United States Department of Agriculture | **Natural Resources Conservation Service** | **11 Campus Boulevard Suite 200 Newtown Square, PA 19073**

Subject: SOI -- Ground-Penetrating Radar **Date:** 25 May 2005

To: Cecil B. Currin
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Purpose:
Ground-penetrating radar (GPR) was used to help characterize two former cranberry beds in Plymouth County, Massachusetts.

Participants:
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Linda Rinta, Planner, Plymouth County Conservation District, West Wareham, MA
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Activities:
All field activities were completed on 19 May 2005

Summary:

1. Two former cranberry beds that are presently in the Wetland Reserve Program were surveyed with GPR using a 70 MHz antenna. The 70 MHz antenna is lighter and more easily transported across beds than the 120 MHz antenna used in Massachusetts. In addition, the 70 MHz antenna provides greater penetration depths than the 120 MHz antenna. The radar surveys revealed that these beds are underlain by relatively thick sequences of organic/mineral deposits. Within these beds, an uncommonly large number of strata were discerned with GPR. These multiple layers made interpretations and depth scales ambiguous.

2. The thickness of organic/mineral deposits was estimated from the radar records. Plots of geo-referenced data from Ashley Holmes Bog revealed a sinuous pattern that possible reflects the former course of a diverted tributary to the Eel River.

It was my pleasure to work in Massachusetts and with members of your fine staff.

With kind regards,

James A. Doolittle
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Background:
Two former cranberry beds were surveyed with GPR in an attempt to determine the thickness of organic deposits. Both beds are in the Wetland Reserve Program (WRP). Efforts are being spent to return each bed to their former, pre-cranberry bed conditions. The Ashley Holmes Bog was brought into production near the end of the nineteenth century. It is presumably located on a former tributary to the Eel River. One plan is to restore the former tributary across this WRP area. Knowledge of the former location of this tributary is essential to this plan. At Brodure Bog, plans require an estimation of the thickness of organic materials beneath the former cranberry bed.

Study sites:
Two former cranberry beds in Plymouth County, Massachusetts were surveyed with GPR. The Ashley Holmes Bog is located about 2 miles southwest of Chiltonville. The Brodure Bog is located in Plymouth Township and is just north of Clear Pond and Route 44. Both beds are mapped as Freetown coarse sand. The very deep, very poorly drained Freetown soil formed in more than 1.3 m of highly decomposed organic materials. Freetown soil is a member of the dysic, mesic Typic Haplosaprists family. Included in mapping are small areas of Swansea soil and areas with less than 0.4 m of organic soil materials. The very poorly drained Swansea soils formed in 0.4 to 1.3 m of highly decomposed organic over sandy materials. Swansea soil is a member of the sandy or sandy-skeletal, mixed, dysic, mesic Terric Haplosaprists family.

Equipment:
The radar unit is the TerraSIRch Subsurface Interface Radar (SIR) System-3000 (here after referred to as the SIR System-3000), manufactured by Geophysical Survey Systems, Inc.[1] The SIR System-3000 consists of a digital control unit (DC-3000) with keypad, SVGA video screen, and connector panel. A 10.8-volt lithium-ion rechargeable battery powers the system. The SIR System-3000 weighs about 9 lbs (4.1 kg) and is backpack portable. With an antenna, the system requires two people to operate. The 70 MHz antenna was used in this study. Daniels (2004) discusses the use and operation of GPR.

The radar record contained in this report was processed with the RADAN for Windows (version 5.0) software program (Geophysical Survey Systems, Inc, 2003).[1] Processing included setting the initial pulse to time zero, color transformation, marker editing, and distance normalization.

An Allegro field computer with the Trackmaker software (Geomar Software, Inc.) and a Garmin Global Positioning System Map 76 receiver (with a CSI Radio Beacon receiver, antenna, and accessories that are fitted into a backpack) were used to record position data.[1]

Field Methods:
Random traverses were conducted across each cranberry bed. Along most traverse line, reference points were spaced at intervals of about 4 m. The 70 MHz antenna was carried by hand and held about 1 to 2 inches above the surface. As the antenna passed a reference point, the operator impressed a mark on the radar record. The locations of the reference points were obtained with the GPS receiver. The Latitude/Longitude coordinate system was used. Horizontal datum is the North American 1983.

Calibration of GPR:
Ground-penetrating radar is a time scaled system. This geophysical tool measures the time it takes electromagnetic energy to travel from an antenna to an interface (i.e., soil horizon, stratigraphic layer) and back. To convert travel time into depth requires knowledge of the velocity of pulse propagation. The velocity of propagation was determined through calibration procedures over targets of known depth. This procedure involves measuring the two-way travel

[1] Manufacturer's names are provided for specific information; use does not constitute endorsement.

time to a known reflector on the radar record and calculating the propagation velocity with the following equation (after Daniels, 2004):

$$V = 2D/T \qquad [1]$$

Equation [1] describes the relationship of the average propagation velocity (V) to the depth (D) and two-way pulse travel time (T) to a reflector.

At one observation point within each bed, the depth to the organic/mineral interface was measured. These measured depths were 2.79 and 5.51 m. Based on these depths and the two-way pulse travel times to the interfaces, the radar records were depth scaled. The two-way travel times to these measured depths produced a flawed velocity of propagation and dielectric constant. In both instances, it is probable that an incorrect interface was selected for depth scaling. An uncharacteristically large number of strata were observed on the radar records from both cranberry beds. The large number of interfaces was assumed to be characteristic of the riverine (rather than kettle) environment of each bed.

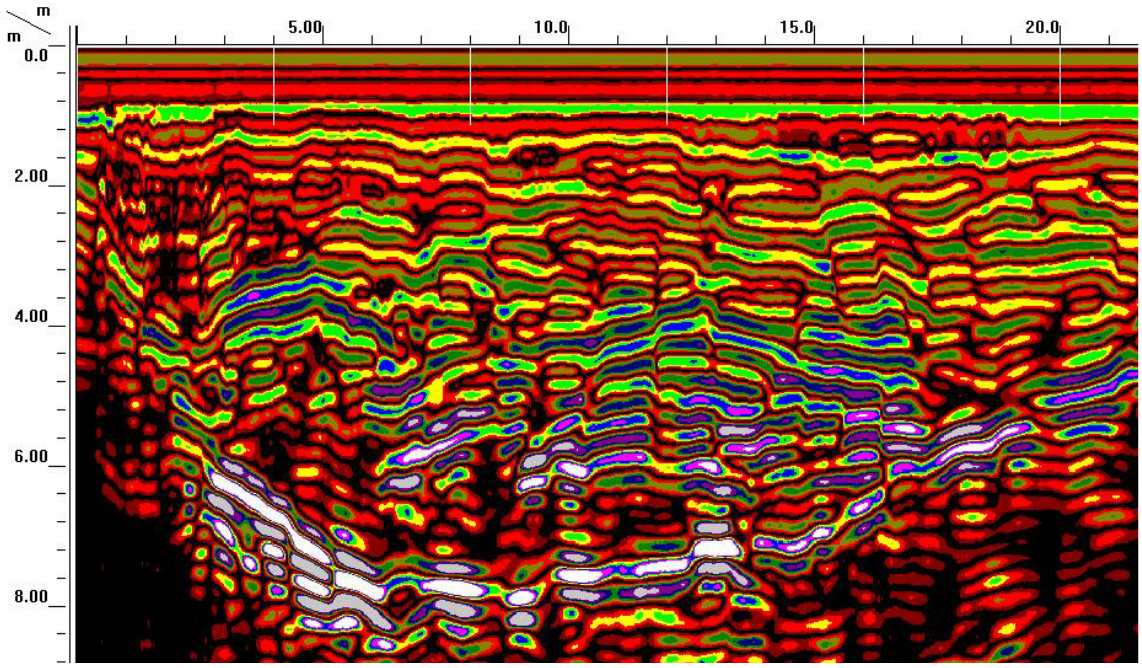

Figure 1. Representative radar record from the Ashley Holmes Bog.

Interpretations:

A representative radar record from Ashley Holmes Bog is shown in Figure 1. All scales are in meters. In this cross-section, a high-amplitude (white), concave-upwards reflector forms what is believed to be the lower boundary of the depression. The depression is filled with multiple reflectors of varying amplitudes (red, yellow, green, and white colored). The number of reflectors within this peatland is considered atypical. Most profiled peatlands in the area consist of thick deposits of organic materials that are virtually free of internal reflectors. The multiple interfaces seen in this radar record suggest stratified mineral and/or organic layers, which may be typical of former riverine environments.

Cranberry beds have a surface layer of sandy fill materials. These materials are deposited on the surface as a management practice. Although the thickness of the sandy fill materials is variable, it commonly ranges in thickness from 25 to 50 cm. The observed thicknesses of the sandy fill materials were noticeably thicker within the two beds. The thicknesses of sandy fill materials were associated with the longevity of cranberry production on these beds.

Results:

Ashley Holmes Bog:
Based on 75 observations, the average thickness of the organic/mineral materials within Ashley Holmes Bog is 4.8 m with a range of 1.66 to 8.63 m. One half of the observations had organic/mineral deposits between 3.35 and 6.76 m thick. Figure 2 is a two-dimensional plot of the interpreted thickness of the organic/mineral deposits within Ashley Holmes Bog. The sinuous pattern suggests a possible thalweg of a tributary to the former Eel River.

Brodure Bog:
Based on 79 observations, the average thickness of the organic/mineral materials within Brodure Bog is 3.99 m with a range of about 1.0 to 9.11 m. One half of the observations had organic/mineral deposits between 2.1 and 5.9 m thick. Although the average thickness was less, the Brodure Bog contained deeper deposits of organic/mineral soil materials than the Ashley Holmes Bog. Because of the limited range that was set on the radar's control unit, the maximum depth of observation was 9.11 m. For the GPR traverses that were conducted on Brodure Bog, 8 % of the observations had organic/mineral deposits greater than 9.11 m thick.

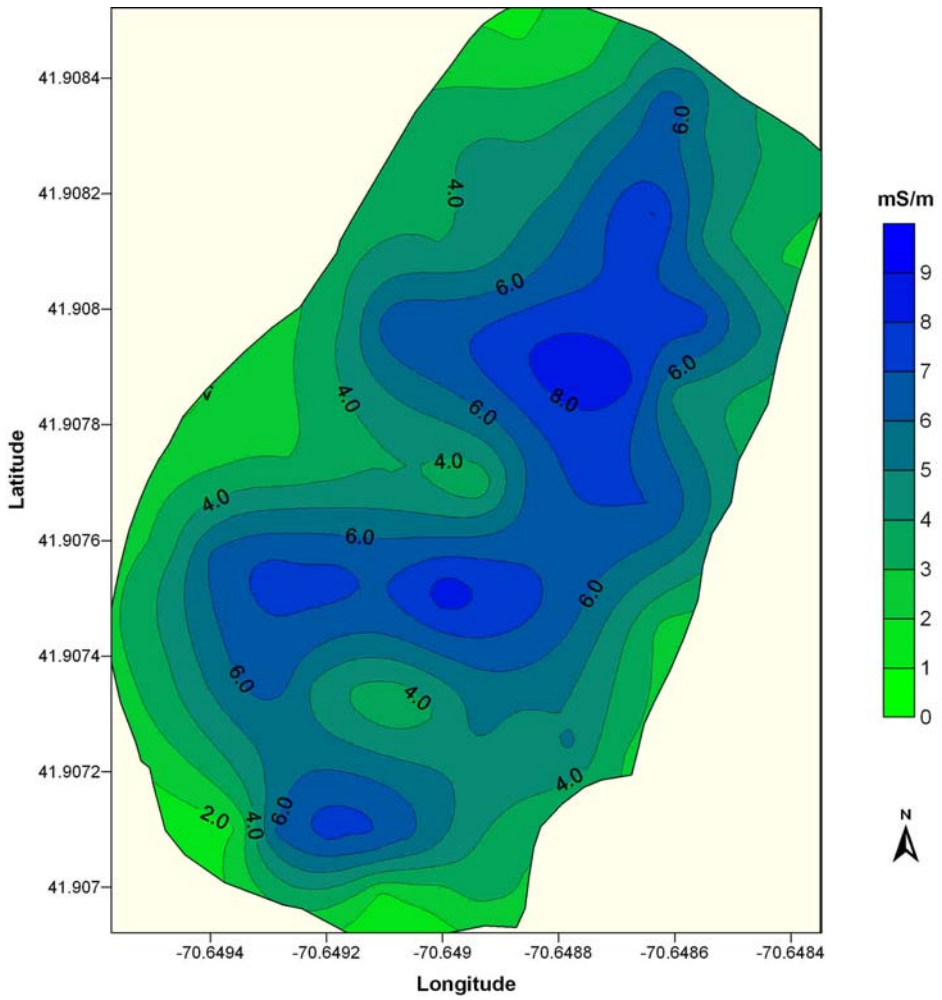

Figure 2. Thickness of organic/mineral soil materials within Ashley Holmes Bog.

Reference:

Daniels, D. J. 2004. Ground Penetrating Radar; 2nd Edition. The Institute of Electrical Engineers, London, United Kingdom.

Geophysical Survey Systems, Inc, 2003. RADAN for Windows Version 5.0; User's Manual. Manual MN43-162 Rev A. Geophysical Survey Systems, Inc., North Salem, New Hampshire.