random points have been identified in each sampling class.

Record their order of selection from 1 through 5. Some sampling locations may not be accessible, so alternate locations must be provided.

Step 4: If the point falls on a sampling unit that is a complex, draw a random number, Y, between zero and the total percentage of the soils in the complex (e.g., a 50-30 percent complex of Tunbridge-Lyman would sum to 80, so the maximum random number is 80). Determine the percentage of the area in the desired sampling class (e.g., Tunbridge is 50 percent). Call this number X. If X is less than Y, draw another set of coordinates. This procedure minimizes the probability that complexes will be overselected for sampling.

Step 5: For each location selected, overlay appropriate maps and note the vegetation class associate with each point as: (1) coniferous, (2) deciduous, (3) mixed, (4) open dryland, or (5) open wetland.

NOTE: For comparison of coniferous, deciduous, and mixed vegetation types to Society of American Foresters (SAF) forest cover types, see Table 2.1.

Within the sampling class, sample the pedons that have one or more of the soils in the sampling class and that have one or more of the vegetation classes noted above.

2.5.3 Sampling Site Locations

The procedure described above is to locate the general vicinity of the site on the watershed soil maps. This procedure is completed, and the soil maps marked with the random points are distributed, before the sampling crew leaves for the field. The point marked on the map may represent an area of 100 m^2 in the field. Within this general vicinity there may be inclusions, rock outcrops, a complex soil, or other factors that make finding a soil of the specific sampling class difficult. The following procedures will be used to select the specific sampling site in the watershed.

2.5.3.1--

Obtain a list of the sampling classes to be determined on that watershed. Also obtain a map that clearly shows the five predetermined random points for selection.

2.5.3.2--

As best as can be determined, the sampling crew will go to the location of the first potential sampling site indicated on the map. If that location is inaccessible, go to the second potential sampling site but note the reasons in the field logbook and, if possible, on the SCS-232 field form.

2.5.3.3--

If the location is accessible and the soil series at the site is in the selected sampling class and the vegetation class is appropriate, sample the pedon.

2.5.3.4--

If the randomly selected site contains a soil series that is not a member of the sampling class, or if the vegetation class is not appropriate from a random-number table, select a random number between 1 and 8, where 1 represents the direction north, 2 represents northeast, 3 represents east,... 8 represents northwest. Walk along a straight line in the direction chosen until the first occurrence of the proper combination of soil series and vegetation class is found. The maximum distance walked corresponds to a radius of 155 m around the randomly selected site. If a proper combination of soil series and vegetation class is not obtained after five tries, go to the next potential site on the list. The number of traits at each site and the number of alternative sites attempted should be recorded on Form SCS-232.

These procedures provide a method for selecting a specific site and locating that site in the field.

Table 2-1. Comparison of Coniferous, Deciduous, and Mixed Vegetation Types to Society of American Foresters (SAF) Forest Cover Types

SAF Cover Type Name	Cover Type Number
Coniferous Vegetation Types	
Jack Pine	1
Balsam Fir	5
Black Spruce	12
Black Spruce - Tamarack	13
White Spruce	107
Tamarack	38
Red Spruce	32
Red Spruce - Balsam Fir	33
Red Spruce - Frasier Fir	34
Northern White Cedar	37
Red Pine	15
Eastern White Pine	21
White Pine - Hemlock	22
Eastern Hemlock	23
Deciduous Vegetation Types	
Aspen	16
Pin Cherry	17
Paper Birch	18
Sugar Maple	27
Sugar Maple - Beech - Yellow Birch	25
Sugar Maple - Basswood	26
Black Cherry - Maple	28
Hawthorn	109
Gray Birch - Red Maple	19
Beech - Sugar Maple	60
Red Maple	108
Northern Pin Oak	14
Black Ash - American Elm - Red Maple	39
Mixed Vegetation Types	
Hemlock - Yellow Birch	24
Red Spruce - Yellow Birch	30
Paper Birch - Red Spruce - Balsam Fir	35
White Pine - Chestnut Oak	51
White Pine - Northern Red Oak - Red Maple	20

2.6 Special Conditions

2.6.1 Inaccessible Watersheds

An attempt should be made to sample every watershed. However, some watersheds may have inaccessible areas or areas where sampling access is denied. Alternative sampling classes are selected during the random selection process as back-up sampling locations to ensure an equitable distribution of samples among sampling classes. Initial estimates of watersheds that may be remote and difficult to sample or that may be inaccessible include one in New Hampshire, one in Massachusetts, two in Connecticut/Rhode Island, three in Maine, and five in New York. Each state will formally document the reasons for excluding each watershed.

2.6.2 Inclusions

Inclusions are not representative of the soils in the sampling class and should not be sampled if the randomly selected site is located on an inclusion. The procedures described earlier accommodate this contingency. Generally, inclusions are soils associated with a sampling class other than the one being sampled. The chemical properties of the inclusion, therefore, are described when the other sampling class is sampled.

2.6.3 Agricultural Sites

The open-dryland class contains some cultivated fields. If these sites are randomly selected and access permission is obtained, the sites will be sampled. Agricultural practices, however, generally alter the chemical characteristics of the soil through fertilization, liming, and other activities.

Note samples taken from agricultural sites on the field forms. During subsequent modeling and statistical analyses, these samples may or may not be incorporated in representing watershed soil chemistry.

2.7 Paired Pedons

Paired pedon sites for sampling are selected and assigned in advance by ERL-C. These sites will be sampled in conjunction with the corresponding routine pedon. The sample code identifying the paired pedon should be treated as a routine pedon.

The location of the paired pedon is determined by the crew leader using the following criteria:

- Establish sufficient distance between the two sampling locations to avoid disturbance of the paired pedon from sampling of the routine pedon.
- Use the same sampling unit and vegetation class as the routine pedon.
- Use the same slope position as the routine pedon.
- Use the same profile description and sampling protocol as the routine pedon.

3.0 Site and Profile Description

3.1 Scope

Complete descriptions of the soils are essential to the soil survey and serve as a basis for soil identification, classification, correlation, mapping, and interpretation. Standards and guidelines are necessary for describing soil properties. Precisely defined standard terms are needed if different people are to record their observations so that others can understand those observations. However, the field scientist must always evaluate the adequacy of standard terms and add needed information.

The description of a body of soil in the field, whether an entire pedon or a sample within it, records the kinds of layers, their depth and thickness, and the properties of each layer. These properties include color, texture, structure, characteristics of failure and disruption, roots and animals (and their traces), reaction, salts, and boundaries between layers. Some properties that apply to the entire sampling unit are also measured and recorded. Generally, external features are observed from study of a pedon that is judged to be representative of the polypedon.

For a soil description to be of greatest value, the part of the landscape that the pedon represents should be known and recorded. Descriptions of pedons that represent an extensive, mappable area are generally more useful than are descriptions of pedons that represent the border of an area or a small inclusion. Consideration is given to external and internal features of the soil, related features such as vegetation and climate, and the setting -- the position of the particular soil in relation to other soils and to the landscape as a whole.

Pedons used for detailed study of a soil are selected tentatively at first. Areas that previous studies have shown to contain the kind of soil to be described and sampled are most commonly chosen. The pedon is usually selected on the basis of external evidence. Depending on the purpose of the study, the selected pedon may be one that has properties either near the middle of the range of the taxon or near the limits of the range. After a sampling site is tentatively located, it is probed with an auger, spade, or sampling tube to verify that the soil at the site does have the diagnostic features of the soil and that its properties at the site represent the desired segment of the soil's range.

A pit that exposes at least one clean, vertical face (approximately 1 m across) to an appropriate depth is convenient for studying most soils in detail. Horizontal variations in the pedon, as well as features too large or too widely spaced to be seen otherwise, can be observed. The sides of the pit are cleaned of all loose material disturbed by digging. The exposed vertical faces are then examined starting at the top and working downward, to identify significant differences in any property that would distinguish between adjacent layers. Boundaries between layers are marked on the face of the pit, and the layers are identified and described.

Photographs can be taken after the layers have been identified but before the vertical section has been disturbed for description. If point counts are to be made for estimation of volume of stones or other features, the counts are made before the layers are disturbed. If samples are to be taken to the laboratory for analyses or other studies, they are collected after the soil has been described.

Horizontal relationships between soil features can be observed in a cross section of each exposed layer by removing the soil above it. Each horizontal section must be large enough to expose any structural units. A great deal more about a layer is apparent when it is viewed from above, in horizontal section, as well as in vertical section. Structural units that are otherwise not obvious, as well as in vertical section. Structural units that are otherwise not obvious, as well as the third dimension of many other features, can be seen and recorded. Patterns or color within structural units, variations of particle size from the outside to the inside of structural units, the pattern in which roots penetrate structural units, and similar features are often seen in horizontal section more clearly than in a vertical exposure.

3.2 Field Properties

The following parameters will be determined in the field by established SCS methods and protocols [1,2,4].

- Horizon type.
- Horizon depth.
- Color.
- Texture.
- Structure.
- Consistence.
- Boundary type.
- USDA/SCS soil taxonomic designation.
- Surface vegetation type and abundance.
- Parent material.
- Physiography.
- Relief.
- Slope.
- Aspect.
- Permeability.
- Erosion class.
- Root distribution.
- Drainage class.
- Depth to bedrock.
- Bedrock exposure.
- Volume percent coarse fragments by visual estimation.
  - 20 to 75 mm.
  - 75 to 250 mm.
  - >250 mm.
- Diagnostic features.
- Mottle type and abundance.

The field crew will use Form SCS-SOI-232 for field description which is coded for easy input onto a computerized data file. The protocol for horizon description is discussed in detail in the *SCS Soil Survey Manual* [2], the *SCS National Soils Handbook* [1], and *Principles and Procedures for Using Soil Survey Laboratory Data* [3].

3.3 Profile Excavation

The exposed face of the pedon must be wide enough to permit pedon description, the collection of bulk-density clods, and the collection of 5.5 kg or more of sample from each of the significant horizons. The pedon face should be photographed (Section 3.4) before destructive sampling begins.

3.4 Photographs of Profile and Site

Photographic documentation of the sampling phase will be useful for later reference and future discussions concerning specific site considerations, and will complement field descriptions. Field crews will provide their own single-lens reflex, 35-mm cameras or equivalent and will obtain film locally. Ektachrome, ASA 400 slide film is recommended, but field crews should determine film speed suitability based on their knowledge of the site. If flash attachments and tripods are available, they should be included in the sampling equipment. For film-quality consistency, all slides should be developed using prepaid Kodak mailers.

Photographic documentation requires that a precise logbook be kept to identify corresponding slides. The indexing system can be developed by the field crew, but must be based on the sample code from NADSS Label A to identify the site. The system must be fully explained in the logbook. Once the slides have been developed, they should be labeled on the slide mounts with the sample code and any other information the field crew deems necessary. Slides will be stored in 3-ring binders in slide files and will be submitted with the logbook to ERL-C at the conclusion of the sampling phase of the survey. Histosols should be photographed by sequential placement of the augered horizons on the surface.

The pedon face, tree canopy, understory vegetation, and representative landscape or landform will be photographed for each site sampled. Scale should be provided by including a meter stick, rule, or other suitable item in the photograph. Pedon face identification can be positively made by including NADSS Label A or an index card displaying Label A information in the photograph. SCS protocols for field photography are outlined in the *SCS National Soil Survey Manual*[2], Chapter 9.

3.5 Important Points Concerning Horizon Descriptions

The sample site should be free of road dust and chemical contamination. State all known spraying of pesticides and herbicides.

Soils will be sampled only from freshly dug pits large enough (1 m x 1 m) to allow sampling of all major horizons to a depth of 1.5 m or to bedrock.

Samples will be taken from continuous horizons >3 cm thick, including the C horizon if present. Discontinuous horizons will be sampled when considered significant by the crew leader.

Clods will be collected for all horizons sampled, except the O_i horizon. The bulk density procedure is detailed in Section 7.0.

All obvious horizons in a pedon are to be sampled, although a maximum of six horizons had been previously specified as a limit for cost estimates and planning purposes. It is the decision of the field soil scientist whether or not a horizon is significant enough, for DDRP purposes, to be sampled and described. Therefore, if the field soil scientist believes there are eight significant horizons, he should sample all eight. Pedons can not be dug in wetlands. The recommended procedure for obtaining a 5.5-kg sample is to use a peat-sampling corer.

Sample pits will be accurately located on the soil survey maps, and the pit dimensions and the azimuth perpendicular to the pit face will be recorded. The location of the pit in the field should be flagged or identified so that it can be revisited, except in areas where this is not possible due to landowner restrictions. One horizons per day will be sampled twice by each field crew. This will be the field duplicate (FD). The choice of which horizon to duplicate is at the discretion of the field crew. The procedure for obtaining this duplicate sample is to alternate when placing trowel or shovelfuls of sample into each sample bag. The horizon that is chosen for a field duplicate should be alternated each day so that a complete range of field duplicates by horizon is achieved.

3.6 Field Data Form - SCS-232

All field data should be recorded on Form SCS-SOI-232, which is reproduced along with a modified legend in Appendix A. The SCS is responsible for making sure that completed copies of these forms are sent weekly to the following groups:

One copy to the preassigned soil preparation laboratory for each crew.

One copy to the EPA Environmental Monitoring Systems Laboratory-Las Vegas (EMSL-LV) to:

Lockheed Engineering and
Sciences Company
1050 E. Flamingo, Suite 120
Las Vegas, Nevada 89109

One copy to Oak Ridge National Laboratory (ORNL) to:

Oak Ridge National Laboratory
P.O. Box X
Building 1505, Room 343
Oak Ridge, Tennessee 37831

and one copy to the EPA ERL-C to:

Environmental Research Laboratory-Corvallis
200 S.W. 35th Street
Corvallis, Oregon 97333

NOTE: The following changes and additions from the normal procedure should be made to complete Form SCS-232.

Page 1 of 4

Under "Sample Number," "unit" is synonymous with "pedon."

Under "Date" add the day as: __/__/__
Month Year Day

Under "Describers Name" add the Crew ID in the upper right hand corner.

Under "Location Description and Free Form Site Notes" the first six digits of line 1 should be the site ID (Lake ID), the seventh digit is a dash, the eight digit is the random number point (1 to 5), the ninth digit is a dash and digits 10 through 12 are the sampling class, digit 13 is a dash, digits 14 through 16 are the azimuth perpendicular to the described pit face, the digit 17 is a degree symbol "°".

Under "Vegetation" describe the three major species by decreasing basal area. Clearcut should be noted as "CC." Describe dominant vegetation types prior to clearcut in the free form site notes.

The following soil description parameters need not be completed by field crews, but may be if information is accessible: Precep, Temperatures °C, Weather Station Number, ER.

Page 2 of 4

Dry color should be determined when needed for classification.

"VOL (LAT/TOT)" need not be completed but may be if information is accessible.

Page 3 of 4

Mottles should be described as indicated in Chapter 4 of the *National Soils Survey Handbook*[1].

"Effervescence" will be determined at the preparation laboratory and need not be completed here.

Page 4 of 4

The three divisions under "Rock Fragments" correspond to the three volume particle size estimates:

line 1 = 2 to 75mm
line 2 = 75 to 250 mm
line 3 = >250 mm

Legend

Under "Site Description Codes" for page 1 add "AA" for a local site description.

4.0 Sampling Procedures

4.1 Scope

The objective of the field sampling phase of the DDRP is to characterize the soil and watershed characteristics across the regions of concern, the northeastern United States, and the southwestern portion of the Blue Ridge Province.

Field sampling includes the collection of a 5.5-kg field sample that will yield a minimum of 2 kg of air-dried material of particle sizes <2 mm. This requires 5.5 kg of mineral soil, or as much soil possible to fill the presupplied 46 cm x 53 cm sample bags, and twice this volume for organic soils. In addition, bulk-density clods will be sampled for laboratory determination of field bulk density.

4.2 Sampling the Pedon

4.2.1 Field Sampling Protocols

Field sampling protocols are based on the standard methods routinely used by SCS. The following procedural steps were developed by the National Soil Survey Laboratory, Lincoln, Nebraska, and are detailed in a publication titled *Principles and Procedures for Using Soil Survey Laboratory Data* [3]. An edited version of these procedures is reproduced here. The protocol for collecting bulk-density samples is specified in Chapter 7.0 of this manual.

4.2.2 Sampling Party Responsibilities

The sampling party has responsibility to obtain samples representative of the pedons selected for characterization. Although some sampling protocol has been specified, field-crew decisions are necessary on how deep to sample, horizon delineation, thickness of horizon (or interval) sampled, what material should be excluded from the sample, and the usefulness of compositing samples. The sampling party ensures that site and pedon descriptions are adequate.

4.2.3 Pedons for Characterization

Pedons for characterization studies should be sampled to a depth of 1.5 m where possible. In cases where the lower depths of the profile appear homogenous and the C horizon material is particularly difficult to penetrate in (e.g., dense basal till), it may be feasible to dig the pit to 1.5 m. However, it is still possible that a dense basal till will show a variable pH from the upper to the lower sections of the C horizon. If this were true, a sample would be desirable even if the material is hard to dig. These types of decisions are judments to be made to the best of the ability of the sampling-crew leader and should be documented in the field sampling notebook. The sampling party needs to be alert to taxonomic questions that may arise and sample appropriately to resolve the questions (i.e., base saturation for Alfisol versus Ultisol may require subsamping at a specific depth). Appropriate sampling increments depend on the kind of material and the proximity of the horizon to the soil surface. Horizons in the upper 1 m would usually be split for sampling if they are more than 30 cm thick, excluding organic horizons. Uniform horizons below 1 m are usually split for sampling if they are more than 75 cm thick. The sampling party must exercise good judgment in this decision process. The ideal sample contains each soil material within the horizon in proportion to its occurrence in the pedon. The sampler attempts to approximate the ideal sample by carefully sampling a selected section of the horizon. The sample is usually taken along a pit face from horizon boundary to horizon boundary and between arbitrary lateral limits.

4.2.4 Lateral Limits

Lateral limits encompass short-range variability observed at the site. If a recurring pattern (i.e., mottles, durinodes, nodules, plinthite) is discerned, extend the lateral limits to four or five cycles of the pattern. If this produces too much material, the sample is mixed, quartered, and subsampled. At some point, the repeat cycles become too large or soil properties change sufficiently that lateral extension is impractical or undersirable. An example is the gilgai pattern in Vertisols. Proper characterization may warrant the sampling of two sets of horizons or pedons.

4.2.5 Stratified Horizons

If a horizon is stratified or otherwise contains contrasting materials, each material should be carefully described. Some contrasting materials can be sampled independently, but in many cases the materials are intertwined to the point that practicality dictates they be sampled together. Each material should be described and the proportions should be noted, however. A decision on what, if any, materials should be excluded from the sample is an integral part of collecting a representative sample. The sampling party may decide to include soil material in cicada casts and nodules as part of the sample, but to exclude material from a badger tunnel.

Coarse fragments (>20 mm) will be excluded from all samples sent to the laboratory except for bulk-density clods.

4.2.6 Composite Samples

One sampling technique designed and used here to average lateral variability is to sample three or four relatively small segments (20 to 30 cm wide) of the same pedon at several points around the pit. The samples are composited, mixed, and a representative sample is sent to the laboratory for analysis.

4.2.7 Filling Sample Bag

Approximately 5.5 kg or more of soil less than 20 mm in diameter should be placed in each plastic sample bag. However, the amount of soil obtained for chemical analysis is highly dependent on the amount of coarse fragments contained in each horizon.

For example, if the horizon is determined to contain 50 percent coarse fragments by a visual estimate, the corresponding weight estimate for coarse fragments is 65 percent (Table 4.1). This estimate indicates that a 5.5-kg sample will contain 35 percent of material <2 mm or only 1.8 kg of sample. Field sampling protocols specify that a minimum of 2 kg of soil of particle size <2 mm is necessary for the chemical and physical analyses specified. Care must be taken to ensure that field samples will yield the minimum 2 kg of soil in the <2 mm particle-size class. Table 4.1 illustrates that a 5-kg sample from horizons containing coarse fragments greater than 60 percert by weight or 45 percent by volume will not be sufficient to obtain a minimum 2-kg sample. Minimum sample weights for horizons with coarse fragments and weights in this category are provided in Table 4.1.

NOTE: This table is included as a guide and probably will not be most useful in the field, but the concept explained is important.

The general rule to follow is that the minimum amount of *field* sample is 5.5 kg of the ≤20-mm particle-size fraction. If the estimated 2- to 20-mm size class exceeds 45 percent by the volume estimate, then two 5.5 kg samples or two full sample bags of mineral soil is necessary. Two full bags of organic horizon material are requested in every case possible. Plastic sample bags should be pre-labeled with NADSS Label A. Attach the label to the center of the bag, not near the top of the bag. Double check that all designations are correct, complete, and legible. Large, easily removed nonmineral material should not be included in the sample. Limit handling of the soil sample to avoid contamination.

Table 4-1. Visual Estimate of Percent Volume of Rock Fragments Greater than 75 mm Correlated to Percent Weight

% Volume	% Weight	Weight of <20 mm particles in a 5-kg sample	Sample weight required to obtain a minimum 2-kg sample
0	0	5.00	5.0
3	5	4.75	5.0
7	10	4.50	5.0
10	15	4.25	5.0
13	20	4.00	5.0
16	25	3.75	5.0
20	30	3.50	5.0
23	35	3.25	5.0
27	40	3.00	5.0
31	45	2.75	5.0
35	50	2.50	5.0
40	55	2.25	5.0
45	60	2.00	5.0
50	65	1.75	5.7
56	70	1.50	6.6
62	75	1.25	8.0
68	80	1.00	10.0
74	85	0.75	13.0
80	90	0.50	20.0

In wet soils, such as Histosols, excess water should be drained before sealing the sample bag.

The top of the plastic sample bags should be folded down in 2.5-cm sections. The folded sections should then be stapled or tied with twist-ties to seal.

The plastic bags should then be placed within pre-labeled canvas bags. Label the canvas bag below the center with indelible ink or use presupplied label stamps. Record exactly the same information contained on NADSS Label A. Seal the canvas bag by tying or stapling. Place the samples in coolers with Blue Ice as soon as possible after field sampling. Transport samples to the preparation laboratory as soon as possible.

4.2.8 NADSS Label A (Figure 4-1)

The date sampled is entered in the format DD MMM YY. For example, March 14, 1985, will be 1 4 M A R 8 5. The crew ID will consist of four digits: the first two are alphabetic, representing the state; the second two are the number assigned to each crew for the state, for example, NY 01. The site ID consists of six digits and appears on the assigned watershed map as:

1	2	3	4 5 6
Region	Subregion	Alkalinity Class	Watershed ID

The sample code represents the SCS (FIPS) soil ID code and the sample type. The first three digits of the sample code represent the type of sample (R11 = routine sample, one bag, one sample; R23 = routine sample, 2nd of 3 bags; R33 = routine sample, 3rd of 3 bags; Field Duplicate = FD0, [FD1, FD2 are used for compound bags of field duplicates] etc.), digits 4 to 5 are the SCS state code, 6 to 8 are the SCS county code, digit 9 is a dash, digits 10 to 11 are the county pedon number and digits 12 to 13 are the horizon number. Upper and lower split horizons will be identified by the depth designations (written after the horizon designation). A "U" or an "L" can also be written after the horizon depth to help to differentiate these samples for the preparation laboratories. The Set ID is a four-digit number beginning with 0. The field sampling crews are assigned the following ideal set of 100 Set ID numbers for sampling in the Northeast:

100-199	ME02	700-799	MA01
200-299	ME03	800-899	MA02
300-399	NH01	900-999	CT01
400-499	NY01	1000-1099	PA01
500-599	NY02	1100-1199	VT01

The field sample will be passed through a 75-mm sieve. All coarse fragments remaining on the sieve can be subdivided manually into two size classes; 75 to 250 mm and ≥250 mm.

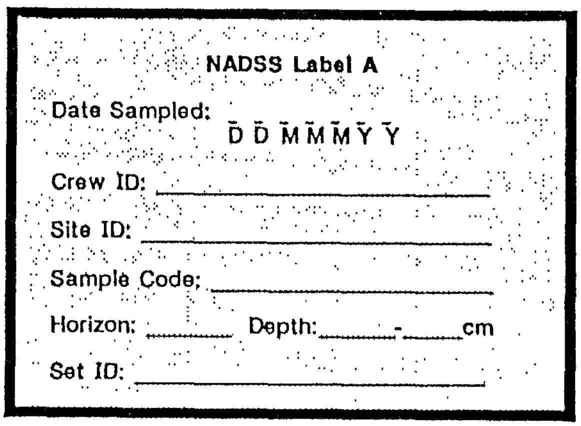

Figure 4-1. NADSS Label A.

An estimate will be made of the volume percent of material in these classes. A volume estimate of the percent coarse fragments for the 20- to 75-mm fraction will be made as well. This information will be entered on SCS Form 232 under the Rock Fragments category, Size (SZ, 1 = 20 to 75 mm, 2 = 75 to 250 mm, and 3 = ≥250 mm). The preparation laboratory will determine the percent coarse fragments in the 2- to 20-mm fraction. The sieved soil <20 mm should be used as the soil sample and should be placed in the sample bag according to procedures in Section 4.2.7.

4.3 Delivery

The soil samples should be delivered to the pre-assigned soil preparation laboratory. The following preparation laboratory assignments are for the Northeast sampling crews. Preparation laboratories for the southeastern sampling crews will be assigned at a later date.

Field Crew	*Preparation Laboratory*
Maine	University of Maine
New Hampshire, Vermont, Massachusetts	University of Massachusetts
Connecticut, Rhode Island	University of Connecticut
New York, Pennsylvania	Cornell University

Samples will be kept as cold as possible in the field by storage in coolers with Blue Ice gel packs until delivery to the preparation laboratory. Temperature checks in the cooler should be made routinely to keep a 4 °C ambient air temperature. These readings should be recorded in the field logbook. Due to the location of some watersheds, some samples may not be delivered to the preparation laboratory until three to four days after they are sampled. Each field sampling crew will deliver field samples as soon as possible after collection. If major problems occur, notice must be given as soon as possible to the QA Officer. Every effort should be made to get the field samples to the preparation laboratory as soon as possible.

Great care should be taken not to drop or puncture sample bags in transport to the preparation laboratory.

5.0 Soil Preparation Laboratory

5.1 Scope

The samples will be received by the preparation laboratory supervisor. The supervisor will check the samples for spillage or other problems and to be certain that each sample has an accompanying NADSS Label A (Figure 4-1). Field samples and all QC samples will be logged in on NADSS Form 101 (Figure 5-1). The QC samples will be randomly assigned in the batch by the preparation laboratory. One set of samples will be defined as the total number of samples taken in one day by one crew. Each set will include one field duplicate, because one horizon per day is to be sampled twice as a field duplicate. Two pre-assigned audit samples will be randomly inserted into each batch. In addition, one sample per batch will be randomly selected, divided into two samples, and tracked as the preparation laboratory duplicate (PLD). One batch including routine field samples, field duplicates, a preparation laboratory duplicate, and two audit samples will contain a maximum of 42 samples. Therefore, the number of sets combined to make one analytical batch depends on the number of samples in each set. The total number of samples in the combined sets should not exceed 39.

5.2 Sample Storage

The samples will be sealed and stored at 4 °C at all times when not involved in processing. This procedure will greatly reduce microbial decomposition of organic matter without alteration of the crystalline structures. If the samples cannot be dried immediately at the preparation laboratory, they should be placed in storage until processing.

5.3 Sample Preparation

After the samples are received, sample numbers are assigned on NADSS Form 101. The samples should be air-dried and sieved (<2 mm) (see Section 5.3.1). Care must be taken to be certain that the soils are not separated from their labels during the air-drying process. The percentage of coarse fragments (>2 mm) must be weighed as specified in Section 5.3.2 and the percent coarse fragments reported on NADSS Form 101. The coarse-fragment fraction should be labeled and set aside. If the qualitative test for inorganic carbon is positive, the analysis for total inorganic carbon must be performed on this sample, and the 2- to 20-mm fraction must be crushed and shipped to the analytical laboratory. The results of the determination of effervescence are recorded on NADSS Form 101.

5.3.1 Sample Drying and Mixing

5.3.1.1--

The soil is laid out on a tray and allowed to air-dry at room temperature until constant weight is achieved (30 to 35 °C is ideal). Constant weight is defined as that time when a subsample does not change by more than 2.5 percent moisture content on two consecutive days. Constant weight must be determined before the sieving process is started. The drying period could range from two days to seven or more days, depending on organic matter content and particle size of the sample.

Date Received D D M M M Y Y
By Data Mgt. _ _ _ _ _ _ _

National Acid Deposition Soil Survey (NADSS) Form 101

Batch ID ______
Crew ID ______
Prep Lab ID ______
Lab Set Sent to ______
Date Shipped ______

Set ID ______ Date Sampled ______ Date Received ______ Date Prep Completed ______ No. of Samples ______	______ ______ ______ ______ ______	______ ______ ______ ______ ______

Sample No.	Site ID	Sample Code	Set ID	Coarse Fragments % CF	Air-dried Moisture %		Inorg. Carbon (IC) Y=yes N=no	Bulk Density g/cc
					W	RSD		
01								
02								
03								
04								
05								
06								
07								
08								
09								
10								
11								
12								
13								
14								
15								
16								
17								
18								
19								
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35								
36								
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39								
40								
41								
42								

Signature of Preparation Laboratory Supervisor:
Comment:

Figure 5-1. National Acid Deposition Soil Survey (NADSS) Form 101.

5.3.1.2--

After the soil is air-dried, place the complete sample in the orginal sample bags and store them at 4 °C until further preparation laboratory analysis is performed.

5.3.1.3--

After the soil is air-dried, place the complete sample minus the calibration sample in the original sample bags and store them at 4 °C until preparation laboratory analysis.

5.3.2 Coarse Fragment Determination

5.3.2.1--

The fragment size class that will be separated during this procedure is the class that is small enough to pass through a 20-mm sieve. Coarse fragments larger than 20 mm will be determined in the field.

5.3.2.2--

The total sample should be weighed and quantitatively passed through a clean, dry, square-holed, 2-mm sieve to segregate coarse fragments (2 mm to 20 mm) from the soil. The material larger than 2 mm should be saved until the test for inorganic carbon is complete. The soil that passed through the sieve (0 to 2 mm) should be placed in a sealed container if further processing will not occur at this time.

5.3.2.3--

The amount of soil that did not pass through the sieve should be weighed and divided by the inital amount and multiplied by 100. This percentage is then recorded as percent coarse fragments (%CF). The coarse fragments (2 to 20 mm) must be saved until the qualitative test for inorganic carbon has been completed.

5.3.3 Soil Mixing

After the soil has passed through a 2-mm sieve and %CF is determined, quantitatively load the soil into the Jones type 3/8-inch riffle splitter. The soil should be passed through the riffle splitter at least seven times. Before reloading the splitter each time, level the soil on the tray to ensure random particle addition. It is best to remove the 1-kg subsample for the analytical laboratory at this time. If the 1-kg subsample is to be removed later, the entire sample must again be passed through the riffle splitter before a well-mixed subsample can be removed. After completion of the soil preparation procedures, the soils should be placed into a new inner plastic liner supplied by EPA-LV. Complete NADSS Label B (Figure 5-2) and place it on the exterior of the inner bag that is to be sent to the analytical lab.

Remove NADSS Label A from the original field bag and tape it into a preparation laboratory notebook, grouped in order by set number and batch number. Record the date either on the label or below it. Initial the label by writing partially on the label and partially on the page. This procedure will help to replace labels that may become unattached. The air-dried soil in the inner bag should be sealed with a plastic-coated wire twist.

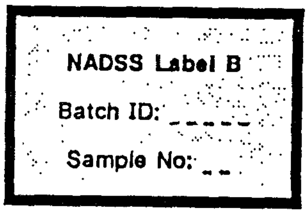

Figure 5-2. NADSS Label B.

At this point, the exterior canvas bag will have the field coding written on it and the inner bag will show the batch number and sample number.

The field coding on the outer plastic bag should be crossed out so it is not legible, and the batch number and the sample number should be written on the exterior with indelible ink. The soil should be packed tightly in the boxes supplied by EPA-LV. After all subsamples have been removed for shipment to the analytical laboratories, the remaining sample should be placed in a clean plastic bag and stored at 4 °C. The samples should be clearly and permanently labeled with NADSS Label B and stored in such a manner that they are easily retrievable if necessary.

5.3.4 Qualitative Test for Inorganic Carbon

5.3.4.1--

Carbonates are used frequently as criteria to differentiate soil series. A qualitative test for carbonates will be performed on the ≤2-mm size class. If the test for effervescence is positive, the coarse-fragment size class (2 to 20 mm) will be crushed and sent to the analytical laboratory for quantitative total inorganic carbon analysis. For the following procedures, the word "soil" is defined as that material which has been air-dried and passed through a 2-mm sieve.

5.3.4.2--

Place 1 g of soil in a porcelain spot plate. Saturate the soil with deionized (DI) water and stir with a glass rod to remove entrapped air. Place plate under a binocular microscope.

5.3.4.3--

Add 4 N HCl by dropwise addition and observe through microscope for effervescence.

5.3.4.4--

Repeat this procedure with another 1 g of soil from the sample.

5.3.4.5--

Record in laboratory notebook for each subsample whether effervescence was or was not noted.

5.3.4.6--

If effervescence was noted either time, inorganic carbon must be determined for this sample.

5.3.4.7--

If effervescence was observed, the coarse-fragment fraction from this soil sample should be crushed to pass an 80-mesh sieve. A 100-gram subsample should be prepared using a riffle splitter, and should be shipped separately (without the soil sample) for inorganic carbon determination. The subsample should be packaged in a plastic bag and labeled with NADSS Label B. Coarse-fragment subsamples do not require storage at 4 °C until shipment to the analytical laboratory.

5.4 Shipment of Subsample to Analytical Laboratories

5.4.1 Shipping Method

Subsample will be shipped to the analytical laboratories by batch. Each box shipped must contain copies of NADSS Shipping Form 102 (Figure 5-3). The results of the bulk density determination and percent coarse fragment determinations must also appear on Form 102. If Form 102 indicates a positive inorganic carbon test, the coarse fragment sample must be shipped to the analytical laboratory for total inorganic carbon analysis. As indicated on the bottom of NADSS Form 101, the canary, pink, and gold copies should be enclosed with each sample box. The white copy should be sent to the Sample Management Office (SMO) after a photocopy is made to keep at the preparation laboratory. The address for shipment to SMO is:

National Acid Deposition Soil Survey
Sample Management Office
P.O. Box 818
Alexandria, Virginia 22313

The shipping carrier to be used and specific shipping protocols required to ship samples to the analytical laboratory will be supplied to the preparation laboratory by the QA Manager.

5.4.2 NADSS Form 101

NADSS Form 101 is used to combine field sets into an analytical set. A maximum of six sets should be combined to achieve a maximum of 39 routine and field duplicate samples. In addition, there will always be one preparation laboratory duplicate (PLD) and two audit samples per batch for a combined maximum number of 42 samples. If four to six sets are used for one batch, the second section of Form 101 should be modified to fit, ignoring the predrawn lines and utilizing space as necessary. Air-dried moisture (or column "w") should be the final moisture content used to verify air-dryness, reported to two decimal places. NADSS Form 101 should be completed in black ink and should not contain any mistakes, crossouts, or white out. The form should be mailed within 24 hours after the batch has been shipped to the analytical laboratory. The white copy should be sent to ORNL at the following address:

Oak Ridge National Laboratory (ORNL)
P.O. Box X
Building 1505, Room 343
Oak Ridge, Tennessee 37831

The gold copy should be sent to the EPA ERL-C, in care of:

Environmental Research Laboratory, Corvallis
200 S.W. 35th Street
Corvallis, Oregon 97333

The pink copy should be sent to EPA EMSL-LV, in care of:

Lockheed Engineering and Sciences
Company, Inc.
1050 E. Flamingo Road, Suite 120
Las Vegas, Nevada 89109

5.5 Sample Receipt by the Analytical Laboratory from the Preparation Laboratory

The analytical laboratory should immediately compare the samples and the data on Form 102. Record should be made as to when the samples were received, and their condition upon receipt. All missing samples should be noted. This information should be recorded on Form 102 and initialed by the recipient.

If NADSS Form 102 is incomplete, immediately notify SMO at (703) 557-2490. The gold NADSS Form 102 should be kept as the analytical laboratory. The canary NADSS Form 102 should be sent to SMO at the address indicated in Section 5-4 and the pink copy should be mailed to EMSL-LV at the following address:

Lockheed Engineering and Sciences
Company, Inc.
1050 E. Flamingo Road, Suite 120
Las Vegas, Nevada 89109

The recipient should check to be sure that all samples for inorganic carbon analysis have been included.

5.6 Shipment of Mineralogical Samples

Horizons to be subsampled for mineralogical analysis will be designated by the QA Manager. Approximately 10 percent of the pedons sampled will require this analysis. Subsamples (100 g EMSL-LV. NADSS Label B (Figure 5-2) will be placed on those bottles and shipping Form 115 (Figure 5-4) will be included in each box shipped. Sample receipt protocol by the mineralogical laboratory is the same as that specified in Section 5-4 for analytical examples.

Date Received D D M M M Y Y
By Data Mgt. _ _ _ _ _ _ _

National Acid Deposition Soil Survey (NADSS) Form 102

Prep Lab ID______________
Batch ID______________
Analytical Lab ID______________

D D M M M Y Y
Date Recieved _ _ _ _ _ _ _
Date Shipped _ _ _ _ _ _ _

Sample No.	Air-dried Moisture % W	RSD	Inorganic Carbon (IC) Y=yes N=no	Coarse Fragments Shipped? (Check Y if yes)
01				
02				
03				
04				
05				
06				
07				
08				
09				
10				
11				
12				
13				
14				
15				
16				
17				
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34				
35				
36				
37				
38				
39				
40				
41				
42				

Signature of Preparation Laboratory Manager:
Comments:

SML = White Canary = ANA. Lab w/copy to SMC Pink = ANA. Lab w/copy to EMSL-LV Gold = ANA. Lab

Figure 5-3. National Acid Deposition Soil Survey (NADSS) Form 102.

Date Received D D M M M Y Y
By Data Mgt. _ _ _ _ _ _ _

National Acid Deposition Soil Survey (NADSS) Form 115

Prep Lab ID________________
Analytical Lab ID________________

D D M M M Y Y
Date Recieved _ _ _ _ _ _ _
Date Shipped _ _ _ _ _ _ _

Sample No.	Batch ID	Sample No.
01		
02		
03		
04		
05		
06		
07		
08		
09		
10		
11		
12		
13		
14		
15		
16		
17		
18		
19		
20		
21		
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32		
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34		
35		
36		
37		
38		
39		
40		
41		
42		

Signature of Preparation Laboratory Manager:
Comments:

SML = White   Canary = ANA. Lab w/copy to SMC   Pink = ANA. Lab w/copy to EMSL-LV   Gold = ANA. Lab

Figure 5-4. National Acid Deposition Soil Survey (NADSS) Form 115.

6.0 Summary of Physical and Chemical Parameters and Methods

6.1 Physical Parameters

6.1.1 Particle Size

Soil-texture analysis is routinely determined for soil characterization and classification purposes. The standard pipet method is used. Particles greater than 20 mm will be determined by field sieving and weighing; coarse fragments (2 to 20 mm) will be determined at the soil preparation laboratory and soil less than 2 mm will be determined at the analytical laboratory. This analysis will be performed on all mineral horizon samples, including the additional samples from each impervious layer less than 3 cm thick.

6.1.2 Mineralogy

Clay minerals are identified by X-ray diffraction, whereas light and heavy minerals of the fine-sand fraction are identified by optical mineralogy. Mineralogical identification is necessary to: (1) help characterize the soil, (2) provide an indication of weathering rates, and (3) yield information about minerals weathered from the parent material. This analysis will be performed only on samples selected by ERL-C.

6.1.3 Specific Surface Area

Specific surface is measured because this is highly correlated with anion adsorption/desorption, cation exchange capacity, and the type of clay mineral. The method specified is saturation with ethylene glycol monomethyl ether. This analysis will be performed on all mineral horizon samples.

6.2 Chemical Parameters

6.2.1 pH

pH is a measurement of free hydrogen ion activity. pH measurements are determined in three different soil extracts. The extracts are DI water 0.01 M $CaCl_2$, and 0.002 M $CaCl_2$ in a 1:2 ratio in a mineral soil and a 1:5 ratio for organic horizon samples. These analyses will be performed on all samples.

6.2.2 Total Carbon and Total Nitrogen

Total carbon and total nitrogen are critical parameters due to their close relationship with microbial decomposition of soil organic matter. The method specified is oxidation followed by thermal conductivity detection using an automated CHN analyzer. These analyses will be performed on all samples.

6.2.3 Inorganic Carbon

Quantification of inorganic carbon is necessary due to the inherent ability of carbonates to buffer acid inputs. If carbonates exist, they will be determined by manometric detection of evolved CO_2 after extraction with a strong acid, or by an automated CHN analyzer. Carbonates are not expected because the soils being sampled are generally thought to be acid sensitive. Inorganic carbon analyses will be performed only on soil samples reacting positively to a test for effervescence upon the addition of drops of 4 N HCl.

6.2.4 Extractable Sulfate

The amount of extractable sulfate will indicate the sulfate saturation of the anion exchange sites. Extractable sulfate is determined in two different extracts (DI water and 500 mg/L P). Extractable sulfate is then determined by ion chromatography. These analyses will be performed on all samples.

6.2.5 Sulfate Adsorption Isotherms

The ability of soil to adsorb sulfate is perhaps the most important parameter in determining if a soil unit will show direct or delayed response to added sulfate deposition. Isotherms will be developed by placing soil samples in six separate sulfate solutions for 1 hour and determining the amount adsorbed by analysis of the solution for sulfate after contact with the solution. These isotherms will represent the maximum sulfate adsorption capacity of the soil at the given conditions. Sulfate adsorption isotherms will not be required for organic horizons, but will be performed on all mineral horizons.

6.2.6 Total Sulfur

Total sulfur is measured because of its close relationship with extractable sulfate, and to inventory existing sulfur levels to monitor future inputs of anthropogenic sulfur. An automated method involving sample combustion followed by titration of evolved sulfur will be used.

6.2.7 Cation Exchange Capacity

Cation Exchange Capacity (CEC) is a standard soil characterization parameter and indicates the ability of the soil to adsorb exchangeable bases. Therefore, it is well correlated with soil buffering capacity. Ammonium chloride (NH_4Cl, pH 7.0), and ammonium acetate (NH_4OAc, pH 7.0), and 0.002 M calcium chloride ($CaCl_2$) will be used as the replacement solutions. The extractable bases (Na^+, K^+, Ca^{2+}, Mg^{2+}) will then be determined on the extracts by flame atomic absorption spectroscopy (AA) or inductively-coupled plasma-atomic emission spectroscopy (ICP). These analyses will be performed on all samples.

6.2.8 Exchangeable Acidity

Exchangeable acidity is a measure of the remaining exchangeable soil cations that are not part of the base saturation. Two methods are specified. One employs a $BaCl_2$--triethanolamine extraction and the other employs a KCl extraction. The former extraction quantifies total exchangeable acidity and the latter quantifies effective exchangeability acidity. Aluminum acidity is also determined in the KCl extract by analyzing the extract for Al by AA or ICP. These analyses will be performed on all samples.

6.2.9 Extractable Iron and Aluminum

Iron oxides and aluminum oxides are highly correlated to sulfate adsorption and are important in standard soil characterization. Extractable Fe and Al are determined by AA or ICP in three different extracts. Each extract yields an estimate of a specific Al or Fe fraction. The three extracts (and fractions) are sodium pyrophosphate (organic Fe and Al), acid-oxalate (organic plus sesquioxides), and citrate-dithionite (nonsilicate Fe and Al). These analyses will be performed on all samples.

6.2.10 Lime and Aluminum Potential

Lime potential is used as an input for certain models instead of base saturation; it is defined as pH-1/2 pCa. Another characteristic shown to be important to watershed models is the relationship of pH to solution Al^{3+} levels, defined as the aluminum potential (K_A), which is 3pH-pAL. The method involves extracting the soil with 0.002 m $CaCl_2$ and determining pH, Ca, and Al in the extract. The remaining base cations, Na^+, K^+, and Mg^{2+}, as well as exchangeable Fe, will also be determined on this extract because of expediency and comparability to other extracts. These analyses will be performed on all samples.

7.0 Bulk-Density Determination

7.1 Scope

Bulk density is defined as the weight per unit volume of a soil. Bulk density generally ranges between 1.0 and 2.0 g/cm^3. For organic soils, bulk density commonly ranges from 0.050 to 0.355 g/cm^3. Bulk density will be determined by the field collection and Saran coating of clods from each horizon, followed by weighing the clods by the preparation laboratories.

This method was chosen because of routine use in the field, relative ease of performance, and elimination of compaction problems inherent in core methods. It will be impossible to collect clods from certain horizons. Relationships between the particle-size distribution and surface area data and pre-existing data may be used to derive values for missing data. The laboratory method was provided by the Soil Morphology Laboratory, University of Massachusetts, Amherst, Massachusetts.

7.2 Apparatus and Materials

7.2.1 Dow Saran S310 Resin

The Saran resin dissolves readily in acetone or methylethyl ketone. Acetone is preferred and will be used because it is readily available and less toxic.

7.2.2 Coating Solution

The coating solution will be prepared by the preparation laboratories and will be supplied to the field crews. To prepare the solution, calculate the amount of acetone required to make a 1:4 solution of resin to acetone. If a 1:7 solution is desired, the stock solution can be diluted with a precalculated volume of acetone. The resin is not readily soluble in acetone and will require mixing. Because the solvent is flammable, care should be taken during mixing. The solution should be made in an exhaust hood. A nonsparking electric stirrer should be used. If a high-speed stirrer is used, the resin dissolves in about 1 hour. If the solution must be made in the field, mix well and often with a wooden stick. Metal paint cans will be supplied as mixing containers, although other containers may be used as well. Some plastic containers are unsuitable because the acetone dissolves the plastic. Containers that can be tightly closed are most desirable because the solution is highly volatile and rapid evaporation will result in excesses of acetone being used. If the solution becomes thick, add more acetone until the desired consistency is reached.

7.3 Procedure

Collect natural clods (three per horizon) of about 100 cm^3 to 200 cm^3 in volume (approximately fist-size). Remove a piece of soil larger than the clod from the face of a sampling pit with a spade. From this piece, prepare a clod by gently cutting or breaking off protruding peaks and material sheared by the spade. If roots are present, they can be cut conventiently with scissors or side cutters. In some soils, clods can be removed directly from the face of the pit with a knife or spatula. No procedure for taking samples will fit all soils; the procedure must be adjusted to meet the conditions in the field at the time of sampling.

The clods are tied with fine copper wire or placed in hairnets and suspended from a rope or string, then hung like a clothesline. The clods themselves should be labeled with some type of tag that can be attached to the hairnet or string. The label should record the sample code, horizon, and replicate number. Moisten clods with a fine mist spray. The suspended clods are dipped by raising a container of the dipping mixture upward to submerse each clod momentarily. The number of times a clod is dipped should be recorded on the label. The Saran-coated clods should be allowed to dry for 30 minutes or longer.

7.3.1 Transport of Clods

Clods should be sealed in the presupplied 6" × 8" plastic bags, then placed in the compartmentalized clod boxes. The top (inner face) of the clod box should be labeled with the same information on the clod tag (i.e., sample code, horizon, replicate number, and how many times the clod was dipped in the Saran). Great care must be taken to ensure that the clods are not broken or damaged during handling and shipping. Space not occupied by the clods in each compartment should be filled with packing material; for example, leaves, newspaper, or extra plastic bags. Clod boxes may be reused by removing the old labels.

7.3.2 Preparation Laboratory Handling of Clods

Upon receipt of clods, labels should be removed and placed in the Bulk Density Preparation Laboratory Notebook. However, the clods must be relabeled with the appropriate sample number to retain identity. Notes should be made in the notebook regarding the condition of the clod upon arrival, how many times the clod was dipped in Saran in the field, label clarity, and the time of receipt. At the end of the project, this notebook should be submitted to Lockheed-EMSCO (EPA EMSL-LV) Data Audit Supervisor.

7.3.3 Bulk-density Procedure

7.3.3.1--

Weigh the clod and record this weight in the laboratory notebook as m_1.

7.3.3.2--

Dip the clod briefly in a Saran:acetone (1:6 w/w) solution and allow the coating to dry.

7.3.3.3--

Reweigh the clod and record this weight as m_2.

7.3.3.4--

Repeat steps 7.3.3.2 and 7.3.3.3 as needed to obtain an impervious coating. Record weights after each coating as m_3, m_4, etc.

7.3.3.5--

Place a 1-L beaker that contains 600 to 700 mL of de-aired and distilled water of known temperature (recorded as T) on balance pan and record the tare weight as M_A.

7.3.3.6--

Suspend the clod over the beaker, lower it gently into the water until totally submerged, then record the weight displayed on the balance as M_B.

7.3.3.7--

Suspend the clod in a convection oven at 105°C for 48 hours.

7.3.3.8--

Remove the clod from the oven, weigh it, and record this weight as M_{OD}.

7.3.3.9--

Place the clod in an appropriate container and put the container into an electric muffle furnace for 2 hours at 400°C.

7.3.3.10--

After the sample has cooled, weigh the contents of the container and record this as m_t.

7.3.3.11--

Pass the sample through a 2-mm sieve and obtain the weights of coarse fragments and the fine-earth fraction. Record these as M_{CF} and m_{fc}, respectively.

7.3.3.12 Calculations--

$$BD_{FM} = \frac{M_{OD} - [M_{CF} + M_{TS}\ (0.85)]}{\dfrac{M_V}{r\ H_2O_T} - \dfrac{M_{CF}}{2.65} + \dfrac{M_{TS}}{1.30}}$$

where BD_{FM} is the field moist bulk density.
M_{OD} is the oven-dry weight of the clod (Step 7.3.3.8).
M_{CF} is the weight of the coarse fragments in the clod (Step 7.3.3.11).
M_{TS} is the weight of the air-dry Saran coating which may be estimated as follows:

$$M_{TS} = \frac{X\ (m_a - m_1)}{a - 1}$$

where X is the total number of coatings (field + lab).
a is the number of laboratory coatings.
m_a is the clod weight after the final coating.
m_1 is the initial clod weight after unpacking.
M_V is equal to $M_{B\,.\,M}A$ (from steps 7.3.3.5 and 7.3.3.6).

r H_2O_T is the density of water obtained from Table 7.1 for the temperatures measured in Step 7.3.3.5.

The final value to be reported on Form 101 is the coarse-fragment, and Saran-weight corrected value.

7.3.3.13 Assumptions--

Four assumptions are made concerning the bulk-density procedure:

- The weight of the individual, field-applied Saran coatings is equivalent to that applied in the laboratory, and the Saran has not infiltrated the clod.
- The specific gravity of the coarse fragments is 2.65.
- The specific gravity of air-dried Saran is 1.30.
- The Saran loses 15 percent of its weight upon oven drying at 105°C for 48 hours.

Table 7-1. Specific Gravity* of Water

°C	0	1	2	3	4	5	6	7	8	9
0	0.9999	0.9999	1.0000	1.0000	1.0000	1.0000	1.0000	0.9999	0.9999	0.9999
10	0.9997	0.9996	0.9995	0.9994	0.9993	0.9991	0.9990	0.9988	0.9986	0.9984
20	0.9982	0.9980	0.9978	0.9976	0.99973	0.9971	0.9968	0.9965	0.9963	0.9960
30	0.9957	0.9954	0.9951	0.9947	0.9944	0.9941	0.9937	0.9934	0.9930	0.9926
40	0.9922	0.9919	0.9915	0.9911	0.9907	0.9902	0.9898	0.9894	0.9890	0.9885
50	0.9881	0.9876	0.9872	0.9867	0.9862	0.9857	0.9852	0.9848	0.9842	0.9838
60	0.9832	0.9827	0.9822	0.9817	0.9811	0.9806	0.9800	0.9795	0.9789	0.9784
70	0.9778	0.9772	0.9767	0.9761	0.9755	0.9749	0.9743	0.9737	0.9731	0.9724
80	0.9718	0.9712	0.9706	0.9699	0.9693	0.9686	0.9680	0.9673	0.9667	0.9660
90	0.9653	0.9647	0.9640	0.9633	0.9626	0.9619	0.9612	0.9605	0.9598	0.9591

*Also the density or unit weight of water in grams per milliliter.

8.0 Crews, Supplies, and Equipment

8.1 Scope

Field crews will consist of four SCS employees. The lead soil scientist in each crew will supervise all field operations. This person will be responsible for selecting each sampling site in the field and for documenting all field data. The following is a list of supplies needed for each field crew.

- 35-mm camera (macro lens or wide-angle lens).
- ASA-400 film and Kodak premailer envelopes.
- 2 clinometers.
- Munsell color charts.
- Magnetic compass.
- Hand lens.
- 2 brass sieves (3/4", 10 mesh, 19 mm)*.
- 2 thermometers* (centigrade).
- 5 coolers*.
- 40 Blue Ice gel packs*.
- Stereoscope.
- 0.1 N HCl or 10% 4 N HCl and drop bottle.
- Visqueen 6-mil sheets, (4' x 4')*.
- Spring scale (optional; use an exterior canvas bag for weighing).
- Plastic inner sample bags (20/day)*.
- Canvas exterior sample bags (20/day)*.
- NADSS Label A (30/day)*.
- Orange flagging (1 roll/day)*.
- Yellow marker flags (20/day)*.
- 5 indelible-ink markers*.
- SCS Form SOI 232 and clipboard.

- Field logbook*.
- 1-gallon paint can with lid*.
- Saran* and acetone (Note: acetone must be purchased locally).
- Hairnets (1 per clod)*.
- 6" x 8" plastic bags, 1 mil (enough for one per clod)*.
- 24-cell, 17.50" x 11.94" x 3.75" boxes (1 box per day - reusable)*.
- 2" x 2" blank vinyl labels (attach to box for individualized clod compartments)*.
- Hand auger (for sampling Histosols; optional, may use spades).
- Staplers*.
- Saran Dow-310 resin*.

An asterisk indicates that the item will be shipped by EPA EMSL-LV. The amount of equipment sent to each preparation laboratory is based on the number of crews assigned to that laboratory.

The crews from New York and Pennsylvania (4) will receive supplies from the Cornell University soil preparation laboratory. Maine crews (2) will receive supplies from the University of Maine at Orono Soil Preparation Laboratory. Rhode Island-Connecticut (1), New Hampshire (1), and Massachusetts crews will receive supplies from the University of Massachusetts at Amherst, Massachusetts.

8.2 Equipment Notes

8.2.1 Coolers and Gel Packs

For each day of sampling, five coolers and eight gel packs per cooler should be stored in the field sampling vehicle. The gel packs should be frozen in advance. Enough frozen gel packs should be stored in a storage cooler to replace softened gel packs if ambient temperature in the cooler falls below 4 °C. Coolers containing gel packs and soil samples should be taped shut before transit. Two thermometers per crew will be provided for routine temperature checks on coolers containing gel packs and soil samples. Temperature readings to the nearest tenth of a degree should be recorded in the field notebook. Time and date should also be recorded in the notebook.

8.2.2 Marker Flags and Flagging

Upon arrival at the sample site, orange flagging should be tied to surrounding shrubbery at eye level. This flagging is necessary in case of return visit to the pedon. The 21-inch stake yellow flags should be placed at least 6 inches into the ground at the four corners of the pedon before leaving the sample site.

8.2.3 Visqueen Plastic Sheets

Visqueen plastic sheets (4' x 4', 6 mil) will be provided for each crew. All soil materials less than 20 mm should be sieved into these sheets. The sample is then poured into the inner plastic, prelabeled sample bag. If by visual estimate the 2 to 20 mm particle-size class exceeds 50 percent by volume, two 5.5-kg samples should be bagged and sieved for that sample. A canvas sheet may be substituted for the 4' x 4' plastic sheet, but the use of this should be noted in the field notebook and should be immediately reported to the EPA EMSL-LV QA officer.

8.2.4 Field Notebook

Daily activities of the field crew should be logged in a field notebook. Each day's activities should be recorded; specific problems, solutions, and other miscellaneous notes should be recorded, along with location and identification of each sample pedon. These field notebooks will be submitted to Lockheed-ESC (EPA-EMSL-LV) in care of:

Lockheed Engineering and Sciences
Company
1050 E. Flamingo Road, Suite 120
Las Vegas, Nevada 89109

9.0 References

USDA/SCS. 1983. *National Soils Handbook.* Part 600-606. U.S. Government Printing Office, Washington D.C. 609 pp.

USDA/SCS. 1984. *SCS National Soil Survey Manual.* U.S. Government Printing Office, Washington D.C.

Mausbach, M., R. Yeck, D. Nettleton, and W. Lynn. 1983. *Principles and Procedures for Using Soil Survey Laboratory Data.* National Soil Survey Laboratory. Lincoln, Nebraska. 130 pp.

USDA/SCS. 1972. *Soil Survey Laboratory Methods and Procedures for Collecting Soil Samples.* Soil Survey Investigations Report No. 1. U.S. Government Printing Office, Washington D.C. 68 pp.

Appendix A

Field Data Forms and Legends

U.S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

SOIL DESCRIPTION

SCS-SOI-232
3-87

SOIL SERIES REPRESENTED	DATE MO DAY YR	SITE ID ST COUNTY UNIT	SUB	MLRA	LATITUDE DEG MIN SEC	DIR	LONGITUDE DEG MIN SEC	DIR

[redacted]

%	SHP UA	G M	H S	ASP DEG.	[redacted]	PHYS MAJ LOC	PEDON CLASSIFICATION O SO GG SG PSC MIN RX TMP OTH

PRECIP	WATERTABLE DEPTH DAYS	KND	L U	S T	H C	D R	ELEVATION	PARENT MATERIAL 1 W B M ORIG, 2 W B M ORIG, 3 W B M ORIG, 4 W B M ORIG	DOR

TEMPERATURES °C AVERAGE AIR ANN SUM WINTER	AVERAGE SOIL ANN SUM WINTER	MST RGE	WEATHER STATION NO	CONTROL SECTION PSC	CR WR	AN CR

DIAGNOSTIC FEATURES DEPTH	KND	DEPTH	KND	DEPTH	KND	DEPTH	KND	DEPTH	KND	FLOODING FRQ	[redacted]	PONDING FRQ	[redacted]

VEGETATION SPECIES

1	2	3	4	5
6	7	8	9	10

[redacted]

DESCRIBERS NAMES

LOCATION DESCRIPTION

NOTES

WATERSHED ID	CLASS	ST	TRANSECT DIR DIST	CREW ID	WATERSHED NAME

Figure A-1. Form SCS-SOI-232 (page 1 of 4).

	DEPTH UPPER / LOWER	HORIZON DESIGNATION: DISC	MASTER LETTER	SUFFIX	THICKNESS AVE(A) / MAX(X) / MIN(N)	DRY COLOR LOC	%	HUE	VAL	CHR	MOIST COLOR LOC	%	HUE	VAL	CHR	TEXTURE CLASS	MOD
1					a b c												
2					a b c												
3					a b c												
4					a b c												
5					a b c												
6					a b c												
7					a b c												
8					a b c												
9					a b c												
10					a b c												

FREE FORM NOTES

	SAMPLE NUMBERS	BULK DENSITY NO	BULK DENSITY	HORIZON NOTES
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				

Figure A-1. Continued (page 2 of 4).

STRUCTURE			CONSISTENCE			MOTTLES						SURFACE FEATURES									
GRD	SZ	SHP	a) DRY b) MOIST c) OTHER	a) ST b) PL	CEM	AB	SZ	CON	HUE	VAL	CHR	KND	AB	CN	DST	LOC	HUE	VAL	CHR	BOUNDARY	
			a b c	a b																	1
			a b c	a b																	2
			a b c	a b																	3
			a b c	a b																	4
			a b c	a b																	5
			a b c	a b																	6
			a b c	a b																	7
			a b c	a b																	8
			a b c	a b																	9
			a b c	a b																	10

FREE FORM NOTES

Figure A-1. Continued (page 3 of 4).

EFFER-VES-CENCE	FIELD MEASURED PROPERTIES		FIELD MEASURED PROPERTIES		WETNESS	HYDRO COND	ROOTS			PORES				CONCENTRATIONS				ROCK FRAGMENTS				ROCK FRAGMENTS			
CL AO EX	KND	AMOUNT	KND	AMOUNT			QT	SZ	LOC	SHP	QT	SZ	CN	KND	QT	SHP	SZ	KND	%	RND	SZ	KND	%	RND	SZ
	P																								
	C L																								
	P																								
	C L																								
	P																								
	C L																								
	P																								
	C L																								
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	C L																								
	P																								
	C L																								
	P																								
	C L																								
	P																								
	C L																								

FREE FORM NOTES

LOG	
WEATHER	
SET I.D.	
UNDERSTORY VEG.	
SLIDES #s PED FACE	OVERSTORY
UNDERSTORY	LANDSCAPE

Figure A-1. Continued (page 4 of 4).

2.0 Soil Description Codes for Form SCS-SOI-232

2.1 Great Group Codes

Alfisols

AAQAL Albaqualf
AAQFR Fragiaqualf
AAQNA Natraqualf
AAQPN Plinthaqualf
AAQUM Umbraqualf
ABOEU Eutroboralf
ABOGL Glossoboralf
ABOPA Paleboralf
AUDAG Agrudalf
AUDFR Fragiudalf
AUDGL Glossudalf
AUDNA Natrudalf
AUDTR Tropudalf
AUSHA Haplustalf
AUSPN Plinthustalf
AXEDU Durixeralf
AXEHA Haploxeralf
AXEPA Palexeralf
AXERH Rhodoxeralf

AAQDU Duraqualf
AAQGL Glossaqualf
AAQOC Ochraqualf
AAQTR Tropaqualf
ABOCR Cryoboralf
ABOFR Fragiboralf
ABONA Natriboralf
ASUPA Paleustalf
AUDFE Ferrudalf
AUDFS Fraglossudalf
AUDHA Hapludalf
AUDPA Paleudalf
AUSDU Durustalf
AUSNA Natrustalf
AUSRH Rhodustalf
AXEFR Fragixeral
AXENA Natrixeralf
AXEPN Plinthoxeralf

Aridisols

DARDU Durargid
DARND Nadurargid
DARPA Paleargid
DORCM Camborthid
DORGY Gypsiorthid
DORSA Salorthid

DARHA Haplargid
DARNT Natrargid
DORCL Calciorthid
DORDU Durorthid
DORPA Paleorthid

Entisols

EAQCR Cryaquent
EAQHA Haplaquent
EAQPS Psammaquent
EAQTR Tropaquent
EFLCR Cryofluvent
EFLTR Tropofluvent
EFLUS Ustifluent
EORCR Cryorthent
EORTR Troporthent
EORUS Ustorthent
EPSCR Cryopsamment
EPSTO Torripsamment
EPSUD Udipsamment
EPSXE Xeropsamment

EAQFL Fluvaquent
EAQHY Hydraquent
EAQSU Sulfaquent
EARAR Arent
EFLTO Torrifluvent
EFLUD Udifluvent
EFLXE Xerofluvent
EORTO Torriorthent
EORUD Udorthent
EORXE Xerorthent
EPSQU Quartzipsamment
EPSTR Tropopsamment
EPSUS Ustipsamment

Histosols

HFIBO	Borofibrist	HFICR	Cryofibrist
HFILU	Luvifibrist	HFIME	Medifibrist
HFISP	Sphagnofibrist	HFITR	Tropofibrist
HFOBO	Borofolist	HFOCR	Cryofolist
HFOTR	Tropofolist	HHEBO	Borohemist
HHECR	Cryohemist	HHELU	Luvihemist
HHEME	Medihemist	HHESI	Sulfihemist
HHESO	Sulfohemist	HHETR	Tropohemist
HSABO	Borosaprist	HSACR	Cryosaprist
HSAME	Medisaprist	HSATR	Troposaprist

Inceptisols

IANCR	Cryandept	IANDU	Durandept
IANDY	Dystrandept	IANEU	Eutrandept
IANHY	Hydrandept	IANPK	Placandept
IANVI	Vitrandepth	IAQAN	Andaquept
IAQCR	Cryaquept	IAQFR	Fragiaquept
IAQHL	Halaquept	IAQHP	Haplaquept
IAQHU	Humaquept	IAQPK	Palacaquept
IAQPN	Plinthaquept	IAQSU	Sulfaquept
IAQTR	Tropaquept	IOCCR	Cryochrept
IOCDU	Durochrept	IOCDY	Dystrochrept
IOCEU	Eutrochrept	IOCFR	Fragiochrept
IOCUS	Ustochrept	IOCXE	Xerochrept
IPLPL	Plaggept	ITRDY	Dystropept
ITREU	Eutropept	ITRHU	Humitropept
ITRSO	Sombritropept	ITRUS	Ustropept
IUMCR	Cryumbrept	IUMFR	Fragiumbrept
IUMHA	Haplumbrept	IUMXE	Xerumbrept

Mollisols

MALAR	Argialboll	MALNA	Natralboll
MAQAR	Argiaquoll	MAQCA	Calciaquoll
MAQCR	Cryaquoll	MAQDU	Duraquoll
MAQHA	Haplaquoll	MAQNA	Natraquoll
MBOAR	Argiboroll	MBOCA	Calciboroll
MBOCR	Cryoboroll	MBOHA	Haploboroll
MBONA	Natriboroll	MBOPA	Paleboroll
MBOVE	Vermiboroll	MRERE	Rendoll
MUDAR	Argiudoll	MUDHA	Hapludoll
MUDPA	Paleudoll	MUDVE	Vermudoll
MUSAR	Argiustoll	MUSCA	Calciustoll
MUSDU	Durustoll	MUSHA	Haplustoll
MUSNA	Natrustoll	MUSPA	Paleustoll
MUSVE	Vermustoll	MXEAR	Argixeroll
MXECA	Calcixeroll	MXEDU	Durixeroll
MXEHA	Haploxeroll	MXENA	Natrixeroll
MXEPA	Palexeroll		

Oxisols

OAQGI	Givvsiaquox
OAQPN	Plinthaquox
OHUAC	Acrohumox
OHUHA	Haplohumox
OORAC	Acrorthox
OORGI	Gibbsiorthox
OORSO	Sombriorthox
OTOTO	Torrox
OUSEU	Eutrustox
OUSSO	Sombriustox
OAQOC	Ochraquox
OAQUM	Umbraquox
OHUGI	Gibbsihumox
OHUSO	Sombrihumox
OOREU	Eutrorthox
OORHA	Haplorthox
OORUM	Umbriorthox
OUSAC	Acrustox
OUSHA	Haplustox

Spodosols

SAQCR	Cryaquod
SAQFR	Fragiaquod
SAQPK	Placaquod
SAQTR	Tropaquod
SHUCR	Cryohumod
SHUHA	Haplohumod
SHUTR	Tropohumod
SORFR	Fragiorthod
SORPK	Placorthod
SAQDU	Duraquod
SAQHA	Haplaquod
SAQSI	Sideraquod
SFEFE	Ferrod
SHUFR	Fragihumod
SHUPK	Placohumod
SORCR	Cryorthod
SORHA	Haplorthod
SORTR	Troporthod

Ultisols

UAQAL	Albaquult
UAQOC	Ochraquult
UAQPN	Plinthaquult
UAQUM	Umbraquult
UHUPA	Palehumult
UHUSO	Sombrihumult
UUDFR	Fragiudult
UUDPA	Paleudult
UUDRH	Rhodudult
UUSHA	Haplustult
UUSPN	Plinthustult
UXEHA	Haploxerult
UAQFR	Fragiaquult
UAQPA	Paleaquult
UAQTR	Tropaquult
UHUHA	Haplohumult
UHUPN	Plinthohumult
UHUTR	Tropohumult
UUDHA	Hapludult
UUDPN	Plinthudult
UUDTR	Tropudult
UUSPA	Paleustult
UUSRH	Rhodustult
UXEPA	Palexerult

Vertisols

VTOTO	Torrert
VUDPE	Pelludert
VUSPE	Pellustert
VXEPE	Pelloxerert
VUDCH	Chromudert
VUSCH	Chromustert
VXECH	Chromxerert

2.2 Subgroup Codes

AA	Typic	AB	Abruptic
ABO4	Abruptic aridic	AB08	Abruptic cryic
AB10	Abruptic haplic	AB14	Abruptic ultic
AB16	Abruptic xerollic	AE	Aeric
AE03	Aeric arenic	AE05	Aeric grossarenic
AE06	Aeric humic	AE08	Aeric mollic
AE09	Aeric tropic	AE10	Aeric umbric
AE12	Aeric xeric	AL	Albaquic
AL02	Albaquultic	AL04	Albic
AL08	Albic glossic	AL10	Alfic
AL12	Alfic arenic	AL13	Alfic andeptic
AL16	Alfic lithic	AN	Andic
AN01	Andeptic	AN03	Andaquic
AN06	Andic Dystric	AN11	Andeptic glossoboric
AN22	Andic ustic	AN24	Andaqueptic
AN30	Anthropic	AQ	Aqualfic
AQ02	Aquentic	AQ04	Aqueptic
AQ06	Aquic	AQ08	Aquic arenic
AQ14	Aquic duric	AQ16	Aquic duriorthidic
AQ18	Aquicdystric	AQ24	Aquichaplic
AQ26	Aquiclithic	AQ31	Aquicpsammentic
AQ34	Aquollic	AQ36	Aquultic
AR	Arenic	AR02	Arenicaridic
AR03	Arenicorthoxic	AR04	Arenicplinthaquic
AR06	Arenicplinthic	AR08	Arenicrhodic
AR10	Arenicultic	AR14	Arenicumbric
AR16	Arenicustalfic	AR18	Arenicustollic
AR22	Argiaquic	AR24	Argiaquicxeric
AR26	Argic	AR28	Argiclithic
AR30	Argicpachic	AR32	Argicvertic
AR34	Aridic	AR36	Aridiccalcic
AR42	Aridicduric	AR50	Aridicpachic
AR52	Aridicpetrocalcic		
BO	Boralfic	BO02	Borolficlithic
BO04	Boroalficudic	BO06	Borollic
BO08	Borollic glossic	BO10	Borollic lithic
BO12	Borollic vertic		
CA	Calcic	CA04	Calcic pachic
CA06	Calciorthidic	CA10	Calcixerollic
CA20	Cambic	CH	Chromic
CH06	Chromudic	CR	Cryic
CR10	Cryic lithic	CR14	Cyric pachic
CU	Cumulic	CU02	Cumulic udic
CU04	Cumulic ultic		
DU	Durargidic	DU02	Duric
DU08	Durixerollic	DU10	Durixerollic lithic
DU11	Durochreptic	DU12	Durorthidic

DU14	Durorthidic xeric	DY02	Dystric
DY03	Dystric entic	DY04	Dystric Fluventic
DY06	Dystric lithic	DY08	Dystropeptic
EN	Entic	EN02	Enticlithic
EN06	Enticultic	EP	Epiaquic
EP10	Epiaquicorthoxic	EU	Eutric
EU02	Eutrochreptic	EU04	Eutropeptic
FE	Ferrudalfic	FI	Fibric
FI02	Fibricterric	FL02	Fluvaquentic
FL06	Fluventic	FL12	Fluventic umbric
FR10	Fragiaquic	FR18	Fragic
GL02	Glossaquic	GL04	Glossic
GL10	Glossicudic	GL12	Glossicustollic
GL14	Glossoboralfic	GL16	Glossoboric
GR	Grossarenic	GR01	Grossarenicentic
GR04	Grossarenicplinthic		
HA	Haplaquodic	HA01	Haplaquic
HA02	Haplic	HA05	Haplohumic
HA07	Haploxerollic	HA09	Hapludic
HA12	Hapludollic	HA16	Haplustollic
HE	Hemic	HE02	Hemicterric
HI	Histic	HI02	Histiclithic
HI06	Histicpergelic	HU	Humic
HU02	Humiclithic	HU05	Humicpergelic
HU06	Humoxic	HU10	Humaqueptic
HY	Hydric	HY02	Hydriclithic
LE	Leptic	LI	Limnic
LI01	Lithic	LI04	Lithicmollic
LI06	Lithicrupticalfic	LI07	Lithicruptic-argic
LI08	Lithicrupticenticerollic	LI09	Lithicruptic-entic
LI10	Lithicudic	LI11	Lithicrupticxerorthentic
LI12	Lithicultic	LI13	Lithicruptic-ultic
LI14	Lithicumbric	LI15	Lithicrupticxerochreptic
LI16	Lithicustic	LI18	Lithicustollic
LI20	Lithicvertic	LI22	Lithicxeric
LI24	Lithicxerollic		
MO	Mollic	NA06	Natric
OC	Ochreptic	OR	Orthidic
OR01	Orthic	OR02	Orthoxic
OX	Oxic		
PA	Pachic	PA02	Pachicudic
PA04	Pachicultic	PA06	Paleorthidic
PA08	Paleustollic	PA10	Palexerollic
PA20	Paralithicvertic	PE	Pergelic
PE01	Pergelicruptichistic	PE02	Pergelicsideric

PE04	Petrocalcic	PE06	Petrocalcicustalfic
PE08	Petrocalcicustollic	PE14	Petrocalcicxerollic
PE16	Petroferric	PE20	Petrogypsic
PK	Placic	PK10	Plaggeptic
PK12	Plaggic	PL	Plinthaquic
PL04	Plinthic	PL06	Plinthudic
PS	Psammaquentic	PS02	Psammentic
QU	Quartzipsammentic		
RE	Rendollic	RH	Rhodic
RU02	Rupticalfic	RU09	Rupticlithic
RU11	Rupticlithic-entic	RU15	Rupticlithicxerochreptic
RU17	Rupticultic	RU19	Rupticvertic
SA	Salorthidic	SA02	Sapric
SA04	Sapricterric	SI	Sideric
SO04	Sombrihumic	SP	Sphagnic
SP02	Sphagnicterric	SP04	Spodic
SU	Suflic		
TE	Terric	TH04	Thaptohistic
TH06	Thaptohistictropic	TO	Torrertic
TO02	Torrifluventic	TO04	Torriorthentic
TO06	Torripsammentic	TO10	Torroxic
TR	Tropaquodic	TR02	Tropeptic
TR04	Tropic	AA	Typic
UD	Udertic	UD01	Udalfic
UD02	Udic	UD03	Udollic
UD05	Udorthentic	UD10	Udoxic
UL	Ultic	UM	Umbreptic
UM02	Umbric	US	Ustalfic
US02	Ustertic	US04	Ustic
US06	Ustochreptic	US08	Ustollic
US12	Ustoxic		
VE	Vermic	VE02	Vertic
XE	Xeralfic	XE02	Xerertic
XE04	Xeric	XE08	Xerollic

2.3 Slope Shape Codes

1 convex   2 plane   3 concave   4 undulating   5 complex

2.4 Geomorphic Position Codes

01	summit crested hills	11	summit interfluve
02	shoulder crested hills	12	shoulder interfluve
22	shoulder headslope	42	shoulder noseslope
03	backslope crested hills	23	backslope headslope

33 backslope sideslope
24 footslope headslope
44 footslope noseslope
25 toeslope headslope
43 backslope noseslope
34 footslope sideslope
05 toeslope crested hills
35 toeslope sideslope

2.5 Slope Aspect Codes

1 northeast
2 east
3 southeast
4 south
5 southwest
6 west
7 northwest
8 north

2.6 Pedon Position Codes

1 on the crest
2 on slope and crest
3 on upper third
4 on middle third
5 on lower third
6 on a slope
7 on a slope and depression
8 in a depression
9 in a drainageway

2.7 Regional Landform Codes

A coastal plains
E lake plains
G glaciated uplands
I bolson
L level or undulating uplands
N high hills
R hills
B intermountain basin
F river valley
H glaciofluvial landform
M mountains or deeply disected plateaus
P piedmonts
U plateaus or tablelands
V mountain valleys or canyons

2.8 Local Landform Codes

AA depression
A fan
C cuesta or hogback
E escarpment
G crater
I hillside or mountainside
K kamefield
M mesa or butte
P flood plain
R upland slope
T terrace--stream or lake
V pediment
X salt marsh
Z back barrier flat
B bog
D dome or volcanic cone
F broad plain
H abandoned channel
J moraine
L drumlin
N low sand ridge--nondunal
Q playa or alluvial flat
S sand dune or hill
U terrace--outwash or marine
W swamp or marsh
Y barrier bar

2.9 Particle Size Codes

002 not used

005 ashy
008 ashy over loamy
019 ashy over medial
007 ashy over cindery
013 ashy over loamy-skeletal
009 ashy-skeletal

003 cindery
015 cindery over medial-skeletal
006 cindery over loamy
004 cindery over sandy or sandy-skeletal

114 clayey
116 clayey over fragmental
120 clayey over loamy-skeletal
056 clayey-skeletal
122 clayey over fine-silty
124 clayey over loamy
118 clayey over sandy or sandy-skeletal
058 clayey-skeletal over sandy

080 coarse-loamy
084 coarse-loamy over sandy or sandy-skeletal
088 coarse-silty
092 coarse-silty over sandy or sandy-skeletal
082 coarse-loamy over fragmental
086 coarse-loamy overy clayey
090 coarse-silty over fragmental
094 coarse-silty over clayey

126 fine
102 fine-loamy over clayey
100 fine-loamy over sandy or sandy-skeletal
112 fine-silty over clayey
110 fine-silty over sandy or sandy-skeletal
096 fine-loamy
098 fine-loamy over fragmental
106 fine-silty
108 fine-silty over fragmental

036 fragmental

068 loamy
050 loamy-skeletal
051 loamy-skeletal over fragmental
072 loamy over sandy or sandy-skeletal
054 loamy-skeletal over clayey
052 loamy-skeletal over sand

010 medial
014 medial over clayey
018 medial over loamy
022 medial over sandy or sandy-skeletal
012 medial over cindery
016 medial over fragmental
020 medial over loamy-skeletal
024 medial over thixotropic

062 sandy
066 sandy over clayey
044 sandy-skeletal
047 sandy-skeletal over clayey
063 sandy or sandy-skeletal
064 sandy over loamy
046 sandy-skeletal over loamy

026 thixotropic
034 thixotropic over loamy
030 thixotropic over sandy or sandy-skeletal
028 thixotropic over fragmental
032 thixotropic over loamy-skeletal
027 thixotropic-skeletal

134 very fine

2.10 Mineralogy Codes

02 not used
04 calcareous
05 carbonatic
09 chloritic
07 clastic
08 coprogenous
10 diatomaceous
12 ferrihumic
14 ferritic
18 gibbsitic
20 glauconitic
22 gypsic
24 halloysitic
26 illitic
27 illitic (calcareous)
28 kaolinitic
30 marly
32 micaceous
34 mixed
35 mixed (calcareous)
37 montmorillonitic
38 montmorillonitic (calcareous)

40 oxidic	42 sepiolitic	44 serpentinitic
46 siliceous	50 vermiculitic	

2.11 Reaction Codes

02 not used	04 acid	08 dysic
10 euic	12 nonacid	14 noncalcareous

2.12 Temperature Regime Codes

02 not used	04 frigid	06 hyperthermic
08 isofrigid	10 isohyperthermic	12 isomesic
14 isothermic	16 mesic	18 thermic

2.13 Other Family Codes

02 not used	04 coated	05 cracked
06 level	08 micro	12 ortstein
14 shallow	15 shallow and coated	17 shallow and uncoated
16 sloping	20 uncoated	

2.14 Kind of Water Table Codes

1 flooded	2 perched	3 apparent
4 ground		

2.15 Landuse Codes

C cropland	I cropland irrigated
E forest land grazed	F forest land not grazed
G pasture land and native pasture	H horticultural land
L waste disposal land	N barren land
P rangeland grazed	S rangeland not grazed
R wetlands	Q wetlands drained
T tundra	U urban and built-up land

2.16 Permeability Codes

1 very slow	2 slow	3 moderately slow	4 moderate
5 moderately rapid	6 rapid	7 very rapid	

2.17 Drainage Codes

1 very poorly drained	2 poorly drained
3 somewhat poorly drained	4 moderately well drained
5 well drained	6 somewhat excessively drained
7 excessively drained	

2.18 Parent Material Weathering Codes

1 slight   2 moderate   3 high

2.19 Parent Material Mode of Deposition Codes

A alluvium
D glacial drift
L lacustrine
M marine
R solid rock
H volcanic ash
E eolian
G glacial outwash
V local colluvium
O organic
Y solifluctate
S eolian-sand
T glacial till
W loess
X residuum
U unconsolidated sediments

2.20 Parent Material Origin Codes

Mixed Lithology

Y0 mixed
Y1 mixed-noncalcareous
Y2 mixed-calcareous
Y3 mixed
Y4 mixed-igneous-metamorphic and sedimentary
Y5 mixed-igneous and metamorphic
Y6 mixed-igneous and sedimentary
Y7 mixed-metamorphic and sedimentary

Conglomerate

CO conglomerate
C1 conglomerate-noncalcareous
C2 conglomerate-calcareous

Igneous

I0 igneous
I1 igneous-coarse
I2 igneous-basic
I3 igneous-intermediate
I4 igneous-granite
I5 igneous-fine
I6 igneous-basalt
I7 igneous-andesite
I8 igneous-acid
I9 igneous-ultrabasic

Metamorphic

M0 metamorphic
M1 gneiss
M2 metamorphic-acidic
M3 metamorphic-basic
M4 serpentine
M5 schist and thyllite
M6 metamorphic-acidic
M7 metamorphic-basic
M8 slate
M9 quartzite

Sedimentary

SO sedimentary
S1 marl
S2 glauconite

Interbedded Sedimentary

B0 interbedded sedimentary
B1 limestone-sandstone-shale
B2 limestone-sandstone
B3 limestone-shale
B4 limestone-siltstone
B5 sandstone-shale
B6 sandstone-siltstone
B7 shale-siltstone

Sandstone

A0 sandstone
A1 sandstone-noncalcareous
A2 arkosic-sandstone
A3 other sandstone
A4 sandstone-calcareous

Shale

H0 shale
H1 shale-noncalcareous
H2 shale-calcareous

Siltstone

T0 siltstone
T1 siltstone-noncalcareous
T2 siltstone-calcareous

Limestone

L0 limestone
L1 chalk
L2 marble
L3 dolomite
L4 limestone-phosphatic
L5 limestone-arenaceous
L6 limestone-argillaceous
L7 limestone-cherty

Pyroclastic

P0 pyroclastic
P1 tuff
P2 tuff-acidic
P3 tuff-basic
P4 volcanic breccia
P5 breccia-acidic
P6 breccia-basic
P7 tuff-breccia
P8 aa
P9 pahoehoe

Ejecta Material

E0 ejecta-ash
E1 acidic-ash
E2 basic-ash
E3 basaltic-ash
E4 andesitic-ash
E5 cinders
E6 pumice
E7 scoria
E8 volcanic bombs

Organic Materials

K0 organic
K1 mossy material
K2 herbaceous material
K3 woody material

K4 wood fragments
K6 charcoal
K9 other organics
K5 logs and stumps
K7 coal

2.21 Moisture Regime Codes

AQ aquic moisture regime
PU perudic moisture regime
UD udic moisture regime
XE xeric moisture regime
AR aridic moisture regime
TO torric moisture regime
US ustic moisture regime

2.22 Erosion Codes

0 none
1 slight
2 moderate
3 severe

2.23 Runoff Codes

0 none
1 ponded
2 very slow
3 slow
4 moderate
5 rapid
6 very rapid

2.24 Diagnostic Feature Codes

A anthropic
O ochric
D durinodes
W paralithic contact
T argillic
G gypsic
E petrocalcic
Y salic
V sulfuric
H histic
P plaggen
Z duripan
Q albic
C calcic
N natric
J petrogypsic
I sombric
F fragipan
M mollic
U umbric
L lithic contact
R argic
B cambic
X oxic
K placic
S spodic

2.25 Horizon Codes

Color Location Codes

0 unspecified
1 ped interior
2 ped exterior
3 rubbed or crushed

Texture Classes

C	clay
CL	clay loam
COSL	coarse sandy loam
CE	coprogenous earth
FB	fibric material
FSL	fine sandy loam
G	gravel
ICE	ice or frozen soil
LCOS	loamy coarse sand
LS	loamy sand
CIND	cinders
COS	coarse sand
CSCL	coarse sandy clay loam
DE	diatomaceous earth
FS	fine sand
FM	fragmental material
GYP	gypsiferous earth
L	loam
LFS	loamy fine sand
LVFS	loamy very fine sand

MARL	marl
MPT	mucky peat
PDOM	partially decomposed organics
PEAT	peat
SG	sand and gravel
SCL	sandy clay loam
SP	sapric material
SIL	silt loam
SICL	silty clay loam
U	unknown texture
VAR	variable
VFSL	very fine sandy loam
MUCK	muck
OPWD	oxide protected weathered bedrock
S	sand
SC	sandy clay
SL	sandy loam
SI	silt
SIC	silty clay
UDOM	undecomposed organics
UWB	unweathered bedrock
VFS	very fine sand
WB	weathered bedrock

Texture Modifiers

AY	ashy
BYX	extremely bouldery
CBV	very cobbly
CNV	very channery
CRC	coarse cherty
CY	cindery
FLX	extremely flaggy
GRF	fine gravelly
GY	gritty
MK	mucky
SH	shaly
SR	stratified
STX	extremely stony
BY	bouldery
CB	cobbly
CBX	extremely cobbly
CNX	extremely channery
CRV	very cherty
FL	flaggy
GR	gravelly
GRV	very gravelly
GYV	very gritty
PT	peaty
SHV	very shaly
ST	stony
SY	slaty
BYV	very bouldery
CBA	angular cobbly
CN	channery
CR	cherty
CRX	extremely cherty
FLV	very flaggy
GRC	coarse gravelly
GRX	extremely gravelly
GYX	extremely gritty
SHX	extremely shaly
STV	very stony
SYV	very slaty
SYX	extremely slaty

Grade of Structure

1 weak
2 moderate
3 strong
4 very strong
5 weak and moderate
6 moderate and strong

Size of Structure

EF	extremely fine
F	fine
MC	medium and coarse
VF	very fine
FM	fine and medium
CO	coarse
FF	very fine and fine
M	medium
CV	coarse and very coarse

Structure Shape

ABK	angular blocky
CDY	cloddy
GR	granular
PL	platy
WEG	wedge
BK	blocky
COL	columnar
LP	lenticular
PR	prismatic
SBK	subangular blocky
CR	crumb
MA	massive
SGR	single grain

Dry Consistence

L	loose
S	soft
SH	slightly hard

H	hard	VH	very hard	EH	extremely hard
SWH	somewhat hard				

Moist Consistence

L	loose	VFR	very friable	FR	friable
FI	firm	VFI	very firm	EFI	extremely firm

Other Consistence

WSM	weakly smeary	SM	smeary	MS	moderately smeary
B	brittle	R	rigid	VR	very rigid
CO	uncemented	VWC	very weakly cemented	WC	weakly cemented
SC	strongly cemented	I	indurated	SD	semideformable
D	deformable				

Stickiness

SO	nonsticky	SS	slightly sticky	S	sticky	VS	very sticky

Plasticity

PO	nonplastic	SP	slightly plastic	P	plastic	VP	very plastic

Cementation Agent

H	humus	I	iron	L	lime	S	silica
X	lime and silica						

Mottle Abundance Codes

F	few	C	common	M	many

Mottle Size Codes

1	fine	2	medium	3	coarse

Mottle Contrast Code

F	faint	D	distinct	P	prominent

Surface Features

A	skeletans over cutans	B	black stains
C	chalcedony on opal	D	clay bridging
G	gibbsite coats	I	iron stains
K	intersecting slickensides	L	lime or carbonate coats
M	manganese or iron-manganese stains	O	organic coats
P	pressure faces	Q	nonintersecting slickensides

S skeletans (sand or silt)
U coats
T clay films
X oxide coats

Surface Feature Amount Codes

V very few
F few
C common
M many

Surface Feature Continuity Codes

P patchy
D discontinuous
C continuous

Surface Feature Distinctness Codes

F faint
D distinct
P prominent

Location of Surface Features

P on faces of peds
V on vertical faces of peds
U on upper surfaces of peds or stones
L on lower surfaces of peds or stones
M on bottoms of plates
B between sand grains
I in root channels and/or pores
T throughout
H on horizontal faces of peds
Z on vertical and horizontal faces of peds
C on tops of columns
S on sand and gravel
R on rock fragments
F on faces of peds and in pores
N on nodules

Boundary

A abrupt
S smooth
C clear
W wavy
G gradual
I irregular
D diffuse
B broken

Effervescence

0 very slightly effervescent
2 stongly effervescent
1 slightly effervescent
3 violently effervescent

Effervescence Agent Codes

H HCl (10%)
P H_2O_2 (unspecified)
I HCl (unspecified)
Q H_2O_2 (3 to 4%)

Field Measured Property Kind Codes

For organic materials

Column 1

F fiber
H hemic
B unrubbed
W woody

Column 2

R rubbed
H herbacious

L limnic	S sphagnum	C coprogenous earth
S sapric	D diatomaceous earth	M marly
	F ferrihumic	U humilluvic
	O other	L sulfidic

For mineral materials

ON sand	OI silt	OA clay

pH

pB Bromthymol blue	pC Cresol red	pH Hellige-Truog
pL Lamotte-Morgan	pM pH meter (1:1 H_2O)	pN pH (0.1 M $CaCl_2$)
pP Phenol red	pS soiltex	pT Thymol blue
pY Ydrion		

Soil Moisture Codes

D dry	M moist	V very moist	W wet

Quantity (Roots, Pores, Concretions)

VF very few	FF very few to few	F few	FC few to common
CM common to many	C common	M many	

Size (Roots, Pores, Concretions)

M micro	M1 micro and fine	V1 very fine
11 very fine and fine	1 fine	12 fine and medium
2 medium	23 medium and coarse	3 coarse
4 very coarse	5 extremely coarse	13 fine to coarse

Location of Roots

C in cracks	M in mat at top of horizon
P between peds	S matted around stones
T throughout	

Shape of Pores

IR interstitial	IE filled with coarse material
IT interstitial and tubular	IF void between rock fragment
TU tubular	TC continuous tubular
TD discontinuous tubular	TE dendritic tubular
TS constricted tubular	VS vesicular
VT vesicular and tubular	TP total porosity

Kind of Concentrations

A2	clay bodies	B1	barite crystals
B2	soft masses of barite	C1	calcite crystals
C2	soft masses of lime	C3	lime concretions
C4	lime nodules	D1	mica flakes
D2	soft dark masses	D3	dark concretions
D4	dark nodules	E3	gibbsite concretions
E4	gibbsite nodules	F1	plinthite segregations
F2	soft masses of iron	F3	iron concretions
F4	ironstone nodules	G1	gypsum crystals
G2	masses of gypsum	H1	halite crystals
H2	salt masses	K2	soft masses of carbonate
K3	carbonate concretions	K4	carbonate nodules
M1	nonmagnetic shot	M2	soft masses of iron-manganese
M3	iron-manganese concretions	M4	magnetic shot
S1	opal crystals	S2	soft masses of silica
S3	silica concretions	S4	durinodes
T2	worm casts	T3	insects casts
T4	worm nodules		

Shape of Concentrations

C	cylindrical	D	dendritic	O	rounded
P	plate like	T	threads	Z	irregular

Rock Fragment Kind Codes

A	sandstone	B	mixed sedimentary rocks	E	ejecta
F	ironstone	H	shale	I	igneous rocks
K	organic fragments	L	limestone	M	metamorphic rocks
O	oxide-protected rock	P	pyroclastic rocks	R	saprolite
S	sedimentary rocks	T	siltstone	Y	mixed lithogoy

Rock Fragment Size Codes

1	pebbles	5	channers
2	cobbles	6	flagstones
3	stones	C	20- to 75-mm fragments
4	boulders		

Appendix B

Changes to Protocols

This appendix contains the notes assembled during the sampling and preparation laboratory training workshop that was held on August 7 and 8, 1985. The material has undergone minor editorial revisions.

Subject: Changes Discussed on August 8, 1985, During Field Training

From: Discussion Leader

To: Participants of Sampling Workshop, August 7-8, 1985

RE: Major Revisions to Field Sampling Manual

Section to be Added (Section 9) - Data Documentation
Points to be included on the field data form:

(1) Vegetation

- The major, second, and third fields should include the dominant tree species by order of basal area.
- For recent clear-cut areas (since mapping conducted) use the code CC. Describe the dominant vegetation types prior to the clear-cut in the free-form site notes.

(2) Azimuth

- Azimuth values will be added in columns 13 to 17 as follows: -_ _ _ °, where "-" is the field separator, and "°" is degrees. Use leading zeros. The azimuth will be determined by the face of the pit described in a perpendicular direction based on magnetic North.
- If azimuth cannot readily be determined, as in the Histosols, use-N/A° in this field.

(3) Site description codes

- Local Physiographic Component (GM): Add code 00 in case other categories are not appropriate.

Section 1.2.1

(1) The sentence, "The field sampling crews will consist of State Soil Conservation employees." will be replaced by "The field sampling crews will consist of soil scientists experienced in the National Cooperative Soil Survey."

(2) Delete the second sentence, i., "at least three soil scientists."

(3) Add to Section 1.2.1 "The field crew leader will have ultimate responsibility for placement of pedon within sampling class.

Section 1.2.2

(1) The RCC has established dates with the crew leaders for site visits. He will evaluate the watershed mapping and monitor the sampling. A copy of the map that was sent to Corvallis from each state is needed, as well as stereo pairs for the mapping evaluation. It was suggested that if the RCC visits a crew twice, the sampling should be done in different types, if possible.

Log Books

(1) The log book will document crews' activities for each day of sampling. The set ID should be documented.

(2) Use an indelible ink pen for logging. If an error is made, mark through the entered material and initial. Use a free form style for documenting the sampling activities.

(3) Include the Label A information in the log book to serve as a cross-check if labeling problems should occur.

(4) Log books will be submitted to the Data Audit Section - EPA/EMSL-LV.

Section 4.2.8 Label A

(1) For combined samples, use two sample codes, two horizon designations, and two depth designations for organic layers.

(2) Mineral soil layers that cannot be sampled separately will never be combined. The leaders of the sampling teams will use their own judgment in sampling horizons <3 cm thick.

(3) Use FD0 for field duplicate sample.

Section 4.2.7

(1) Two full bags of sample will be required for organic soils.

Section 4.2.3

(1) The subdivision of thick horizons of organic soils will not be required.

Section 7.3.1

(1) Add: One label should be attached to the specific clod while drying. This label is in addition to a 2-inch by 2-inch label that is placed on the inside cover of the clod box. Information necessary on these labels is the horizon, the sample code, and the replicate number.

Contacts

(1) Direct questions in field to people at the EPA/EMSL-LV office.

(2) The EPA QA manager will be auditing 5 to 10 percent of the pedons for quality control. a checklist will be developed and distributed to the sampling crews.

Other Miscellaneous

(1) Label A stamps for the canvas bags will be provided by EPA/EMSL-LV.

(2) Thin tip indelible pens to be used in completing the field data form and broad tip indelible pens for completing the labels on samples will be provided.

(3) Interagency agreements for the preparation laboratories are being prepared.

(4) Saran may be at MSL-LV next week for distribution to the preparation laboratories. The clod labels and boxes may not be delivered until the week of August 26, 1985.

(5) SCS will receive a copy of all data submitted.

(6) Send the QA manager at EMSL-LV any changes in the protocols in writing for inclusion in the next draft.

(7) Estimated dates to begin sampling:

Maine - August 19
New York - August 19 (2 crews); August 26 (1 crew)
New Hampshire - August 26
Massachusetts - August 26 (1 crew); September 2 (1 crew)

Pennsylvania - August 19
Connecticut - August 26

Workshop Notes

Major Revisions and Clarifications to the Field Sampling Manual

Section	*Page*	*Comment*
1.2.2	3 of 5	The Regional Coordinator/Correlator will monitor 3 to 5 percent of the sampling sites (at least one pit per state) with the SCS state office staff.
1.2.4	4 of 5	SCS state office staff will monitor one site per state with the RCC. SCS stat office staff may be involved in sampling but may not be involved in sampling during QA evaluation. Note: Three different descriptions will be generated during the joint reviews of the RCC and the SCS state office staff site visits. If the description of the sampling crew changes during the sampling, they will modify their descriptions, but the RCC and state office staff will not.
2.5.1	8 of 20	The five SAF vegetation cover type aggregates will be further defined and all cover types associated with each of these aggregates will be listed in the next revision of this manual.
2.8.2	15 of 20	If the randomly selected site does not satisfy the criteria for sampling class and vegetation, proceed pacing 20 foot sections until an appropriate sampling class and vegetation class is located or 500 feet have been traversed. A random number table, along with instructions, will be provided in the next revision of this manual.
2.10	20 of 20	Paired pedon selection and sampling--30 sites were identified and assigned by ERL-C. These sites will be sampled in conjunction with the corresponding routine pedon. The location of this pedon will be determined by the crew leader using the following criteria: (1) Establish sufficient distance to avoid disturbance from sampling of the routine pedon. (2) Use same sampling unit and vegetation as the routine pedon. (3) Use the same slope position as the routine pedon. (4) Use the same profile description and sampling protocol as the routine pedon.
3.2	6 of 9	Item 23, the field carbonate test is omitted.
3.4	7 of 9	For film quality consistency, all slides will be developed using prepaid Kodak mailers. Histosols will be photographed by sequential placement of the augered horizons on the surface.
3.5	8 of 9	Discontinuous horizons will be sampled when considered significant by the crew leader.
	9 of 9	All horizons in a pedon which are greater than 3 cm will be sampled.

This entire section will be revised for clarification.

4.2.5	3 of 10	Delete the last sentence on this page which begins "The coarse fragments..."
4.2.7	4 of 10	The minimum amount of field sample is 5.5 Kg of less than or equal to 20 mm particle size fraction unless the estimated 2 to 20-mm size class exceeds 45 percent by estimated volume, then take two 1 gallon samples.
4.2.8	7 of 10	Label A - The first three digits of the sample code will be assigned as follows: (1) Compound field duplicate samples will be labeled FD1 and FD2. (2) Compound routine samples will be labeled R12, R22, etc. (i.e., split horizon samples from horizons greater than or equal to 75 cm). (3) Single routine samples will be labeled R11. (4) Include depth (in cm) after the horizon name.
4.2.8	7 of 10	The following sets of ID ranges are assigned to the respective crews:

0-999	ME01
100-199	ME02
200-299	ME03
300-399	NH01
400-499	NY01
500-599	NY02
600-699	NY03
700-799	MA01
800-899	MA02
900-999	CT01
1000-1099	PA01
1100-1199	VT01

4.2.8	8 of 10	The second sentence read "...digits 4 to 5 are SCS state code, 6 to 8 are the SCS county code, digit 9 is a dash, digits 10 to 11 are the county pedon number, the digits 12 to 13 are the horizon number."
4.3	8 of 10	Delete information referring to carbonate test. Other information in this section will be incorporated into Section 4.2.7.
8.1	4 of 6	Items 31 and 32, the staplers and the Saran resin, will be provided to the preparation laboratories by EMSL-LV.

Revisions to the field data form

Page *Comment*

1 of 4

(1) Under Sample Number "unit" is synonymous with pedon.

(2) Add the day to Date.

(3) Add the crew ID to Describers' Names.

(4) Under Location Description, the first six digits of line 1 are the site ID, the seventh digit is a dash, the eighth digit is the random number point (1-5), the ninth digit is a dash, and digits ten through twelve are the sampling codes.

2 of 4 (5) The Dry Color will be determined when needed for classification.

4 of 4 (6) The three divisions under Rock Fragments correspond to the three particle size fractions:

line 1 = 2 to 75mm
line 2 = 75 to 250mm
line 3 = greater than 250mm

1 of 4 (7) Add Site Description Code, Physiography, Local; AA = depression.

(8) The following Soil Description parameters need not be completed by the field crew: Precip, Temperatures °C, Weather Station Number, ER WA, Vol LAT/TOT, Effervescence, and Pores.

3 of 4 (9) Mottles should be described as indicated in Chapter 4 of the Soil Survey Handbook.

(10) The distribution of the field data form is listed below:

Original to:	SCS
Copy 1 to:	Oak Ridge National Laboratory (ORNL)
Copy 2 to:	EMSL-LV
Copy 3 to:	ERL-C
Copy 4 to:	preparation laboratory

Letters or codes exceeding the given space should be written one above the other.

NOTE: Samples should *never* be frozen.

Appendix C

Letter to Landowner

This appendix reproduces the content of the letter that was written by the technical director of the project to inform landowners about the EPA study. Reportedly, the letter was a help in gaining access to privately owned land which contained sampling locations.

September 16, 1985

Dear Landowner:

One of the most important environmental concerns for our nation is the potential effect of acid rain on lakes and streams. It is crucial to know how many lakes and streams are at risk of being acidified by acid rain in the near future (called, "direct response systems"), and how many are protected by the antacid actions of soil, rocks, and other parts of the watershed ("delayed response systems"). To find out, the U.S. Environmental Protection Agency is looking at a large number of lakes, streams, and watersheds in the eastern United States. The Soil Conservation Service is cooperating in this project by describing and sampling selected soils on these watersheds. The soil samples will be analyzed to see how much protection from acid rain the soils give to the lakes and streams.

We are requesting your assistance in this project. Your property contains a soil type that is important for us to describe and sample. This would mean digging a hole in the ground. This hole might be up to 5 feet deep but most likely will be shallower than that. The sampling crew will describe the soil and remove a small amount for chemical analysis. Then they will fill in the hole after they are finished.

It is, of course, totally up to you whether you will permit us to sample the soil on your property. We hope you will choose to assist us in this important project. If you wish, the results of the soil description and analysis will be sent to you when they are available. Simply inform the sampling crew of your desire for this information. The results of the soil analysis will most likely be available next summer.

Thank you in advance for your consideration and cooperation in this matter.

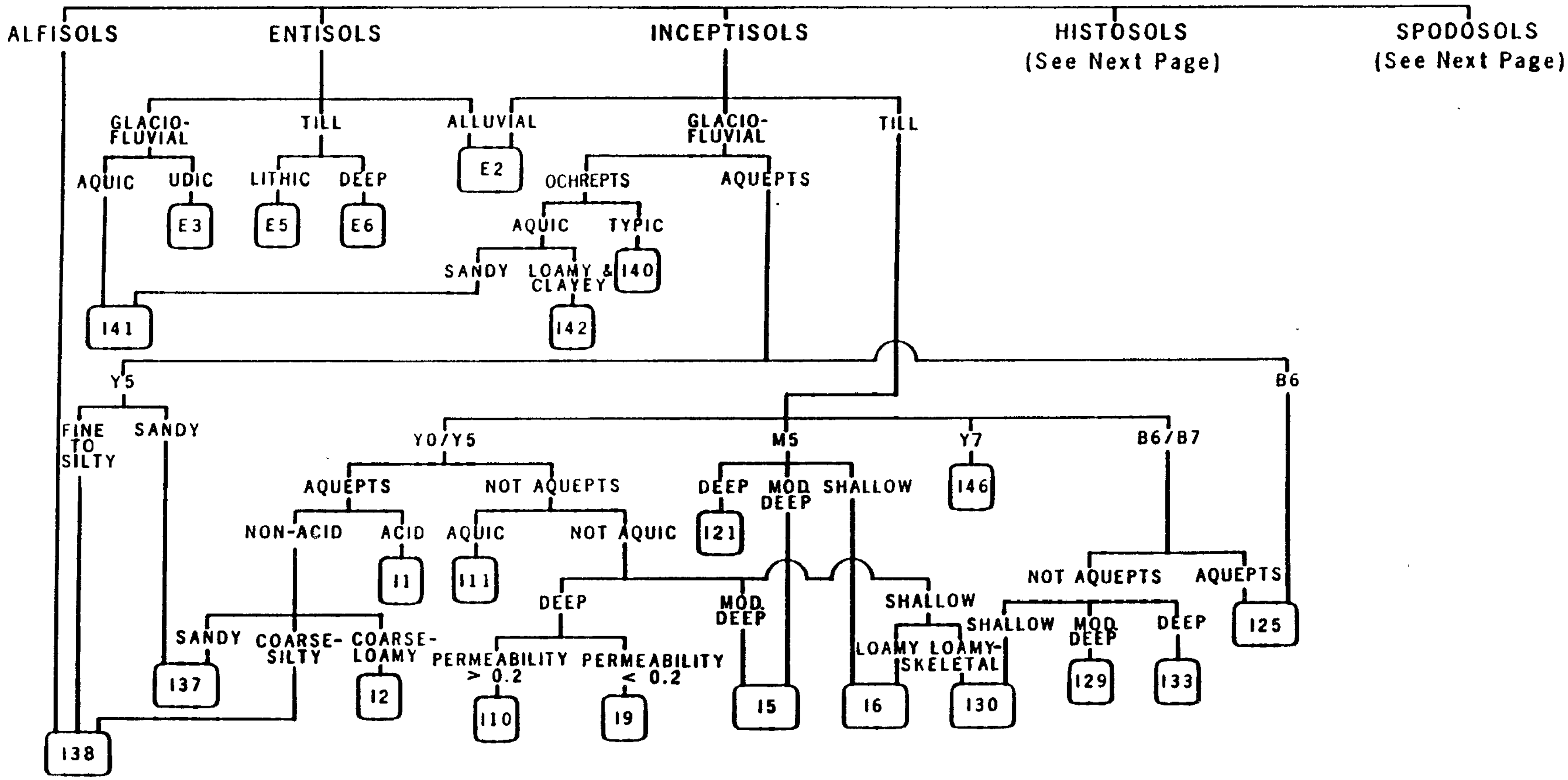
Sincerely,

Technical Director
Direct/Delayed Response Project

Appendix D

Sampling Class Information

The figures and tables in this appendix present information about the sampling classes identified for the Northeastern Soil Survey. The figures are the flowchart which conceptualizes the categories, i.e., sampling classes, to which particular soils belong. Although this flowchart was not available to the sampling crews, it is generally believed that such a flowchart would be an aid to the sampling crews in the field.


ALFISOLS
ENTISOLS
INCEPTISOLS
HISTOSOLS
(See Next Page)
SPODOSOLS
(See Next Page)
GLACIO-FLUVIAL
TILL
ALLUVIAL
GLACIO-FLUVIAL
TILL
AQUIC
UDIC
LITHIC
DEEP
E2
OCHREPTS
AQUEPTS
E3
E5
E6
AQUIC
TYPIC
SANDY
LOAMY & CLAYEY
140
141
142
Y5
B6
FINE TO SILTY
SANDY
Y0/Y5
M5
Y7
B6/B7
AQUEPTS
NOT AQUEPTS
DEEP
MOD. DEEP
SHALLOW
146
NON-ACID
ACID
AQUIC
NOT AQUIC
121
11
111
NOT AQUEPTS
AQUEPTS
DEEP
MOD. DEEP
SHALLOW
SANDY
COARSE-SILTY
COARSE-LOAMY
PERMEABILITY > 0.2
PERMEABILITY < 0.2
LOAMY
LOAMY-SKELETAL
SHALLOW
MOD. DEEP
DEEP
125
137
12
110
19
15
16
130
129
133
138

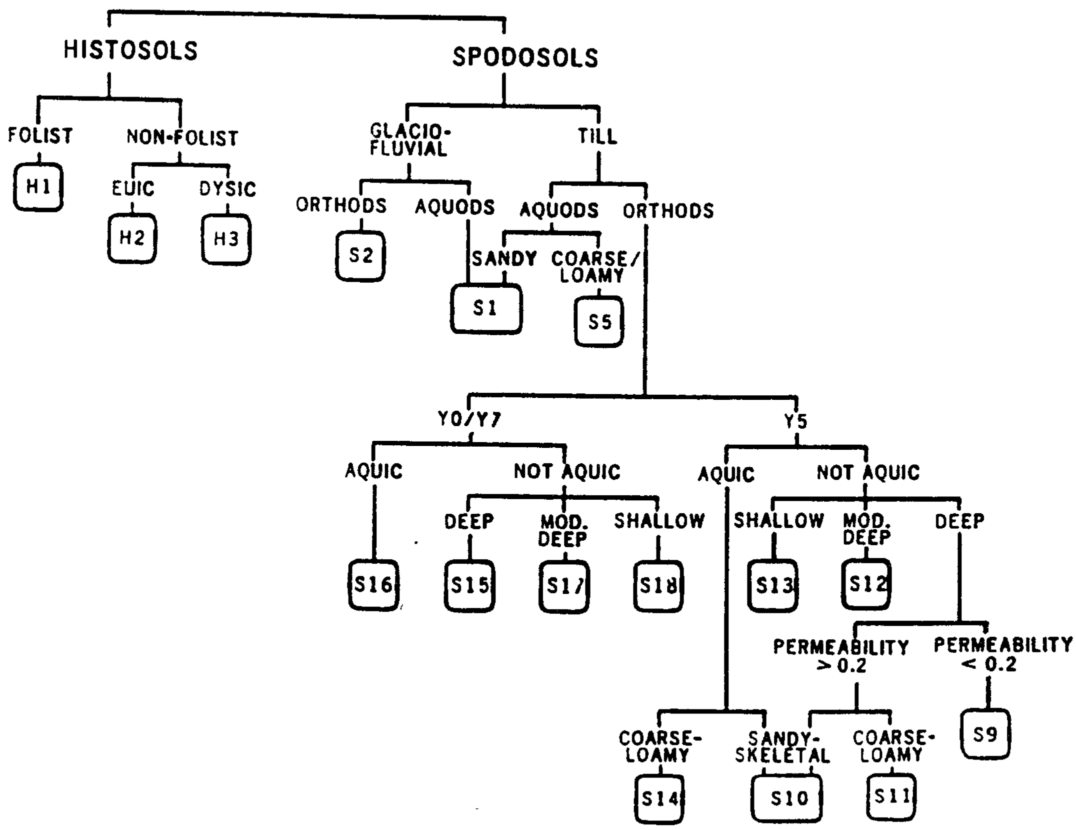

HISTOSOLS
SPODOSOLS
FOLIST
NON-FOLIST
H1
EUIC
DYSIC
H2
H3
GLACIO-FLUVIAL
TILL
ORTHODS
AQUODS
AQUODS
ORTHODS
S2
SANDY
COARSE/LOAMY
S1
S5
Y0/Y7
Y5
AQUIC
NOT AQUIC
AQUIC
NOT AQUIC
DEEP
MOD. DEEP
SHALLOW
SHALLOW
MOD. DEEP
DEEP
S16
S15
S17
S18
S13
S12
PERMEABILITY > 0.2
PERMEABILITY < 0.2
COARSE-LOAMY
SANDY-SKELETAL
COARSE-LOAMY
S9
S14
S10
S11

TABLE D-1. OCCURRENCE OF SAMPLING CLASSES AND LISTING OF SOILS

Sampling Class	Occurrence: Acreage	Occurrence: Number of Watersheds	Soils
Rock	187.0	7	
E2	913.3	26	Aquents, Basher, Charles, Fluvaquents, Medomak, Rumney, Udifluvents
E3	3446.0	20	Carver, Hinckley, Plymouth, Udipsamments, Windsor
E5	1212.6	15	Schoodic, Lithic Udorthents
E6	340.7	7	Udorthents
H1	1550.4	22	Mahoosuc, Ricker
H2	1243.5	18	Adrian, Carbondale, Carlisle, Cathro, Medisaprists, Palms, Rifle
H3	7080.3	83	Beseman, Borosaprists, Chocorua, Dawson, Freetown, Greenwood, Loxley, Lupton, Ossipee, Sebago, Swansea, Waskish
I1	1701.6	29	Haplaquepts, Leicester, Lyme, Neversink, Tughill
I2	7577.3	48	Brayton, Pillsbury, Ridgebury
I5	2824.1	16	Chatfield, Macomber
I6	2117.8	15	Hollis, Nassau, Taconic
I9	1577.0	10	Broadbrook, Montauk, Paxton, Scituate
I10	3320.7	12	Canton, Charlton, Gloucester, Narragansett
I11	2211.0	10	Rainbow, Sutton, Woodbridge
I21	609.0	2	Dummerston, Fullam, Lanesboro
I25	3570.3	17	Chippewa, Massena, Morris, Norwich, Rexford, Scriba, Tuller, Volusia
I29	3825.7	17	Lordstown, Manlius, Oquaga
I30	1645.3	6	Arnot, Insula
I33	8209.5	17	Lackawanna, Mardin, Swartswood, Wellsboro, Wurtzboro
I37	493.0	10	Moosilauke, Scarboro, Searsport
I38	3211.0	21	Biddeford, Humaquepts, Muskellunge, Peacham, Raynham, Roundabout, Swanville, Scantic, Whitman
I40	1007.0	12	Agawam, Braceville, Haven, Merrimac, Riverhead, Wyoming
I41	213.0	7	Deerfield, Sudbury
I42	1460.0	7	Belgrade, Boothbay, Buxton, Scio, Tisbury
I46	1435.8	9	Burnham, Monarda
S01	495.8	16	Naskeag, Naumburg, Pipestone
S02	2580.3	29	Adams, Allagash, Colton, Croghan, Duane, Masardis, Sheepscot
S05	505.3	13	Aeric Haplaquods, Typic Haplaquods
S09	21219.1	70	Becket, Marlow, Potsdam
S10	7302.6	24	Herman, Waumbek
S11	6701.3	42	Berkshire, Danforth, Monadnock
S12	19795.7	77	Rawsonville, Tunbridge
S13	16039.2	82	Hogback, Lyman, Saddleback
S14	21454.7	64	Crary, Peru, Skerry, Sunapee, Worden
S15	1650.6	8	Bangor, Chesuncook, Enchanted
S16	2085.0	14	Dixmont, Howland, Nicholville, Surplus, Telos
S17	1041.8	6	Elliottsville, Winnecook
S18	1285.2	8	Monson, Thorndike

TABLE D-2. CLASSIFICATION AND CHARACTERISTICS OF SOILS IN SAMPLING CLASSES.

Soil Name	Taxonomic Category	Particle Size Class	Depth (cm) To Bedrock	Depth (cm) To Impermeable Material	Named Mapping Units
Sampling Class E2					
Aquents	Aquents	—	>150	>150	178A
Basher	Fluvaquic Dystrocrepts	coarse-loamy	>150	23	18A
Charles	Aeric Fluvaquents	coarse-silty	>150	>150	44A
Fluvaquents	Fluvaquents	loamy	>150	76	71A; 72A
Medomak	Fluvaquic Humaquepts	coarse-silty	>150	>150	118A
Romney	Aeric Fluvaquents	coarse-loamy	>150	>150	175A
Udifluvents	Udifluvents	loamy	—	—	72A
Sampling Class E3					
Carver	Typic Udipsamments	sandy	>150	>150	42A, B, C, D, E
Hinckley	Typic Udorthents	sandy-skeletal	>150	>150	89A, B, C, D
Plymouth	Typic Udipsamments	sandy	>150	>150	156A, B, C, D
Udipsamments, Undulating	Udipsamments	sandy	>150	>150	504B
Udipsamments, Rolling	Udipsamments	sandy	>150	>150	504C
Windsor	Typic Udipsamments	sandy	>150	>150	234A, B, C
Sampling Class E5					
Lithic Udorthents	Lithic Udorthents	loamy-skeletal	10	10	705C, E, F
Lithic Udorthents	Lithic Udorthents	loamy	5	5	263C, E, F
Schoodic	Lithic Udorthents	loamy-skeletal	25	25	181C, E, F
Sampling Class E6					
Udorthents, Strip mine	Udorthents	loamy-skeletal	>150	>150	218
Udorthents, Smoothed	Udorthents	—	>150	>150	217
Sampling Class H1					
Mahoosuc	Typic Borofolists	—	100	100	241B; 356E, F; 176E
Ricker	Lithic Borofolists	—	25	25	242E, F; 254C, E; 263C, E, F; 352C; 353E
Sampling Class H2					
Adrian	Terric Medisaprists	sandy-skeletal	>150	>150	2A
Carlisle	Typic Medisaprists	—	>150	>150	41A
Carbondale	Hemic Borosaprists	loamy	>150	>150	258A
Cathro	Terric Borosaprists	loamy	>150	>150	253A
Medisaprists	Medisaprists	—	>150	>150	178A
Palms	Terric Medisaprists	loamy	>150	>150	144A
Rifle	Typic Borohemists	—	>150	>150	166A
Sampling Class H3					
Beseman	Terric Borosaprists	loamy	>150	127	243A
Borosaprists	Borosaprists	—	>150	>150	30A;248C
Chocorua	Terric Borohemists	sandy-skeletal	>150	>150	53A
Dawson	Terric Borosaprists	—	>150	>150	61A
Freetown	Typic Medisaprists	—	>150	>150	501A; 502A; 506A
Greenwood	Typic Borohemists	—	>150	>150	79A
Loxley	Typic Borosaprists	—	>150	>150	103A
Lupton	Typic Borosaprists	—	>150	>150	104A
Ossipee	Terric Borohemists	loamy	>150	>150	79A
Sebago	Fibric Borohemists	—	>150	>150	188A
Swansea	Terric Medisaprists	sandy	>150	>150	510A
Waskish	Typic Sphagnofibrists	—	>150	>150	226A

(Continued)

TABLE D-2 (Continued).

Soil Name	Taxonomic Category	Particle Size Class	Depth (cm)		Named Mapping Units
			To Bedrock	To Impermeable Material	
Sampling Class I1					
Haplaquepts	Haplaquepts	coarse-loamy	>150	>150	732A; 767A
Leicester	Aeric Haplaquepts	coarse-loamy	>150	>150	98B
Lyme	Aeric Haplaquepts	coarse-loamy	>150	>150	107A, B
Neversink	Aeric Haplaquepts	coarse-loamy	>150	53	136A
Tughill	Histic Humaquepts	loamy-skeletal	>150	76	211A
Sampling Class I2					
Brayton	Aeric Haplaquepts	coarse-loamy	>150	48	32A, B, C
Brayton, Rubbly	Aeric Haplaquepts	coarse-loamy	>150	48	252A
Pillsbury	Aeric Haplaquepts	coarse-loamy	>150	56	150A, B
Ridgebury	Aeric Haplaquepts	coarse-loamy	>150	41	167A, B
Sampling Class I5					
Chatfield	Typic Dystrochrepts	coarse-loamy	50	50	46C; 47C; 48C, E
Macomber	Typic Dystrochrepts	loamy-skeletal	50	50	108C; 704E
Sampling Class I6					
Hollis	Lithic Dystrochrepts	coarse-loamy	25	25	47C; 48C, E; 250C, E; 251F; 514E
Nassau	Lithic Dystrochrepts	loamy-skeletal	25	25	246B
Taconic	Lithic Dystrochrepts	loamy-skeletal	25	25	108C; 704E; 705C, E, F
Sampling Class I9					
Broadbrook	Typic Dystrochrepts	coarse-loamy	>150	61	515B, C
Montauk	Typic Dystrochrepts	coarse-loamy	>150	69	127B, C, D
Paxton	Typic Dystrochrepts	coarse-loamy	>150	61	145B, D
Scituate	Typic Dystrochrepts	coarse-loamy	>150	71	185B, C
Sampling Class I10					
Canton	Typic Dystrochrepts	coarse-loamy o/ sandy-skeletal	>150	>150	38B, C, D
Charlton	Typic Dystrochrepts	coarse-loamy	>150	>150	45B, C; 46C; 47C
Gloucester	Typic Dystrochrepts	sandy-skeletal	>150	>150	76B, C, D, E
Narragansett	Typic Dystrochrepts	coarse-loamy o/ sandy-skeletal	>150	>150	505B, C, D
Sampling Class I11					
Rainbow	Aquic Dystrochrepts	coarse-loamy	>150	61	516B
Sutton	Aquic Dystrochrepts	coarse-loamy	>150	>150	199A, B
Woodbridge	Aquic Dystrochrepts	coarse-loamy	>150	64	236A, B, C
Sampling Class I21					
Dummerson	Typic Dystrochrepts	coarse-loamy	>150	>150	701C, D
Fullam	Aquic Dystrochrepts	coarse-loamy	>150	60	702B, C
Lanesboro	Typic Dystrochrepts	coarse-loamy	>150	76	703B, C
Sampling Class I25					
Chippewa	Typic Fragiaquepts	fine-loamy	>150	40	52A, B
Massena	Aeric Haplaquepts	coarse-loamy	>150	>150	259C
Morris	Aeric Fragiaquepts	coarse-loamy	>150	38	129A, B, C, D
Norwich	Typic Fragiaquepts	fine-loamy	>150	38	138A
Rexford	Aeric Fragiaquepts	coarse-loamy	>150	45	165A
Scriba	Aeric Fragiaquepts	coarse-loamy	>150	33	186A
Tuller	Lithic Haplaquepts	loamy-skeletal	25	25	257B
Volusia	Aeric Fragiaquepts	fine-loamy	>150	33	224A, B, C

(Continued)

TABLE D-2 (Continued).

Soil Name	Taxonomic Category	Particle Size Class	Depth (cm) To Bedrock	Depth (cm) To Impermeable Material	Named Mapping Units
Sampling Class I29					
Lordstown	Typic Dystrochrepts	coarse-loamy	50	50	101B, C, D, E
Manlius	Typic Dystrochrepts	loamy-skeletal	50	50	110C; 246B
Oquaga	Typic Dystrochrepts	loamy-skeletal	50	50	141B, C, D, E, F; 142B, C, D
Sampling Class I30					
Arnot	Lithic Dystrochrepts	loamy-skeletal	25	25	11B; 12C, E, F; 142B, C, D
Insula	Lithic Dystrochrepts	loamy	25	25	259C; 260E; 261F
Sampling Class I33					
Lackawanna	Typic Fragiochrepts	coarse-loamy	>150	61	96B, C, D; 97E
Mardin	Typic Fragiochrepts	coarse-loamy	>150	50	114B, C, D
Swartswood	Typic Fragiochrepts	coarse-loamy	>150	75	97E; 202B, C, D
Wellsboro	Typic Fragiochrepts	coarse-loamy	>150	56	229A, B, C, D
Wurtboro	Typic Fragiochrepts	coarse-loamy	>150	43	239B, C
Sampling Class I37					
Moosilauke	Aeric Haplaquepts	sandy	>150	>150	128B
Scarboro	Histic Humaquepts	sandy	>150	>150	511A
Searsport	Histic Humaquepts	sandy	>150	>150	187A
Sampling Class I38					
Biddeford	Histic Humaquepts	fine	>150	40	28A
Humaquepts	Frigid Humaquepts	coarse-loamy	>150	>150	732A
Humaquepts	Mesic Humaquepts	coarse-loamy	>150	>150	767A
Muskellunge	Aeric Ochraqualfs	fine	>150	30	262A
Peacham	Histic Humaquepts	coarse-loamy	>150	25	146A, B
Raynham	Aeric Haplaquepts	coarse-silty	>150	61	163A
Roundabout	Aeric Haplaquepts	coarse-silty	>150	>150	173A
Scantic	Typic Haplaquepts	fine	>150	28	180A, B
Swanville	Aeric Haplaquepts	fine-silty	>150	56	201A, B
Whitman	Typic Humaquepts	coarse-loamy	>150	38	512A
Sampling Class I40					
Agawam	Typic Dystrochrepts	coarse-loamy o/ sandy-skeletal	>150	>150	4A
Braceville	Typic Fragiochrepts	coarse-loamy	>150	61	31A
Haven	Typic Dystrochrepts	coarse-loamy o/ sandy-skeletal	>150	>150	507A, B, C
Merrimac	Typic Dystrochrepts	sandy	>150	>150	120A, B, C
Riverhead	Typic Dystrochrepts	coarse-loamy	>150	>150	170B, C
Wyoming	Typic Dystrochrepts	loamy-skeletal	>150	>150	240C, D, E
Sampling Class I41					
Deerfield	Aquic Udipsamments	sandy	>150	>150	62A, B
Sudbury	Aquic Dystrochrepts	sandy	>150	>150	503A, B
Sampling Class I42					
Belgrade	Aquic Eutrochrepts	coarse-loamy	>150	100	517B
Boothbay	Aquic Eutrochrepts	fine-silty	>150	56	29B
Buxton	Aquic Eutrochrepts	fine	>150	53	37B
Scio	Aquic Dystrochrepts	coarse-silty	>150	>150	183A, B
Tisbury	Aquic Dystrochrepts	coarse-silty	>150	>150	508A, B
Sampling Class I46					
Burnham	Histic Humaquepts	coarse-loamy	>150	50	36A
Monarda	Aeric Haplaquepts	coarse-loamy	>150	61	123A, B, C

(Continued)

TABLE D-2 (Continued).

Soil Name	Taxonomic Category	Particle Size Class	Depth (cm) To Bedrock	Depth (cm) To Impermeable Material	Named Mapping Units
Sampling Class S01					
Naskeag	Aeric Haplaquods	sandy	50	50	131A, B
Naumburg	Aeric Haplaquods	sandy	>150	>150	134A
Naumburg	Aeric Haplaquods	sandy	>150	>150	135A
Pipestone	Entic Haplaquods	sandy	>150	>150	151A
Sampling Class S02					
Adams	Typic Haplorthods	sandy	>150	>150	1A, B, C, D; 7C
Allagash	Typic Haplorthods	coarse-loamy o/ sandy-skeletal	>150	>150	6B; 7C
Colton	Typic Haplorthods	sandy-skeletal	>150	>150	54A, B, C, D
Croghan	Aquic Haplorthods	sandy	>150	>150	57A, B
Duane	Typic Haplorthods	sandy-skeletal	>150	>150	64A
Masardis	Typic Haplorthods	sandy-skeletal	>150	>150	116B, C, D
Sheepscot	Typic Haplorthods	sandy-skeletal	>150	>150	190B
Sampling Class S05					
Aeric Haplaquods	Aeric Haplaquods	coarse-loamy	>150	50	3A, B
Typic Haplaquods	Typic Haplaquods	coarse-loamy	>150	75	244A
Sampling Class S09					
Becket	Typic Haplorthods	coarse-loamy	>150	80	208B, C, D, E; 21C, E, F
Marlow	Typic Haplorthods	coarse-loamy	>150	61	115B, C, D
Potsdam	Typic Fragiorthods	coarse-loamy	>150	66	160B, C, D; 161C, E
Sampling Class S10					
Hermon	Typic Haplorthods	sandy-skeletal	>150	>150	88B, C, E
Hermon, Rubbly	Typic Haplorthods	sandy-skeletal	>150	>150	87C, D, E
Waumbek	Aquic Haplorthods	sandy-skeletal	>150	>150	227B
Sampling Class S11					
Berkshire	Typic Haplorthods	coarse-loamy	>150	>150	22B, C, D, E, F; 23C; 214C, E
Berkshire, Rubbly	Typic Haplorthods	coarse-loamy	>150	>150	255D, E
Danforth	Typic Haplorthods	loamy-skeletal	>150	>150	59C, D
Monadnock	Typic Haplorthods	coarse-loamy o/ sandy-skeletal	>150	>150	122B, C, D, E
Sampling Class S12					
Rawsonville	Typic Haplorthods	coarse-loamy	50	50	90C; 162C, D
Tunbridge	Typic Haplorthods	coarse-loamy	50	50	161C, E; 213B, C, D; 214C, E; 215C, E, F
Sampling Class S13					
Hogback	Lithic Haplorthods	loamy	25	25	90C; 162C, D
Lyman	Lithic Haplorthods	loamy	25	25	21C, E, F; 23C; 88C, E; 105B, C, D, F; 106C, F; 172F; 214E; 215C, E, F; 254C, E; 263C, E, F
Saddleback	Humic Cryorthods	thixotropic	25	25	176E
Sampling Class S14					
Crary	Aquic Fragiorthods	coarse-loamy	>150	61	56B, C
Peru	Aquic Haplorthods	coarse-loamy	>150	61	148B, C, D
Skerry	Aquic Haplorthods	coarse-loamy	>150	64	192B, C, D
Sunapee	Aquic Haplorthods	coarse-loamy	>150	>150	196B, C
Sunapee, Rubbly	Aquic Haplorthods	coarse-loamy	>150	>150	256B
Worden	Aquic Haplorthods	coarse-loamy	>150	64	238B, C, D

(Continued)

TABLE D-2 (Continued).

Soil Name	Taxonomic Category	Particle Size Class	Depth (cm) To Bedrock	Depth (cm) To Impermeable Material	Named Mapping Units
Sampling Class S15					
Bangor	Typic Haplorthods	coarse-loamy	>150	>150	15B, C, E
Chesuncook	Typic Haplorthods	coarse-loamy	>150	53	51B, C, D, E, F
Enchanted	Humic Cryorthods	thixotropic	100	100	355D, E; 356E, F
Sampling Class S16					
Dixmont	Aquic Haplorthods	coarse-loamy	>150	53	63B, C
Howland	Aquic Haplorthods	coarse-loamy	>150	40	357B, C
Nicholville	Aquic Haplorthods	coarse-silty	>150	>150	137B
Surplus	Typic Cryorthods	thixotropic	>150	66	354C, D, E
Telos	Aquic Haplorthods	coarse-loamy	>150	36	204B, C
Sampling Class S17					
Elliottsville	Typic Haplorthods	coarse-loamy	50	50	67B, C, D, E; 353E;
Winnecook	Typic Haplorthods	loamy-skeletal	50	50	235C, D; 358E
Sampling Class S18					
Monson	Lithic Haplorthods	loamy	25	25	125C; 126E; 352C; 353E
Thorndike	Lithic Haplorthods	loamy-skeletal	25	25	205B, C; 206C, E; 358E

TABLE D-3. CHARACTERISTICS OF SOILS IN THE SAMPLING CLASSES

Class	Description
E2	Soils occur in recent deep alluvial deposits from mixed parent materials on the margins of lakes and in flood plains on low stream terraces where the soil is wet at some time of the year. Soils are very poorly, poorly, or somewhat poorly drained. These mineral soils have an irregular decrease in organic carbon content with depth, or have a relatively high amount of organic carbon in deep layers. The particle size class is loamy.
E3	Soils are deep, sandy, mineral soils with little or no development of pedogenic horizons. Soils are developed in till and glacio-fluvial deposits derived from mixed igneous and metamorphic rocks. Permeability is rapid or very rapid, and the soils are excessively drained.
E5	Soils are mineral soils with a lithic contact within 50 cm of the surface and little or no pedogenic development. Soils are developed in till derived from igneous or metamorphic rocks. The particle size class is loamy or loamy-skeletal. Permeability is moderate or moderately rapid, and soils are well drained to excessively drained.
E6	Soils are on areas disturbed by human activity, including strip mines, pits, quarries, and landfills. Recent disturbance has destroyed or homogenized the pedogenic development of these deep mineral soils. The soil parent material was once deposited as till derived from various rocks. The particle size class is loamy or loamy-skeletal. Permeability is moderately slow to moderately rapid, and soils are well drained or somewhat excessively drained.
H1	Soils are freely drained organic materials derived from leaf litter, twigs, and branches resting on or partly filling interstices in fragmental materials or directly overlying bedrock that is less than one meter from the surface. Soils are cool, have a frigid temperature regime, and are somewhat excessively drained. Thin mineral layers of less than 10 cm may occur, but the combined thickness of the organic material is more than twice that of the mineral material.
H2	Soils are deep organic materials which have been mostly decomposed. These soils differ from those in Class H3 in that the soil reaction is euic, i.e., the pH of undried samples in 0.01 M $CaCl_2$ is 4.5 or higher, in at least some part of the organic materials in the control section rather than dysic. Soils are very poorly drained or poorly drained. Either ground water is at or near the surface nearly all the time, or ground water tends to fluctuate which allows for periodic aerobic decomposition of organic materials. In some soils of this class, mineral layers and layers of less decomposed organic material tend to interfere with water movement.
H3	Soils are composed of deep organic materials which have been mostly decomposed. These soils differ from Class H2 in that the soil reaction is dysic, i.e., the pH in 0.01 M $CaCl_2$ of undried samples is less than 4.5, in all parts of the organic materials in the control section rather than euic. Soils are very poorly drained. Either ground water is at or near the surface nearly all the time, or ground water tends to fluctuate which allows for periodic aerobic decomposition of the organic materials. In some soils of this class, mineral layers and layers of less decomposed organic tend to interfere with water movement.
I1	Soils of this class are deep mineral soils developed in till derived from mixed igneous and metamorphic rocks or interbedded sandstone and siltstone. Unless artificially drained, ground water stands at or near the surface for long periods of time, but not throughout the year. Soils differs from those in Classes I2, I37, and I38 in that the pH is less than 5.0 in 0.01 M $CaCl_2$ throughout the control section. The particle size class is coarse-loamy or loamy-skeletal. Soils are poorly drained or very poorly drained.
I2	Soils are deep mineral soils developed in till derived from mixed igneous and metamorphic rocks. Unless artificially drained, ground water stands at or near the surface for long periods of time, but not throughout the year. Soils have a layer of dense till at a depth of 1 meter or less from the soil surface. The particle size class coarse-loamy. Soils are somewhat poorly drained or poorly drained.
I5	Soils are moderately deep mineral soils developed in till derived from mixed igneous and metamorphic rocks or from schist and phyllite. Soils have base saturation less than 60 percent in all subhorizons between depths of 25 and 75 cm below the soil surface. The particle size class is coarse-loamy or loamy-skeletal. Soils are well drained.
I6	Soils are shallow mineral soils developed in till derived from mixed igneous and metamorphic rocks or from schist and phyllite. Bedrock occurs at less than 50 cm below the soil surface. The particle size class is loamy or loamy-skeletal. Soils are well drained.

(Continued)

TABLE D-3 (Continued).

Class	Description
I9	Soils are deep mineral soils developed in till derived from mixed igneous and metamorphic rocks. Soils have base saturation less than 60 percent in all subhorizons between depths of 25 and 75 cm below the soil surface. The particle size class is coarse-loamy. Soils are moderately well drained or well drained. A slowly permeable layer occurs at a depth of 50 to 100 cm below the soil surface.
I10	Soils are deep mineral soils developed in till derived from mixed igneous and metamorphic rocks. Soils have base saturation less than 60 percent in all subhorizons between depths of 25 and 75 cm below the soil surface. The particle size class ranges from coarse-loamy to sandy-skeletal. Soils are well drained or somewhat excessively drained.
I11	Soils are deep mineral soils developed in till derived from mixed igneous and metamorphic rocks. Soils have base saturation less than 60 percent in all subhorizons between depths of 25 and 75 cm below the soil surface. Ground water is present in the soil in the deep layers during winter, but disappears in summer. The particle size class is coarse-loamy. Soils are moderately well drained.
I21	Soils are deep mineral soils developed in till derived from schist and phyllite. Soils have base saturation less than 60 percent in all subhorizons between 25 and 75 cm below the soil surface. The particle size class is coarse-loamy, and the soils are well drained.
I25	Soils are deep mineral soils developed in till or glacio-fluvial deposits derived from interbedded sedimentary rocks. Most of these soils are underlain by a fragipan a 30 to 50 cm below the soil surface. One soil in this class has bedrock between 25 and 50 cm below the soil surface. Horizons above the fragipan or bedrock are saturated with ground water for some months in most years. The particle size class is loamy or loamy-skeletal, and the soils are very poorly drained to somewhat poorly drained.
I29	Soils are moderately deep mineral soils developed in till derived from interbedded sandstone and siltstone or from siltstone and shale. Soils are underlain by bedrock at depths between 50 and 100 cm below the soil surface. Soils have base saturation less tan 60 percent in all subhorizons at depths between 25 and 75 cm below the soils surface. The particle size class is coarse-loamy or loamy-skeletal, and the soils are well drained or somewhat excessively drained.
I30	Soils are shallow mineral soils developed in till derived from mixed igneous and metamorphic rocks or from sandstone and siltstone. Bedrock occurs at less than 50 cm below the soil surface. The particle size class is loamy or loamy-skeletal, and the soils are well drained and moderately well drained.
I33	Soils are deep mineral soils developed in till derived from sandstone and siltstone. A fragipan occurs at a depth of about 50 cm. Usually ground water is perched above the fragipan at some time of the year. The particle size class is coarse-loamy, and the soils are somewhat poorly drained to well drained.
I37	Soils are deep mineral soils developed in till or glacio-fluvial deposits derived from mixed igneous and metamorphic rocks. Unless artificially drained, ground water stands at or near the surface for long periods of time, but not throughout the year. The particle size class is sandy, and the soils are poorly drained or very poorly drained.
I38	Soils are deep mineral soils derived from mixed igneous and metamorphic rocks. Most soils in this class have a layer of dense till at a depth of less than 1 meter from the soil surface. Soils have an aquic moisture regime, and are somewhat poorly drained to very poorly drained. The particle size class ranges from fine to coarse-loamy.
I40	Soils are acid mineral soils that occur on deep coarse-textured glacio-fluvial deposits derived from sandstone and siltstone or from mixed igneous and metamorphic rocks. The particle size class ranges from coarse-loamy to sandy and from loamy-skeletal to coarse-loamy over sandy-skeletal. Permeability is moderately rapid to very rapid, and soils are moderately well drained to somewhat excessively drained.
I41	Soils are mineral soils that occur on deep sandy glacio-fluvial deposits derived from mixed igneous and metamorphic rocks. Soils are saturated with water within 1 meter of the soil surface during some part of the year. The particle size class is sandy. Permeability is rapid, and soils are moderately well drained.

(Continued)

TABLE D-3 (Continued).

Class	Description
I42	Soils are mineral soils that occur on deep, loamy glacio-fluvial deposits derived from mixed igneous and metamorphic rocks. Soils are saturated with water within 60 cm of the soil surface at some time of the year. The particle size class ranges from fine to coarse-loamy, and soils are moderately well drained or somewhat poorly drained. This class includes soils with and without carbonates or base saturation that is 60 percent or higher in some subhorizon.
I46	Soils are deep mineral soils developed in till derived from mixed metamorphic and sedimentary rocks. Ground water stands at or near the surface of these soils at some time during each year, but not at all seasons. The particle size class is coarse-loamy, and the soils are very poorly drained or poorly drained.
S1	Soils are moderately deep or deep mineral soils developed in till or glacio-fluvial deposits derived from mixed igneous and metamorphic rocks. Soils have fluctuating ground water at or near the soil surface. An ochric epipedon, i.e., a surface horizon too thin or with too little organic carbon to be an umbric horizon, overlies a spodic horizon, i.e., a layer in which an amorphous mixture of organic carbon and aluminum have accumulated. The particle size class is sandy, and soils are poorly drained or somewhat poorly drained.
S2	Soils are deep mineral soils developed in glacio-fluvial deposits derived from mixed igneous or metamorphic rocks. Soils have a spodic horizon of amorphous organic carbon, iron, and aluminum accumulation. Particle size class ranges from sandy to sandy-skeletal, and soils are moderately well drained to excessively drained.
S5	Soils are deep mineral soils developed in till derived from granite or mixed igneous and metamorphic rocks. Soils have fluctuating ground water at or near the soil surface. Soils have a spodic horizon, i.e., a subsoil layer in which an amorphous mixture of organic carbon and aluminum have accumulated. Particle size class is coarse-loamy, and soils are poorly drained of somewhat poorly drained.
S9	Soils are deep mineral soils developed in till derived from mixed igneous and metamorphic rocks. Soils have a spodic horizon of aluminum, iron, and organic carbon accumulation in which no one of these elements dominates. Particle size class is coarse-loamy, and soils are well drained. Permeability is less than 0.2 inches per hour.
S10	Soils are deep mineral soils developed in till derived from mixed igneous and metamorphic rocks. Soils have a spodic horizon of aluminum, iron, and organic carbon accumulation in which no one of these elements dominates. Particle size class is sandy-skeletal, and soils are moderately well drained or somewhat excessively drained.
S11	Soils are deep mineral soils developed in till derived from mixed igneous and metamorphic rocks. These soils have a spodic horizon of aluminum, iron, and organic carbon accumulation in which no one of these elements dominates. The particle size class is coarse-loamy, loamy-skeletal, or coarse-loamy over sandy-skeletal, and the soils are well drained. Permeability is greater than 0.2 inches per hour.
S12	Soils are moderately deep mineral soils developed in till derived from mixed igneous and metamorphic rocks. These soils have a spodic horizon of aluminum, iron, and organic carbon accumulation in which no one of these elements dominates. The particle size class is coarse-loamy, and the soils are well drained.
S13	Soils are shallow mineral soils developed in till derived from mixed igneous and metamorphic rocks. Bedrock occurs at depths less than 50 cm from the soil surface. These soils have a spodic horizon of aluminum, iron, and organic carbon accumulation in which no one of these elements dominates. The particle size class is loamy or thixotropic. Soils are well drained or somewhat excessively drained.
S14	Soils are deep mineral soils developed in till derived from mixed igneous and metamorphic rocks. These soils have a spodic horizon of aluminum, iron, and organic carbon accumulation in which no one of these elements dominates. Ground water fluctuates either in or just below the spodic horizon. The particle size class is coarse-loamy, and the soils are somewhat poorly drained or moderately well drained.
S15	Soils are deep mineral soils developed in till derived from mixed metamorphic and sedimentary rocks. These soils have a spodic horizon of aluminum, iron and organic carbon accumulation in which no one of these elements dominates. Particle size class is coarse-loamy or thixotropic, and the soils are moderately well drained or well drained.

(Continued)

TABLE D-3 (Continued).

Class	Description
S16	Soils are deep mineral soils developed in till or lacustrine deposits derived from mixed metamorphic and sedimentary rocks. These soils have a spodic horizon with a moderate amount of organic carbon. Ground water fluctuates either in or just below the spodic horizon for most soils in this class. Particle size class is coarse-loamy or coarse-silty, except for one soil that is thixotropic. Soils are somewhat poorly drained or moderately well drained.
S17	Soils are moderately deep mineral soils developed in till derived from mixed metamorphic and sedimentary rocks. These soils have a spodic horizon of aluminum, iron, and organic carbon accumulation in which no one of these elements dominates. Particle size class is coarse-loamy or loamy-skeletal. Soils are well drained.
S18	Soils are shallow mineral soils developed in till derived from mixed rocks. Bedrock occurs within 50 cm of the soil surface. Soils have a spodic horizon of aluminum, iron, and organic carbon accumulation in which no one of these elements dominates. Particle-size class is loamy or loamy-skeletal. Soils are somewhat excessively drained.

Appendix E

New York Sampling Phase Outline and Checklist

The Soil Conservation Service in New York prepared a summary of the protocols and a checklist for the sampling crews to use in the field. It is reproduced here with minor editorial revision.

Sampling Phase Outline
(Abbreviated)

I. *Site Selection*

1. Proceed to Point 1 (10 yds. x 10 yds.) shown on map.

   a. Place flag at Point 1 if soil sampling class or vegetation class is not applicable.

   b. Proceed to locate proper sampling class, at 20 feet intervals (straight line) from the marker flag up to a distance of 500 feet.

   c. Direction taken from marker flag will be chosen from a random numbers table (eyes closed - pencil point the table to select a number). North = No. 2, Northeast = 3, East = 4,...up to Northwest = 9.

2. Reasons for not sampling Point 1 and surrounding area.

   a. Inappropriate soil or vegetation sampling class.

   b. Landowner won't give permission.

   c. Inaccessible.

3. If Point 1 cannot be sampled, go to Point 2 and repeat procedure in Item 1 above.

4. If Point 2 cannot be sampled, proceed to Point 3, and so on.

II. *Site Preparation*

1. Ribbon 4 trees (if wooded and allowable) surrounding sampling site for relocation.

2. Dig pit 1 meter square to a depth that will allow sampling to 60 inches (v. deep soils).

III. *Pre-Sampling Activities*

1. Photographs (ASA 400 Ektachrome slides)

   a. Pit face with completed information card attached to upper horizon (ID card must be focused and readable).

   b. Full profile with ID card and measuring tape.

   c. Edge of pit and surrounding landscape.

   d. Major tree canopy (cover type).

   (NOTE: Next photo set will start with the ID card on next sampling pit - features photographed should be in the same order.)

2. Record azimuth facing perpendicular to pit face sampled. (No azimuth for wet organic soils.)

IV. *Profile Description*

   a. Describe on new 232 coding form (to 60") with current SSM, Chapter 4 terminology.

b. Fill out form completely except for the following blocks: (1) Precip., (2) Temp °C, (3) Weather Station No., (4) ERWA, (5) Vol Lat/Tot., (6) Effervescence, and (7) Pores.

c. *Soil Series block* - if at all possible, profile should be within range of characteristics for a series.

d. *PHYS block* - codes will be taken from map unit description.

e. *Describers' Names block* - add crew ID numbers at end -

XXXXXXX - NY01
YYYYY - NY02
ZZZZ - NY03

f. *Location Description block* -

i. (1st Line) - Watershed ID No. - site selected (1,2,etc.) - soil class (E5,I21,etc.) - Azimuth.

ii. (2nd line) - locate pedon from N and E boundary of watershed (ft.) - scale from maps.

g. *Horizon Depth block* - in meters.

h. *Rock Fragment block* - Record by volume the 2 mm to 3" size; 3" to 10" size, and the > 10" size in the 3 blocks provided.

V. *Sampling*

1. Bulk Samples

a. *No. of Horizons sampled* - usually no more than 6 unless additional horizons are unique - a field duplicate horizon will be sampled per pedon (your choice).

b. *Horizon Thickness* - sample no horizon less than 1-1/4 inches thick unless unique (samples from these horizons can be less than 1 gal.).

c. *Split Samples* - generally split horizons if > 12" thick in the upper 1 meter -split > 30 inch thick horizons below 1 meter (exception is wet histosols). Use judgment.

d. *Amount of Sample*
-1 gal. mineral soil
-2 gal. mineral soil if 2 to 20 mm fraction is > 45% by volume
-2 gal. organic soils

e. *Size Fraction to Sample* - < 20mm fraction will be bagged - all samples sieved through a 3/4" sieve.

f. *Horizons to Sample*
-Do not sample Oi horizon in mineral soils.
-Can combine thin Oa and Oe horizons in mineral soils.
-Do not combine mineral soil horizons.
-1 horizon per pedon must be sampled as a field duplicate.

g. *Handling Bag Samples*
-Fold plastic sample bag several times at 1" increments and staple across the top.
-Attach Label A (stick-on) to outside of plastic bag.
-Place plastic bag inside cloth bag and tie.

-Outside of cloth bag should have same information as on DSS label A - use indelible marker on lower right quadrant.

2. *Clod Samples*

a. Obtain 3 clods per horizon where possible - approximately fist size if possible.

b. Prepare clods as prescribed in the field sampling manual - Section 7.

c. Label each clod with sample number on masking tape affixed to the top of the hair nest.

d. Place clod in small plastic bags and in quart containers or clod boxes - label containers or boxes with 2" x 2" sticker label.

VI. *Labels*

a. All samples will be labeled with Label A (example below):

Label A

Date Sampled:_ _ _ _ _ _

NY01-XXXXXXX
NY02-YYYYY ------
NY03-ZZZZ

Crew ID:_ _ _ _

Watershed No.------

Site ID:_ _ _ _ _

R - Routine
FD - Field Duplicate--
A - Audit

Sample Code:_ _ _ _ _ _ _ _ _ _ _

Horizon depth (cm)---

Horizon:_ _ _ _

NY01 will use 400-499
NY02 will use 500-599--
NY03 will use 600-690

Set ID:_ _ _ _ _

(Set ID is number for each day sampled;
i.e., 2 sampled pedons in one day would have the same no.)

b. Split horizons samples -
-Compound routine samples label as R12,R22,etc.
-Compound field duplicate samples label as FD1,FD2.
-Single routine samples label as R11.

VII. *Field Notebooks*

a. Daily activities recorded including any problems; reason for going to 2nd,3rd,etc., sampling site; any field notes; unusual things not recorded on 232 form.

b. Location and identification of each sampled pedon. (Notebooks will be submitted to EPA when project is complete).

VIII. *Sample Transport*

a. Samples from the field should be taken immediately to cold storage facility at one of the staging areas (cold storage = 4°C - not below 0°C).

b. Samples will be transported from cold storage at weeks end to Cornell in ice chests packed with 8 frozen gel packets.

Watershed No._ _ _ _ _ _Team Leader Signature____________
Pedon No._ _ _ _ - NY_ _ _ _ - 0_ _
Soil Sampling Class _ _ _
Veg. Sampling Class _ _ _

NY Sampling Phase Checklist

NOTE: Please check all items when complete for each pedon sampled. Each watershed envelop must contain (1) checklist per pedon sampled or the envelope will not be accepted from the field crew. Watershed envelops will be collected in the field after sampling is complete for a given watershed. Use this list to double check 232's and green notebook.

Completed
Items

I. *Site Selection*

____ 1. If point (pt) 1 is unsuitable, mark with yellow flag and locate suitable sampling class along an azimuth chosen from random numbers table (20 ft. intervals up to 500 ft. from yellow flag).

____ 2. After 5 random azimuths, if pt 1 cannot be sampled, go to pt 2, etc.

____ 3. Record sample point numbers and reasons for not sampling in green notebook and below:

pt1 pt2 pt3 pt4 pt5

__ __ __ __ __ suitable

__ __ __ __ __ unsuitable soil or vegetation class

__ __ __ __ __ no landowner permission

__ __ __ __ __ inaccessible

II. *Site Preparation*

____ 1. Ribbon 4 trees (orange flagging) at sampling site finally chosen.

____ 2. If site chosen for pt1, pt2, pt3, pt4, or pt5, circle the point on xerox copy of the watershed.

____ 3. If site chosen is along a random azimuth, mark the site with a star (*) on the xerox copy of the watershed.

____ 4. Excavate soil pit 1 m x 1 m to depth necessary for sampling (up to 60" for very deep soils).

III. *Pre-Sampling Activities*

____ 1. Fill out yellow photo ID card.

____ 2. Photograph clean pit face with yellow ID card attached to upper horizon (in focus and readable) (fill frame with card and pit face).

____ 3. Photograph full profile with metric tape and yellow card (fill frame with profile).

____ 4. Photograph edge of pit and surrounding landscape.

____ 5. Photograph major tree canopy (record cover type in green notebook).

____ 6. Record photo log in green notebook (pedon no., date, exposure no.;s, roll no., and name of photographer).

____ 7. Record latitude and longitude of sampling pt in green notebook and in lat./long. block on 232 form.

IV. *Profile Description*

____ 1. Fill in all blocks except those marked "blank" (see xerox example 232).

____ 2. Make sure profile characteristics are within range for a series chosen (if possible).

____ 3. Take PHYS block information from map unit description sheet.

____ 4. Describers' names block - add crew ID no.'s at end, as shown on xerox example 232.

____ 5. Location Description block - follow format shown on xerox example 232.

____ 6. Horizon Depth block - record in centimeters.

____ 7. Rock Fragment block - record % by volume in following order; 2 mm-2"; 2"-10"; >10".

____ 8. Record site location in green notebook.

V. *Horizon Sampling* Date_____

		H-1	H-2	H-3	H-4	H-5	H-6
1.	Record horizon symbol-->	__	__	__	__	__	__
2.	Sample 3/4" sieved?	__	__	__	__	__	__
3.	Sample double-bagged?	__	__	__	__	__	__
4.	NADSS label on inner plastic bag?	__	__	__	__	__	__

		H-1	H-2	H-3	H-4	H-5	H-6
5.	Is sample routine and not split (R11) (mineral-1 gal, organic-2 gal)?	___	___	___	___	___	___
6.	Is sample split mineral? (upper & lower) (2 gal total)	___	___	___	___	___	___
7.	Is sampling split organic? (upper & lower) (4 gal total)	___	___	___	___	___	___
8.	Is sample field duplicate? (FDO or FD1, FD2 if split)	___	___	___	___	___	___
9.	Does sample contain >45% rock fragments by volume (need 2 gal) (R12 and R22)	___	___	___	___	___	___
10.	Is info. recorded on outer canvas bag? (Use indelible pen.)	___	___	___	___	___	___
11.	Is Set ID No. current? (Update from previous sampling day.)	___	___	___	___	___	___
12.	Is sample in cooler with frozen gel packs?	___	___	___	___	___	___
13.	Number of clods taken -->	___	___	___	___	___	___
14.	Is each clod labeled? (Masking tape at top of hairnet.)	___	___	___	___	___	___
15.	Is clod information on 2" x 2" label (inside of lid of clod box)?	___	___	___	___	___	___
16.	Is clod information on outside of white quart containers (if used in place of clod box)?	___	___	___	___	___	___
17.	** Are sample and pedon number recorded on hand-written cooler-contents list? (Tape list to inside of cooler before shipping to Cornell.)	___	___	___	___	___	___
18.	Has temperature been take in cooler or cold storage compartment today? (Record in green notebook.)	___	___	___	___	___	___

** Please make handwritten list of samples in each cooler and tape to inside lid before shipping to Cornell. Each list should be signed by the crew member loading the coolers. List need only be the Pedon No. plus all horizon numbers in the cooler, i.e.,

R11-NY071 -005-01
" " "-02
R12 " " -03
R22 " " -03
R11 -NY071 -006-02
FD0-NY071 -006-02

Total number of samples = 6 John Doe 8-26-85

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