United States Department of Agriculture

Soil Conservation Service

Northeast NTC
160 E. 7th Street
Chester, PA 19013

Subject: SOI - GPR Trip Summary - Massachusetts, July 29-August 2, 1985

Date: August 20, 1985

To: Rex O. Tracy
State Conservationist
Soil Conservation Service
Amherst, MA

File Code: 430

PURPOSE

To use the ground penetrating radar to determine the composition of selected map units within the southern part of the Worcester County Survey Area.

PARTICIPANTS

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Maureen Lowry, Soil Scientist, NW Worcester District, Spencer, MA
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Eric Swenson, Party Leader, SCS, Spencer, MA
William Taylor, Party Leader, SCS, Spencer, MA

EQUIPMENT

The equipment used during this field trip was the SIR System-8 with microprocessor, the ADTEK SR-8004H graphic recorder, and the ADTEK DT-6000 tape recorder. To test its operational suitability, only one antenna (120 MH_z) was used. With the exception of areas underlain by phyllite and schist bedrock, the 120 MH_z antenna was suited to all transected sites and soil conditions. The 80 MH_z antenna, based on field studies conducted in Vermont and New Hampshire is more suitable for applications in areas underlain by schist or phyllites. The GPR system operated well with no malfunctions. A tire on the GPR vehicle, was punctured while conducting transects in rough and forested terrain, and was replaced.

ACTIVITIES

Prior to the arrival of the GPR unit, accessible sites were selected for conducting transects in the southern part of Worcester County. Twenty-six transects were conducted during the period of 30 July through 1 August. Heavy rains and generally inclement weather restricted field work on 31 July. Repairing and replacing a punctured tire consumed additional time on 1 and 2 August. Though the GPR unit was not operated in the field on 2 August, several transects were checked for proper soil and drainage classification.

DISCUSSION

Multiple transects were conducted on seven established map units in the southern part of Worcester County. The radar provided clear and interpretable imagery in 24 of the 26 transects and in all map units investigated with the exception of map unit 4C, Brimfield fine sandy loam, 8 to 15 percent slopes. The Brimfield (loamy, mixed, mesic Lithic Dystrochrepts) soils formed in loamy till derived from micaceous schist. While imagery was clear and interpretable in some areas, in others it was too indistinct for reliable interpretations. Therefore, the collected data was not used. Though not used during this study, the 80 MH_z antenna provided the best combination of resolution and penetrating depths on similar soils in Vermont. It will be used in the future.

Sufficient data has been collected to verify the composition of several map units at a high degree of confidence. While additional transects are encouraged, sufficient data has been collected in map units 8C, 37B, and 124C to insure estimates with a 90 or 95 percent level of confidence. Additional transects are required in map units 123C, 123D, and 124D.

The enclosures illustrate an established method for grouping similar soils and expressing confidence levels and limits for complexes. While expressions of confidence levels and limits have been discouraged from the nontechnical portion of soil survey reports, statistical information can be included in tabular form in the technical portion. Table 1 provides an example of a tabular format.

SUMMARY

This was a working trip. The GPR provided measurable results on all but one map unit and soil. The GPR completed 26 transects in 2.5 days of field work (10.4 transects per day). This number will increase as familiarity is increased with the soils. Confidence in the ability of the GPR to discern the soil/bedrock contact has been improved. Compared with traditional methods the GPR is (1) many times faster, (2) minimizes required borings, (3) allows greater areas to be sampled per observation, and (4) is less likely to miss or miscalculate depths to bedrock in deeper zones (greater than 40 inches). But skeptics remain, and will remain, until a comparative study is completed, evaluating results obtained with GPR and traditional methods. I would welcome an opportunity to conduct this study in Massachusetts with members of the Soil Survey Staff and the Soils Department of UMASS as participants.

All profiles have been returned to Bill Taylor.

Thank you for the opportunity to work again in your state and with members of your staff.

James A. Doolittle
Soil Specialist (GPR)

Enclosures

cc:
A. Holland
G. Grice
W. Taylor

J. A. Doolittle
JADoolittle/kmg

TABLE 1

Map Unit Name and Symbol*	# Transects	Components	%	Confid Int	Confid Level	Contrasting Soils	%
8C Chatfield-Hollis-Charlton complex, 8 to 15 percent slopes	7	Chatfield	33%	49-73%	95	Other	6%
		Similar	28%				
		Hollis	11%	7-27%	95		
		Similar	6%				
		Charlton	13%				
		Similar	3%				
37B Sudbury-Merrimac complex, 3 to 8 percent slopes	5	Sudbury	44%	A		Walpole	6%
		Similar	6%			Hinckley	2%
		Merrimac	28%				
		Similar	14%				
124C Paxton-Woodbridge complex, 8 to 15 percent slopes	4	Paxton	42%	A		Ridgeway	5%
		Similar	10%			Chatfield	5%
		Woodbridge	25%				
		Similar	13%				

* Names are based upon dominant soil present and guidelines expressed in NSH. These are not the correlated names.

A Sufficient transects have been collected to verify the accuracy of the dominant soils collectively. More transects may be desired to establish confidence levels for each of the codominant soils.

Enclosure 1

NAME OF MAPPING UNIT 8C Chatfield, fine sandy loam, 8 to 15% slopes

SOIL SURVEY AREA

SOIL SERIES OR PEDON		Transect Numbers 1 %	2 %	3 %	4 %	5 %	6 %	7 %	8 %	9 %	10 %					$\bar{X}$ %	
0-10"	MWD	10														1%	1%
10-20"	ED		10							10						2%	12% Holl
	WD	10	10			10	10			10	10					7%	
	MWD		10				20									3%	
20-40"	ED	10	10	20			10				10					7%	32%
	WD	40	20	20		10	10			60	10					25	
	MWD		10			20	10									4%	
	SWP							20	10		10					4%	4 52
40-60"	ED		20	10												3%	20%
	WD	10	10			10				20	10					7%	
	MWD			20		20	20		30							10%	
	SWP					10		10	10							3%	3
	PD	10									10					2%	2
60-80	WD					10	10	20								4%	26%
	MWD								20		10					3%	
	SWP								10							1%	
80-100	WD							30			20					6%	
	SWP	10						20								3%	
100-120	WD					10										1%	
	MWD								10		10					2%	
120+	WD			30			10		10							6%	
	MWD															100	

NAME OF MAPPING UNIT 8C Chatfield fsl, 8 to 15% → recommend Chatfield-Hollis-Canfield complex

SOIL SURVEY AREA Worcester MA

Breeder low-lying areas

SOIL SERIES OR PEDON	Transect Numbers 1	2	3		5	6	7	8	9	10					$\bar{x}$		If 7+8 are deleted
	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%		
Hollis 0-20" W+ED	10	20	-		10	10	-	-	20	10					9%	13	11%
MWD (sim)	10	10	-		-	20	-	-	-	-					4%		6%
Chatfield 20-40 W+ED	50	30	40		10	20	-	-	60	20					28%	32%	33%
MWD (sim)		10			20	10									4%		6%
20-40 SWP	-	-	-		-	-	20	10	-	10					4%		1%
Deep 40-60 W+ED	10	30	10		10	-	-	-	20	10					10%	20%	13%
MWD (sim)			20		20	20	-	30	-	-					10%		9%
40-60 SWP	-	-	-		10	-	10	10	-	-					3%		1%
40-60 PD	10	-	-		-	-	-	-	-	10					2%		3%
Chesilon WD >60	-	-	30		20	20	50	10	-	20					17%	23	13%
MWD (sim)	-	-	-		-	-	-	30	-	20					6%		3%
>60 SWP	10	-	-	-	-	-	20	10	-	-					4%		1%

COUNTY: Worcester, MA

MAP UNIT: Chatfield-Hollis-Charlton complex, 8 to 15% slopes

SOILS	MEAN $\bar{x} = \frac{\Sigma x}{N}$	STANDARD DEVIATION $S = \sqrt{\frac{\Sigma(\bar{x}-x)^2}{n-1}}$	STANDARD ERROR $Se = \frac{S}{\sqrt{N}}$	CONFIDENCE LIMIT $C = \bar{x} \pm t\,Se$	NUMBER OF TRANSECTS $Nt = \frac{(t)^2(s)^2}{(L)^2}$
Hollis (all < 20")	17.1	11.1	4.19	17 ± 10	4.7 or 5
Chatfield (all WD, MWD, + ΣD soils; 20-60")	61.4	13.4	5.06	61 ± 12	6.9 or 7
Charlton (all WD, MWD soil > 60")	15.7	16.2	6.12	16 ±	10
Chatfield-Hollis-Charlton complex 8 to 15% slopes	93%	9.5	3.6	93 ± 9%	3.46 or 3

1. Confidence interval will be at a specified level of confidence (70,80, 90, or 95 percent)

2. In the Steins Equation for number of transects, L represents the allowable error or the distance that the estimated mean can lie from the true mean. In the NENTC, a 10 percent value will be used for L (.10). The t value of 1.960 will include 95 percent of the population mean and is used in the Stein Equation

Notes:

Sufficient transects have been collected to statistically characterize this unit. It can be said that: In 95 percent of the areas mapped as Chatfield-Hollis-Charlton complex, 8 to 15 percent slopes, Chatfield, Hollis, and Charlton soils make up 84 to 100 percent of the mapped area. Generally mapped areas are 61 percent Chatfield soils, 17 percent Hollis soils, and 16 percent Charlton soils. In the other 5 percent of the mapped areas, Chatfield, Hollis and Charlton soils make up less than 84 percent.

Also sufficient transects have been collected to make individual confidence statements about Hollis and Chatfield soils, but not Charlton (will require 10).

M.U. SC - Worcester MA

Frequency Distribution of soil depths

0-20	20-40	40-60	60-80	80-100	100-120	120-140	140-160
17	22" 37	46	62	93	108	124	156
10	23 23	54	77	91	105	127	
17	22	56	60	97		139	
19	20	49	63				
18	36	59					
17	28	54					
19	36	59					
18	23	51					
18	39	59					
12	37	57					
11	27	40					
12	28	52					
	29	56					
	36	45					
	34	48					
	27	54					
	28	46					
	25						
	22						
	37						
	36						
	39						
	31						
	23						
	31						
	37						

$N = 70$

$\bar{x} = 49.9''$

$\sigma = 44.8''$

median = 37"

NAME OF MAPPING UNIT 37B Merrimac sl, 3 to 8% slopes

SOIL SURVEY AREA Worcester County MA

SOIL SERIES OR PEDON	Transect Numbers														
	22	23	24	25	26										
	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%
Merrimac	20%	30%	10%	50%	30%										
Enfield	-	10%	10%	30%	20%										
Sudbury	80%	60%	50%	-	30%										
Sudbury deep to 2C	-	-	10%	-	20%										
Hinckley	-	-	-	10%											
Walpole	-	-	20%	10%											

COUNTY: Worcester

MAP UNIT: 37B Merrimac sl 3 to 8% slopes

N = 5

SOILS	MEAN $\bar{x} = \frac{\Sigma x}{N}$	STANDARD DEVIATION $S = \sqrt{\frac{\Sigma(\bar{x}-x)^2}{n-1}}$	STANDARD ERROR $Se = \frac{S}{\sqrt{N}}$	CONFIDENCE LIMIT $C = \bar{x} \pm t\,Se$	NUMBER OF TRANSECTS $Nt = \frac{(t)^2(s)^2}{(L)^2}$
[illegible]	28%	14.8			
[illegible]	14%	11.4			
[illegible]	50%	30.0			
[illegible]	2%	4.5			
[illegible]	6%	8.9			
[illegible] soils	42%	[illegible]	11.1		
Sudbury-Merrimac complex	92%	10.9	4.87	92 ± 10	4 at 95% level of confidence

sufficient # transects to characterize unit at 95% level of confidence

1. Confidence interval will be at a specified level of confidence (70,80, 90, or 95 percent)

2. In the Steins Equation for number of transects, L represents the allowable error or the distance that the estimated mean can lie from the true mean. In the NENTC, a 10 percent value will be used for L (.10).

Note: Sudbury soils have a high standard deviation. Perhaps we transected 2 rather than one unit as transect 25 is composed dominantly of well drained soils, while the others are a complex of well and moderately well drained soils. If area is representative, suggest a "Sudbury-Merrimac complex, 3 to 8 percent slopes"; with Enfield being treated as a similar soil to Merrimac. More transects should be gathered during the course of the survey to reduce the variability of Sudbury soil and to test the concept in other areas of the county

J.A.O.

"In 95 percent of the areas mapped as Sudbury-Merrimac complex, 3 to 8% slopes, Sudbury and Merrimac soils make up 82 to 100 percent of the mapped area. Generally, mapped areas are 50 percent Sudbury soils and 42 percent Merrimac soils. In the other 5 percent of the mapped areas, Sudbury and Merrimac soils make up less than 82 percent

NAME OF MAPPING UNIT 123C Paxton fine sandy loam 15 to 25% slopes very stony

SOIL SURVEY AREA Worcester County MA

SOIL SERIES OR PHASE	Transect Numbers														
	13														
	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%
Paxton	50%														
Woodbridge	30%														
Woodbridge shallow to pan	20%														

NAME OF MAPPING UNIT 123D Paxton fsl, 15-35% slopes very stony

SOIL SURVEY AREA Worcester County MA

SOIL SERIES OR PEDON	Transect Numbers														
	14														
	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%
Paxton	70%														
Paxton shallow to pan	30%														

NAME OF MAPPING UNIT 124 C Paxton fine sandy loam 8-15% slopes, extremely stony

SOIL SURVEY AREA Worcester County MA

SOIL SERIES OR PEDON	Transect Numbers														
	15	16	17	18											
	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%
Paxton		80%	50%	40%											
Paxton shallow to pan		10%	10%	20%											
Woodbridge	50%		20%	30%											
Woodbridge shallow to pan	20%	10%	10%	10%											
Ridgeway	20%														
Chatfield	10%		10%												

COUNTY: Worcester County Md

MAP UNIT: 124C Paxton fsl, 8 to 15% slopes, extremely stony

N = 4

SOILS	MEAN $\bar{x} = \frac{\Sigma x}{N}$	STANDARD DEVIATION $S = \sqrt{\frac{\Sigma(\bar{x}-x)^2}{n-1}}$	STANDARD ERROR $Se = \frac{S}{\sqrt{N}}$	CONFIDENCE LIMIT $C = \bar{x} \pm t\,Se$	NUMBER OF TRANSECTS $Nt = \frac{(t)^2(s)^2}{(L)^2}$
Paxton	42.5%	33.0			
Paxton shallow to pan	10.0%	8.2			
Woodbridge	25%	20.8			
Woodbridge shallow to pan	12.5%	5.0			
Ridgeway	5.0%	10.0			
Chatfield	5.0%	5.8			
Paxton	52.5%	37.8			
Woodbridge	37.5%	25			
Paxton-Woodbridge complex	90%	12.2	6.1	90 ± 10	4 at 90%

1. Confidence interval will be at a specified level of confidence (70,80, 90, or 95 percent)

2. In the Steins Equation for number of transects, L represents the allowable error or the distance that the estimated mean can lie from the true mean. In the NENTC, a 10 percent value will be used for L (.10).

Notes:

1) Each of the dominant soils (Paxton + Woodbridge) have high standard deviations (38 and 25). Unit should be sampled more to reduce the high variability.

2) Presently, unit could be expressed as

"In 90 percent of the areas mapped as Paxton-Woodbridge complex, 8 to 15 percent slopes, extremely stony, Paxton and Woodbridge soils make up 80 to 100 percent of the mapped areas. Generally, mapped areas are 52 percent Paxton soil and 38 percent Woodbridge soils. In the other 10 percent of the mapped areas, Paxton and Woodbridge soils make up less than 80 percent."

NAME OF MAPPING UNIT 124 D Paxton fine sandy loam, 15 to 35% extreme, stony

SOIL SURVEY AREA Worcester County MA

SOIL SERIES OR PEDON	Transect Numbers														
	19	20	21												
	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%
Paxton	100	40%	90%												
Paxton shallow to pan	–	10%	10%												
Woodbridge	–	30%	–												
Whitman	–	20%	–												

COUNTY: Worcester

MAP UNIT: 124D Paxton fine sandy loam, 15 to 35 percent extremely stony

SOILS	MEAN $\bar{x} = \frac{\Sigma X}{N}$	STANDARD DEVIATION $S = \sqrt{\frac{\Sigma(\bar{x}-x)^2}{n-1}}$	STANDARD ERROR $Se = \frac{S}{\sqrt{N}}$	CONFIDENCE LIMIT $C = \bar{x} \pm t\, Se$	NUMBER OF TRANSECTS $Nt = \frac{(t)^2(s)^2}{(L)^2}$
Paxton	76.7	32.1			
Paxton shallow to pan	6.7	5.8			
Woodbridge	10	17.3			
Whitman	6.6	11.5			
Paxton	83%	28.8	16.6		5 at 80%

1. Confidence interval will be at a specified level of confidence (70,80, 90, or 95 percent)

2. In the Steins Equation for number of transects, L represents the allowable error or the distance that the estimated mean can lie from the true mean. In the NENTC, a 10 percent value will be used for L (.10).