United States Department of Agriculture

Natural Resources Conservation Service

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Subject: SOI -- Wet-Soils Monitoring Project -- Jasper County, Indiana

Date: 12 February 1999

To: Warren C. Lynn
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Purpose:
The purpose of this investigation was to provide data on water table depths. This study supports the Wet Soil Monitoring Project in Jasper County, Indiana.

Participants:
Jim Doolittle, Research Soil Scientist, USDA-NRCS, Radnor, PA
Byron Jenkinson, Research Assistant, Purdue U., Lafayette, IN

Activities:
All field activities were completed on 10 February 1999.

Equipment:
The radar unit is the Subsurface Interface Radar (SIR) System-2, manufactured by Geophysical Survey Systems, Inc.[1] The SIR System-2 consists of a digital control unit (DC-2) with keypad, VGA video screen, and connector panel. A 12-volt battery powered the system. This unit is backpack portable and requires two people to operate. A 200 mHz antenna was used in this study. The scanning time was 190 nanoseconds (ns); the scanning rate was 32 scan/second were used in this survey.

Discussion:
At the time of this survey, the water table was rising in the inter-dune areas. The heavy snowfall that was received in January had melted, and water was moving through the soil profiles. Radar surveys were conducted by pulling the 200 mHz antenna by hand along the four interior traverse lines. The five traverse lines located on roads were accessible by 4WD vehicle. These traverse lines were surveyed with the antenna towed behind the 4WD vehicle.

Water levels at sixteen monitoring wells were measured immediately following the radar survey. Radar traverses were conducted along the two lines containing the monitoring wells. The measured depths were compared with the interpreted depths to the water table. These data were used to confirm the dielectric permittivity and velocity of propagation of electromagnetic energy through the coarse-textured materials. This information was used to depth scale for the radar profiles and predict water table depths at all observation points.

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

The measured and the interpreted (from radar imagery) depths to the water table at the sixteen monitoring wells (two radar interpretations were made at well 7B) were compared. At these wells, the depth to the water table ranged from 0.82 to 10.13 meters. The coefficient of determination (r2) between the measured depth and interpreted depth was 0.997. At the sixteen wells, differences between measured and interpreted depths to the water table averaged 0.17 m, and ranged from -0.22 to 0.68 m.

Based on the averaged round-trip travel time to the water table, the velocity of propagation was estimated to be 0.1488 m/ns. The dielectric permittivity was estimated to be about 4.06.

The maximum depth of observation was estimated by the equation:

$$D = VT/2$$

Where D is the depth of observation, V is the velocity of propagation, and T is the two-way travel time of a radar pulse. According to this equation, with a scanning time of 190 ns and velocity of propagation of 0.1488 m/ns, the maximum, theoretical observation depth was about 14.14 m.

Table 1
Summary of Basic Statistics
Jasper County Site

	# of Wells Obs.	Min. Depth	Max. Depth	R^2	Max. Diff.	Average Velocity	Dielectric Constant	Antenna
May 1997	7	0.00	9.73	0.993	0.43	0.1245	5.9	300 mHz
July 1997	15	0.75	9.22	0.995	0.22	0.1465	4.2	200 mHz
Sept. 1997	16	1.50	9.46	0.998	0.50	0.1190	6.6	120 mHz
Jan 1998	16	0.63	9.86	0.998	0.28	0.1410	4.6	200 mHz
May 1998	16	0.00	8.71	0.986	0.65	0.1242	5.8	200 mHz
Aug. 1998	16	0.78	9.28	0.990	0.18	0.1366	4.8	200 mHz
Oct. 1998	16	1.37	10.14	0.994	0.41	0.1495	4.0	200 mHz
Feb. 1999	16	0.82	10.13	0.997	0.68	0.1488	4.1	200 mHz

The correlations between observed and interpreted depths to the water table are high (r^2 ranged from 0.993 to 0.999). The continued strength of these correlations confirms the uniform velocity of signal propagation through these coarse-textured soils to the water table. The maximum difference between observed and interpreted depth to the water table was 0.68 m (February 1999).

Table 2
Average Predicted Water Table Depth
Based on GPR Interpretations within the Jasper County Site

Month	Depth (m)
May 1997	2.01
July 1997	2.23
September 1997	3.03
January 1998	2.51
May 1998	1.66
August 1998	2.49
October 1998	3.24
February 1999	2.61

Velocity of propagation varied with the time of the year and the antenna used. Velocities, though rather uniform, varied from 0.1190 to 0. 1495 m/ns. Differences are principally dependent on changes in soil moisture contents within the surface layers.

Within the study site, the dielectric permittivity of the sandy soil materials above the water table ranged from 4.0 to 6.6. These permittivities conform to tabled values for dry sands.

Temporal fluctuations in the water table can be summarized by averages. Based on GPR interpretations, the average predicted water table depth for the study site are shown in Table 2.

Summary:

1. All radar imageries have been stored on disc. At each observation point, the depth to the water table has been predicted from the radar imagery. Hard copies of the radar profile were prepared and have been forwarded to Byron Jenkinson under a separate cover letter.

2. Byron Jenkinson and I discussed the need to present the results of this two-year radar study. We discussed the Wet Soil Monitoring Team meeting in Indiana the week of August 16, 1999. With the concurrence of Warren Lynn and Don Franzmeier, and the availability of travel funds, I could attend this conference and present a paper on the GPR aspects of this study and the need to use this technology in other wet-soil monitoring projects.

3. I will begin to prepare a paper on the GPR aspects of this study. I would like to present this paper at the Eighth International Conference on Ground Penetrating Radar (GPR 2000). Members of USDA-SCS, USDA-ARS, and the University of Florida organized this conference in 1986. This biennial series of international scientific symposia is devoted to the advancement of ground penetrating radar. GPR 2000 will be held at the Gold Coast in Queensland, Australia during 23-26 May, 2000. Co-authors would include Byron Jenkinson, Warren Lynn, and Don Franzmeier. If I can not attend this conference, I would like to publish the paper in the Journal of Geophysics.

4. The next radar survey will be conducted in April 1999.

With kind regards,

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Research Soil Scientist

cc:

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