REPORT OF ASH POND INVESTIGATION

JOHNSONVILLE FOSSIL PLANT
NEWJOHNSONVILLE, TENNESSEE

Prepared For:

TENNESSEE VALLEY AUTHORITY

Chattanooga, Tennessee

Prepared By:

MACTEC ENGINEERING AND CONSULTING, INC.

Knoxville, Tennessee

45

MACTEC PROJECT 3031032136/0001

December 4, 2003

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December 4, 2003

Mr. Ron Purkey
Tennessee Valley Authority
1101 Market Street, LP-2G
Chattanooga, TN 37402

Subject: **Report of Ash Pond Investigation**
Johnsonville Fossil Plant
New Johnsonville, Tennessee
MACTEC Project 3031032136/0001

Dear Mr. Purkey:

MACTEC Engineering and Consulting, Inc., (MACTEC) is pleased to submit this Report of Ash Pond Investigation at the Johnsonville Fossil Plant in New Johnsonville, Tennessee. This report reviews the background information, discusses the site area and subsurface conditions, outlines the elements of our investigation, and presents the results and our conclusions.

We appreciate the opportunity to provide these services to the Tennessee Valley Authority. If you have any questions regarding this report, please contact us at (865) 588-8544.

Sincerely,

MACTEC ENGINEERING AND CONSULTING, INC.

Scott D. Smith
Scott D. Smith, P.G.
Principal Geologist

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1.0 BACKGROUND

The project site is located in New Johnsonville, Tennessee approximately 8 miles southeast of the city of Camden in Humphreys County, Tennessee (see Figure 1).

Based on instructions from the TVA Coal Combustion By-Product Team, we conducted various investigations in Cell 2 of the active ash disposal area. These investigations consisted of:

- Performing nine Geoprobe™ borings in the ash sediments.
- Measuring in-place densities and moisture contents at 20 locations on the ash surface prior to any excavation of the ash.
- Measuring in-place densities and moisture contents at 10 locations on the ash surface after approximately 3 feet of ash had been excavated.
- Measuring densities and moisture contents at the surface of ash which had been loaded into 31 dump trucks.

2.0 GEOPROBE™ INVESTIGATION

We utilized a Geoprobe™ sampling system to obtain ash samples from nine different locations in Cell 2 of the active ash disposal area. The probehole locations were surveyed by TVA and are shown on Figure 2. The holes were generally extended through the ash deposits to refusal or to native soils. In an effort to get as much recovery as possible a combination of sampling methods were utilized. In some cases, we used a Macro-Core Soil Sampler in general accordance Geoprobe's Technical Bulletin No. 95-8500. We also used the DT21 Dual Tube Soil Sampling System in general accordance with Geoprobe's Technical Bulletin No. 982100. Both methods are described in Appendix A. Boring logs for the nine Geoprobe™ borings are included in Appendix B.

Subsequent to retrieval of the ash samples, the acetate liners in which they were retrieved were sealed, and the samples were transported to our laboratory were they were analyzed for Moisture Content and Dry Unit Weight.

Table 1 below contains the results of the laboratory tests.

Table 1
Natural Moisture Content and Unit Weight Laboratory Test Results

Boring Number	Geoprobe™ Sample Length (Feet)	Sample Depth (Feet)	Specific Gravity	Moisture Content (%)	Dry Unit Weight (pcf)
C2-1	3	0 - 3		25.2	78.9
C2-1	3	3 - 6		59.6	55.1
C2-1	3	6 - 9		51.7	84.4
C2-1	3	15 - 18		56.1	63.4
C2-1	3	18 - 21		42.4	71.4
C2-1	3	21 - 24		39.8	75.0
C2-1	3	24 - 27		38.9	76.4
C2-1	3	27 - 30		44.5	72.5
C2-1	3	30 - 33		41.8	74.9
C2-6	4	0 - 4		30.6	80.0
C2-6	4	4 - 8		46.4	69.0
C2-6	4	8 - 12		53.3	63.5
C2-6	4	12 - 16		38.4	75.6
C2-6	4	16 - 20		35.1	89.2
C2-6	4	24 - 28		35.8	78.7
C2-6	4	28 - 32		48.5	70.3
C2-9	4	0 - 4		32.1	73.7
C2-9	4	4 - 8		43.6	72.8
C2-9	4	8 - 12		42.3	71.3
C2-9	4	24 - 28		34.1	84.5
C2-9	4	28 - 30		40.9	---
C2-10	3	0 - 3		27.2	72.2
C2-10	3	3 - 6		45.0	69.5
C2-10	3	6 - 9		50.9	67.1
C2-10	3	9 - 12		50.4	66.6
C2-10	3	12 - 15	2.38	42.5	73.7
C2-10	3	15 - 18		44.7	72.0
C2-10	3	18 - 21		44.0	70.7
C2-10	3	21 - 24		39.6	75.2
C2-16	4	4 - 8	2.32	45.3	69.6
C2-16	4	8 - 12		51.3	59.3
C2-16	4	12 - 16		52.6	65.7
C2-16	4	24 - 28		35.5	75.8
C2-16	4	28 - 32		38.0	77.6
C2-16	4	32 - 36		45.4	78.5
C2-17	3	0 - 3	2.40	30.4	78.1
C2-17	3	3 - 6		41.2	71.2
C2-17	3	6 - 9		38.3	76.9

Table 1
Natural Moisture Content and Unit Weight Laboratory Test Results

Boring Number	Geoprobe™ Sample Length (Feet)	Sample Depth (Feet)	Specific Gravity	Moisture Content (%)	Dry Unit Weight (pcf)
C2-17	3	9 - 12		38.8	75.1
C2-17	3	12 - 15		49.4	67.7
C2-17	3	15 - 18	2.38	44.4	71.8
C2-17	3	18 - 21		40.1	76.6
C2-17	3	21 - 24		40.9	74.1
C2-18	4	0 - 4		30.2	67.6
C2-18	4	4 - 8		49.4	63.5
C2-18	4	8 - 12		47.5	66.7
C2-18	4	17.5 - 20		41.4	73.9
C2-18	4	29 - 30		37.8	81.9
C2-19	4	0 - 4		35.4	71.3
C2-19	4	4 - 8		42.2	65.9
C2-19	4	8 - 12		39.2	73.2
C2-19	4	12 - 16		41.5	73.1
C2-19	4	28 - 32		35.1	85.1
C2-20	4	0 - 4		35.9	63.9
C2-20	4	4 - 8		45.8	64.4
C2-20	4	8 - 12		47.7	71.2
C2-20	4	12 - 16		39.7	77.2
C2-20	4	24 - 28		33.2	62.7
C2-20	4	28 - 32		38.3	---

Prepared By ADA Date 12/4/03 Checked By SDS Date 12/4/03

The boring logs in Appendix B also show the moisture contents and dry unit weights at the depth from which the ash samples were obtained. The variations in moisture content and density reveal some stratification in the ash sediments. There is no consistent pattern of variability with depth. However, during the Geoprobe™ sampling, the ash typically became much wetter and softer at a depth of about 12 to 15 feet. Therefore, sample quality and recovery were more difficult to obtain in the deeper portions of the borings. Although quite variable, the average moisture content was about 42 percent and the average dry density was about 72 pounds per cubic foot (pcf) for the samples of ash that were recovered. Considering the fact that the wetter and softer ash could not be consistently sampled, the "average" moisture content of the recovered samples is assuredly lower than the actual average moisture content of the entire ash deposit. Likewise, the "average" dry density of the recovered samples is assuredly higher than the actual average dry density of the entire ash deposit. Therefore, an average moisture content greater than 42 percent and an average dry density less than 72 pcf should be used in any calculations or estimates.

3.0 DENSITY AND MOISTURE CONTENT MEASUREMENTS AT THE ASH SURFACE IN CELL 2

Twenty density and moisture content measurements were made at the surface of the ash in Cell 2. The measurements were made at the locations shown on Figure 2. The measurements were made with a nuclear density gage using the back scatter position which would provide a representation of the density and moisture of the ash several inches beneath the surface. The measurements were made upon a surface that had previously experienced some construction equipment traffic and had been "back bladed" by a dozer. The surface elevation was reasonable level and varied from 388.67 to 390.32 and averaged 389.76. The measured dry densities varied considerably from 81.7 to 109.1 pounds per cubic foot (pcf) and averaged 99.8 pcf. The moisture contents varied from 11.3 to 20.4 per cent and averaged 15.0 percent.

Subsequently, approximately 3 feet of ash was excavated and 10 density and moisture content measurements were made on that surface which was roughly at elevation 386.5±. These ten tests indicated an average dry density of 87.6 pcf which is a reduction of about 12.2 pcf from the overlying ash deposits and an average increase in moisture content of about 5.8 per cent to 20.8 per cent. These tests reveal a trend that would be generally expected with a decrease in density and an increase in moisture with depth.

Table 2 shows the test results.

Table 2
Test Results

Measurement at the Surface of Cell 2 Before Excavation and After Some Back Blading and Construction Traffic			Measurement After 3 Feet± of Excavation	
Survey Point	**Dry Density (pcf)**	**Moisture Content (%)**	**Dry Density (pcf)**	**Moisture Content (%)**
1	98.0	14.9		
2	105.6	13.7		
3	104.3	15.3		
4	105.2	16.0	86.6	16.5
5	109.1	12.4	81.1	24.5
6	101.7	14.7	100.5	14.7
7	99.9	15.4		
8	101.0	17.8	72.8	30.6
9	94.6	20.4	95.3	18.2
10	87.3	16.0		
11	100.8	13.6		
12	106.2	14.3		

Table 2
Test Results

Measurement at the Surface of Cell 2 Before Excavation and After Some Back Blading and Construction Traffic			**Measurement After 3 Feet± of Excavation**	
Survey Point	**Dry Density (pcf)**	**Moisture Content (%)**	**Dry Density (pcf)**	**Moisture Content (%)**
13	100.4	13.9		
14	102.2	12.4		
15	94.4	11.3	94.3	15.8
16	81.7	16.0	82.7	18.9
17	105.2	14.1		
18	95.5	16.8	92.9	18.6
19	100.2	16.7	83.4	26.7
20	101.7	14.4	86.3	23.9
Average	99.8	15.0	87.6	20.8

Prepared By ADA Date 12/4/03 Checked By SDS Date 12/4/03

4.0 DENSITY AND MOISTURE CONTENT MEASUREMENTS AT THE ASH SURFACE IN LOADED TRUCKS

Thirty-one density and moisture content measurements were made at the surface of the ash that had been loaded into 31 different trucks. This ash was being hauled from Cell 2 excavation. The measurements were made with a nuclear density gage using the back scatter position which would provide a representation of the density and moisture of the ash several inches beneath the surface. The measured dry densities varied from 65.3 to 80.0 pcf and averaged about 70.5 pcf. The variation in density most likely reflects the amount of tamping, if any, of the ash surface by the excavator bucket after loading. Therefore, the measured surface densities are probably higher than the overall average density for all the ash being hauled in a particular truck load.

The measured moisture contents varied from 11.9 to 27.0 per cent and averaged about 16.9 per cent. These measurements indicate a reduction in average moisture content of about 1.7 per cent from those measured at the three feet deep excavation level in Cell 2. This reduction would be consistent with the likelihood of some drying taking place during excavation and loading of the trucks. Table 3 shows the results of the density and moisture content measurements.

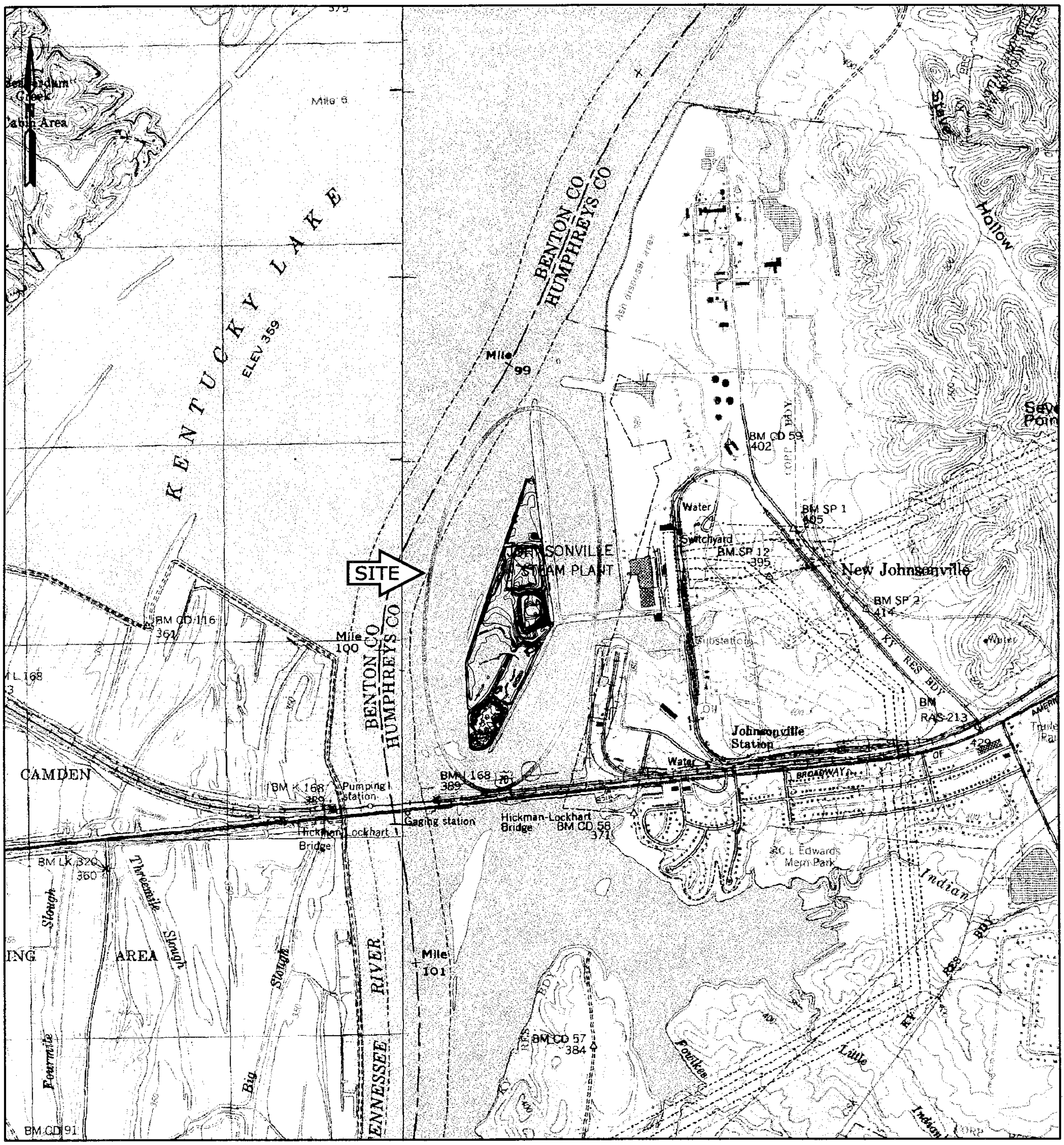
Table 3
Measurements at Surface of Ash in Loaded Trucks

	Dry Density (pcf)	Moisture Content (%)
	70.7	15.6
	69.9	18.0
	69.9	16.6
	72.6	16.1
	70.5	13.3
	70.3	14.6
	66.7	18.1
	72.1	16.5
	71.5	16.8
	71.0	15.4
	73.4	15.6
	77.9	12.8
	70.9	18.8
	80.0	12.6
	67.0	19.7
	70.0	16.6
	71.8	15.0
	70.8	16.1
	68.7	21.9
	72.5	13.9
	70.6	16.6
	65.7	21.2
	67.9	21.4
	70.4	17.0
	74.2	11.9
	65.4	20.9
	65.3	18.2
	68.5	18.2
	71.3	14.7
	69.8	27.0
	68.1	12.3
Average	70.5	16.9

Prepared By ________ Date 12/4/03

Checked By SDS Date 12/4/03

FIGURES



SOURCE: USGS TOPOGRAPHIC MAPS OF CAMDEN AND JOHNSONVILLE, TN QUADRANGLES

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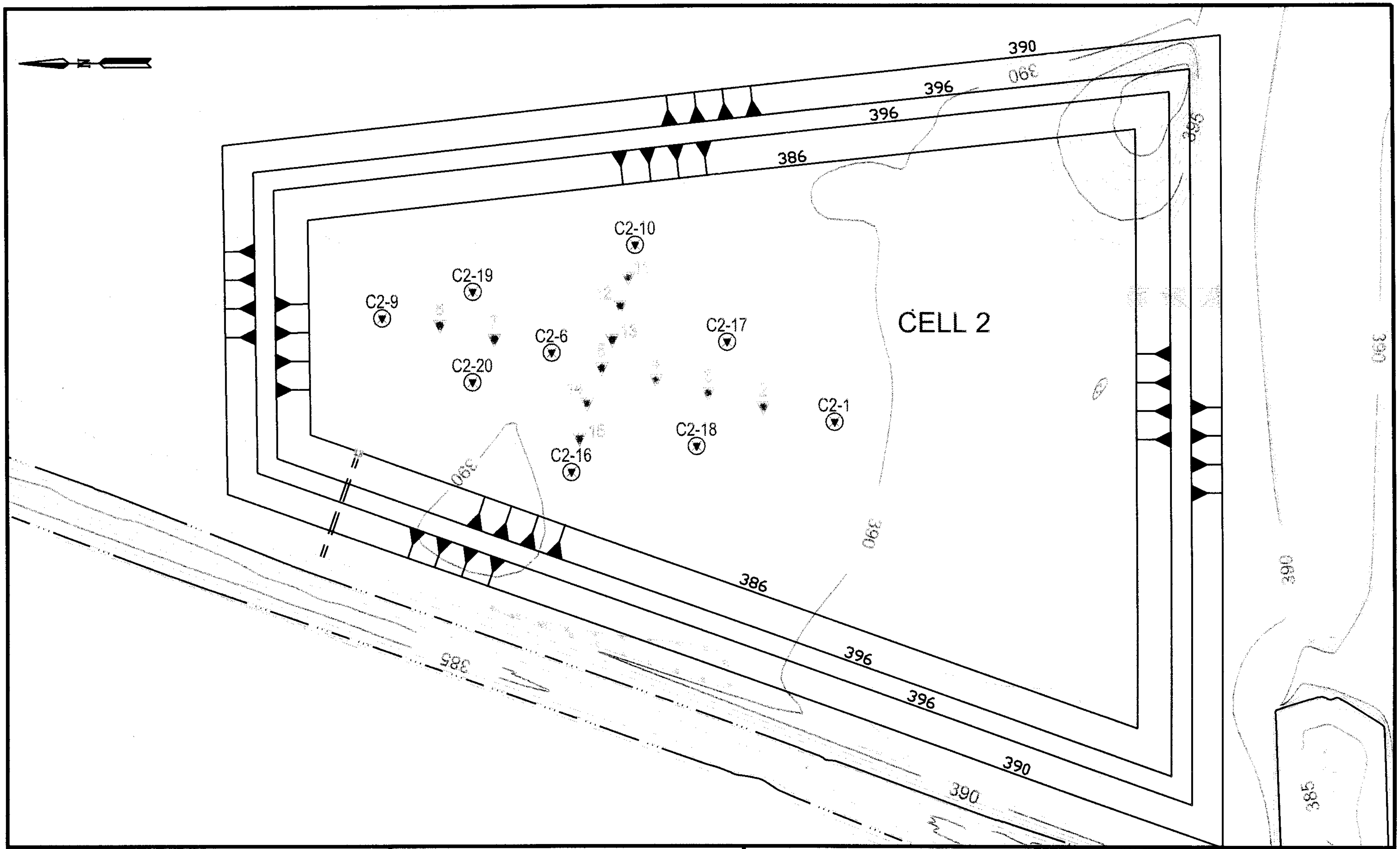
FIGURE 1: SITE LOCATION MAP
TVA - JOHNSONVILLE FOSSIL PLANT
NEW JOHNSONVILLE, TENNESSEE

DRAFTING BY: RSS	PREPARED BY: ADA	CHECKED BY: SDS
JOB NUMBER: 3031032136/0001	DATE: NOVEMBER 19, 2003	SCALE: 0 2500'

COORDINATES: N 36°01'37" W 87°59'36"

3031032136_01_FIG1.dwg Wed, 19 Nov 2003 - 11:55am reverdin



LEGEND

DENSITY TEST LOCATION
AND IDENTIFICATION

C2-1 DENSITY TEST LOCATION
AND GEOPROBE BORING
LOCATION AND IDENTIFICATION

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FIGURE 2: DENSITY TEST AND GEOPROBE LOCATION PLAN
TVA - JOHNSONVILLE FOSSIL PLANT
NEW JOHNSONVILLE, TENNESSEE

DRAFTING BY:
PREPARED BY:
CHECKED BY: SDS
JOB NUMBER: 3031032136/0001
DATE: NOVEMBER 19, 2003
SCALE: 0 80'

COORDINATES: N 36°01'37" W 87°59'36"

3031032136_01_FIG2_GLP.dwg Wed, 19 Nov 2003 - 10:15am reverenc

APPENDIX A

GEOPROBE™ TECHNICAL BULLETINS

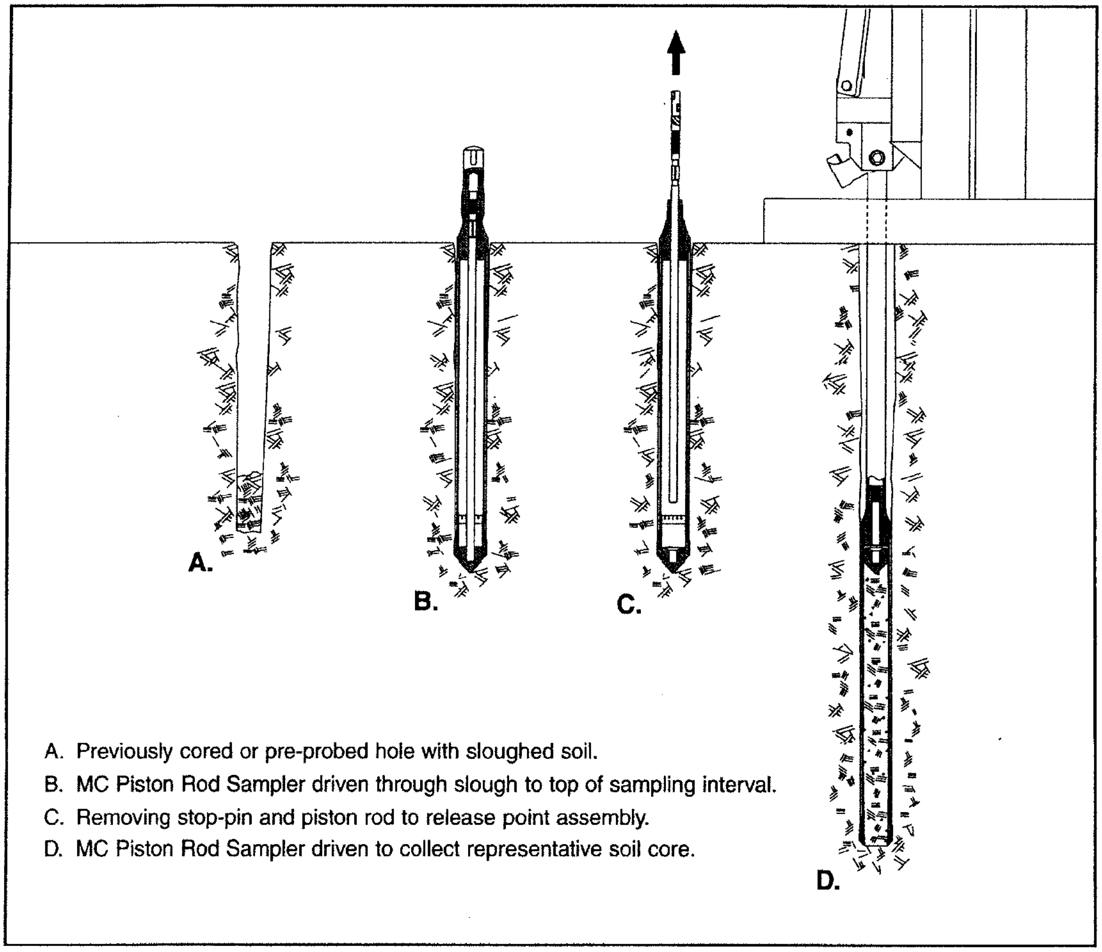
GEOPROBE MACRO-CORE® SOIL SAMPLER

STANDARD OPERATING PROCEDURE

Technical Bulletin No. 95-8500

PREPARED: November, 1995

REVISED: September, 1998



A. Previously cored or pre-probed hole with sloughed soil.
B. MC Piston Rod Sampler driven through slough to top of sampling interval.
C. Removing stop-pin and piston rod to release point assembly.
D. MC Piston Rod Sampler driven to collect representative soil core.

OPERATION OF MACRO-CORE® PISTON ROD SOIL SAMPLING SYSTEM

1.0 OBJECTIVE

The objective of this procedure is to collect a representative soil sample at depth and recover it for visual inspection and/or chemical analysis.

2.0 BACKGROUND

2.1 Definitions

Geoprobe®*: A brand name of high quality, hydraulically-powered machines that utilize both static force and percussion to advance sampling and logging tools into the subsurface.
** Geoprobe® is a registered trademark of Kejr, Inc., Salina, Kansas*

Macro-Core® Soil Sampler*: A solid barrel, direct push device for collecting continuous core samples of unconsolidated materials at depth. Although other lengths are available, the standard Macro-Core® Sampler has an assembled length of approximately 52 inches (1321 mm) with an outside diameter (OD) of 2.2 inches (56 mm). Collected samples measure up to 1300 ml in volume in the form of a 1.5-inch x 45-inch (38 mm x 1143 mm) core contained inside a removable liner. The Macro-Core® Sampler may be used in an open-tube or closed-point configuration.
** Macro-Core® is a registered trademark of Kejr, Inc., Salina, Kansas*

Liner: A removable/replaceable, thin-walled tube inserted inside the Macro-Core® sample tube for the purpose of containing and storing soil samples. While other lengths are available, the standard Macro-Core® Liner is 1.75 inches OD x 46 inches long (44 mm x 1168 mm). Liner materials include stainless steel, Teflon®, PVC, and PETG.

2.2 Discussion

In this procedure, an assembled Macro-Core® Soil Sampler is driven one sampling interval into the subsurface and then retrieved using a Geoprobe soil probing machine. The collected soil core is removed from the sampler along with the used liner. After decon, the Macro-Core® sampler is reassembled using a new liner. The clean sampler is then advanced back down the same hole to collect the next soil core. The Macro-Core® Sampler may be used as an open-tube or closed-point sampler.

The Macro-Core® Soil Sampler is most commonly used as an open-tube sampler (Fig. 2.1A). In this configuration, coring starts at the ground surface with a sampler that is open at the leading end. The sampler is driven into the subsurface and then pulled from the ground to retrieve the first soil core. In stable soils, an open-tube sampler is advanced back down the same hole to collect the next core.

In unstable soils which tend to collapse into the core hole, the Macro-Core® Sampler can be equipped with a piston rod point assembly (Fig. 2.1B). The point fits firmly into the cutting shoe and is held in place by a piston rod and stop-pin. The MC Piston Rod System prevents collapsed soil from entering the sampler as it is advanced to the bottom of an existing hole, thus ensuring collection of a reprentative sample.

The Macro-Core® Piston Rod Sampler is not designed to be driven through undisturbed soil. A probe hole must be opened above the sampling interval either by removing continuous soil cores with an open-tube sampler, or by advancing a Macro-Core® Pre-Probe to depth.

Once a hole is opened to the appropriate depth, an assembled MC Piston Rod Sampler is advanced through any slough material to the top of the next sampling interval. Extension rods are inserted through the probe rod string and threaded onto the MC Stop-Pin Assembly. When unthreaded, the stop-pin is removed from the tool string with the extension rods. (MC Piston rod is removed with stop-pin if MC Stop-Pin Coupler is utilized). With the point assembly now released, the tool string is driven into the subsurface to fill the sampler with soil. The point assembly is later retrieved from the sampler with the liner and soil core.

Loose soils may fall from the bottom of the sampler as it is retrieved from depth. The MC Core Catcher (Fig. 3.1) alleviates this problem. Excellent results are obtained when the core catcher is used with saturated sands and other non-cohesive soils. A core catcher should not be used with tight soils as it may actually inhibit sample recovery. Constructed of PVC, the core catcher is suitable for use with all Geoprobe liners.

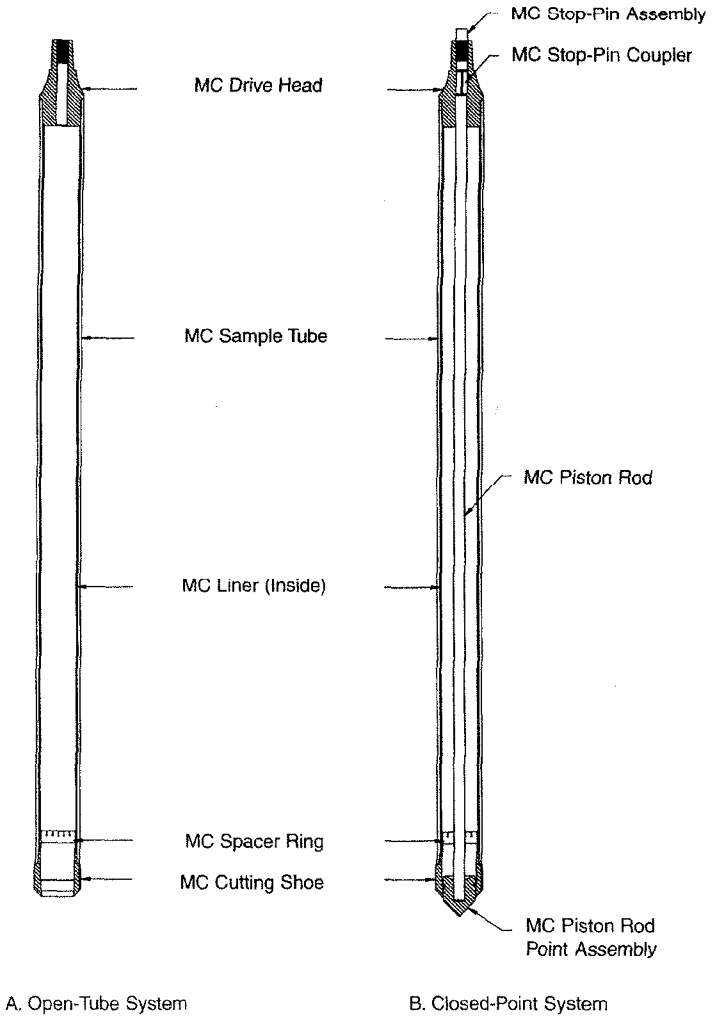


FIGURE 2.1
Macro-Core® Soil Sampler Configurations

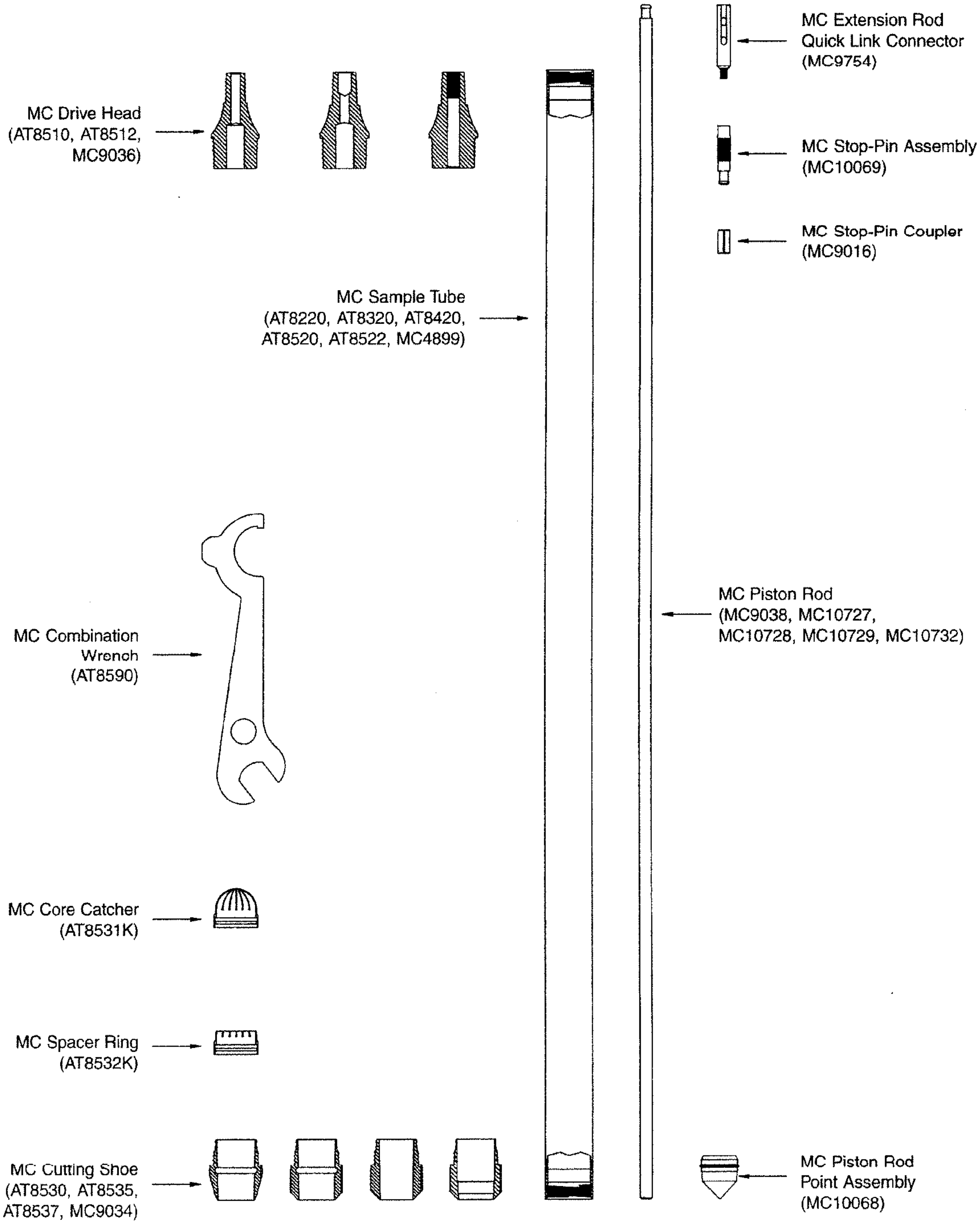


FIGURE 3.1
Macro-Core® Soil Sampler Parts

3.0 REQUIRED EQUIPMENT

The following equipment is used to recover samples using the Geoprobe Macro-Core® Soil Sampler and probing system. Although many options are available (sampler length, liner material, etc.), the basic sampler configuration does not change. Refer to Figure 3.1 (previous page) to view the major components of the Macro-Core® sampler.

MACRO-CORE® SAMPLER PARTS	**PART NUMBER**
MC Drive Head, for use with 1.0-inch probe rods	AT8510
MC Drive Head, for use with 1.25-inch probe rods	AT8512
MC Sample Tube, 24-inch, unplated	AT8220
MC Sample Tube, 36-inch, unplated	AT8320
MC Sample Tube, 1-meter, unplated	AT8420
MC Sample Tube, 48-inch, Ni-plated	AT8520
MC Sample Tube, 48-inch, unplated	AT8522
MC Sampler Tube, 60-inch, unplated	MC4889
MC Cutting Shoe, standard	AT8530
MC Cutting Shoe, heavy-duty	AT8535
MC Cutting Shoe, 0.125 inches undersized	AT8537
MC Combination Wrench	AT8590
Nylon Brush for MC Sample Tubes	BU700

MACRO-CORE® PISTON ROD SYSTEM PARTS	**PART NUMBER**
O-Rings for MC Stop-Pin (pkg. of 25)	AT6312R
O-Rings for MC Piston Rod Point (pkg. of 25)	DT4070R
MC Stop-Pin Coupler (pkg. of 5)	MC9016
MC Cutting Shoe, for use with piston rod point	MC9034
MC Drive Head, for use with 1.25-inch probe rods and stop-pin	MC9036
MC Piston Rod, 48-inch	MC9038
MC Extension Rod Quick Link Connector	MC9754
MC Piston Rod Point Assembly	MC10068
MC Stop-Pin Assembly	MC10069
MC Piston Rod/Stop-Pin Assembly, 48-inch	MC10070
MC Piston Rod, 60-inch	MC10727
MC Piston Rod, 36-inch	MC10728
MC Piston Rod, 24-inch	MC10729
MC Piston Rod, 1-meter	MC10732
MC Piston Rod/Stop-Pin Assembly, 60-inch	MC11881
MC Piston Rod/Stop-Pin Assembly, 36-inch	MC12028
MC Piston Rod/Stop-Pin Assembly, 24-inch	MC12029
MC Piston Rod/Stop-Pin Assembly, 1-meter	MC12030
MC Quick Link Kit	MC12131

MACRO-CORE® LINERS AND ACCESSORIES	PART NUMBER
MC Stainless Steel Liner Assembly, 48-inch	AT7235
MC Teflon® Liner Assembly, 48-inch	AT724
MC PETG Liner, thin-wall, 48-inch, (box of 66)	AT725K
MC Vinyl End Caps (66 pair)	AT726K
MC Heavy-Duty PETG Liner Assembly, 48-inch (box of 66)	AT825K
MC PVC Liner Assembly, clear, 24-inch (box of 66)	AT922K
MC PVC Liner Assembly, clear, 36-inch (box of 66)	AT923K
MC PVC Liner Assembly, clear, 1-meter (box of 66)	AT924K
MC PVC Liner Assembly, clear, 48-inch (box of 66)	AT925K
MC Liner Cutter Kit	AT8000K
MC Liner Cutting Tool*	AT8010
MC Liner Cutter Holder*	AT8020
MC Liner Cutter Blades (pkg. of 5)*	AT8030
MC Liner Circular Cutting Tool	AT8050
MC Core Catchers (pkg. of 25)	AT8531K
MC Spacer Rings (pkg. of 25)	AT8532K
MC PVC Liner Assembly, clear, 60-inch (box of 66)	11984

GEOPROBE TOOLS**	PART NUMBER
Drive Cap, for use with 1.25-inch probe rods	AT1200
Slotted Drive Cap, for use with 1.25-inch probe rods	AT1202
Pull Cap, for use with 1.25-inch probe rods	AT1204
Probe Rod, 1.25 inches x 36 inches	AT1236
Probe Rod, 1.25 inches x 1 meter	AT1239
Probe Rod, 1.25 inches x 48 inches	AT1248
Probe Rod, 1.25 inches x 60 inches	AT1260
MC Pre-Probe, 2-inch OD	AT1247
MC Pre-Probe, 2.5-inch OD	AT1242
MC Pre-Probe, 3-inch OD	AT1252
Extension Rod, 36-inch	AT67
Extension Rod, 48-inch	AT671
Extension Rod, 1-meter	AT675
Extension Rod Coupler	AT68
Extension Rod Handle	AT69
Extension Rod Quick Links	AT694K
Machine Vise	FA300

ADDITIONAL TOOLS

Combination Wrench, 1/2-inch (or) Adjustable Wrench
Pipe Wrenches (2)

---

*The items are included in the MC Liner Cutter Kit (AT8000K).

**Geoprobe tools and accessories are also available for use with 1.0-inch OD (outside diameter) probe rods.

4.0 OPERATION

Size and material options have resulted in an extensive list of Macro-Core® part numbers. To simplify the instructions presented in this document, part numbers are listed in the illustrations only. Refer to Pages 6 and 7 for a complete parts listing.

4.1 Decontamination

Before and after each use, thoroughly clean all parts of the soil sampling system according to project requirements. A new, clean liner is recommended for each sample if using PETG, PVC, or Teflon® liners.

Stainless Steel Liners from Geoprobe Systems are cleaned at the factory with an agitated detergent bath at a temperature of approximately 180 degrees F. After rinsing with 180-degree tap water, the liner is air dried, wrapped in PVC outer cladding, and capped with vinyl end caps.

Thoroughly clean the sampler before assembly, not only to remove contaminants but also to ensure correct operation. Dirty threads complicate assembly and may lead to sampler failure. Sand is particularly troublesome as it can bind liners in the sample tube resulting in wasted time and lost samples.

4.2 Field Blank

It is suggested that a field blank be taken on a representative sample liner prior to starting a project and at regular intervals during extended projects. Liners can become contaminated in storage. A field blank will prove that the liners do not carry contaminates which can be transferred to soil samples. The following information is offered as an example method which may be used to take a field blank. Make the appropriate modifications for the specific analytes of interest to the investigation.

Example Procedure:

REQUIRED EQUIPMENT

MC Liner	(1)
MC Vinyl End Caps	(2)
Distilled Water	*(100 ml)*
VOA Vial (or other appropriate sample container)	(1)

1. Place a vinyl end cap on one end of the liner.

2. Pour 100 milliliters of distilled water (or other suitable extracting fluid) into the liner.

3. Place a vinyl end cap on the open end of the liner.

4. From the vertical position, repeatedly invert the liner so that the distilled water contacts the entire inner surface. Repeat this step for one minute.

5. Remove one end cap from the liner, empty contents into an appropriate sample container, and cap the container.

6. Perform analysis on the extract water for the analytes of interest to the investigation.

4.3 Open-Tube Sampler Assembly

1a. **(With MC Core Catcher)** Place the open end of an MC Core Catcher over the threaded end of an MC Cutting Shoe as shown in Figure 4.1. Apply pressure to the core catcher until it snaps into the machined groove on the cutting shoe.

NOTE: AT725K (thin-wall PETG) liners have a swedged end which is generally slipped directly over the groove in the cutting shoe (Fig. 4.2). To use a core catcher with these liners, cut approximately 0.25 inches (6 mm) of material from the swedged end of the liner and proceed to Step 2.

1b. **(Without MC Core Catcher)** Push the base of an MC Spacer Ring onto the threaded end of a cutting shoe until it snaps into place (Fig. 4.3).

NOTE: With the exception of AT-725K (thin-wall PETG) liners, all liners must utilize either a spacer ring or core catcher. PETG liners have a swedged end which slides directly over the end of the cutting shoe. Attach the liner to the cutting shoe (Fig. 4.2) before proceeding to Step 2.

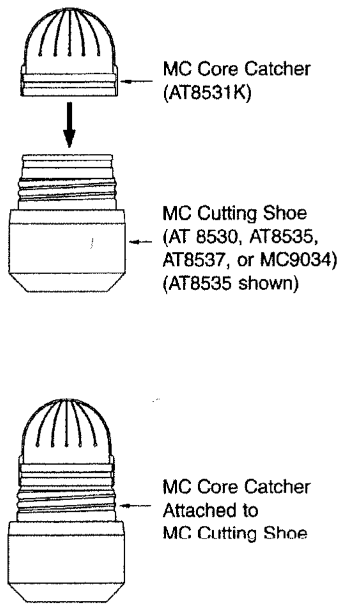


FIGURE 4.1
Core Catcher Attachment

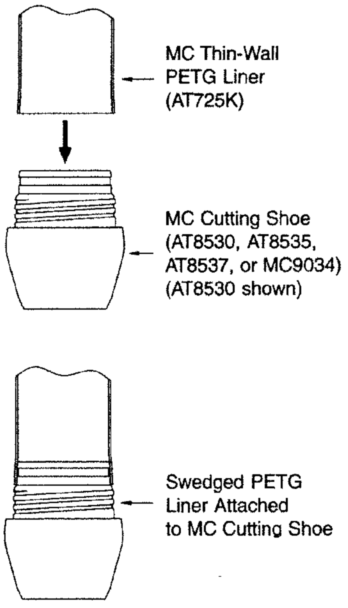


FIGURE 4.2
Thin-Wall Liner Attachment

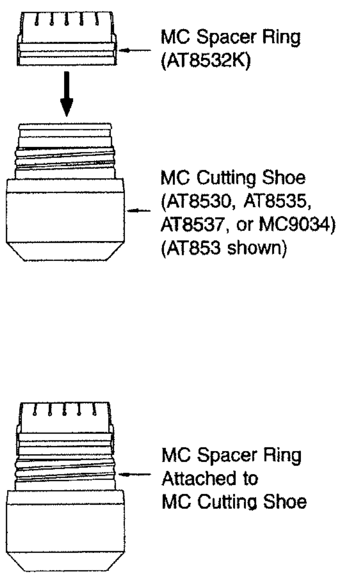


FIGURE 4.3
Spacer Ring Attachment

Refer to Figure 4.4 for identification of sampler parts and assembly sequence

2. Thread the cutting shoe into one end of an MC Sample Tube (Fig. 4.5). Tighten shoe with MC Combination Wrench (Fig. 4.6) until end of sample tube contacts machined shoulder of cutting shoe.

3. Insert a liner into the opposite end of the sample tube (Figure 4.7). The liner is all ready installed if using thin-wall PETG liners (AT725K) without an MC Core Catcher.

4. Thread an MC Drive Head into the top of the sample tube (Fig. 4.8) and securely tighten with the MC Combination Wrench (Fig. 4.9). Ensure that the end of the sample tube contacts the machined shoulder of the drive head.

Sampler Assembly is Complete.

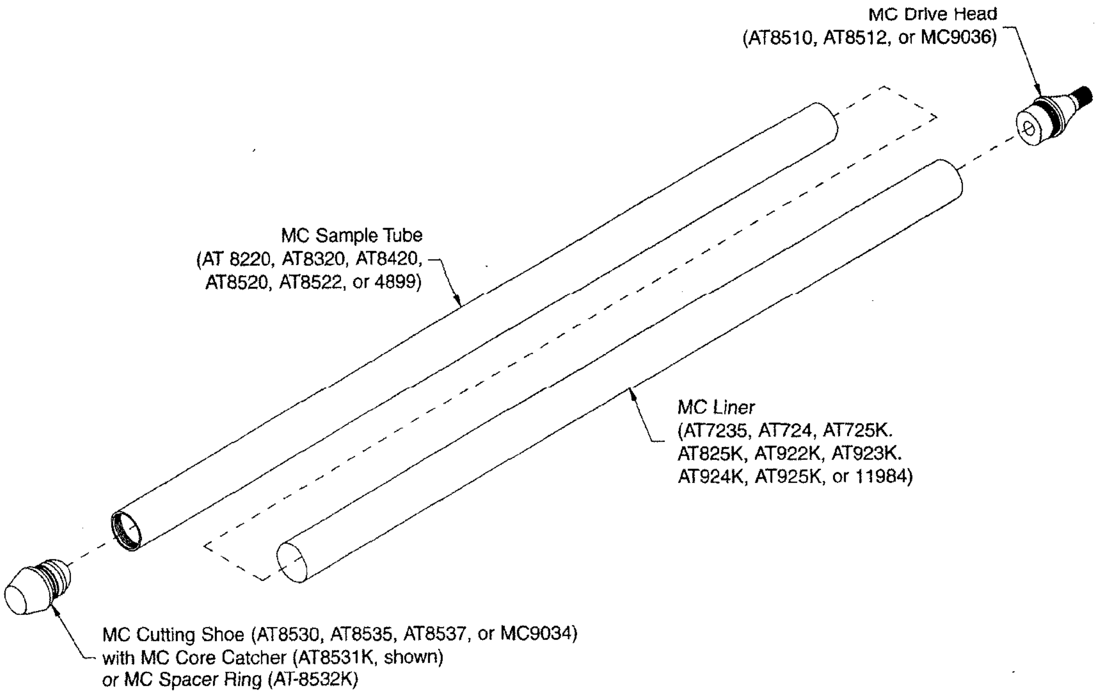


FIGURE 4.4
Macro-Core® Open-Tube Sampler Assembly

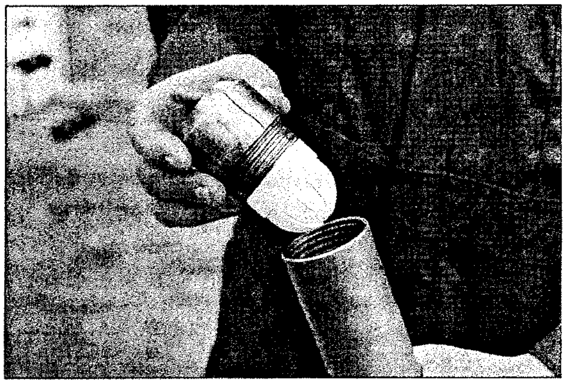


Figure 4.5. Thread an MC Cutting Shoe (shown with MC Core Catcher) into either end of a MC Sample Tube.

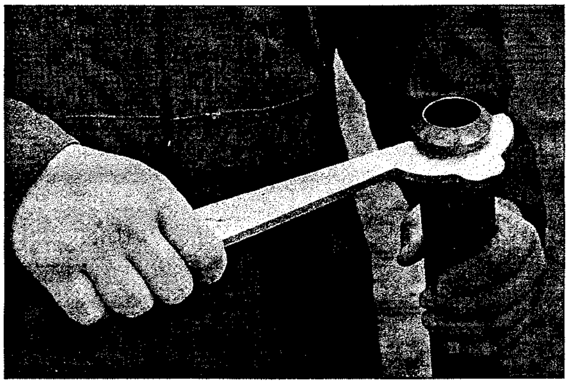


Figure 4.6. Tighten MC Cutting Shoe with MC Combination Wrench.

Figure 4.7. Insert liner into opposite end of MC Sample Tube.

Figure 4.8. Thread MC Drive Head into top of MC Sample Tube.

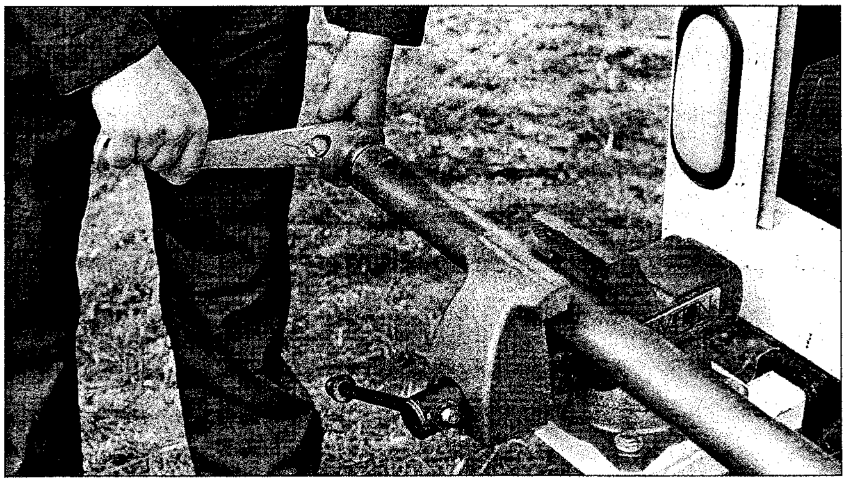


Figure 4.9. Tighten MC Drive Head with MC Combination Wrench. A vise is often used to hold the MC Sample Tube during this step.

4.4 Stop-Pin Coupler

The Stop-Pin Coupler attaches the Stop-Pin to the Piston Rod (Fig. 4.10). When connected together, these three parts form the Stop-Pin/Piston Rod Assembly. All three items may be ordered either individually or together as one complete assembly. Refer to Section 3.0 for specific assembly and item part numbers.

It is not always necessary to use the stop-pin coupler with the MC Piston Rod System. The coupler allows the piston rod to be removed from the sampler along with the stop-pin so that sample recovery is not hindered by the weight of the piston rod. If you find that recovery is not a problem with the formation you are sampling (such as clays), do not use the stop-pin coupler.

If sampling in formations where sample recovery may be a problem (such as loose sands), the stop-pin coupler is highly recommended. Removing the piston rod with the stop-pin significantly reduces the amount of tooling weight that the soil core must support as the sampler is driven. Sample compression is also reduced when the stop-pin coupler is utilized.

Instructions for connecting the stop-pin coupler to the stop-pin and piston rod are given below.

1. Hold a piston rod in vertical position with leading end resting on a solid surface.
2. Place a Stop-Pin Coupler on top of the Piston Rod and tap with a hammer to seat (Fig. 4.11).
3. Snap a Stop-Pin into the coupler using a hammer or 12-inch probe rod and drive cap (Fig. 4.12).

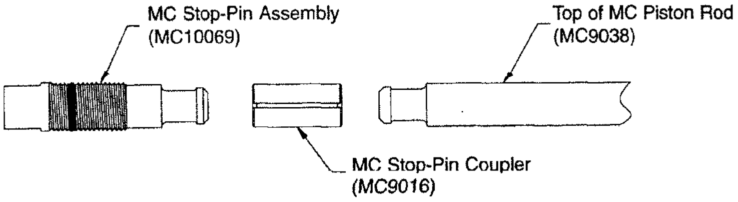


FIGURE 4.10
MC Stop-Pin Coupler Attaches MC Stop-Pin to MC Piston Rod

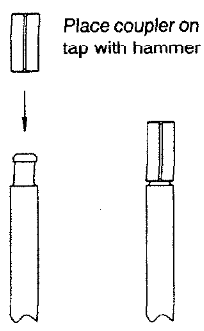


FIGURE 4.11
Tap Stop-Pin Coupler onto Piston Rod

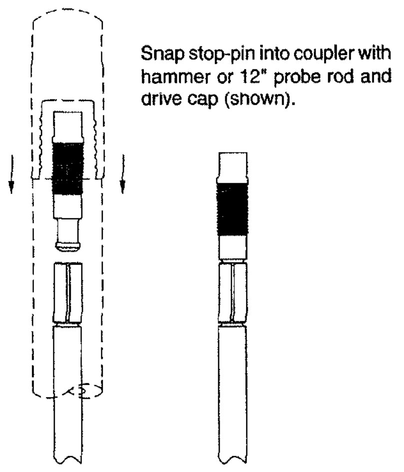


FIGURE 4.12
Tap Stop-Pin into Coupler with Probe Rod

4.5 MC Piston Rod Sampler (closed-point system) Assembly

The MC Piston Rod System seals the leading end of the sampler with a point assembly that is held in place with a piston rod and stop-pin. Once advanced to the top of the sampling interval, the stop-pin is removed with extension rods that are inserted down through the probe rod string. The piston rod will be extracted along with the stop-pin if a stop-pin coupler was used. Refer to Section 4.4 for help in determining when a stop-pin coupler is needed.

NOTE: The MC Piston Rod System requires an MC9036 MC Drive Head and an MC9034 MC Cutting Shoe. No other Macro-Core® drive heads or cutting shoes are compatible with this system. The larger 1.25-inch OD Probe Rods are also required to operate MC Piston Rod System.

1. Install an O-ring in the machined groove on the piston rod point (Fig. 4.13). Lubricate the O-ring with a small amount of deionized water.

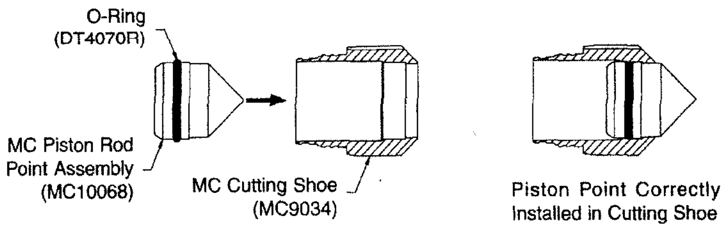


FIGURE 4.13
Installation of MC Piston Rod Point Assembly in MC Cutting Shoe

2. Push the piston rod point completely into the cutting shoe as shown in Figure 4.13.

3a. **(With MC Core Catcher)** Place the open end of a core catcher over the threaded end of the cutting shoe as shown in Figure 4.14. Apply pressure to the core catcher until it snaps into the machined groove on the cutting shoe.

NOTE: AT725K (thin-wall PETG) liners have a swedged end that is slipped directly over the groove in the cutting shoe (Fig. 4.15). To use a core catcher with these liners, simply cut approximately 0.25 inches (6 mm) of material from the swedged end of the liner and continue to Step 4.

3b. **(Without Core Catcher)** Push the base of an MC Spacer Ring onto the threaded end of the cutting shoe until it snaps into place (Fig. 4.16).

NOTE: With the exception of AT725K (thin-wall PETG) liners, all liners must utilize either a spacer ring or core catcher. Thin-wall liners have a swedged end which slides directly over the end of the cutting shoe. If using thin-wall liners, attach the liner to the cutting shoe (Fig. 4.15) before proceeding.

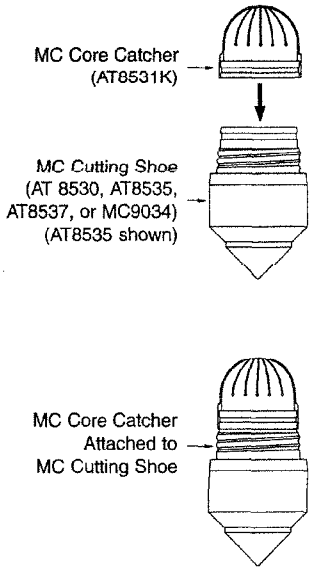


FIGURE 4.14
Core Catcher Attachment With Point Assembly

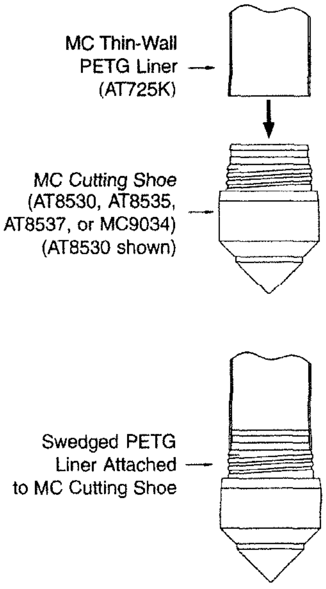


FIGURE 4.15
Thin-Wall Liner Attachment With Point Assembly

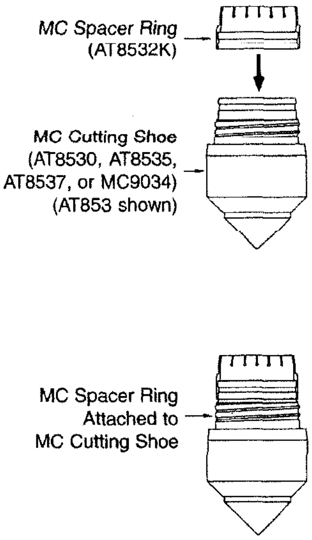


FIGURE 4.16
Spacer Ring Attachment With Point Assembly

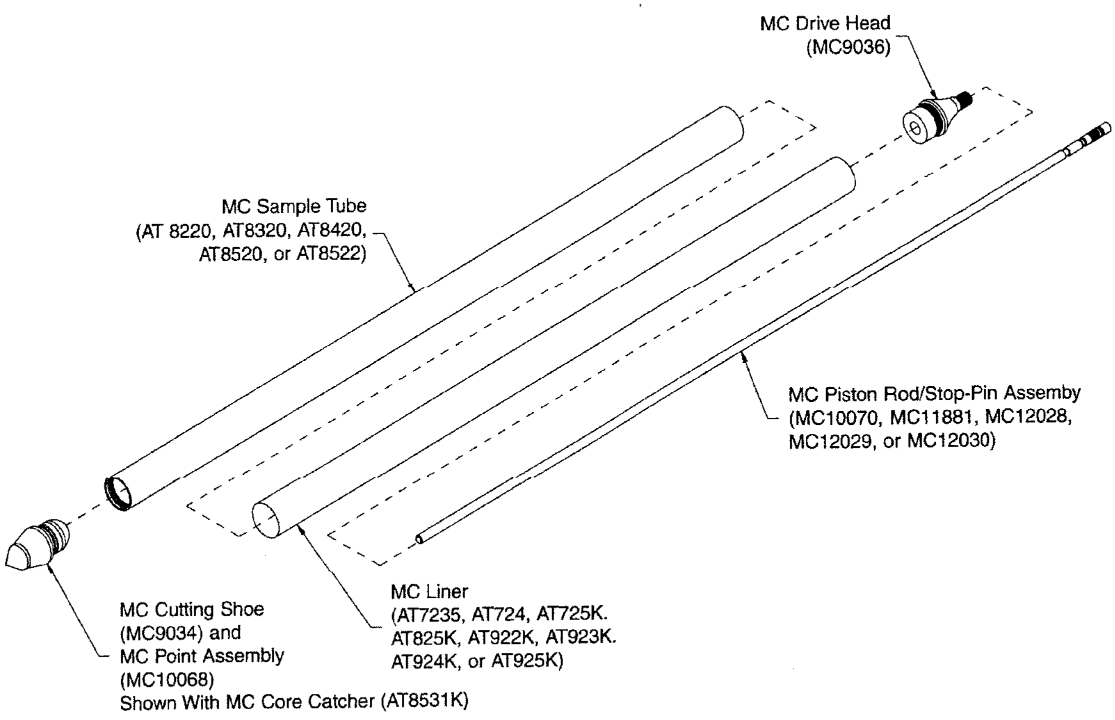


FIGURE 4.17
Macro-Core® Closed-Point Sampler Assembly

Refer to Figure 4.17 for identification of sampler parts and assembly sequence

4. Thread the cutting shoe (with point) into one end of an MC Sample Tube. Tighten until the end of the sample tube contacts the machined shoulder of the cutting shoe.

5. Insert an appropriate MC Liner into the sample tube (Fig. 4.18). The liner is all ready installed if using thin-wall PETG liners without a core catcher.

6. Thread an MC Drive Head into the top of the sample tube (Fig. 4.19) and securely tighten with the combination wrench (Fig. 4.20) until the end of the sample tube contacts the machined shoulder of the drive head.

(continued on Page 16)

Figure 4.18. Insert liner into opposite end of MC Sample Tube.

Figure 4.19. Thread MC Drive Head into top of MC Sample Tube.

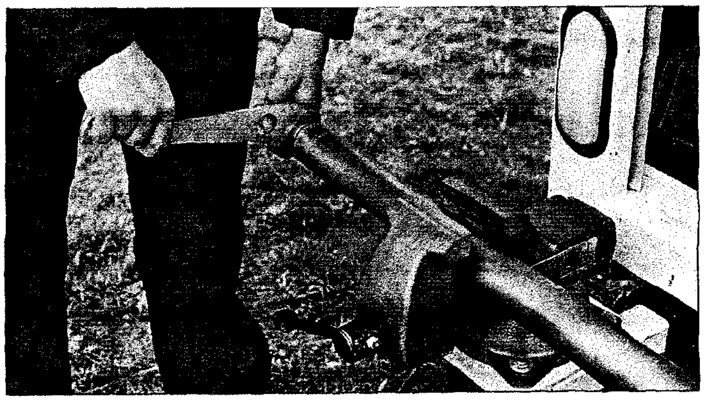


Figure 4.20. Tighten MC Drive Head with MC Combination Wrench. A vise is often used to hold the MC Sample Tube during this step.

7. Insert an MC Piston Rod/Stop-Pin Assembly through the drive head until the stop-pin threads contact the top of the drive head (Fig. 4.21). Ensure that an O-ring has been placed on the stop-pin.

   The leading end of the piston rod may hangup on the core catcher during assembly. When this happens, raise the assembly 6-8 inches above the core catcher and then allow the assembly to fall back down into the sampler. This should allow the piston rod to pass through the fingers of the core catcher.

   Note: The MC Stop-Pin Coupler may be omitted under certain sampling conditions. Refer to Section 4.4 for information regarding when a coupler is needed and instructions for coupler installation.

8. Thread the stop-pin into the drive head (left-hand threads) with an adjustable or 1/2-inch combination wrench. Fully tighten the stop-pin and then back it off slightly (~10 degrees). This avoids locking the stop-pin threads and allows it to later be unthreaded from the ground surface with extension rods.

Sampler Assembly is Complete.

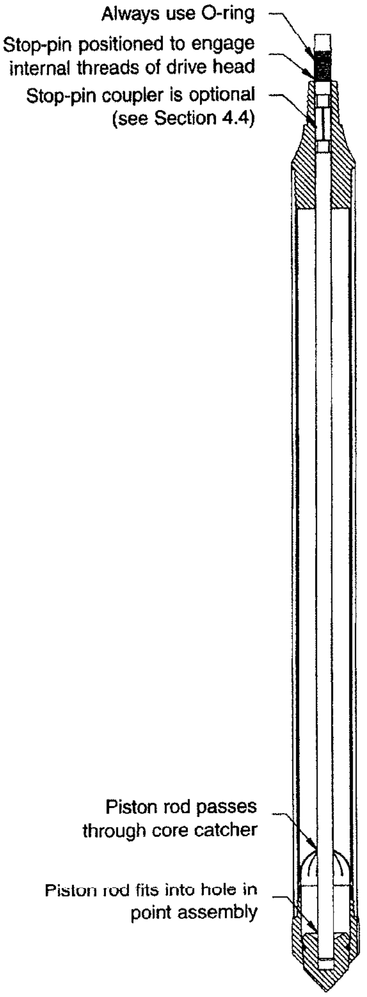


FIGURE 4.21
MC Piston Rod/Stop-Pin Assembly Installs Through MC Drive Head

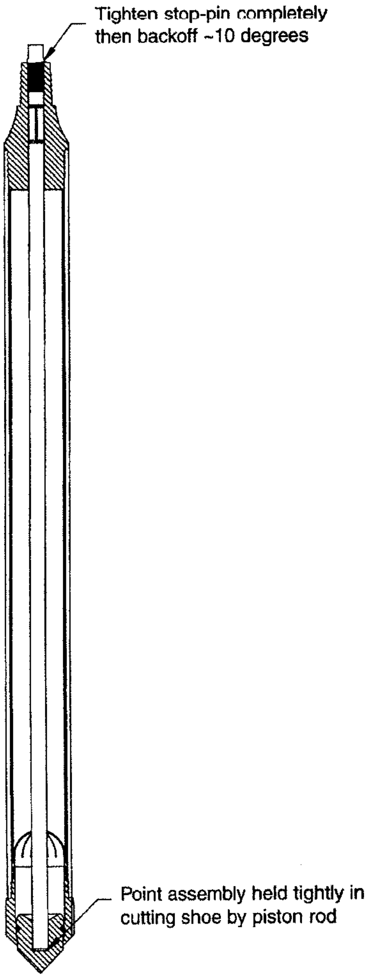


FIGURE 4.22
Thread MC Stop-Pin tachment with Piston Assembly

4.6 Pilot Hole

A pilot hole prevents excessive sampler wear in tough soils and saves time when a discrete soil core is desired. The pilot hole is created by driving a 2.0-, 2.5-, or 3.0-inch MC Pre-Probe (see Section 3.0 for part numbers) to the top of the sampling interval. Soil surfaces containing gravel, asphalt, hard sands, or rubble should be pre-probed to reduce wear on the cutting shoe and to avoid damage to the sampler. To save time when collecting a discrete soil core, pre-probe to the sampling interval rather than coring to depth with the sampler.

4.7 Open-Tube Sampling

The Macro-Core® Open-Tube Sampler is used to gather continuous soil cores beginning from ground surface. A representative soil sample is obtained by driving the assembled sampler one sampling interval into the subsurface through undisturbed soil. Upon retrieving the sampler, the liner and soil core are removed. The sampler is then properly decontaminated, reassembled with a new liner, and inserted back down the same hole to collect the next soil core.

Instructions for operationg of the Open-Tube Macro-Core® Sampler are given in this section.

1. Thread a Drive Cap (AT1200) onto the drive head of an assembled Open-Tube Macro-Core® Sampler as shown in Figure 4.23. (Refer to Section 4.3 for sampler assembly).
2. Raise the probe unit hammer assembly to its highest position by fully extending the probe cylinder.
3. Position the MC Sampler for driving as shown in Figure 4.24. Place the sampler directly under the hammer with the cutting shoe centered between the toes of the probe foot. The sampler should now be parallel to the probe derrick. Step back from the unit and visually check sampler alignment.
4. Apply static weight and hammer percussion to advance the sampler until the drive head reaches the ground surface (Fig. 4.25A)

   ***NOTE:* Activate hammer percussion whenever collecting soil. Percussion helps shear the soil at the leading end of the sampler so that it moves into the sample tube for increased recovery.**

5. Raise the hammer assembly a few inches to provide access to the top of the sampler.
6. Remove the drive cap and thread a Pull Cap (AT1204) onto the sampler drive head.
7. Lower the hammer assembly and hook the hammer latch over the pull cap (Fig. 4.26). Raise the hammer assembly to pull the sampler completely out of the ground.
8. Procede to Section 4.9 for instructions on recovering the soil core from the MC Sampler.

To sample consecutive soil cores, advance a clean sampler down the previously opened hole (Fig. 4.25B) to the top of the next sampling interval (Fig. 4.25C). Drive the tool string the length of the sampler to collect the next soil core (Fig. 4.25D). Switch to an MC Piston Rod Sampler if excessive side slough is encountered.

***NOTE:* *Use caution when advancing or retrieving the sampler within an open hole.* Low side friction may allow the sampler and probe rods to drop down the hole when released. To prevent equipment loss, hold onto the tool string with a pipe wrench when needed.**

Figure 4.23. Thread drive cap onto sampler drive head.

Figure 4.24 MC Sampler positioned for driving into subsurface.

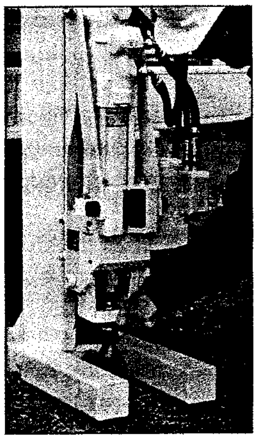
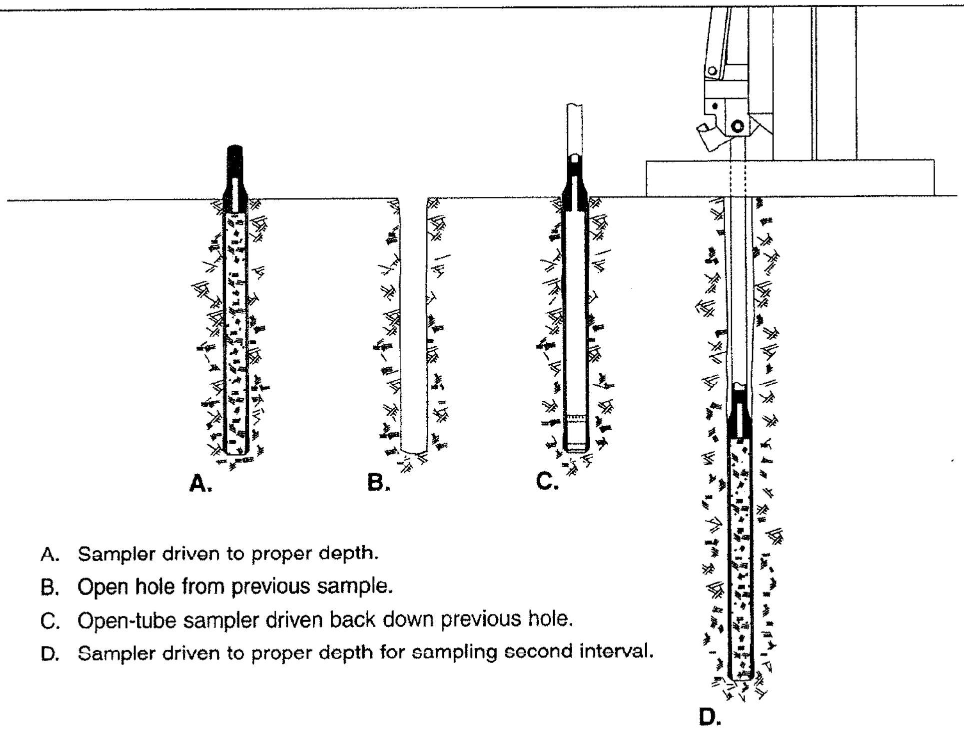


Figure 4.26. Hook hammer latch onto pull cap.



A. Sampler driven to proper depth.
B. Open hole from previous sample.
C. Open-tube sampler driven back down previous hole.
D. Sampler driven to proper depth for sampling second interval.

FIGURE 4.25
Phases of Macro-Core® Open-Tube Soil Sampling

4.8 Closed-Point Sampling with the MC Piston Rod System

Material collapsing from the probe hole sidewall can make it difficult to collect representative soil cores from significant depths with an open-tube sampler. To overcome this problem, the Macro-Core® Sampler can be equipped with a point assembly that is held tightly in the cutting shoe with a piston rod and threaded stop-pin. This allows the sealed sampler to pass through the slough material and then opened at the appropriate sampling interval. Intructions for sampling with the MC Piston Rod System are given in this section.

NOTE: The MC Piston Rod System is designed for continuous core sampling. A probe hole must be opened above the sampling interval either by removing soil with an open-tube Macro-Core® Sampler or by preprobing to depth. Never drive the MC Piston Rod System through undisturbed soil.

1. Attach a Slotted Drive Cap (AT1202) to the drive head of an assembled MC Piston Rod Sampler as shown in Figure 4.27. (Refer to Section 4.5 for sampler assembly.)

   NOTE: The MC Stop-Pin extends slightly from the top of the MC Drive Head. A slotted drive cap is therefore required to allow room for the stop-pin (Fig. 4.27). A standard drive cap may be used once probe rods are added to the tool string.

2. Raise the probe unit hammer assembly to its highest position by fully extending the probe cylinder.

3. Place the leading end of the MC Sampler into the **previously opened hole** (Fig. 4.28A).

4. Advance the sampler down the open hole for the full stroke of the probe machine.

   NOTE: Use caution when advancing the sampler down an open hole. Low side friction may allow the sampler and probe rods to drop down the hole when released. To prevent equipment loss, hold onto the tool string with a pipe wrench when needed.

5. Remove the slotted drive cap and thread a probe rod onto the MC Drive Head. Thread a standard Drive Cap (AT1200) onto the probe rod.

6. Continue advancing the sampler and adding probe rods to the tool string until the desired sampling interval is reached (Fig. 4.28B).

7. Raise the hammer assembly and retract the probe derrick to gain access to the top probe rod.

8. Remove the drive cap and insert extension rods down the inside of the probe rod string. A male Extension Rod Quick Link and an MC Extension Rod Quick Link Connector should be placed on the leading end of the extension rod string (Fig. 4.29) if an MC Stop-Pin Coupler was used during assembly. Nothing is placed on the leading extension rod if a stop-pin coupler was not used.

   Use Extension Rod Couplers or Extension Rod Quick Links (Fig. 4.30) to connect extension rods together until the leading rod contacts the stop-pin . Use an Extension Rod Jig (Fig. 4.30) to hold the down-hole rods while adding more rods to the string.

9. Attach an Extension Rod Handle (Fig. 4.30) to the rod string and slowly rotate the handle clockwise to engage the stop-pin threads. The rods will become harder to turn when the stop-pin threads are fully engaged. Pull up on the rod string to ensure that it is connected to the stop-pin. Continue rotating and periodically lifting the extension rods until the stop-pin is completely unthreaded from the drive head.

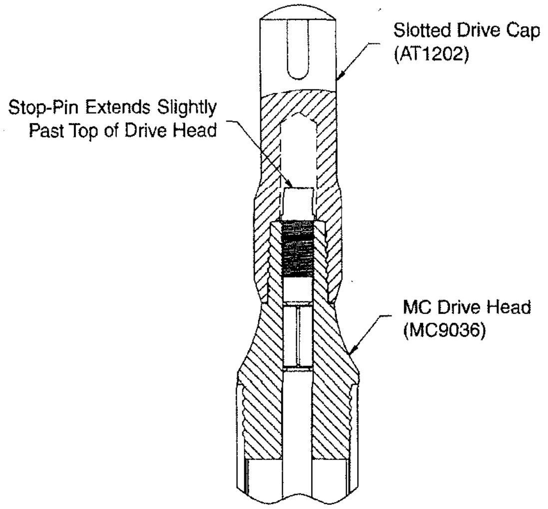
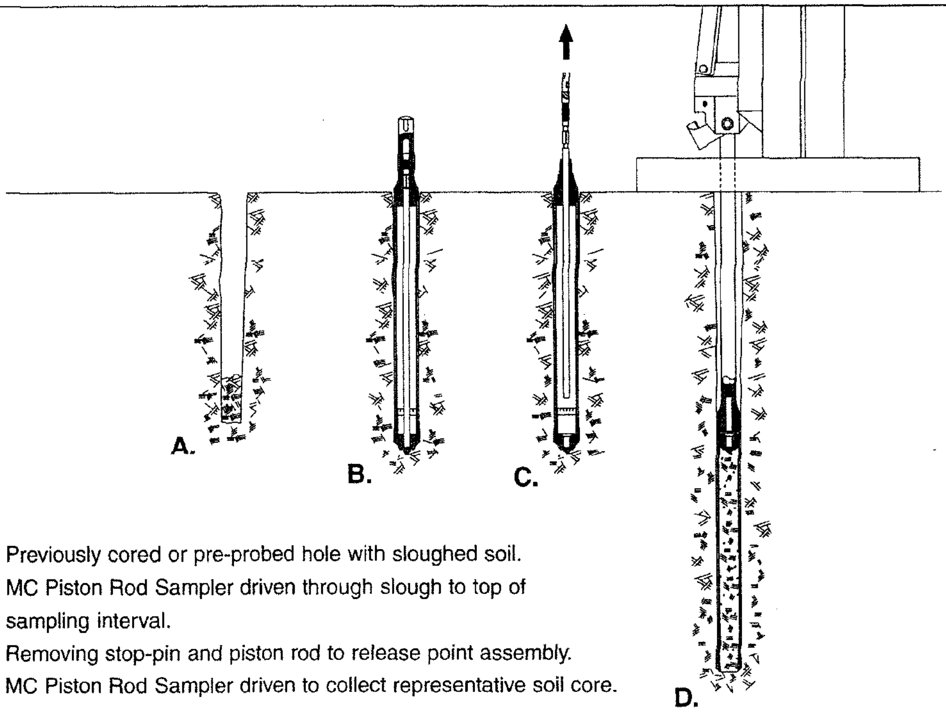


FIGURE 4.27
Slotted Drive Cap Accomodates Stop-Pin



A. Previously cored or pre-probed hole with sloughed soil.
B. MC Piston Rod Sampler driven through slough to top of sampling interval.
C. Removing stop-pin and piston rod to release point assembly.
D. MC Piston Rod Sampler driven to collect representative soil core.

FIGURE 4.28
Phases of Macro-Core® Closed-Point (Piston Rod System) Sampling

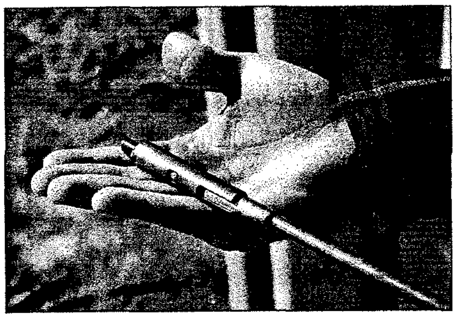


Figure 4.29. Use an MC Extension Rod Quick Link Connector if stop-pin coupler was used in sampler.

NOTE: If the stop-pin is excessively difficult to unthread, pull the entire tool string up approximately 2 inches. This should relieve the force exerted on the point assembly and make releasing the stop-pin much easier.

10. Lift and remove extension rods until the stop-pin is visible above the drive head (Fig. 4.28-C). The stop-pin and piston rod will both be removed from the sampler if a stop-pin coupler was used during assembly (Fig. 4.31-A). Only the stop-pin will be connected to the last extension rod if a coupler was not used (Fig. 4.31-B). Remove the extension rod and stop-pin if the piston rod is not attached.

11. If the piston rod is attached to the stop-pin, carefully unhook the extension rod and male quick link from the MC Extension Rod Quick Link Connector (Fig. 4.31-A). Take care not to deform the stop-pin coupler when removing the extension rod. Now remove the piston rod from inside the tool string.

12. Thread the Drive Cap (AT1200) onto a probe rod and then attach the probe rod to the tool string.

13. Completely raise the probe unit hammer assembly and reposition the probe derrick over the tool string.

14. Apply static weight and hammer percussion to advance the tool string the length of the sampler and collect the soil core (Fig. 4.28-D).

    NOTE: Activate hammer percussion whenever collecting soil. Percussion helps shear the soil at the leading end of the sampler so that it moves into the sample tube for increased recovery.

15. Raise the hammer assembly a few inches to provide access to the top of the tool string.

16. Remove the drive cap and thread a Pull Cap (AT1204) onto the top probe rod.

17. Lower the hammer assembly and hook the hammer latch over the pull cap. Raise the hammer assembly to pull the first probe rod out of the ground. Remove the rod and place the pull cap on the next rod of the tool string. Continue pulling probe rods until the MC Sampler is brought to the ground surface.

    NOTE: Use caution when retrieving the MC Sampler from depth. Low side friction may allow the sampler and probe rods to drop down the hole when released. To prevent equipment loss, hold onto the tool string with a pipe wrench when needed.

18. Procede to Section 4.9 for instructions on recovering the soil core from the MC Sampler.

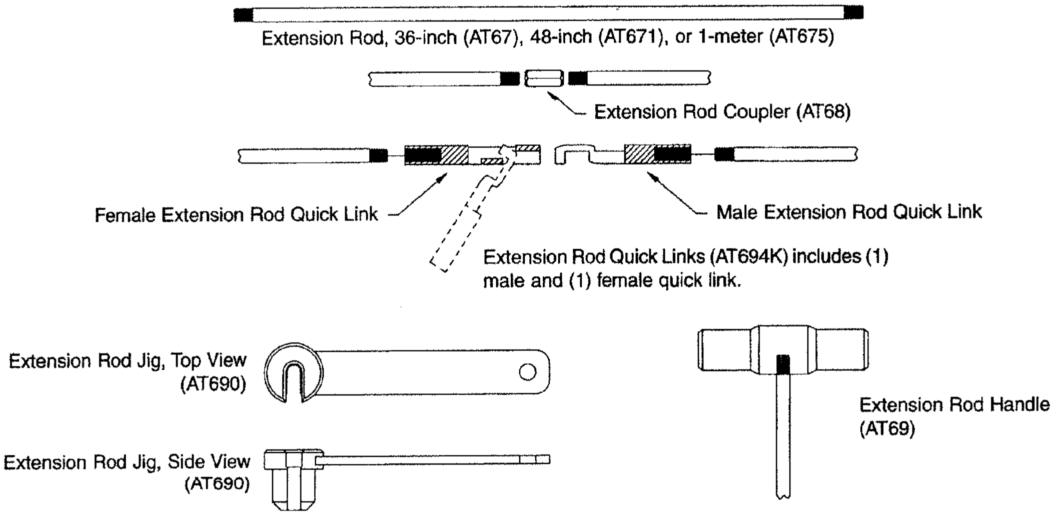


FIGURE 4.30
Extension Rods and Accessories

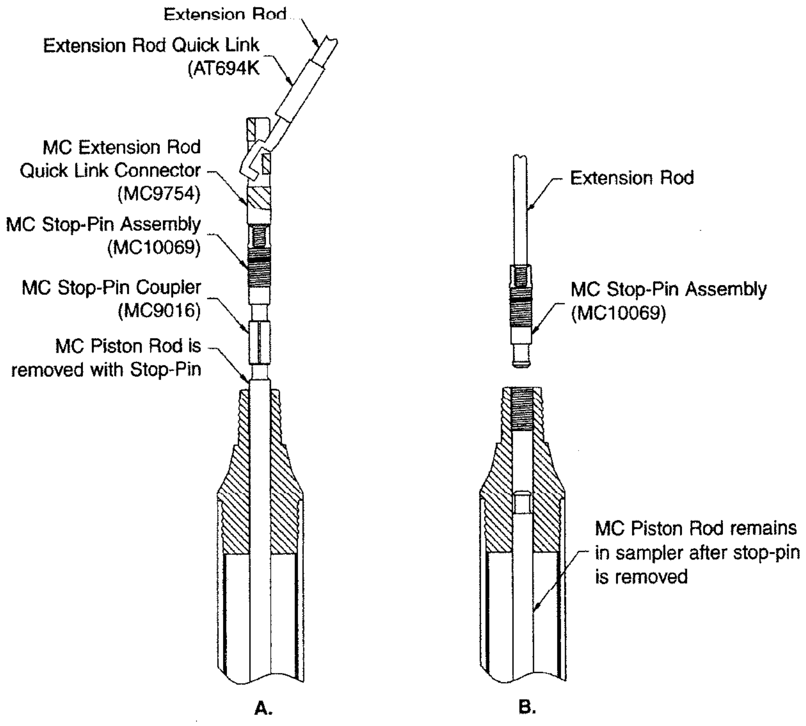


FIGURE 4.31
MC Piston Rod is Removed With Stop-Pin if Stop-Pin Coupler was Used

4.9 Soil Core Recovery

The soil sample is easily removed from the Macro-Core® Sampler by unthreading the cutting shoe and pulling out the liner. A few sharp taps on the cutting shoe with the combination wrench will often loosen the threads sufficiently to allow removal by hand. If needed, the exterior of the cutting shoe features a notch for attaching the combination wrench to loosen tight threads (Fig. 4.32). With the cutting shoe removed (Fig. 4.33), simply pull the liner and soil core from the sample tube (Fig. 4.34).

If the closed-point sampler is used, the MC Piston Rod Point Assembly is now retrieved from the end of the liner (Fig. 4.35). Secure the soil sample by placing a vinyl end cap on each end of the liner.

Undisturbed soil samples can be obtained from Teflon®, PVC, and PETG liners by splitting the liner. Geoprobe offers two tools for cutting sample liners. The MC Liner Cutter Kit (AT8000K) is used to make longitudinal cuts in the liner and includes a tool that holds the liner for cutting (Fig. 4.36). The MC Liner Circular Cutting Tool (AT8050) is used to segment the liner by cutting around the outside circumference of the liner (Fig. 4.37).

Figure 4.32. Loosening the MC Cutting Shoe with the MC Combination Wrench.

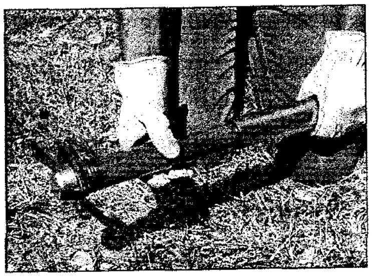


Figure 4.33. Removing MC Cutting Shoe and liner from MC Sampler Tube.

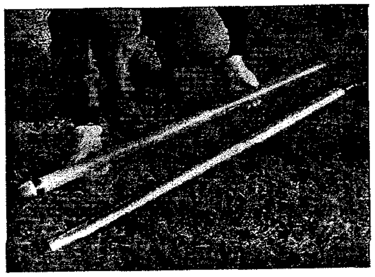


Figure 4.34. Macro-Core® liner filled with soil core.

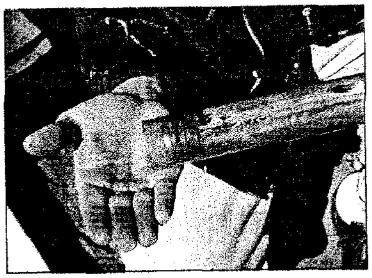


Figure 4.35. MC Piston Rod Point Assembly is retrieved from top of liner.

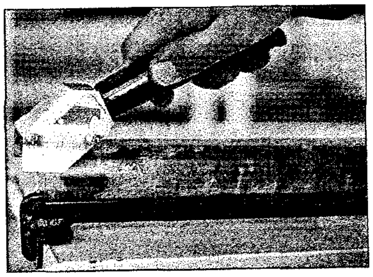


Figure 4.36. MC Liner Cutter makes two longitudinal cuts in polymer liners.

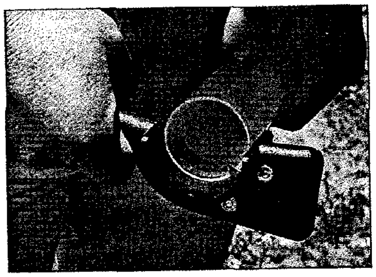


Figure 4.37. MC Circular Cutting Tool cuts around the outside of MC liner.

4.10 MC Piston Rod Sampler Tips

Macro-Core® Samplers are available in lengths of 24 inches, 36 inches, 1 meter, 48 inches, and 60 inches. This means that MC Sample Tubes, MC Liners, MC Piston Rods and MC Piston Rod/Stop-Pin Assemblies are also available in these five sizes. Keep this in mind when ordering Macro-Core® parts to ensure that the items you receive are of the appropriate length.

During development of the MC Piston Rod System, it was common for operators to remove the MC Piston Rod/Stop-Pin assembly from inside the probe rods with the last extension rod still threaded onto the stop-pin. The MC Stop-Pin Coupler is not designed to withstand the considerable side load placed on it by the extension rod and is easily damaged if the extension rod is allowed to swing around unsupported. The MC Quick Link Connector was developed to prevent damage to the coupler by allowing the last extension rod to be disconnected from the piston rod/stop-pin assembly before removing the assembly from the probe rods. Always use the quick link connector whenever the sampler is assembled with a stop-pin coupler.

4.11 Tips to Maximize Sampling Productivity

The following suggestions are based on the collective experiences of Geoprobe operators:

1. Organize your truck or van. Assign storage areas to all tools and equipment for easy location. Transport sample tubes, piston rods, extension rods, probe rods, and liners in racks. Above all, minimize the number of items lying loose in the back of the vehicle.

2. Take three or four samplers to the field. This allows the collection of several samples before stopping to clean and decontaminate the equipment. A system is sometimes used where one individual operates the probe while another marks the soil cores and decontaminates the used samplers.

3. A machine vise is recommended. With the sampler held in a vise, the operator has both hands free to remove the cutting shoe (Fig. 4.38), drive head, and sample liner (Fig. 4.39). Cleanup is also easier with both hands free. Geoprobe offers an optional Machine Vise (FA300) that mounts directly on the probe derrick (Fig. 4.40).

4. Extension Rod Quick Links (Fig. 4.41) are real time savers. A good method for deploying extension rods is to assemble sections of up to three rods using threaded connnectors. Each section is then connected with Quick Links so that up to three rods can be added or removed from the string at once.

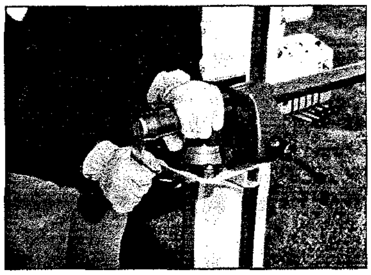


Figure 4.38. Removing MC Cutting Shoe with sample tube held in machine vise.

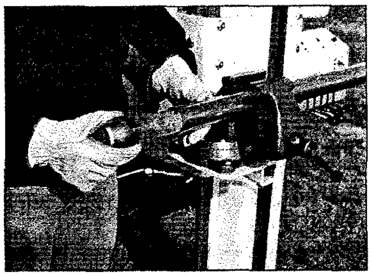


Figure 4.39. Removing filled liner with sample tube held in machine vise.

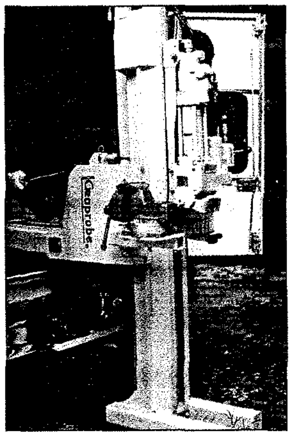


Figure 4.40. Machine vise mounted directly on Geoprobe Soil Probing Unit.

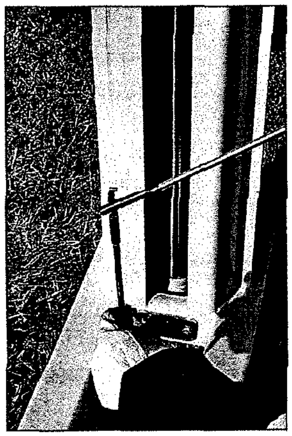


Figure 4.41. Using Extension Rod Quick Links to connect Extension Rods.

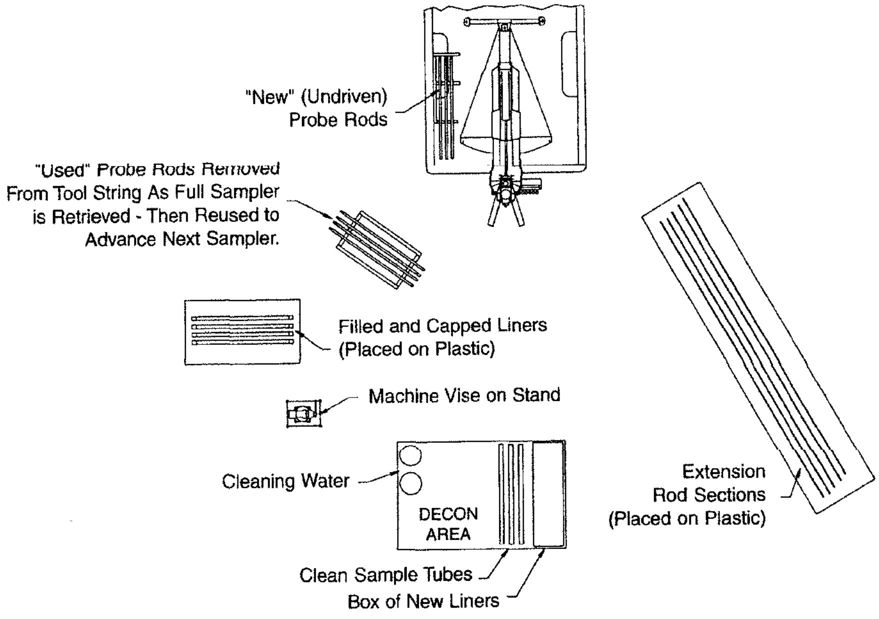


FIGURE 4.42
Equipment Layout Example to Maximize Sampling Productivity.

5. When releasing the stop-pin, a pair of locking pliers can be used to turn the extension rods. Locking pliers may be quicker and easier to install than the extension rod handle.

6. Organize your worksite. Practice with the sampler to identify a comfortable setup and then use this layout whenever sampling. An example layout is shown in Figure 4.42.

   A collapsible table or stand is handy to hold decontaminated sampler tubes and liners. Equipment may also be protected from contamination by placing it on a sheet of plastic on the ground.

   Instead of counting probe rods for each trip in-and-out of the probe hole, identify separate locations for "new" rods and "used" rods. Collect the first sample from the open hole using "new" rods. As each probe rod is removed during sampler retrieval, place it in the "used" rod location. Now advance a clean sampler back down the same hole using all of the rods from the "used" location. Add one "new" rod to the string and then drive the tools to collect the next soil core. Once again, remove each probe rod and place it in the "used" rod location as the sampler is retrieved. Repeat this cycle using all the "used" rods to reach the bottom of the probe hole, and one "new" rod to fill the sampler.

7. Cleanup is very important from the standpoint of operation as well as decontamination. Remove all dirt and grit from the threads of the drive head, cutting shoe, and sample tube with a nylon brush (BU700). Without sufficient cleaning, the cutting shoe and drive head will not thread completely onto the sample tube. The threads may be damaged if the sampler is driven in this condition.

Ensure that all soil is removed from inside the sample tube. Sand particles are especially troublesome as they can bind liners in the sampler. Full liners are difficult to remove under such conditions. In extreme cases the soil sample must be removed from the liner before it can be freed from the sample tube.

8. Although MC Drive Heads are available for open-tube sampling with 1.0-inch OD probe rods, 1.25-inch rods are recommended for the Macro-Core® Sampler. The larger rod diameter limits downhole deflection of the tool string and ultimately provides a more durable system. The double-lead thread design also makes the 1.25-inch rods thread together faster than previous 1-inch probe rods.

9. The Heavy-Duty MC Cutting Shoe (AT8535) is machined with more material at the critical wear areas. It can be used in place of the Standard MC Cutting Shoe (AT8530) and is designed to lengthen service life under tough probing conditions.

   Expansive clays and coarse sands can "grab" and collapse liners as the sample tube is filled with soil. A 1/8-inch Undersized MC Cutting Shoe (AT8537) helps alleviate this problem. The smaller core (1.375 inches OD) allows expanding clays and coarse sands to travel past the liner without binding.

   The standard, heavy-duty, and undersized cutting shoes will not accept the MC Piston Rod Point Assembly (MC10068). Only the MC9034 cutting shoe is compatible with the MC Piston Rod System.

10. Maximize the thread life of the sample tube by varying the ends in which the drive head and cutting shoe are installed. The dynamic forces developed while driving the sampler are such that the threads at the drive head wear more quickly than at the cutting shoe. Regularly switching ends will maintain relatively even wear on the sample tube.

5.0 REFERENCES

Geoprobe Systems, September, 1997, "97-98 Tools and Equipment Catalog."

Geoprobe Systems, May, 1995, "1995-96 Tools and Equipment Catalog."

Equipment and tool specifications, including weights, dimensions, materials, and operating specifications included in this brochure are *subject to change without notice.* Where specifications are critical to your application, please consult Geoprobe Systems 1-800-436-7762.

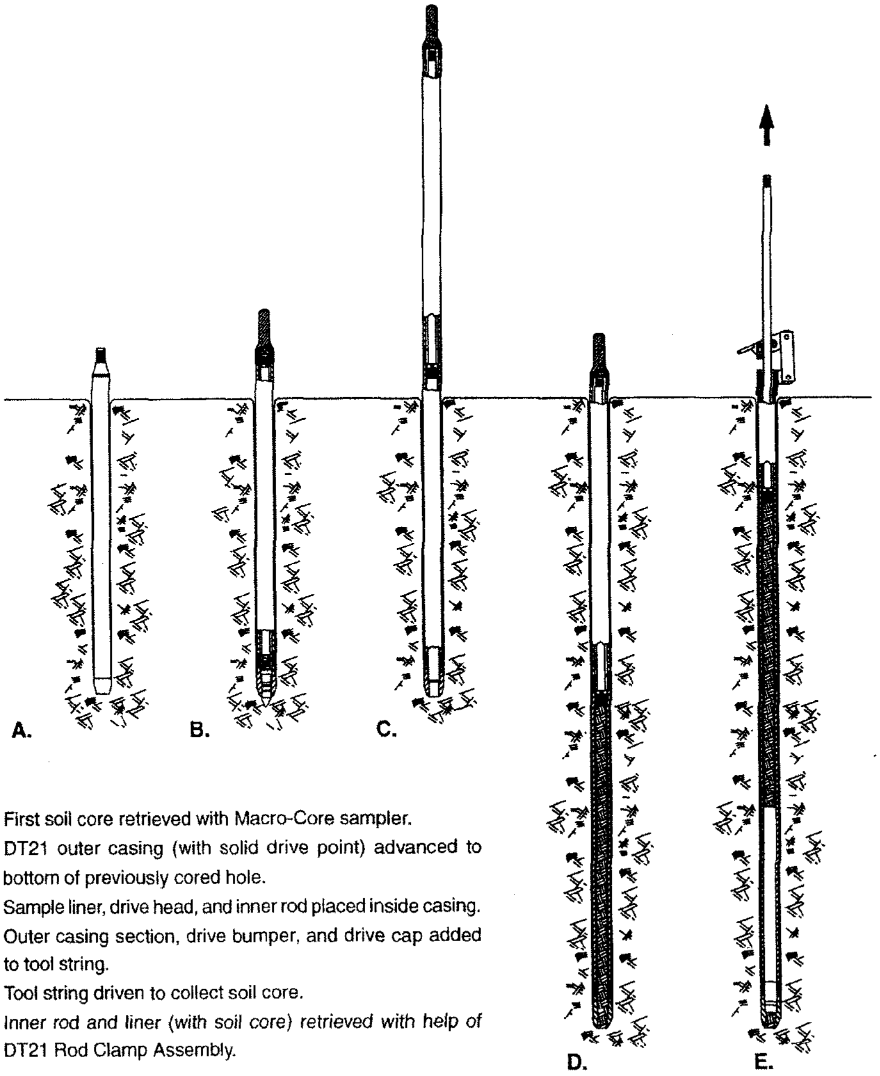
GEOPROBE DT21 DUAL TUBE SOIL SAMPLING SYSTEM

CONTINUOUS CORE SOIL SAMPLER

STANDARD OPERATING PROCEDURE

Technical Bulletin No. 982100

September, 1998



A. First soil core retrieved with Macro-Core sampler.
B. DT21 outer casing (with solid drive point) advanced to bottom of previously cored hole.
C. Sample liner, drive head, and inner rod placed inside casing. Outer casing section, drive bumper, and drive cap added to tool string.
D. Tool string driven to collect soil core.
E. Inner rod and liner (with soil core) retrieved with help of DT21 Rod Clamp Assembly.

OPERATION OF THE DUAL TUBE 21 SOIL SAMPLING SYSTEM

1.0 OBJECTIVE

The objective of this procedure is to collect a representative soil sample at depth through an enclosed casing and recover it for visual inspection and/or chemical analysis.

2.0 BACKGROUND

2.1 Definitions

Geoprobe®: A brand name of high quality, hydraulically-powered machines that utilize both static force and percussion to advance sampling and logging tools into the subsurface. The Geoprobe® brand name refers to both machines and tools manufactured by Geoprobe® Systems, Salina, Kansas. Geoprobe® tools are used to perform soil core and soil gas sampling, groundwater sampling, soil conductivity and contaminant logging, grouting, and materials injection.
** Geoprobe® is a registered trademark of Kejr Engineering, Inc., Salina, Kansas*

Dual Tube 21 Soil Sampling System: A direct push system for collecting continuous core samples of unconsolidated materials from within a sealed casing of Geoprobe 2.125-inch (54 mm) OD probe rods. Samples are collected and retrieved within a liner that is threaded onto the leading end of a string of Geoprobe 1.0-inch (25 mm) OD probe rods and inserted to the bottom of the outer casing. Collected samples measure up to approximately 800 ml in volume in the form of a 1.125-inch x 48-inch (29 mm x 1219 mm) core.

Liner: A 1.375-inch (35 mm) OD thin-walled, PETG tube that is inserted into the outer casing on the leading end of the inner rod string for the purpose of containing and retrieving core samples. Liner lengths include 25 inches (635 mm), 37 inches (940 mm), 40.4 inches (1026 mm), and 49 inches (1245 mm).

2.2 Discussion

Dual tube sampling gets its name from the fact that two sets of probe rods are used to retrieve continuous soil core samples from the subsurface. One set of rods is driven into the ground as an outer casing (Fig. 2.1). These rods receive the driving force from the hammer and provide a sealed casing through which soil samples may be recovered. The second, smaller set of rods are placed inside the outer casing with a sample liner attached to the leading end of the rod string (Fig. 2.1). These smaller rods hold the liner in place as the outer casing is driven to fill the liner with soil. The inner rods are then retracted to retrieve the full liner.

Standard Geoprobe 2.125-inch OD probe rods provide the outer casing for the DT21 Dual Tube Soil Sampling System. A cutting shoe is threaded into the leading end of the rod string. When driven into the subsurface, the cutting shoe shears a 1.125-inch OD soil core which is collected inside the casing in a clear plastic liner.

The second set of rods in the DT21 system are standard Geoprobe 1.0-inch OD probe rods. A sample liner is attached to the end of these smaller rods and then inserted into the casing. The 1.0-inch rods hold the liner tight against the cutting shoe as the outer casing is driven to collect the soil core. Once filled with soil, the liner is removed from the bottom of the outer casing by lifting out the 1.0-inch rods.

The outer, 2.125-inch probe rods provide a cased hole through which to sample. The main advantage of sampling through a cased hole is that there is no side slough to contend with. In addition, the outer casing effectively seals the probe hole when sampling through perched water tables. These factors mean that sample cross-contamination is eliminated. The DT21 sampling system is therefore ideal for continuous coring in both saturated and unsaturated zones.

A Solid Drive Tip (DT4070) can be placed on the leading end of the 1.0-inch probe rod string in place of a sample liner (Fig. 2.2). When installed in the outer casing, the drive tip firmly seats within the cutting shoe and effectively seals the tool string as it is driven into the subsurface. This enables the operator to advance the outer casing to the bottom of a pre-core hole or through undisturbed soil to reach the top of the sampling interval.

The DT21 system allows bottom-up grouting through the primary tool string. This means that a cement or bentonite grout mix can be pumped through the outer casing as it is withdrawn from the ground. This is in contrast to most other soil samplers which require driving a second set of tools back down the probe hole in order to deliver the grout mix.

An expendable cutting shoe enables the operator to install a Geoprobe Prepacked Screen Monitoring Well through the outer casing of the DT21 Dual Tube System. After the collection of continuous soil cores to the desired depth, prepacked screens can be inserted to the bottom of the outer casing on the leading end of a PVC riser string. The well is finished, complete with grout barrier, bentonite well seal, and a high-solids bentonite slurry/neat cement grout, during retrieval of the outer casing.

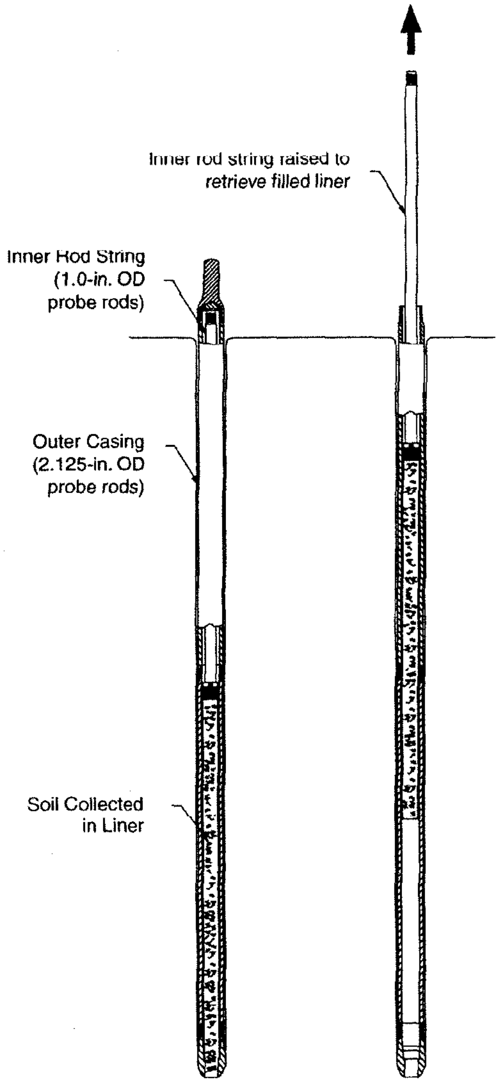


FIGURE 2.1
Outer Casing Driven With Liner

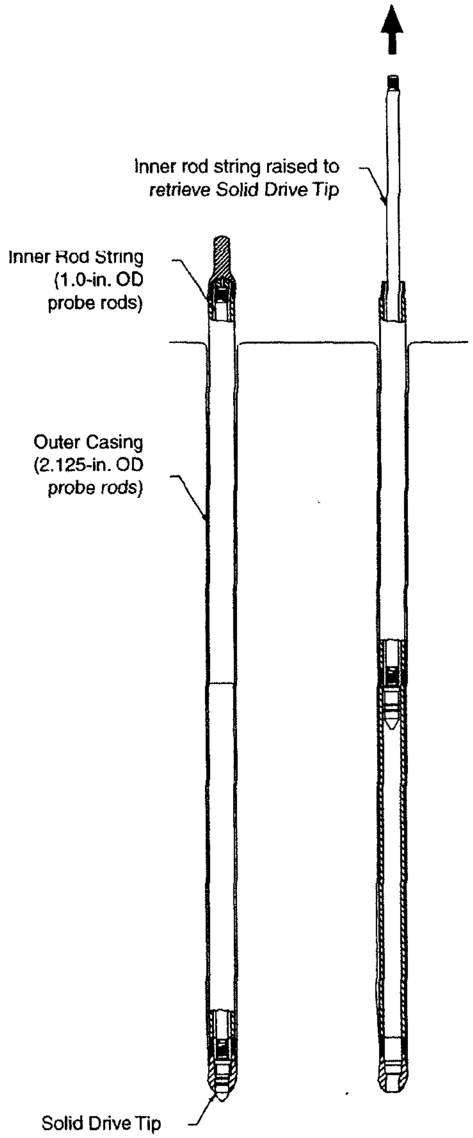


FIGURE 2.2
Outer Casing Driven With Solid Drive Tip

3.0 REQUIRED EQUIPMENT

The following equipment is used to recover samples with the Geoprobe Dual Tube 21 Soil Sampling and probing systems. Note that the operator may choose to utilize 2.125-inch probe rods in lengths of 36 inches (914 mm), 1 meter, or 48 inches (1219 mm). It is not necessary to have all three rod lengths on-hand. Refer to Figure 3.1 for parts identification.

DUAL TUBE 21 SAMPLER PARTS	**QUANTITY**	**PART NUMBER**
DT21 Drive Bumper, Pkg. of 5	-1-	DT4010K
DT21 Threadless Drive Cap (1.0-inch probe rods)	-1-	DT4020
DT21 Cutting Shoe, Large, 2.375 in. OD	-1-	DT4030
DT21 Cutting Shoe, Small, 2.205 in. OD	-1-	DT4035
DT21 Expendable Cutting Shoe Holder	-1-	DT4040
DT21 Expendable Cutting Shoe, 2.375 in. OD	variable	DT4045
O-rings for Expendable Cutting Shoe, Pkg. of 50	variable	DT4045R
DT21 Liners, PETG, 24-inch, Box of 50*	variable	DT4024K
DT21 Vinyl End Caps, Pkg. of 100 (50 pair)	variable	DT4026K
DT21 Liner, PETG, 36-inch, Box of 50*	variable	DT4036K
DT21 Liner, PETG, 1-meter, Box of 50*	variable	DT4039K
DT21 Liner, PETG, 48-inch, Box of 50*	variable	DT4048K
DT21 Liner Drive Head Assembly (1.0-inch probe rods)	-1-	DT4050
DT21 Rebuild Kit for Liner Drive Head	-1-	DT4051K
DT21 Rod Clamp Assembly (1.0-inch probe rods)	-1-	DT4060
DT21 Solid Drive Tip (1.0-inch probe rods)	-1-	DT4070
O-rings for Solid Drive Tip, Pkg. of 25	variable	DT4070R

GEOPROBE TOOLS AND EQUIPMENT	**QUANTITY**	**PART NUMBER**
Probe Rod, 1.0 inch OD x 36 inches*	variable	AT10B
Probe Rod, 1.0 inch OD x 39 inches (1 meter)*	variable	AT1039
Probe Rod, 1.0 inch OD x 48 inches*	variable	AT104B
Probe Rod, 1.0 inch OD x 24 inches*	variable	AT105B
O-rings for 2.125-inch Probe Rods	variable	AT2100R
Drive Cap (2.125-inch probe rods)	-1-	AT2101
Pull Cap (2.125-inch probe rods)	-1-	AT2104
Probe Rod, 2.125 inches OD x 36 inches*	variable	AT2136
Probe Rod, 2.125 inches OD x 39 inches (1 meter)*	variable	AT2139
Probe Rod, 2.125 inches OD x 48 inches*	variable	AT2148
MC Combination Wrench	-1-	AT8590
Rod Grip Pull System	-1-	GH3000K

ADDITIONAL TOOLS	**QUANTITY**
Hex Key, 3/32 in.	-1-
Utility Knife (with straight blade)	-1-
Pipe Wrench	-2-

* Match length of probe rods to desired liner length. Use 36-inch probe rods with 36-inch liners, 1-meter probe rods with 1-meter liners, and 48-inch probe rods with 24- and 48-inch liners. A 1.0 inch x 24 inches probe rod is also required when utilizing 24-inch sample liners.

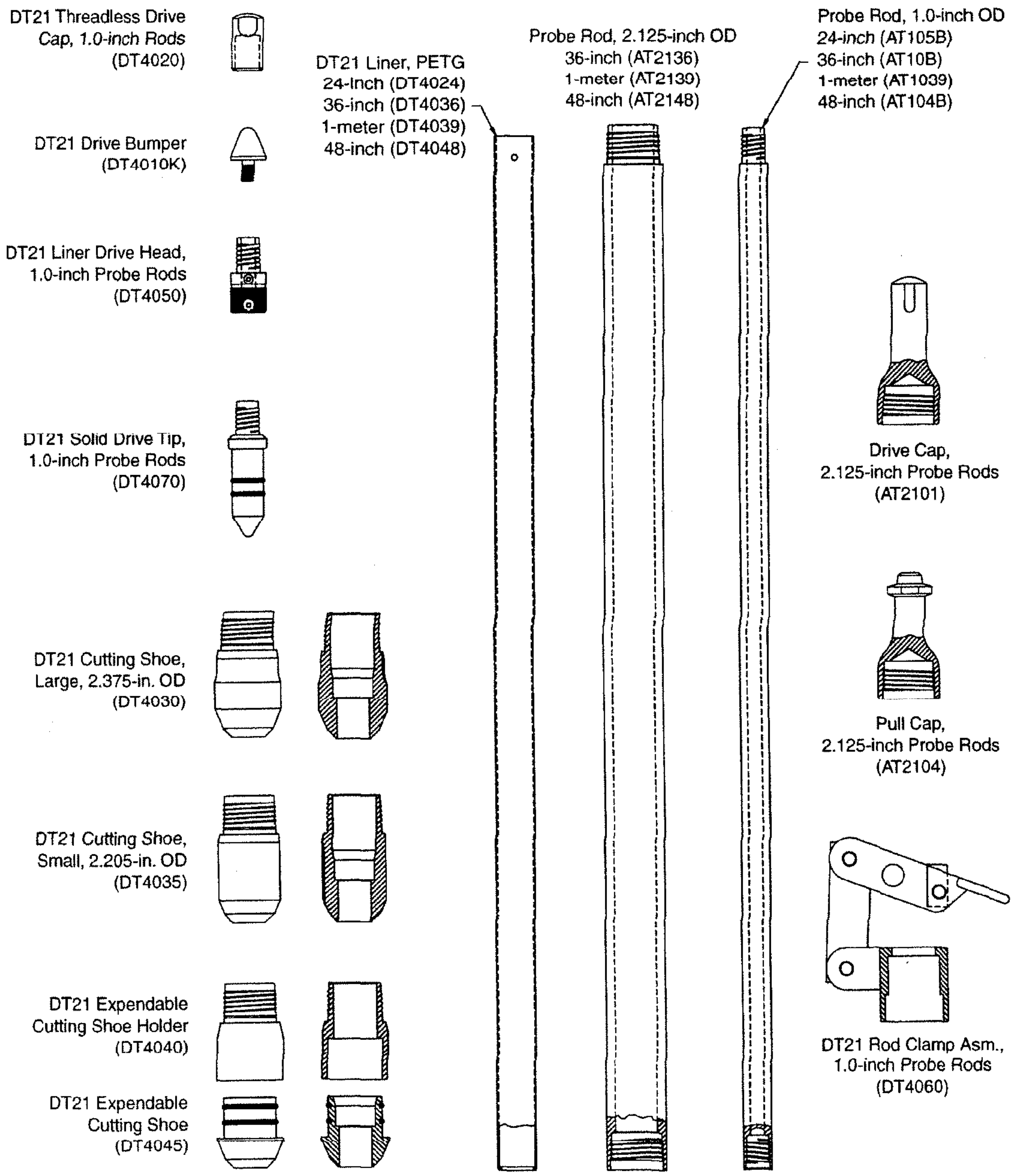


FIGURE 3.1
Dual Tube 21 Soil Sampling System Parts

3.1 Tool Options

Three major components of the DT21 Soil Sampling System are probe rods, sample liners, and cutting shoes. These items are manufactured in a variety of sizes to fit the specific needs of the operator. This section identifies the specific tool options available for use with the DT21 Dual Tube System.

Probe Rods

Standard Geoprobe 1.0-inch (25 mm) OD and 2.125-inch (54 mm) OD probe rods are required to operate the DT21 Soil Sampling System. The specific length of rods may be selected by the operator. Available rod lengths are 36 inches (914 mm), 48 inches (1,219 mm), and 1 meter. Both rod sets (1.0-inch and 2.125-inch) must be of the same length.

Sample Liners

Sample liners are made of a heavy-duty clear plastic for convenient inspection of the soil sample. Lengths of 24 inches (610 mm), 36 inches (914 mm), 48 inches (1219 mm), and 1 meter are available with an OD of 1.375 inches (35 mm). Choose the liner length corresponding to the length of probe rods used (e.g. 36-inch liners with 36-inch probe rods).

The shorter length of the 24-inch liners helps to recover samples from flowing sands and highly expansive clays. These liners are used with 48-inch probe rods, but also require a single 1.0-inch x 24-inch probe rod.

Cutting Shoes

Three cutting shoes are available for use with the DT21 Dual Tube System (Fig. 3.2). The DT21 Large Cutting Shoe (DT4030) and DT21 Small Cutting Shoe (DT4035) thread into the leading end of the 2.125-inch probe rods and are recovered after sampling. Dimensions for the large cutting shoe are 1.125 inches (29 mm) ID and 2.375 inches (60 mm) OD. The small cutting shoe also has an ID of 1.125 inches (29 mm) but the OD is only 2.205 inches (56 mm). To reduce side friction and make driving easier, the large cutting shoe (DT4030) is oversized to provide a small annulus between the outer casing and soil. By contrast, the small cutting shoe (DT4035) is for use in soil conditions where an annulus is undesirable.

The DT21 sampling system may also employ an expendable cutting shoe. In this arrangement, a DT21 Expendable Cutting Shoe Holder (DT4040) is threaded into the leading end of the outer casing. A DT21 Expendable Cutting Shoe (DT4045) is then inserted into the holder. Upon completion of soil sampling, the outer casing is withdrawn slightly. The expendable cutting shoe detaches from the holder, leaving an open casing through which a prepacked screen monitoring well may be installed. Dimensions for the expendable cutting shoe are the same as the large cutting shoe (ID = 1.125 in. (29 mm) and OD = 2.375 in. (60 mm)).

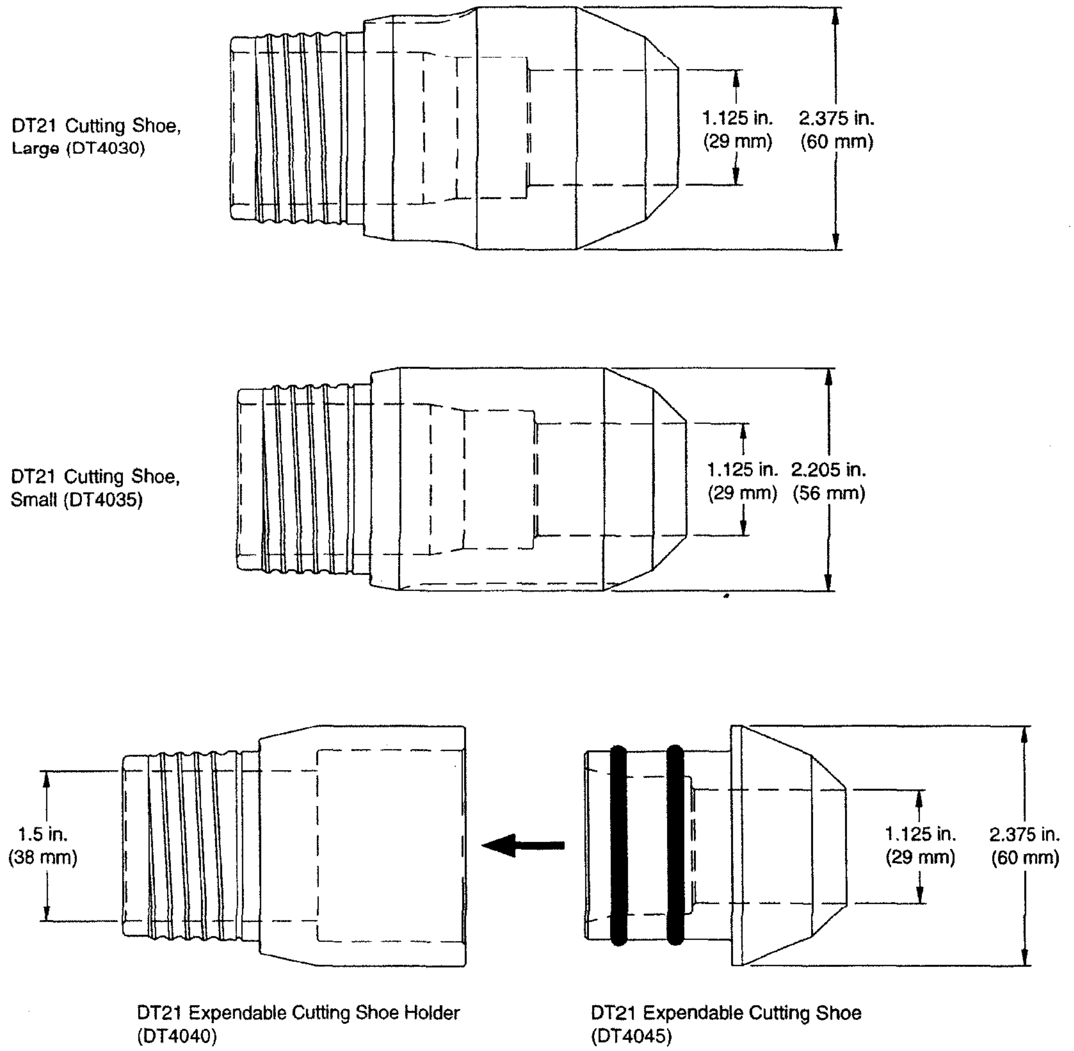


FIGURE 3.2
Cutting Shoe Options for the DT21 Dual Tube Soil Sampling System

4.0 OPERATION

4.1 Decontamination

Before and after each use, thoroughly clean all parts of the soil sampling system according to project requirements. Parts should also be inspected for wear or damage at this time. During sampling, a clean new liner is used for each soil core.

4.2 Operational Overview

The DT21 Soil Sampling System is designed to collect continuous soil cores. Sampling may begin either from ground surface or a predetermined depth below ground. Once sampling begins, consecutive soil cores must be removed as the outer casing is advanced to greater depths

When sampling is to begin at the ground surface, the first soil core should be collected with an Open-Tube Macro-Core Soil Sampler* (Fig. 4.1-A). The Macro-Core Sampler normally has better recovery from this interval than is possible with the DT21 Dual Tube System. This is especially true when the first core is composed of dry loose soil.

With the first soil core removed with the MC Sampler, a section of outer casing is sealed with a DT21 Solid Drive Tip and advanced to the bottom of the remaining probe hole (Fig.4.1-B). Once at the bottom of the pre-cored hole, the solid drive tip is removed from the outer casing. A liner is inserted to the bottom of the outer casing (Fig. 4.1-C) and the entire tool string is driven to fill the liner with soil (Fig. 4.1-D). The filled liner is removed from the outer casing to retrieve the second soil core (Fig. 4.1-E). A new liner is then inserted to the bottom of the outer casing and the entire assembly is driven to collect the third soil core. This process is repeated for the entire sampling interval.

When the sampling interval begins at some depth below ground surface, a DT21 Solid Drive Tip is installed in the outer casing and the entire assembly is driven from ground surface directly through undisturbed soil (Fig. 4.2-A). This enables the operator to reach the top of the sampling interval without stopping to remove unwanted soil cores. Once the interval is reached, the solid drive tip is removed (Fig 4.2-B) and sampling continues as described in the preceding paragraphs (Fig. 4.2-C, Fig. 4.2-D, and Fig. 4.2-E).

NOTE: Once the first soil core is collected, the DT21 Solid Drive Tip cannot be reinstalled in the cutting shoe. Consecutive soil cores must be removed in order for the outer casing to be driven to greater depths.

Specific instructions for the assembly and operation of the DT21 Dual Tube Soil Sampling System are given in the following sections.

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*Refer to Geoprobe Macro-Core Soil Sampler Standard Operating Procedure (Technical Bulletin No. 958500).

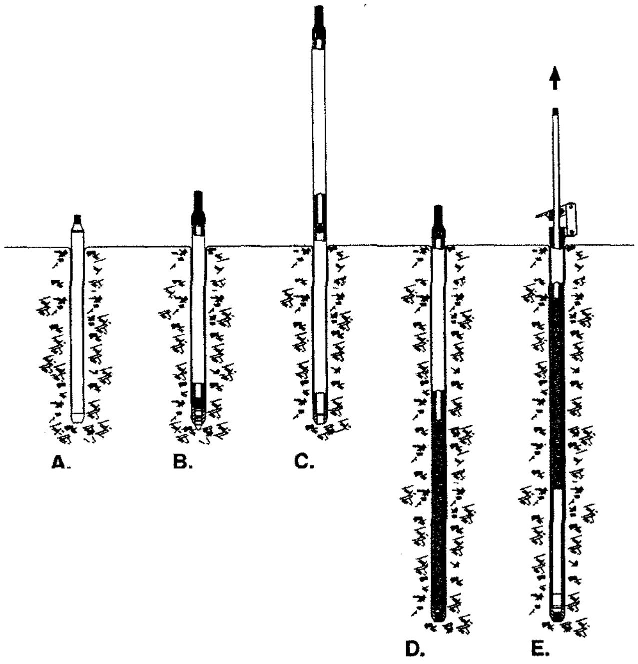


FIGURE 4.1
Continuous Core Sampling From Ground Suface with Dual Tube 21 System

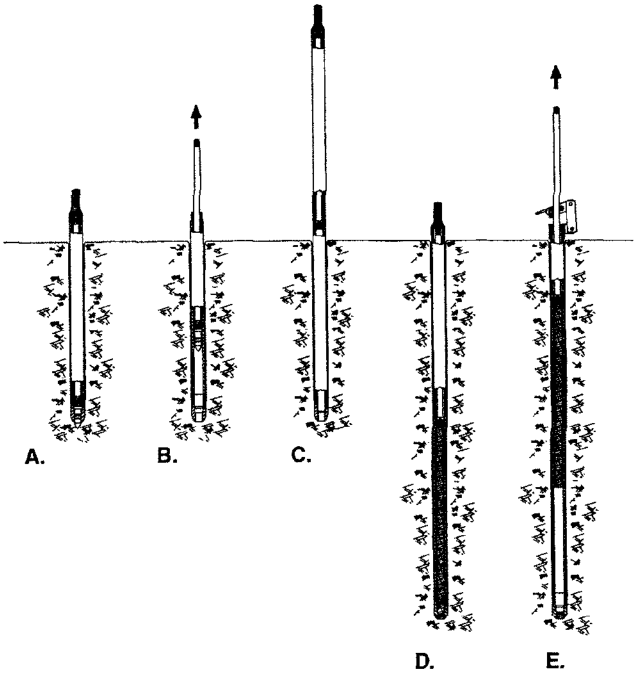


FIGURE 4.2
Outer Casing Driven Through Undisturbed Soil to Begin Sampling with DT21 System

4.3 Assembling and Driving the Outer Casing Using a DT21 Solid Drive Tip

No matter if sampling begins at the bottom of a pre-cored hole or under several feet of undisturbed soil, the outer casing of the DT21 Dual Tube System is always initially driven with a DT21 Solid Drive Tip installed in the leading end. The solid drive tip seals the outer casing as it is driven to the top of the sampling interval. Once this interval is reached, the solid drive tip is removed to begin sampling. This section describes assembling and driving the outer casing using the DT21 Solid Drive Tip.

1. If using a DT21 Large or Small Cutting Shoe (DT4030 or DT4035) install an O-Ring (AT2100R) at the base of the threads as shown in Figure 4.3. If using an expendable cutting shoe, install an AT2100R O-Ring on the DT21 Expendable Cutting Shoe Holder (DT4040) and two DT4045R O-Rings on the DT21 Expendable Cutting Shoe (DT4045) (Fig. 4.3).
2. Thread the DT21 Cutting Shoe or DT21 Expendable Point Holder into the leading end of a 2.125-inch OD Probe Rod (AT2136, AT2139, or AT2148). Completely tighten the cutting shoe or cutting shoe holder using a machine vise and MC Combination Wrench (AT8590) as shown in Figure 4.4.
3. Install an O-Ring (DT4070R) in both grooves of the DT21 Solid Drive Point (DT4070) (Fig.4.5).
4. Thread the solid drive point into the female end of a 1.0-inch OD probe rod of the same length as the 2.125-inch probe rod (outer casing).
5. Lubricate the O-rings on the solid drive point with a small amount of deionized water. Insert the point and probe rod into the outer casing until the point partially extends from the bottom of the cutting shoe.

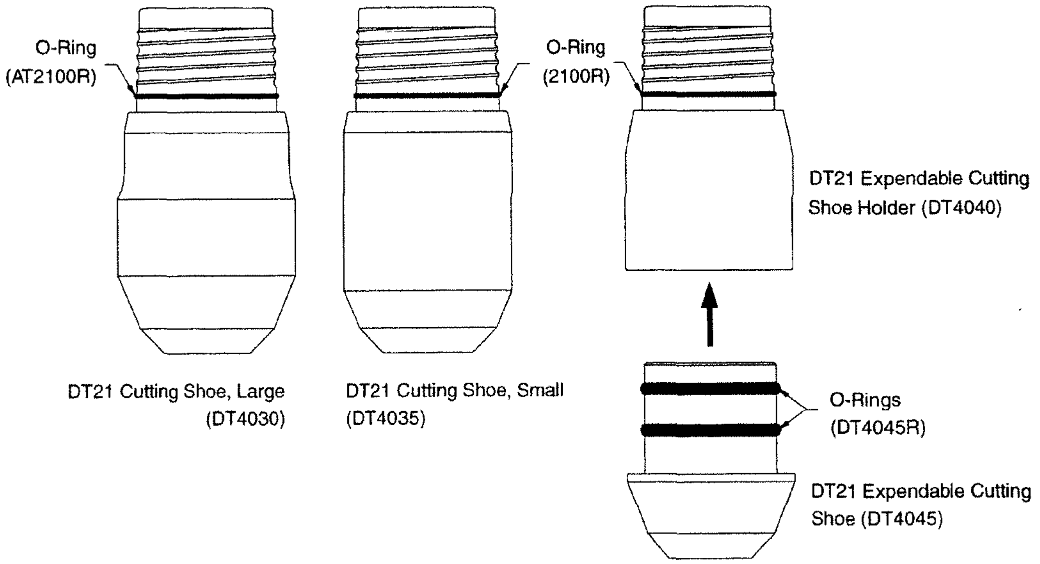


FIGURE 4.3
DT21 Cutting Shoes Utilize O-Ring Seals

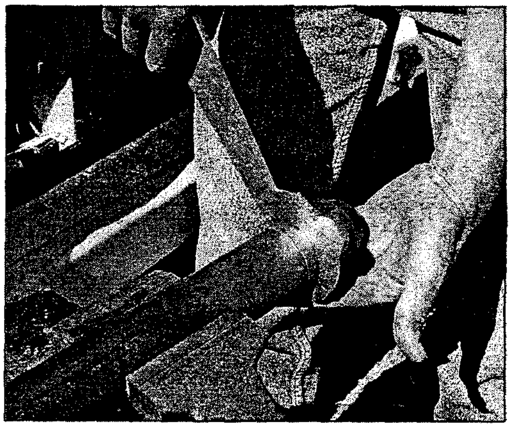


Figure 4.4. Place probe rod (outer casing) in vise and tighten cutting shoe with MC Combination Wrench.

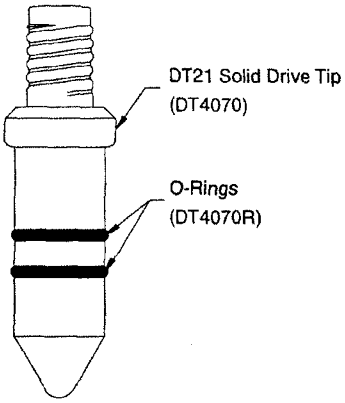


FIGURE 4.5
Solid Drive Point is Fitted with Two O-Rings

6. Place a DT21 Threadless Drive Cap (DT4020) on top of the inner rod (Fig. 4.6). This drive cap is threadless for quick installation/removal, yet still provides protection for the probe rod threads.

7. Thread a Drive Cap (AT2101) onto the 2.125-inch probe rod (outer casing) (Fig. 4.6).

   NOTE: Current AT2101 Drive Caps are manufactured using a drilling process that leaves an angled surface inside the cap (Fig. 4.7). This provides room for the Threadless Drive Cap (DT4020). Older AT2101 Drive Caps were manufactured using a boring process that leaves a flat surface inside the cap (Fig. 4.7). These older drive caps cannot be used with the DT21 Dual Tube System.

8. Place the assembled outer casing section under the probe unit for driving. Position the casing directly under the hammer with the cutting shoe centered between the toes of the probe foot.

9. Lower the hammer onto the drive cap and advance the outer casing into the subsurface.

10. Raise the hammer and remove the DT21 Threadless Drive Cap.

    If the first soil core was collected with a Macro-Core Open-Tube Sampler, the outer casing is now at the bottom of the pre-cored hole. Thread a 1.0-inch probe rod onto the inner rod string and remove the DT21 Solid Drive Point from the outer casing. Continue with Section 4.4 to begin sampling with the DT21 Dual Tube System.

    If the outer casing is to be driven deeper before sampling, continue with Step 11 of this section.

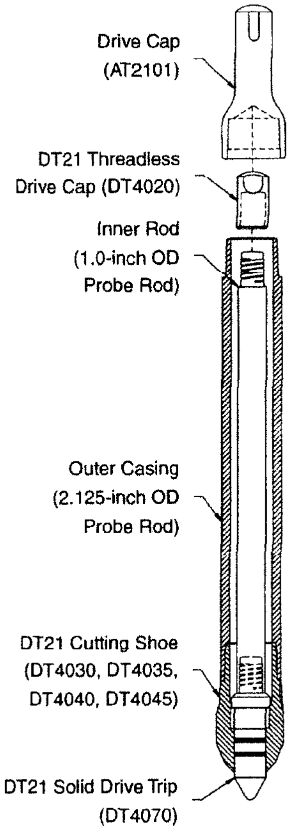


FIGURE 4.6
Outer Casing with Solid Drive Tip

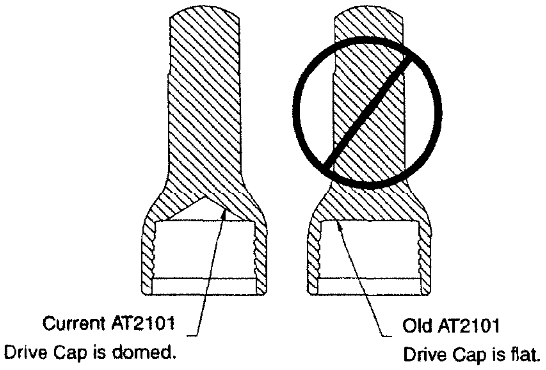


FIGURE 4.7
Comparison of AT2101 Drive Caps

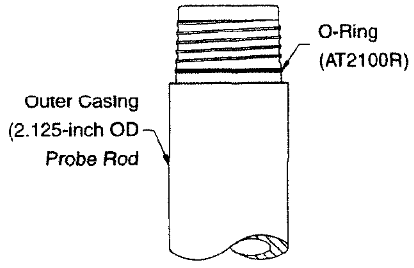


FIGURE 4.8
Outer Casing Joints are Sealed with O-Rings

11. Place an O-Ring (AT2100R) on the outer casing section that extends from the ground (Fig. 4.8).

12. Thread a 1.0-inch probe rod onto the inner rod string. Place a 2.125-inch probe rod over the inner rods and thread it onto the outer casing (Fig. 4.9). Completely tighten the outer casing using a pipe wrench.

13. Place the threadless drive cap on top of the inner rod. Thread the 2.125-inch drive cap over the threadless drive cap and onto the outer casing.

14. Lower the hammer onto the drive cap and advance the outer casing into the subsurface.

    Repeat Steps 10-13 until the leading end of the outer casing is at the top of the proposed sampling interval. Continue with Step 15 to remove the DT21 Solid Drive Point for sampling.

15. Raise the hammer and retract the probe derrick to provide access to the top of the tool string.

16. Unthread the 2.125-inch drive cap and remove the threadless drive cap from the inner rods.

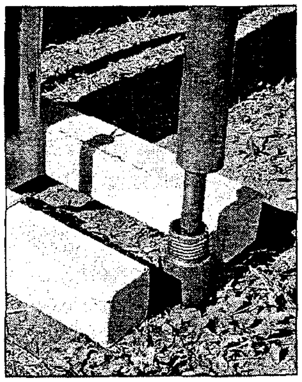


Figure 4.9. Place a 2.125-inch probe rod over the 1.0-inch rod and thread it onto the outer casing string.

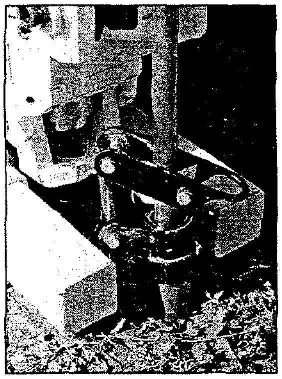


***Figure 4.10. The DT21 Rod* Clamp Assembly holds the inner rod string while adding or removing 1.0-inch rods.**

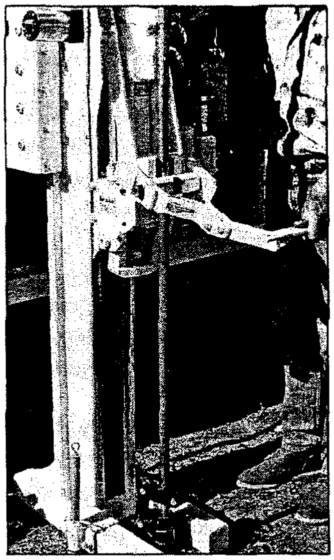


Figure 4.11. Raise the inner rod string using the probe hammer and a Rod Grip Pull Sytem if rods are too heavy to lift by hand.

17. Thread a 1.0-inch OD probe rod onto the inner rod string. Lift and remove the inner rods from the outer casing. The DT21 Solid Drive Point is removed from the leading end of the casing with the inner rods.

    NOTE: Hold the inner rod string with a DT21 Rod Clamp Assembly (DT 4060) while unthreading the retracted rods (4.10). Use the probe hammer and Rod Grip Pull System (GH3000K) to pull the inner rods if they are too heavy to lift comfortably by hand (Fig. 4.11).

The outer casing is now ready for sampling. Continue with Section 4.4 for more instructions.

4.4 Liner Drive Head Assembly

The main function of the DT21 Liner Drive Head Assembly (DT4050) is to connect a PETG liner to the leading end of the inner rod string. This enables the inner rods to hold the liner tight against the cutting shoe to fill the liner with soil as the outer casing is driven. The inner rods are then used to retrieve the full liner from within the outer casing.

The liner drive head assembly includes an internal check ball to improve sample recovery (Fig. 4.12) A considerable vacuum is created below the filled liner as it is lifted from the bottom of the outer casing. Because the inner rod string and liner drive head are hollow, air can rush through the rods and into the top of the liner. The check ball seals the liner drive head so that air does not push the soil sample out the bottom of the liner during retrieval. Then when a new liner is advanced back down the outer casing and when soil enters the liner during sampling, the check ball allows air to escape up through liner drive head and inner rod string.

Saturated conditions can also challenge sample recovery. Water enters the outer casing either from the saturated formation or is deliberately poured from the ground surface to keep flowing sands out of the casing. As with air in unsaturated formations, the check ball lets water pass through the liner drive head as a new liner is lowered to the bottom of the casing and during sampling as the liner is filled with soil. The check ball then seals the drive head during retrieval so that water draining from the inner rods does not wash the sample out the bottom of the liner. A drain hole located on the side of the liner drive head (Fig. 4.12) allows water to exit the inner rods and travel harmlessly along the outside of the liner.

The liner drive head assembly is made up of five parts as shown in Figure 4.13. The two 3/8-inch flat head socket cap screws are used to attach liners to the liner drive head. The longer 5/8-inch flat head socket cap screw holds the stainless steel check ball within the liner drive head. To disassemble the liner drive head for cleaning, simply unthread the 5/8-inch cap screw and remove the check ball.

Instructions for attaching a liner to the DT21 Liner Drive Head Assembly (DT4050) are given below.

1. Visually inspect the liner drive head assembly to ensure that the check ball moves freely within the drive head and the drain hole is unobstructed.

2. Place the liner drive head assembly in a machine vise so that either one of the 3/8-inch caps screws is on top as shown in Figure 4.14.

   NOTE: Only one 3/8-inch cap screw is used to attach a liner to the liner drive head assembly. Two 3/8-inch cap screws are included on the drive head to provide a backup in case one incurs thread damage. Either cap screw may be used to attach the liner.

3. Remove the 3/8-inch cap screw using a 3/32-inch hex key.

4. Place the open end of a DT21 Liner against the bottom of the liner drive head. Align the hole in the liner with the hole in the liner drive head as shown in Figure 4.15. Wiggle the free end of the liner back-and-forth while pushing the liner onto the drive head (Fig. 4.15).

   NOTE: Use the DT21 Liner that matches the length of your probe rods (36 inches, 1 meter, or 48 inches). The 24-inch DT21 Liners (DT4024K) are to be used with 48-inch probe rods only. One 1.0-inch x 24-inch probe rod (AT105B) is also required when using the DT4024K liners.

5. Thread the 3/8-inch cap screw through the liner and back into the liner drive head (Fig. 4.16). Tighten the cap screw with the 3/32-inch hex key.

The DT21 Liner is now attached to the DT21 Liner Drive Head Assembly (Fig. 4.17).

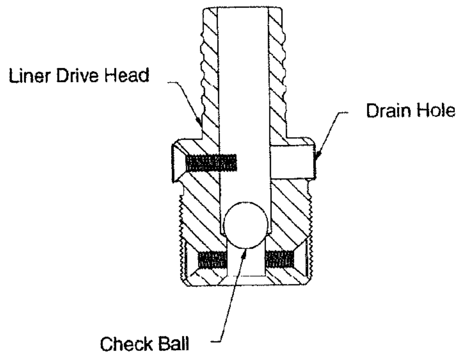


FIGURE 4.12
Cross-Section of Liner Drive Head

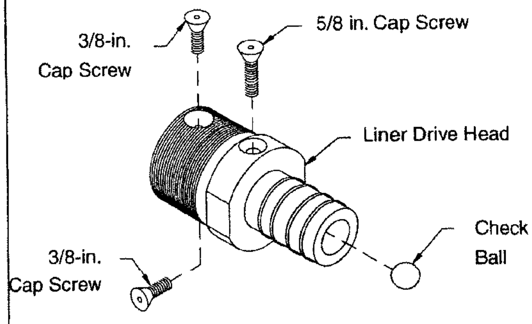


FIGURE 4.13
Liner Drive Head Assembly Components

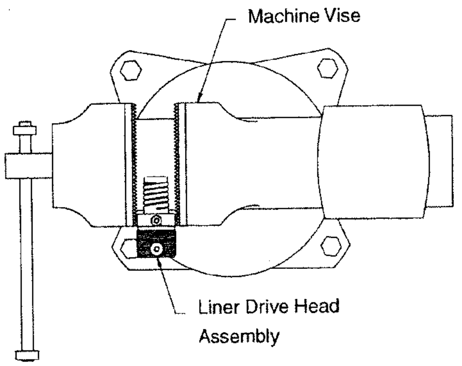
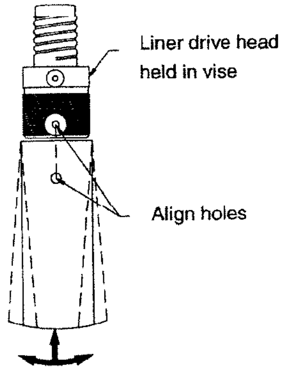


FIGURE 4.14
Place Liner Drive Head in Vise



Move end of liner back and forth while pushing on to drive head

FIGURE 4.15
Push Liner Onto Liner Drive Head

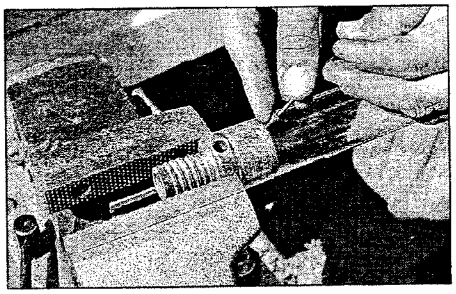


Figure 4.16. Thread cap screw into liner drive head to secure liner.

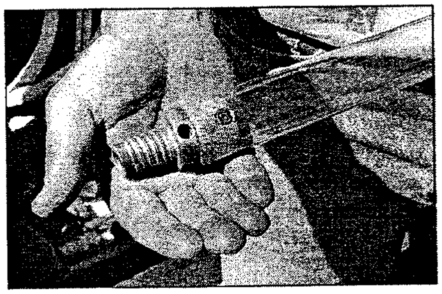


Figure 4.17. Liner attached to liner drive head and ready for sampling.

4.5 Soil Core Collection

This section describes the procedure for collecting continuous core samples from within the sealed outer casing of the DT21 Dual Tube Soil Sampling System. The procedure is to be performed after the outer casing is driven to the top of the sampling interval using a DT21 Solid Drive Tip.

1. Place an O-Ring (AT2100R) in the groove just below the male threads on the top section of the outer casing (Fig. 4.18).

2. Thread a 1.0-inch probe rod onto an assembled DT21 Liner Drive Head and DT21 Liner (Fig. 4.19).

   NOTE: A 1.0-inch x 24-inch Probe Rod (AT105B) is first threaded onto the DT21 Liner Drive Head Assembly (DT4050) if using a 24-inch DT21 Liner (DT4024K).

3. Insert the liner and probe rod into the outer casing (Fig. 4.20).

   The inner rod will extend past the top of the outer casing if only one section of casing was previously driven into the ground. If the casing was driven to a greater depth, continue adding 1.0-inch probe rods until the last rod extends from the casing. Use the DT21 Rod Clamp Assembly to hold the inner tool string while adding rods if desired.

4. Place a 2.125-inch probe rod over the inner rods and thread it onto the outer casing (Fig. 4.21). Completely tighten the outer casing using a pipe wrench.

5. Put a DT21 Drive Bumper (DT4010K) on top of the inner rod as shown in Figure 4.22.

6. Thread a Drive Cap (AT2101) onto the 2.125-inch probe rod (Fig. 4.22). Completely tighten the drive cap with a pipe wrench.

   NOTE: Current AT2101 Drive Caps are manufactured using a drilling process that leaves an angled surface inside the cap (Fig. 4.23). This provides room for a Drive Bumper (DT4010K). Older AT2101 Drive Caps were manufactured using a boring process that leaves a flat surface inside the cap (Fig. 4.23). These older caps do not leave room for a drive bumper and therefore cannot be used with the DT21 Dual Tube System.

7. Lower the hammer onto the drive cap and advance the outer casing one liner length into the subsurface to collect the first soil core. Apply hammer percussion to the tool string as this helps move soil through the cutting shoe and into the liner for increased sample recovery.

8. Raise the hammer and retract the probe derrick to provide access to the top of the tool string.

9. Unthread the Drive Cap (AT2101) and remove the DT21 Drive Bumper (DT4010K).

10. Thread a 1.0-inch OD probe rod onto the inner rod (Fig. 4.24). Rotate the inner rod string 2 or 3 revolutions to shear the soil core at the bottom of the liner. Raise the inner rods to retrieve the filled liner from the outer casing.

    NOTE: Hold the inner rod string with a DT21 Rod Clamp Assembly (DT 4060) while unthreading the retracted rods (Fig. 4.25). Use the probe hammer and Rod Grip Pull System (GH3000K) to pull the inner rods if they are too heavy to lift comfortably by hand (Fig. 4.26).

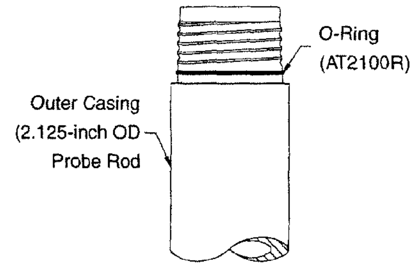


FIGURE 4.18
Outer Casing Joints are Sealed with O-Rings

Figure 4.19. Thread liner and liner drive head into 1.0-inch probe rod.

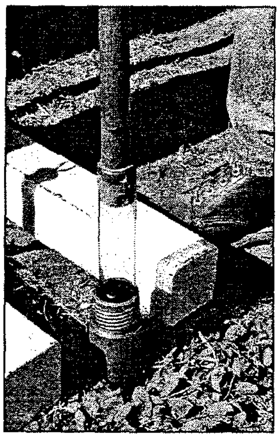


Figure 4.20. Lower liner to bottom of outer casing on leading end of inner rods.

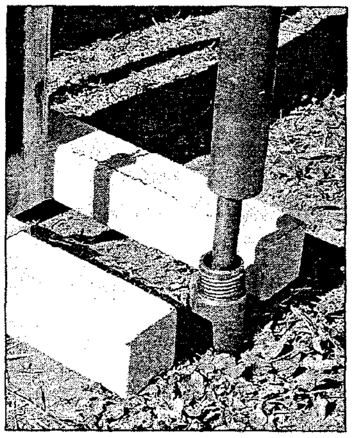


Figure 4.21. Place a 2.125-inch probe rod over the 1.0-inch probe rod and thread it onto the outer casing string.

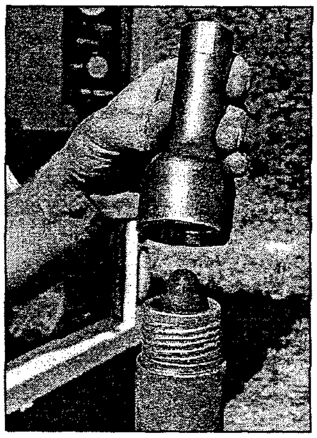


Figure 4.22. Place a drive bumper on top of the inner rods and thread a drive cap onto the outer casing.

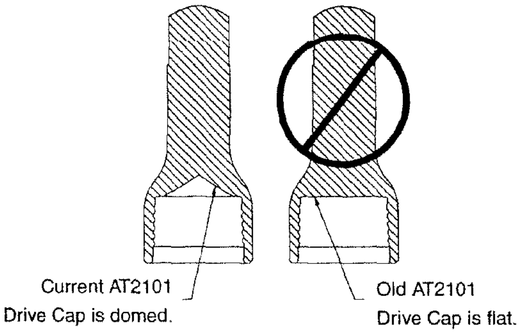


FIGURE 4.23
Comparison of AT2101 Drive Caps

Figure 4.24. Thread a 1.0-inch probe rod onto inner rod string to retrieve filled liner.

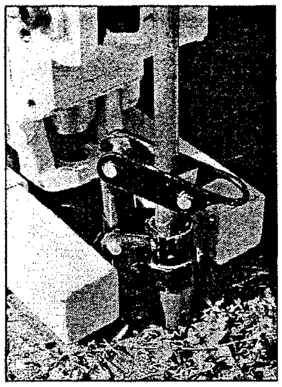


Figure 4.25. The DT21 Rod Clamp Assembly holds the inner rod string while adding or removing 1.0-inch rods.

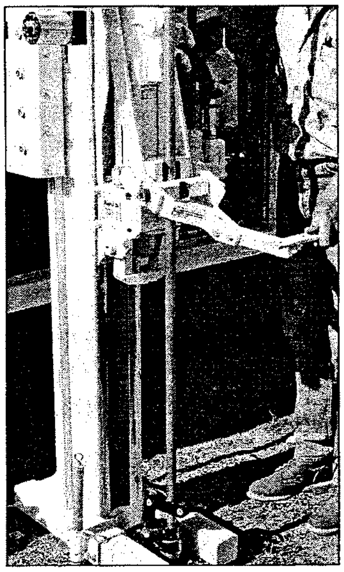


Figure 4.26. Raise the inner rod string using the probe hammer and a Rod Grip Pull Sytem if rods are too heavy to lift by hand.

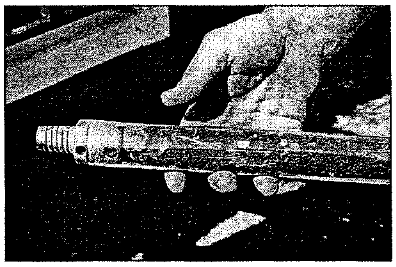


Figure 4.27. Liner drive head attached to filled liner after retrieval from outer casing.

Figure 4.28. Score a line from top of liner to base of liner drive head using a utility knife.

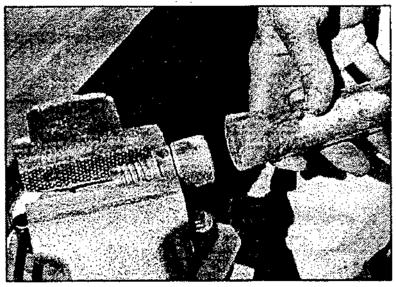


Figure 4.29. Move free end of liner back-and-forth to split liner and free it from the liner drive head.

11. Unthread the last probe rod from the liner/drive head assembly. The DT21 Drive Head Assembly remains attached to the DT21 Liner (Fig. 4.27).

12. Place the liner drive head in a machine vise so that the 3/8-inch cap screw threaded through the liner is on top. Remove the cap screw with a 3/32-inch hex key.

13. Using a utility knife, score a line from the top of the liner to the bottom of the drive head (Fig. 4.28). Move the free end of the liner back-and-forth until the top of the liner splits and releases from the drive head (Fig. 4.29). The soil core is now prepared for storage or analysis according to project guidelines.

Repeat the procedure given in this section to collect consecutive soil core samples.

4.6 Dual Tube Soil Sampling Tips

Saturated sands are the hardest formations to sample with the DT21 system. Saturated conditions place a positive pressure on the soil outside of the outer casing. In saturated, noncohesive formations (e.g. sands) below the water table, it may be necessary to add water to the bore of the probe rods. Adding water to the probe rods puts a positive head on the system and may keep these materials from flowing into the rods as a sample is retracted. Additionally, the shorter 24-inch liners may be used to collect samples under these conditions. Collecting a shorter sample will minimize the vacuum created as the sample is retracted inside the rod bore. This may help minimize the heave of noncohesive materials into the rods. A shorter sample interval may also enhance sample recovery in sandy materials.

Some clay materials will expand as they are sampled. Under these conditions using a shorter sample interval (24-inch liners) may also improve sample recovery by minimizing the wall friction as the material is sampled.

4.7 Outer Casing Retrieval

The outer casing of the DT21 Dual Tube System may be retrieved in one of three ways:

1. Casing pulled then probe hole sealed from ground surface with granular bentonite.

   The outer casing may be pulled from the ground with the probe machine and a Pull Cap (AT2104) or a Rod Grip Pull System (GH3000K) if the probe hole is to be sealed with granular bentonite from the ground surface (Fig. 4.30). This method is used for shallow probe holes in stable formations only. Such conditions allow the entire probe hole to be sealed with granular bentonite.

2. Casing pulled with probe hole sealed from bottom-up during retrieval.

   Bottom-up grouting should be performed during casing retrieval in unstable formations where side slough is probable. Such conditions create void spaces in the probe hole if granular bentonite is installed from the ground surface.

   A GS500 or GS1000 Grout Machine is used to deliver a sealing material (high-solids bentonite slurry or neat cement grout) to the bottom of the outer casing through flexible tubing. The grout mix is pumped through the tubing to seal the void remaining as the outer casing is retrieved (Fig. 4.31). This is an advantage of the DT21 Dual Tube System as other soil samplers require a second set of tools to deliver grout to the bottom of the probe hole. Contact Geoprobe Systems for more information on bottom-up grouting with the GS500 and GS1000 Grout Machines.

3. Casing pulled with Geoprobe Prepacked Screen Well installed during retrieval.

   The final option is to install a Geoprobe Prepacked Screen Monitoring Well in the probe hole during retrieval of the outer casing. A DT21 Expendable Cutting Shoe Holder (DT4040) and a DT21 Expendable Cutting Shoe (DT4045) allow the operator to collect continuous soil cores as the outer casing is driven to depth. When sampling is complete, the outer rods are raised and the expendable cutting shoe is removed from the leading rod. This leaves an open casing through which a set of prepacked screens is lowered on the leading end of a PVC riser string (Fig. 4.32). The well is finished, complete with grout barrier, bentonite well seal, and a high-solids bentonite slurry/neat cement grout, during retrieval of the outer casing.

Refer to the Geoprobe Prepacked Screen Monitoring Well Standard Operating Procedure (Technical Bulletin No. 962000) for specific information on well installation.

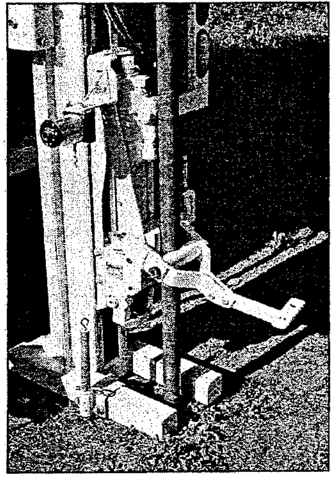


Figure 4.30 Outer casing may be retrieved with a pull cap or rod grip pull system if the probe hole is sealed with granular bentonite.

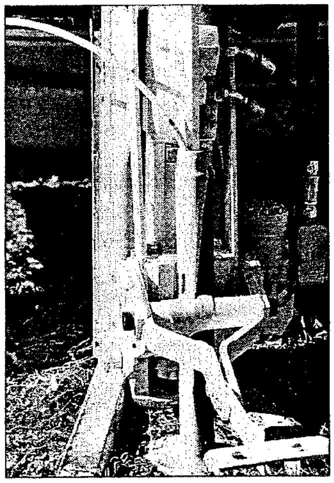


Figure 4.31. A grout machine and flexible tubing allow bottom-up grouting as the outer casing is retrieved.

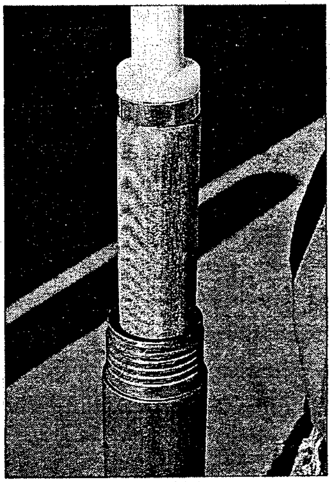


Figure 4.32. Geoprobe prepacked screens may be installed through the outer casing when an expendable cutting shoe is used.

5.0 REFERENCES

Geoprobe Systems, October, 1997, "1998-99 Tools and Equipment Catalog".

Geoprobe Systems, Macro-Core® Soil Sampler SOP, Technical Bulletin No. 958500, 1998

Geoprobe Systems, Prepacked Screen Monitoring Well SOP, Technical Bulletin No. 962000, 1998

Equipment and tool specifications, including weights, dimensions, materials, and operating specifications included in this brochure are subject to change without notice. Where specifications are critical to your application, please consult Geoprobe Systems.

APPENDIX B

BORING LOGS

SOIL CLASSIFICATION AND REMARKS SEE KEY SYMBOL SHEET FOR EXPLANATION OF SYMBOLS AND ABBREVIATIONS BELOW.	LEGEND	DRY DENSITY (PCF)	MOISTURE CONTENT (%)
FLY ASH - DRY		78.9	25.2
		55.1	59.6
FLY ASH - WET		84.4	51.7
FLY ASH - VERY WET; VERY LITTLE RECOVERY		---	---
FLY ASH - WET		63.4	56.1
		71.4	42.4
		75	39.8
		76.4	38.9
		72.5	44.5
FLY ASH - A LITTLE WET		74.9	41.8
FLY ASH - DRY			
BROWN SILTY CLAY			
BORING TERMINATED AT 36.0'			

DEPTH (ft)	ELEV (ft)
0	390.2
5	385.2
10	380.2
15	375.2
20	370.2
25	365.2
30	360.2
35	355.2
40	350.2
45	345.2

PL (%) — LL (%)

▲ FINES (%)

● SPT (bpf)

10 20 30 40 50 60 70 80 90 100

0 10 20 30 40 50 60 70 80 90 100

GEOPROBE_COORDS_DRY_MOIST 3031032136_01.GPJ LAW_GIBB.GDT 11/26/03

REMARKS:

THIS RECORD IS A REASONABLE INTERPRETATION OF SUBSURFACE CONDITIONS AT THE EXPLORATION LOCATION. SUBSURFACE CONDITIONS AT OTHER LOCATIONS AND AT OTHER TIMES MAY DIFFER. INTERFACES BEWEEN STRATA ARE APPROXIMATE. TRANSITIONS BETWEEN STRATA MAY BE GRADUAL.

Driller : S. Smith
Prepared By: KCC
Checked By:

GEOPROBE TEST BORING RECORD

PROJECT: Johnsonville Fossil Plant
DRILLED: November 10, 2003 **BORING NO.:** C2-1
COORDINATES: North: 602411.39, East: 1410696.53
PROJ. NO.: 3031032136/0001 **PAGE** 1 **OF** 1

MACTEC

DEPTH (ft)	SOIL CLASSIFICATION AND REMARKS SEE KEY SYMBOL SHEET FOR EXPLANATION OF SYMBOLS AND ABBREVIATIONS BELOW.	LEGEND	ELEV (ft)	DRY DENSITY (PCF)	MOISTURE CONTENT (%)	PL (%) LL (%) ▲ FINES (%) ● SPT (bpf) 10 20 30 40 50 60 70 80 90 100
0	FLY ASH - DRY		390.1	80	30.6	
5			385.1	69	46.4	5
				63.5	53.3	
10			380.1			10
				75.6	38.4	
15			375.1			15
	FLY ASH - WET			89.2	35.1	
20	NO RECOVERY		370.1			20
				---	---	
	FLY ASH - WET					
25			365.1	78.7	35.8	25
				70.3	48.5	
30			360.1			30
	BORING TERMINATED AT 32.0'					
35			355.1			35
40			350.1			40
45			345.1			0 10 20 30 40 50 60 70 80 90 100

REMARKS:

THIS RECORD IS A REASONABLE INTERPRETATION OF SUBSURFACE CONDITIONS AT THE EXPLORATION LOCATION. SUBSURFACE CONDITIONS AT OTHER LOCATIONS AND AT OTHER TIMES MAY DIFFER. INTERFACES BEWEEN STRATA ARE APPROXIMATE. TRANSITIONS BETWEEN STRATA MAY BE GRADUAL.

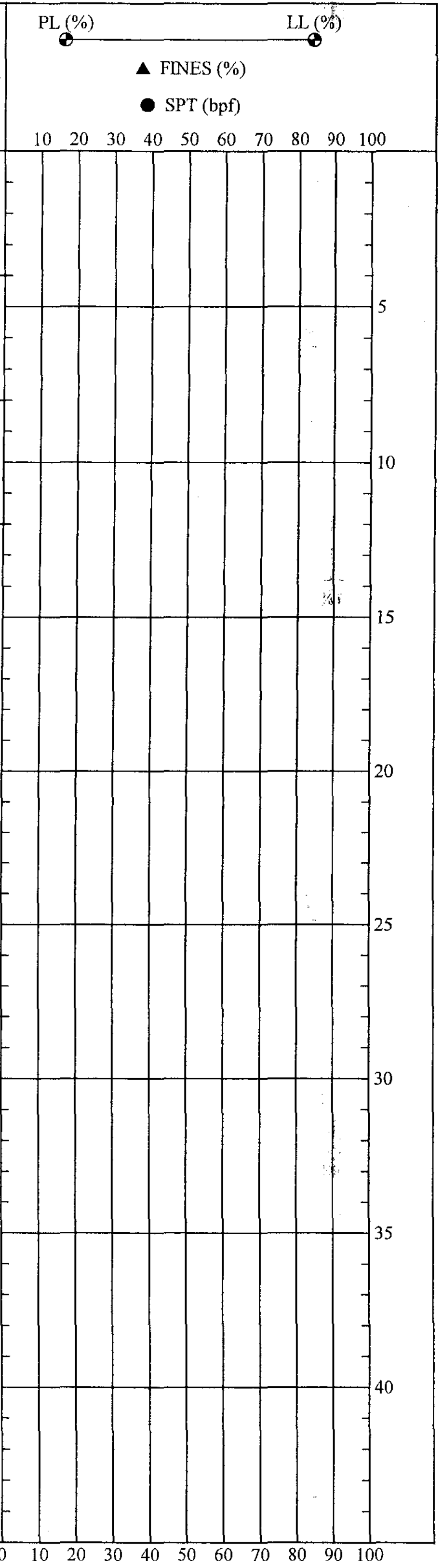
Driller : S. Smith
Prepared By: KJC
Checked By: ADL

GEOPROBE TEST BORING RECORD

PROJECT: Johnsonville Fossil Plant
DRILLED: November 11, 2003 **BORING NO.:** C2-6
COORDINATES: North: 602581.44, East: 1410738.05
PROJ. NO.: 3031032136/0001 **PAGE** 1 **OF** 1

MACTEC

DEPTH (ft)	SOIL CLASSIFICATION AND REMARKS SEE KEY SYMBOL SHEET FOR EXPLANATION OF SYMBOLS AND ABBREVIATIONS BELOW.	LEGEND	ELEV (ft)	DRY DENSITY (PCF)	MOISTURE CONTENT (%)
0	FLY ASH - WET		389.4		
				73.7	32.1
5			384.4	72.8	43.6
				71.3	42.3
10			379.4		
15			374.4		
	FLY ASH - NO RECOVERY				
				---	---
20	FLY ASH - WET		369.4		
25			364.4	84.5	34.1
				---	40.9
30	BROWN SILTY CLAY		359.4		
	BORING TERMINATED AT 32.0'				
35			354.4		
40			349.4		
45			344.4		



GEOPROBE_COORDS_DRY_MOIST 3031032136_01.GPJ LAW_GIBB.GDT 11/26/03

REMARKS:

THIS RECORD IS A REASONABLE INTERPRETATION OF SUBSURFACE CONDITIONS AT THE EXPLORATION LOCATION. SUBSURFACE CONDITIONS AT OTHER LOCATIONS AND AT OTHER TIMES MAY DIFFER. INTERFACES BEWEEN STRATA ARE APPROXIMATE. TRANSITIONS BETWEEN STRATA MAY BE GRADUAL.

Driller : S. Smith
Prepared By:
Checked By:

GEOPROBE TEST BORING RECORD

PROJECT: Johnsonville Fossil Plant
DRILLED: November 11, 2003 **BORING NO.:** C2-9
COORDINATES: North: 602683.29, East: 1410758.93
PROJ. NO.: 3031032136/0001 **PAGE** 1 **OF** 1

MACTEC

DEPTH (ft)	SOIL CLASSIFICATION AND REMARKS SEE KEY SYMBOL SHEET FOR EXPLANATION OF SYMBOLS AND ABBREVIATIONS BELOW.	LEGEND	ELEV (ft)	DRY DENSITY (PCF)	MOISTURE CONTENT (%)	PL (%) — LL (%) ▲ FINES (%) ● SPT (bpf) 10 20 30 40 50 60 70 80 90 100
0	FLY ASH - DRY		389.8	72.2	27.2	
				69.5	45	
5			384.8			
				67.1	50.9	
	FLY ASH - WET					
10			379.8	66.6	50.4	
				73.7	42.5	
15			374.8	72	44.7	
				70.7	44	
20			369.8			
				75.2	39.6	
	BORING TERMINATED AT 24.0'					
25			364.8			
30			359.8			
35			354.8			
40			349.8			
45			344.8			0 10 20 30 40 50 60 70 80 90 100

GEOPROBE_COORDS_DRY_MOIST 3031032136_01.GPJ LAW_GIBB.GDT 11/26/03

REMARKS:

THIS RECORD IS A REASONABLE INTERPRETATION OF SUBSURFACE CONDITIONS AT THE EXPLORATION LOCATION. SUBSURFACE CONDITIONS AT OTHER LOCATIONS AND AT OTHER TIMES MAY DIFFER. INTERFACES BEWEEN STRATA ARE APPROXIMATE. TRANSITIONS BETWEEN STRATA MAY BE GRADUAL.

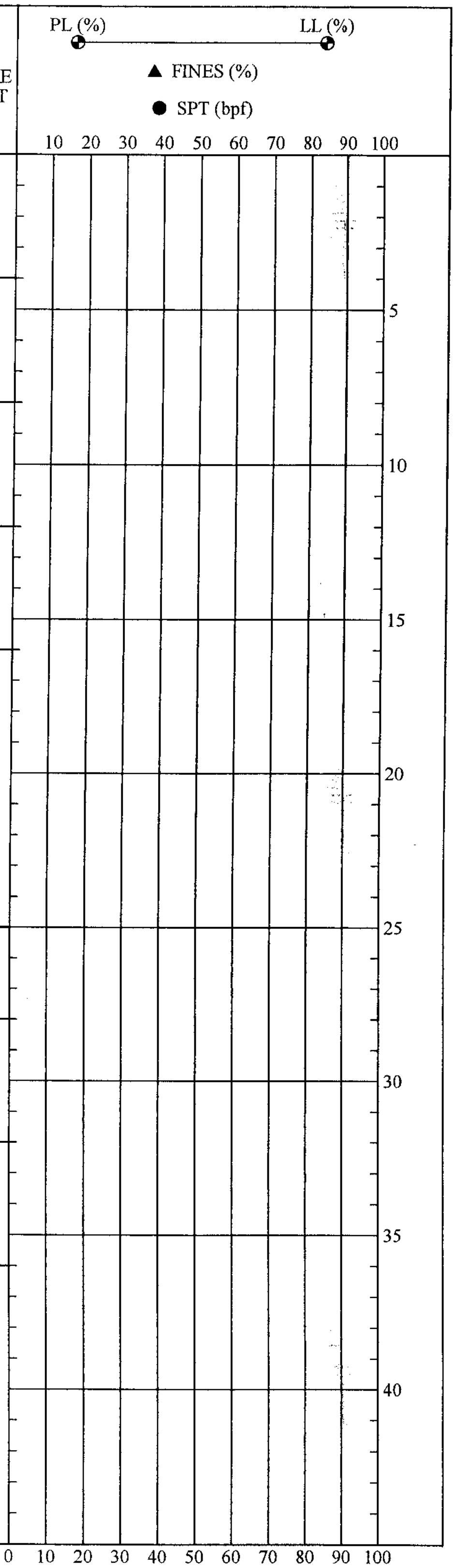
Driller : S. Smith
Prepared By: KCC
Checked By: ADA

GEOPROBE TEST BORING RECORD

PROJECT: Johnsonville Fossil Plant
DRILLED: November 10, 2003 **BORING NO.:** C2-10
COORDINATES: North: 602530.93, East: 1410802.03
PROJ. NO.: 3031032136/0001 **PAGE** 1 **OF** 1

MACTEC

DEPTH (ft)	SOIL CLASSIFICATION AND REMARKS SEE KEY SYMBOL SHEET FOR EXPLANATION OF SYMBOLS AND ABBREVIATIONS BELOW.	LEGEND	ELEV (ft)	DRY DENSITY (PCF)	MOISTURE CONTENT (%)
0	FLY ASH - DRY		389.7		
				---	---
5			384.7	69.6	45.3
				59.3	51.3
10			379.7		
	FLY ASH - WET			65.7	52.6
15			374.7		
	FLY ASH - NO RECOVERY				
20	FLY ASH - VERY WET		369.7	---	---
	FLY ASH - WET, GOOD RECOVERY				
25			364.7	75.8	35.5
	FLY ASH - WET			77.6	38
30			359.7		
				78.5	45.4
	BROWN SILTY CLAY				
35			354.7		
	BORING TERMINATED AT 36.0'				
40			349.7		
45			344.7		



GEOPROBE_COORDS_DRY_MOIST 3031032136_01.GPJ LAW_GIBB.GDT 11/26/03

REMARKS:

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Driller : S. Smith
Prepared By: Kol
Checked By: SDA

GEOPROBE TEST BORING RECORD

PROJECT: Johnsonville Fossil Plant
DRILLED: November 11, 2003 **BORING NO.:** C2-16
COORDINATES: North: 602569.88, East: 1410666.96
PROJ. NO.: 3031032136/0001 **PAGE** 1 **OF** 1

MACTEC

DEPTH (ft)	SOIL CLASSIFICATION AND REMARKS SEE KEY SYMBOL SHEET FOR EXPLANATION OF SYMBOLS AND ABBREVIATIONS BELOW.	LEGEND	ELEV (ft)	DRY DENSITY (PCF)	MOISTURE CONTENT (%)
0	FLY ASH - DRY		390.1	78.1	30.4
				71.2	41.2
5			385.1		
				76.9	38.3
	FLY ASH - WET				
10			380.1	75.1	38.8
				67.7	49.4
15			375.1	71.8	44.4
	FLY ASH - VERY WET			76.6	40.1
20			370.1	74.1	40.9
	BORING TERMINATED AT 24.0'				
25			365.1		
30			360.1		
35			355.1		
40			350.1		
45			345.1		

PL (%) LL (%)

▲ FINES (%)

● SPT (bpf)

10 20 30 40 50 60 70 80 90 100

0 10 20 30 40 50 60 70 80 90 100

GEOPROBE_COORDS_DRY_MOIST 3031032136_01.GPJ LAW_GIBB.GDT 11/26/03

REMARKS:

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Driller : S. Smith
Prepared By: KOL
Checked By: ADL

GEOPROBE TEST BORING RECORD

PROJECT: Johnsonville Fossil Plant
DRILLED: November 10, 2003 **BORING NO.:** C2-17
COORDINATES: North: 602475.70, East: 1410744.16
PROJ. NO.: 3031032136/0001 **PAGE** 1 **OF** 1

MACTEC

DEPTH (ft)	SOIL CLASSIFICATION AND REMARKS SEE KEY SYMBOL SHEET FOR EXPLANATION OF SYMBOLS AND ABBREVIATIONS BELOW.	LEGEND	ELEV (ft)	DRY DENSITY (PCF)	MOISTURE CONTENT (%)	PL (%) ● — ● LL (%) ▲ FINES (%) ● SPT (bpf) 10 20 30 40 50 60 70 80 90 100
0	FLY ASH - DRY USED MACRO SAMPLER		390.0	67.6	30.2	
5	FLY ASH - DRY		385.0	63.5	49.4	5
10	FLY ASH - WET		380.0	66.7	47.5	10
15	FLY ASH - VERY WET		375.0	---	---	15
				73.9	41.4	
20	FLY ASH - VERY WET, VERY LITTLE RECOVERY		370.0	---	---	20
25	NO RECOVERY		365.0	---	---	25
30	FLY ASH - VERY WET, LITTLE RECOVERY		360.0	81.9	37.8	30
35	GRAY SILTY CLAY		355.0			35
40	BORING TERMINATED AT 37.0'		350.0			40
45			345.0			0 10 20 30 40 50 60 70 80 90 100

GEOPROBE_COORDS_DRY_MOIST 3031032136_01.GPJ LAW_GIBB.GDT 11/26/03

REMARKS:

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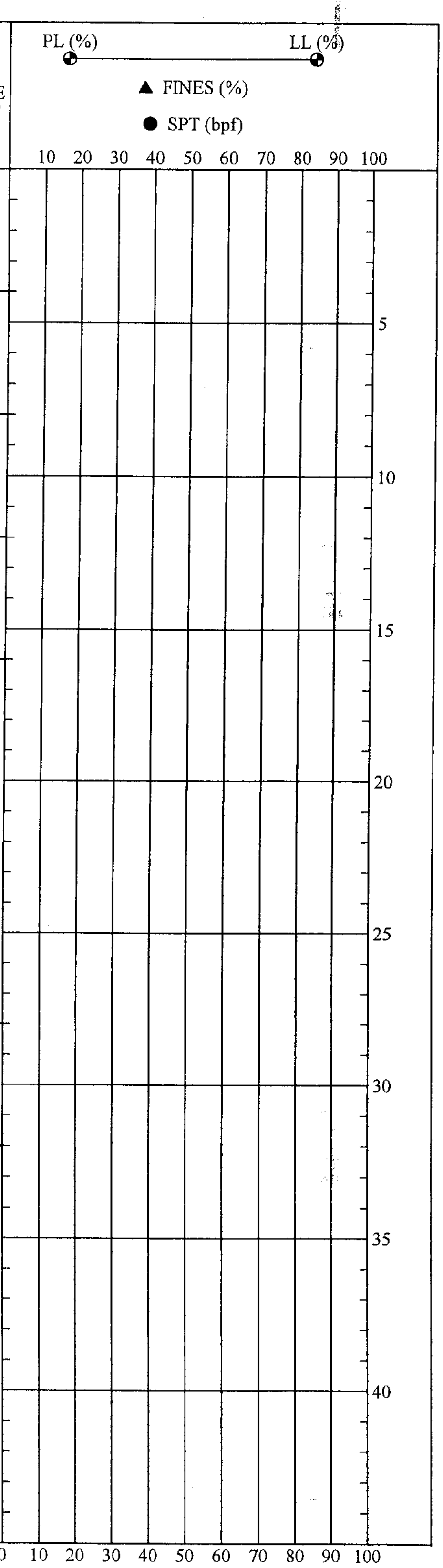
Driller : S. Smith
Prepared By: Kel
Checked By: SDS

GEOPROBE TEST BORING RECORD

PROJECT: Johnsonville Fossil Plant
DRILLED: November 11, 2003 **BORING NO.:** C2-18
COORDINATES: North: 602494.31, East: 1410682.14
PROJ. NO.: 3031032136/0001 **PAGE** 1 **OF** 1

MACTEC

DEPTH (ft)	SOIL CLASSIFICATION AND REMARKS SEE KEY SYMBOL SHEET FOR EXPLANATION OF SYMBOLS AND ABBREVIATIONS BELOW.	LEGEND	ELEV (ft)	DRY DENSITY (PCF)	MOISTURE CONTENT (%)
0	FLY ASH - DRY		388.7	71.3	35.4
5			383.7	65.9	42.2
	FLY ASH - WET			73.2	39.2
10			378.7		
				73.1	41.5
15			373.7		
	FLY ASH - VERY WET, LITTLE RECOVERY				
20	NO RECOVERY		368.7		
				---	---
	FLY ASH - VERY WET				
25			363.7		
	FLY ASH - WET			85.1	35.1
30			358.7		
	SANDY BROWN CLAY				
	BORING TERMINATED AT 32.0'				
35			353.7		
40			348.7		
45			343.7		



GEOPROBE_COORDS_DRY_MOIST 3031032136_01.GPJ LAW_GIBB.GDT 11/26/03

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Driller : S. Smith
Prepared By: kl
Checked By: SDS

GEOPROBE TEST BORING RECORD

PROJECT: Johnsonville Fossil Plant
DRILLED: November 11, 2003 **BORING NO.:** C2-19
COORDINATES: North: 602628.87, East: 1410774.41
PROJ. NO.: 3031032136/0001 **PAGE** 1 **OF** 1

MACTEC

DEPTH (ft)	SOIL CLASSIFICATION AND REMARKS SEE KEY SYMBOL SHEET FOR EXPLANATION OF SYMBOLS AND ABBREVIATIONS BELOW.	LEGEND	ELEV (ft)	DRY DENSITY (PCF)	MOISTURE CONTENT (%)
0	FLY ASH - DRY		389.3		
				63.9	35.9
5			384.3	64.4	45.8
	FLY ASH - WET			71.2	47.7
10			379.3		
				77.2	39.7
15			374.3		
20			369.3	---	---
25			364.3	62.7	33.2
					38.3
30			359.3	---	
	BROWN SILTY CLAY AND GRAVEL				
	BORING TERMINATED AT 32.0'				
35			354.3		
40			349.3		
45			344.3		

PL (%) LL (%)

▲ FINES (%)

● SPT (bpf)

10 20 30 40 50 60 70 80 90 100

0 10 20 30 40 50 60 70 80 90 100

REMARKS:

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Driller : S. Smith

Prepared By:

Checked By:

GEOPROBE TEST BORING RECORD

PROJECT: Johnsonville Fossil Plant

DRILLED: November 11, 2003 **BORING NO.:** C2-20

COORDINATES: North: 602629.22, East: 1410720.62

PROJ. NO.: 3031032136/0001 **PAGE** 1 **OF** 1

MACTEC