Hydrologic and Meteorological Data for an Unsaturated-Zone Study Area near the Radioactive Waste Management Complex, Idaho National Engineering and Environmental Laboratory, Idaho, 1990–96

By Kim S. Perkins, John R. Nimmo, and John R. Pittman

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CONVERSION FACTORS AND VERTICAL DATUM

Multiply	by	To obtain
millimeter (mm)	0.03937	inch
centimeter (cm)	0.3937	inch
meter (m)	3.281	foot
kilometer (km)	0.6214	mile
square kilometer (km^2)	0.3861	square mile
cubic meter (m^3)	35.31	cubic foot
meter per second (m/s)	2.237	mile per hour
watt per square meter (W/m^2)	2.064	calorie per square centimeter per day
Kilopascal (KPa)	0.01	bar

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Abstract

Trenches and pits at the Radioactive Waste Management Complex (RWMC) Subsurface Disposal Area (SDA) at the Idaho National Engineering and Environmental Laboratory (formerly known as the Idaho National Engineering Laboratory) have been used for burial of radioactive waste since 1952. In 1985, the U.S. Geological Survey (USGS), in cooperation with the U.S. Department of Energy, began a multi-phase study of the geohydrology of the RWMC to provide a basis for estimating the extent of and the potential for migration of radionuclides in the unsaturated zone beneath the waste trenches and pits. This phase of the study provides hydrologic and meteorological data collected at a designated test trench area adjacent to the northern boundary of the RWMC SDA from 1990 through 1996 (fig. 1). The test trench area was constructed by the USGS in 1985.

Hydrologic data presented in this report were collected during 1990–96 in the USGS test trench area. Soil-moisture content measurements from disturbed and undisturbed soil were collected approximately monthly during 1990–96 from 11 neutron-probe access holes with a neutron moisture gage. In 1994, three additional neutron access holes were completed for monitoring. A meteorological station inside the test trench area provided data for determination of evapotranspiration rates. This station measured soil surface temperature, net radiation, air temperature, relative humidity, vapor pressure, windspeed, wind direction, soil heat flux, and precipitation. Meteorological data for the test trench area are available for 1994–96.

The soil-moisture and meteorological data are contained in files on 3-1/2 inch diskettes (disks 1 and 2) included with this report. The data are presented in simple American Standard Code for Information Interchange (ASCII) format with tab-delimited fields. The files occupy a total of 1.5 megabytes of disk space.

INTRODUCTION

The Radioactive Waste Management Complex (RWMC) occupies about 0.75 km^2 of the Idaho National Engineering and Environmental Laboratory (INEEL) in southeastern Idaho (fig. 1). From 1952 to 1970, chemical, low-level radioactive, and transuranic wastes were buried in trenches and pits excavated into a thin layer of surficial sediments at the RWMC Subsurface Disposal Area (SDA). Since 1970, only low-level radioactive waste has been buried; transuranic waste has been stored on above-ground asphalt pads in retrievable containers. As of 1986, about 180,000 m^3 of radioactive wastes had been buried at the RWMC SDA. This quantity includes the transuranic wastes buried prior to 1970. An estimated 335 m^3 of organic wastes also were buried before 1970 (Pittman, 1995). The RWMC is managed by the U.S. Department of Energy (DOE) and was operated by EG&G Idaho, Inc., a DOE contractor at the INEEL, until 1994. On October 1, 1994, Lockheed Martin Idaho Technologies Company took over as contractor.

Radionuclides have been detected in core and drill cuttings from several boreholes drilled into the surficial sediments and underlying rock units at the RWMC (Pittman, 1995). Because of the potential

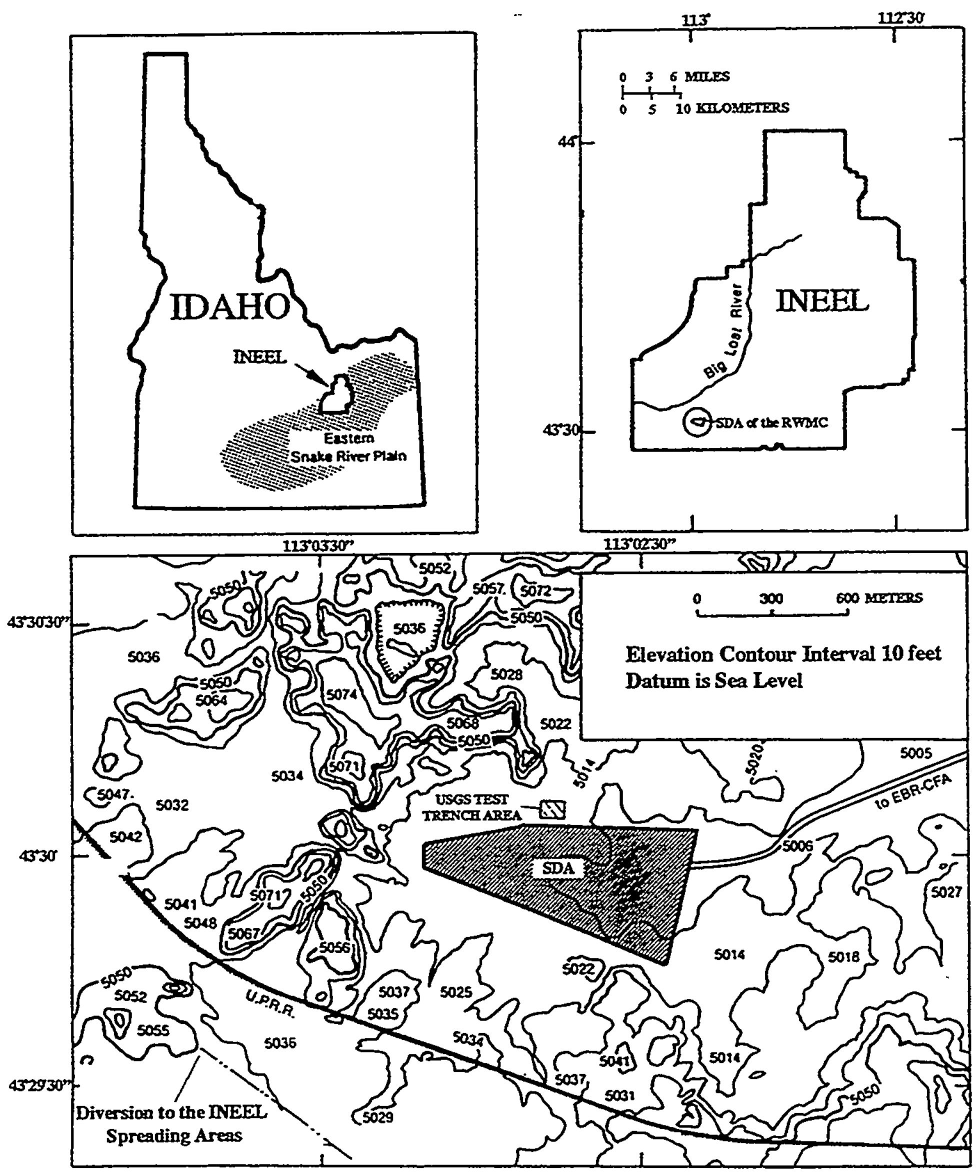


Figure 1. Location of the Idaho National Engineering and Environmental Laboratory showing the Subsurface Disposal Area (SDA) of the Radioactive Waste Management Complex (RWMC), and the USGS test trench area. [The SDA comprises 52 percent of the RWMC].

for the migration of radionuclides from the RWMC to the Snake River Plain aquifer, about 177 m below land surface, a study was begun in 1985 by the U.S. Geological Survey (USGS), in cooperation with the DOE. The objectives and methods used in the study are described in a two-volume planning document by the DOE, the USGS, and EG&G Idaho, Inc. (1983).

Purpose and Scope

The purpose of this report is to provide site-specific data needed to estimate the amount of precipitation that percolates downward through the subsurface and eventually recharges the Snake River Plain aquifer. The amount of percolation is one of the primary factors influencing the potential migration of radionuclides in the unsaturated zone. The quantity of water that moves through the buried waste depends on the timing and amount of rainfall and snowmelt, on meteorological variables, and on soil hydraulic properties.

The study of the movement of water through the unsaturated surficial sediment is one of several studies in a comprehensive program of subsurface investigations at the RWMC. This study will determine the potential for downward movement of water through the surficial sediment and waste by quantifying soil-moisture content as it varies with depth and time, soil temperature, physical properties of the soil, and evapotranspiration rates. This report presents available hydrologic and meteorological data collected during 1990–96 as a continuing part of the test trench study. Prior reports present data for 1985-86 (Pittman, 1989), 1987 (Davis and Pittman, 1990), and 1988–89 (Pittman, 1995).

Acknowledgments

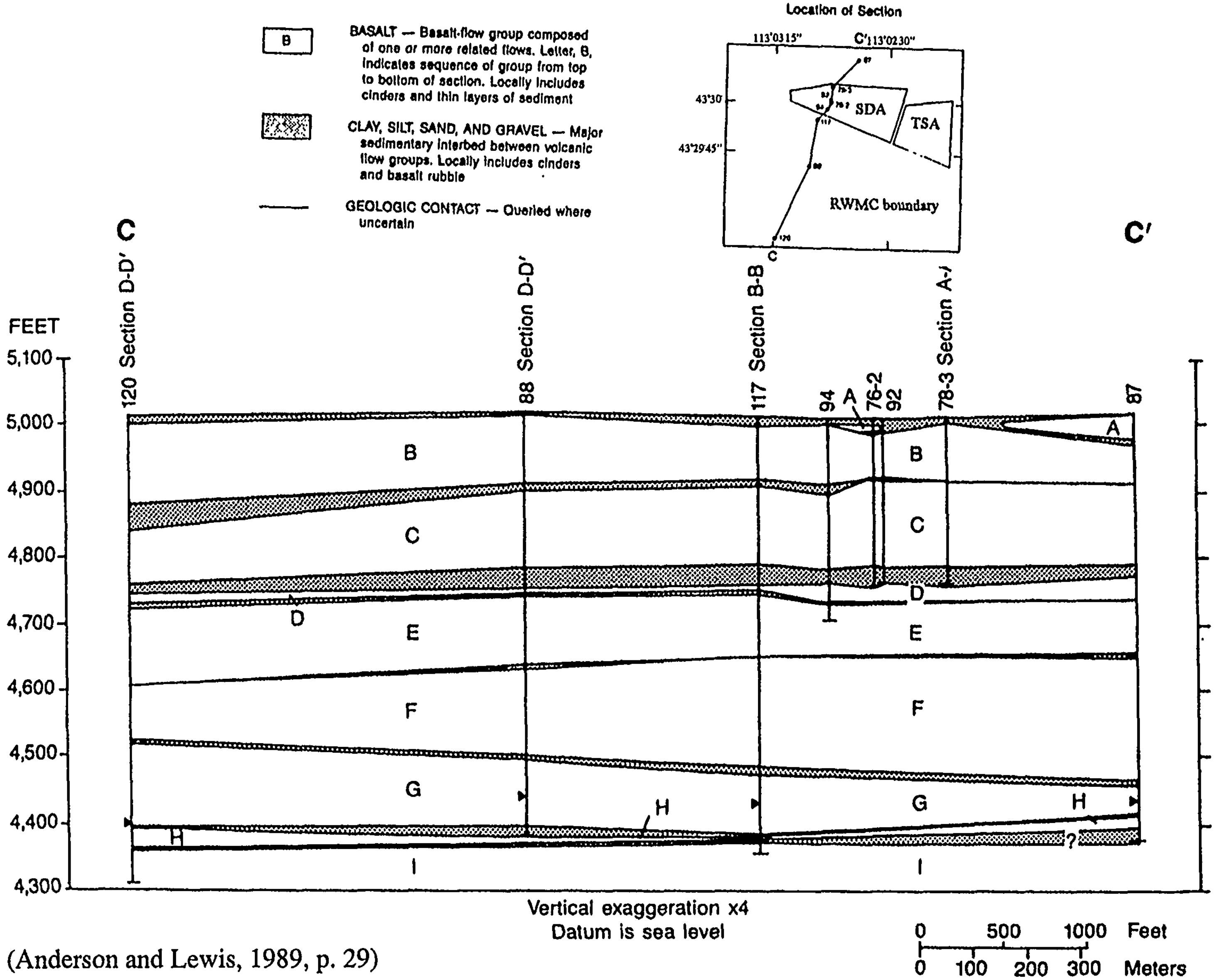
Technical support in neutron moisture probe data logging during 1990–96 was provided by the following USGS Water Resources Division employees: Donald L. Boyce, Linda C. Davis, John H. Doss, Daniel D. Edwards, Michael R. Greene, Steven R. Hannula, Larry L. Matson, Stephanie Shakofsky, and Beverly Bowers. Stephanie Shakofsky also supported the monitoring of the meteorological station during 1994–96.

Physical and Geologic Setting

The eastern Snake River Plain is a structural basin about 325 km long and 80 to 110 km wide, bounded by mountain ranges and high plateaus. Many of the high peaks in these ranges exceed 3,500 m above sea level. Streams within alluvial valleys separating the mountain ranges to the north and northwest flow onto the plain and the INEEL in response to rainfall and snowmelt.

The eastern Snake River Plain is underlain by a sequence of basaltic lava flows interbedded with sedimentary deposits. The sediments consist of fluvial, lacustrine, and eolian deposits of clay, silt, sand, and gravel. Rhyolitic lava flows and tuffs crop out locally at the surface and occur at depth below the basalt-sediment sequence (Mann, 1986). The INEEL occupies about 2,300 km^2 of semiarid sagebrush-covered terrain on the northwestern side of the plain (fig. 1). According to calculations derived from data taken by the National Oceanic and Atmospheric Administration (N. Hukari, NOAA, electronic communication, 1997), the average air temperature at the Central Facilities Area during 1990–96 was 6.6 °C and the average annual total precipitation was 217 mm.

The RWMC is in the southwestern part of the INEEL in a shallow topographic depression (fig. 1). The surficial sediments at the RWMC consist of about 0.6 to 7.0 m of clay, silt, sand, and gravel. The surficial sediments are underlain by a thick sequence of basaltic lava flows intercalated with sedimentary deposits (fig. 2, Anderson and Lewis, 1989). Substantial sedimentary deposits occur at depths of about 9, 34, and 73 m below land surface. The 73-m deposit underlies all of the RWMC and may underlie a large part of the INEEL. The 9- and 34-m deposits are discontinuous, although the 34-m deposit underlies a large part of the RWMC. Other sedimentary deposits of lesser areal extent occur at depth at the RWMC. Boreholes and wells at the RWMC penetrate about 215 m of basaltic lava flows and sedimentary deposits. Most boreholes are completed in the upper 90 m of the unsaturated zone; thus, the extent of the 9-, 34-, and 73-m deposits are better known than that of the deeper interbeds. Well INEL-1 (total depth 3,519 m), 16 km north-northeast of the RWMC,



(Anderson and Lewis, 1989, p. 29)

Figure 2. Cross section of subsurface geology at the Radioactive Waste Management Complex (RWMC).

penetrated 658 m of basalt flows and sedimentary deposits before penetrating a series of tuffaceous interbeds, welded tuffs, and rhyodacite ash flows (Mann, 1986). The basaltic lava flows and sedimentary deposits form the Snake River Plain aquifer.

The study area for this project, designated as the test trench area, is adjacent to the northern boundary of the RWMC SDA (fig. 1). Dominant vegetation in the test trench area consists of big sagebrush (*Artemisia tridentata ssp. wyomingensis*) and crested wheatgrass (*Agropyron cristatum*). The thickness of the surficial sediments in the test trench area ranges from about 3 to 6 m.

HYDROLOGIC AND METEOROLOGICAL INSTRUMENTATION AT THE TEST TRENCH AREA

The test trench area adjacent to the RWMC was constructed in 1985 for use in unsaturated zone investigations. A 61- by 46-m area was fenced to preserve natural vegetation and to prevent vehicular traffic. The test trench area was modeled after those described by Morgan and Fischer (1984). Three distinct trenches in this area are designated as east, west, and simulated-waste trenches (fig. 3). Pittman (1989) described the conceptual design and procedures used for construction of the east, west, and simulated-waste trenches.

In 1985, neutron-probe access holes 1–9 (fig. 3) were installed, each penetrating to the base of the surficial sediment in and near the test trench area for collection of spatially distributed soil-moisture profile data. Soil cores taken when the access holes were installed were used for calibration of the neutron probe, analysis of particle-size distribution, and determination of soil hydraulic properties (Pittman, 1989). During 1987, neutron-probe access hole 10 was installed to extend the area over which soil-moisture measurements were taken. In September 1988, four additional access holes, 15, 16, 17, and 18, were installed for subsurface investigations in and near the simulated waste trench. In spring of 1994, holes 19, 20, and 21 were installed to expand data collection for an infiltration and redistribution test in the simulated-waste trench (John Nimmo, USGS, written commun., 1998).

Access holes 2, 3, 8, and 9 are located within the undisturbed restricted-foot-traffic areas adjacent to the east and west trenches. Holes 15, 17, 19, and 21 are located within the disturbed soil of the simulated-waste trench. Access holes 1, 4, 7, 10, 16, 18, and 20 are located outside the test trenches within the undisturbed area (fig. 3).

Simulated-Waste Trench

The simulated-waste trench, designed to contain simulated waste and tracers, was constructed in late 1987 and instrumented in early 1988 (fig. 4). This trench has been used to study changes in soil hydraulic properties caused by waste burial disturbance (Shakofsky, 1995: John Nimmo, USGS, written commun., 1998). The trench was constructed to simulate methods of waste burial historically used at the RWMC (Pittman, 1995).

Infiltration and Redistribution Tests

During August 1990, an infiltration test was performed in the restricted foot-traffic area near the west test trench (fig.3). A 2- by 4.4-m area was ponded with 8 cm of water for 24 hours on August 16 and 17. The ponding period was followed by drainage and redistribution (Kaminsky, 1991). In August 1994, another infiltration test was conducted using the same techniques in the area overlying the simulated-waste trench (John Nimmo, USGS, written commun., 1998).

Neutron Probe

The neutron moisture depth gage, also called a neutron probe, contains a source of fast high-energy neutrons and a slow (thermal) neutron detector. Hydrogen present in the soil water slows the movement of neutrons for detection by the probe. The probe is lowered into an aluminum cased hole to a specified depth and slow neutrons are measured. Volumetric water content then is calculated from these raw neutron counts (Campbell Pacific Nuclear, 1984, p. 1).

Calibration equations based on linear regressions of the neutron-probe data were developed using the calculated volumetric water content of

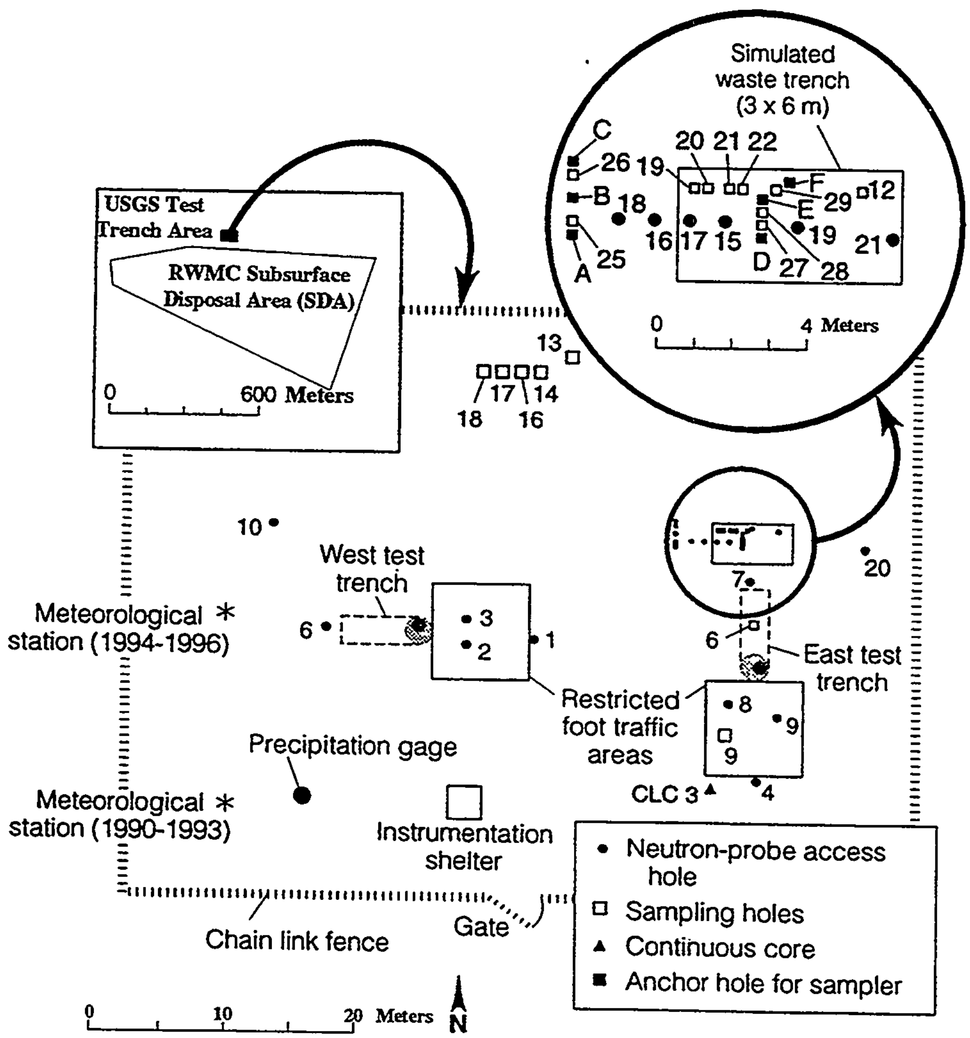


Figure 3. Location of the USGS test trench area, monitoring facilities, and soil sample collection sites.

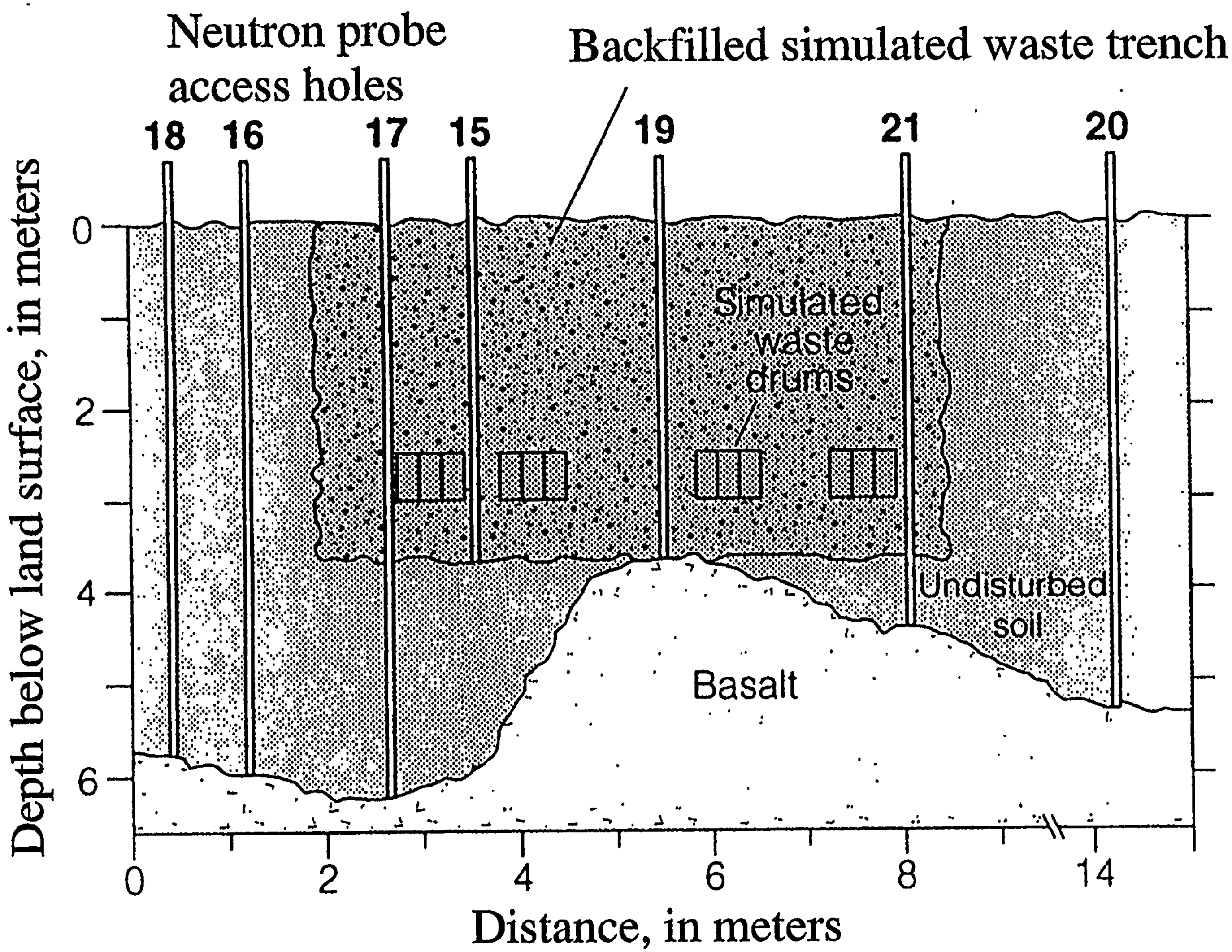


Figure 4. Cross section of simulated-waste trench within the USGS test trench area showing excavated area and location of neutron access holes.

the soil cores and the ratio of the raw neutron count to the standard count computed by the neutron probe. A single calibration equation for undisturbed soil was developed for field data from the neutron probe (Pittman, 1989, p. 12). The raw counts were converted to volumetric water content using this calibration equation. The standard error of the volumetric water content, which was based on the calibration equation, was ±2.8 percent. A separate calibration equation was not developed for disturbed soil (Pittman, 1995).

Meteorological Station

Evapotranspiration is one of the factors affecting the amount of water that infiltrates the surficial sediments and eventually recharges the aquifer. Through 1993, a meteorological station described by Pittman (1995) provided data during selected periods for evapotranspiration calculations. A station was installed in February 1994 (fig. 3). The instruments installed in 1994 were:

(1) two sets of thermocouple probes and two heat flux plates to measure soil heat flux in W/m^2;

(2) a net radiometer to measure net radiation in W/m^2;

(3) two thin-film-capacitance-change probes and thermistors to measure relative humidity in KPa and air temperature in degrees celsius at 1 and 2 m above land surface;

(4) one anemometer to measure windspeed in m/s;

(5) a wind vane to measure wind direction in degrees;

(6) a heated rain gage to measure precipitation in mm.

Vapor pressure was calculated in KPa using temperature and relative humidity data (Fritchen and Gay, 1979). The sensors were scanned every 20 seconds with a 20-minute output interval. Data from these instruments were collected hourly beginning on February 14, 1994.

HYDROLOGIC DATA

During 1990–96, soil-moisture content was measured approximately monthly in neutron-probe access holes 1, 2 4, 7, 9, 10, 15, 16, 17, and 18. Measurements in holes 19, 20, and 21 began in June of 1994. These holes are completed in disturbed and undisturbed soil. No data are presented for neutron probe access holes 3, 5, 6, and 8 because they were not monitored during this period. Moisture contents are presented as percent by volume at various depths below the surface in meters. Soil-moisture profiles generally were driest in September and wettest in April or May after infiltration from snowmelt or rainfall. Temporal variations in moisture content tended to decrease with increasing depth. Few temporal variations in moisture content were observed below 3 m.

Soil-moisture content profiles at holes 15, 16, 17, and 18 prior to and after the infiltration test of 1994 are shown in Figure 5. On August 19 and 20, a 2- by 4.4-m area was ponded for 24 hours to initiate a period of infiltration and redistribution. Moisture content at access hole 15, which is located in the area ponded for the experiment, increased during the test. Holes 17 and 18 located adjacent to the ponded area show no significant increase in moisture content. Hole 16, also adjacent to the test trench and positioned between 17 and 18, showed a possible effect of lateral flow subsequent to the test which may be due to the presence of a layer of lower permeability near the 175-cm depth (Shakofsky, 1995).

METEOROLOGICAL DATA

Meteorological data from the test trench area were available for 1993, 1995, and 1996, except for periods during which no data were recorded. These periods are as follows:

1994:	Jan 1-Feb 14, Sep 19-Oct 4, Oct 11-21
1995:	May 27-Jun 13, Jun 17-26, Aug 19-Sept 1, Sep 20-Oct 2, Oct 10-Nov 7, Nov 29-Dec 3,
1996:	Jan 24-Feb 21, Aug 16-Sep 3, Oct 25-Nov 16

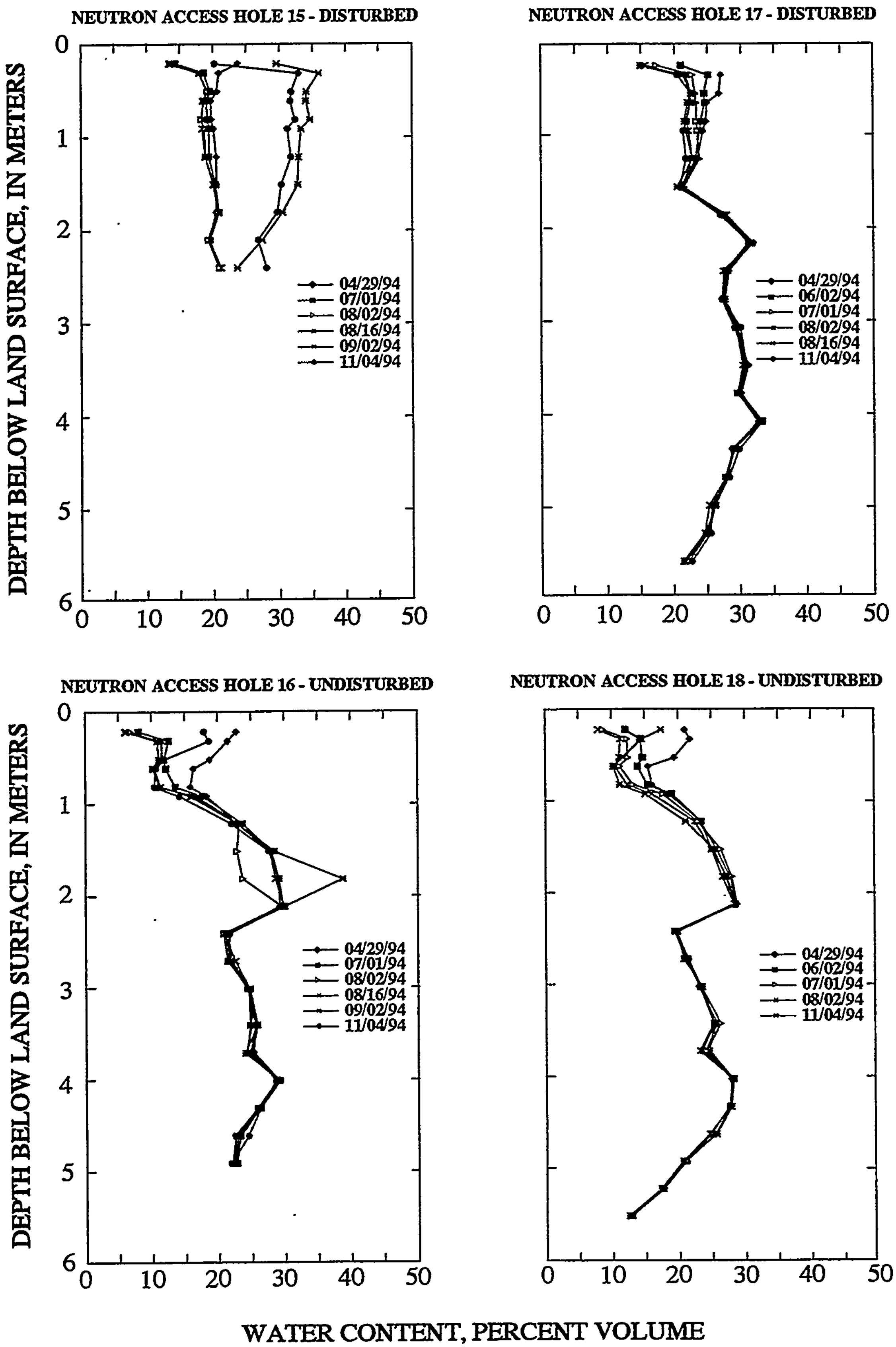


Figure 5. Soil moisture profiles for holes 15, 17, 16, and 18 before and after the August 1994 infiltration and redistribution test.

Construction of buildings to the east and southeast began in late 1995 and continued through 1997. The structures themselves, which include a batch plant adjacent to the test trench area on the east and several structures a few hundred yards to the southeast, as well as the heavy equipment traffic, may have had some effect on the meteorological data presented here.

DESCRIPTION OF DATA FILES

Fourteen separate files containing available soil-moisture content data are presented on a 3-1/2 inch floppy disk (disk 1) in American Standard Code for Information Interchange (ASCII) format as tab-delimited files. These files can be used by most software capable of importing raw data. An additional 3-1/2 inch floppy disk (disk 2) with the same format contains three files with hourly meteorological data by year for 1994–96. Examples of moisture content and meteorological data are given in Tables 1 and 2. Blanks within the files indicate a lack of data for that time or depth. The disk numbers, file names, and disk space occupied (in megabytes) are as follows

Disk 1:	%h2o-#.txt *	0.09
Disk 2:	1994met.txt	0.47
	1995met.txt	0.42
	1996met.txt	0.48

*The # represents the number of the neutron access hole of interest and includes holes 1, 2, 3, 4, 7, 9, 10, 15, 16, 17, 18, 19, 20, and 21.

SUMMARY

Since 1985, the USGS, in cooperation with the DOE, has been investigating the potential for and extent of migration of radionuclides from waste pits and trenches at the RWMC through the unsaturated zone to the Snake River Plain aquifer, 177 m below land surface.

Two test trenches and a simulated-waste trench were installed in the surficial sediment adjacent to the RWMC SDA and were instrumented for collection of hydrologic data from undisturbed and disturbed soil. These data and data collected at a meteorological station are being used to quantify soil-moisture content and variability with depth and time, soil temperature, physical properties of the soil, hydraulic conductivities, and evapotranspiration. Quantification of these properties allows for the estimation and comparison of soil-moisture flux in two different subsurface environments: (1) undisturbed native surficial soil, and (2) disturbed soil in a simulated-waste trench.

During 1990–96, soil-moisture content was measured approximately monthly in 14 neutron-probe access holes using a neutron moisture gage. Meteorological data collected at the test trench area during 1993–96 included air temperature, precipitation, net radiation, wind speed, and wind direction. During 1994–96, soil-surface temperature, soil-heat flux, and relative humidity also were measured.

REFERENCES CITED

Anderson, S.R., and Lewis, B.D., 1989, Stratigraphy of the unsaturated zone at the Radioactive Waste Management Complex, Idaho National Engineering Laboratory, Idaho: U.S. Geological Survey Water-Resources Investigations Report 89-4065 (DOE/ID-22080), 54 p.

Bartholomay, R.C., Tucker, B.J., Ackerman, D.J., and Liszewski, M.J., 1997, Hydrologic conditions and distribution of selected radiochemical and chemical constituents in water, Snake River Plain Aquifer, Idaho National Engineering Laboratory, Idaho, 1992 through 1995: U.S. Geological Survey Water-Resources Investigations Report 97-4086 (DOE/ID-22137), 13 p.

Campbell Pacific Nuclear, 1984, Operator's manual 503DR Hydroprobe moisture depth gauge: Pacheco, Calif., 34 p.

Clawson, K.L., Start, G.E., and Ricks, N.R., eds., 1989, Climatography of the Idaho National Engineering Laboratory (2d ed.): U.S. Department of Energy Report DOE/ID-12118, 155 p.

Davis, L.C., and Pittman, J.R., 1990, Hydrological, meteorological, and geohydrological data for an unsaturated zone study near the Radioactive Waste Management Complex, Idaho National Engineering Laboratory, Idaho—1987: U.S. Geological Survey Open-File Report 90-114, 208 p.

Fritchen, Leo J., and Gay, Lloyd W., 1979, Environmental Instrumentation. Springer-Verlag, New York, p.120-121.

Lewis, B.D., 1984, Installation and instrumentation of a test-trench facility in the unsaturated zone at the Idaho National Engineering Laboratory: Sixth Annual Participants' Information Meeting, U.S. Department of Energy Low-Level Waste Management Program, Denver, Colo., September 11-13, 1984, Proceedings, p. 220-233.

Kaminsky, Jon F., In situ characterization of unsaturated hydraulic properties of surficial sediments adjacent of the Radioactive Waste Management Complex, Idaho National Engineering Laboratory, Idaho. M.S. thesis, Idaho State University, ID.

Mann, L.J., 1986, Hydraulic properties of rock units and chemical quality of water for INEL-1—a 10,365-foot deep test hole drilled at the Idaho National Engineering Laboratory, Idaho: U.S. Geological Survey Water-Resources Investigations Report 86-4020 (IDO-22070), 23 p.

Morgan, D.S., and Fischer, J.M., 1984, Unsaturated zone instrumentation in coarse alluvial deposits of the Amargosa Desert near Beatty, Nevada: Sixth Annual Participants' Information Meeting, U.S. Department of Energy Low-Level Waste Management Program, Denver, Colo., September 11-13, 1984, Proceedings, p. 617-630.

Pittman, J.R., 1989, Hydrological and meteorological data for an unsaturated zone study near the Radioactive Waste Management Complex, Idaho National Engineering Laboratory, Idaho—1985-86: U.S. Geological Survey Open-File Report 89-74 (DOE/ID-22079), 175 p.

Pittman, J.R.,1995, Hydrological and meteorological data for an unsaturated-zone study area near the Radioactive Waste Management Complex, Idaho National Engineering Laboratory, Idaho- 1988-89: U.S. Geological Survey Open-File Report 95-112, (DOE/ID-22118), 120 p..

Shakofsky, Stephanie, 1995, Changes in soil hydraulic properties caused by construction of a simulated waste trench at the Idaho National Engineering Laboratory, Idaho: U.S. Geological Survey Water-Resources Investigative Report 95-4058 (DOE/ID-22121), 26 p.

U.S. Department of Energy, U.S. Geological Survey, and EG&G Idaho, Inc., 1983, A plan for studies of subsurface radionuclide migration at the Radioactive Waste Management Complex of the Idaho National Engineering Laboratory: U.S. Department of Energy Report DOE/ID-10116, v. 1 and 2, variously paginated.

Table 1. Example of neutron probe soil-moisture data from file %h2o-1.txt on disk 1. These data are taken from neutron access hole 1. Data tables are arranged in rows by date of measurement. Columns are headed by depth of neutron probe reading in meters below land surface.

Date	0.2 m	0.3 m	0.5 m	0.6 m	0.8 m	0.9 m	1.2 m	1.5 m	1.8 m	2.1 m	2.4 m	2.7 m	3 m
1/18/90	19.49	12.18	10.73	9.65	10.78	11.32	12.26	14.93	18.58	24.01	27.78	26.5	24.59
2/23/90	19.92	12.69	11.2	10.39	10.83	11.66	12.82	14.97	19.55	24.24	28.45	27.28	25.41
4/17/90	16.18	25.49	27.46	25.23	22.12	19.22	13.66	15.4	19.23	24.47	28.53	26.71	25.08
6/5/90	16.27	23.33	25.09	21.54	19.78	18.38	15.48	15.89	18.57	24.91	28.3	27.21	25.17
7/18/90	2.85	11.69	-6.11	14.87	14.37	14.36	14.24	15.3	18.52	24.07	28.21	26.6	24.97
8/30/90	3.15	10.4	11.2	10.2	10.55	11.64	12.5	14.99	18.77	24.26	27.37	25.14	25.7
9/20/90	2.95	9.64	10.45	9.1	9.84	10.74	12.42	14.4	18.63	24.17	28.47	26.43	25.26
10/30/90	2.38	8.86	10.02	8.9	9.67	10.9	12.09	14.58	18.16	24.1	27.5	26.54	24.96
12/9/90	4.32	8.7	9.52	9	9.53	10.99	11.77	14.38	17.64	23.65	27.03	26.11	24.52
1/16/91	7.02	9.24	10.05	8.93	10.23	10.89	12.62	14.39	18.29	23.47	26.91	26.1	24.48
3/20/91	16.15	21.71	12.93	9.52	10.14	11.4	12.87	14.37	18.55	23.88	27.32	25.99	24.68
4/23/91	15.43	20.18	16.48	10.54	10.15	11.74	13.02	14.84	18.24	24.18	27.46	26.14	24.65
5/9/91	19.64	20.93	16.29	10.9	10.3	11.68	12.65	14.9	18.46	23.66	27.74	26.03	24.49
6/1/91	12.81	25.3	29.13	26.91	26.07	25.22	25.3	22.21	19.25	24.51	27.51	25.66	24.36
6/17/91	6.54	14.75	16.06	12.79	9.98	11.83	12.6	15.4	18.86	24.05	27.63	26.54	24.19
7/8/91	2.85	9.7	9.9	10.14	10.35	10.85	12.49	14.58	18.19	24.17	27.28	25.52	24.18
7/29/91	4.28	9.72	9.93	9	9.91	10.77	12.71	14.88	18.11	24.11	27.1	26.71	25.07
8/13/91	1.78	8.94	9.69	8.87	9.47	10.26	12.21	14.03	18.25	23.59	27.35	26.29	24.85
9/12/91	10.87	9.67	9.26	8.63	9.62	10.64	12.11	14.39	17.68	23.47	27.05	26.65	24.47
10/17/91	3	8.96	9.26	8.46	9.24	10.62	11.98	14.41	18.57	23.76	27.24	26.37	25.06
3/30/92	13.02	20.42	16.39	10.63	10.49	11.56	12.03	14.68	18.67	24.02	27.02	26.09	24.65
5/12/92	3.6	12.26	12.96	11.01	10.62	11.28	12.89	14.8	18.93	24.3	26.81	25.92	24.2
6/2/92	3.09	10.31	10.87	10.28	10.62	11.14	12.68	14.76	18.49	24.04	27.6	25.78	24.75
7/2/92	6.82	10.6	10.69	9.52	10.27	11.09	12.34	14.91	18.07	24.08	27.19	26.32	24.31
7/23/92	2.9	9.68	9.89	8.95	10.18	10.63	12.4	14.64	18.58	24.39	27.77	26.83	24.36
8/11/92	1.98	9.42	9.1	9.11	9.55	10.66	12.4	14.46	18.03	24.25	27.41	26.34	24.37
9/9/92	2.91	8.43	8.96	8.32	9.63	10.35	12.05	14.7	18.01	24.26	26.88	25.7	24.83
11/24/92	5.29	8.27	8.88	7.76	10.86	9.94	11.85	14.4	18.5	23.06	25.91	25.96	24.31
1/19/93	6.43	8.3	8.38	7.94	8.73	9.93	12.07	13.83	17.41	22.78	25.72	25.08	23.69
3/26/93	32.12	34.15	29.72	10.7	9.43	10.24	11.8	14.37	17.78	23.06	26.26	25.25	23.54
4/28/93	16.9	27.51	30	28.53	27.77	26.75	24.5	17.32	18.59	23.99	27.01	25.13	24.49
5/8/93	27.34	31.77	30.9	29.27	27.95	26.64	24.06	18.8	18.29	23.88	26.64	25.38	24.29
5/13/93	19.49	29.45	31.04	28.82	28.01	26.8	25.19	19.2	18.51	23.88	26.26	25.91	23.81
7/29/93	7.56	13.79	18.9	18.47	18.36	18.03	20.15	20.61	19.63	24.35	27.14	25.83	24.2

Table 2. Example of hourly meteorological data from file 1995met.txt on disk 2. The data are arranged in rows by date and time. Columns are headed as follows: Up T and Low T are air temperatures in degrees Celsius at 2 and 1 meters above land surface. Up VP and Low VP are vapor pressures in kilopascals at 2 and 1 meters above land surface. RN is net radiation in watts per meter squared. Wind sp is wind speed in meters per second. Wind dir is wind direction in degrees. Precp is precipitation in millimeters. Flux 1 and Flux 2 are soil heat fluxes 8 centimeters below the surface under vegetation and bare soil. Soil T is surface temperature in degrees Celsius.

Date	Time	Up T	Low T	Up VP	Low VP	RN	Wind sp	Wind dir	Precp	Flux 1	Flux 2	Soil T
01-Jan	100	-21.15	-21.33	0.09	0.09	-20.08	1.22	211	0	-23.33	-9.97	-5.57
01-Jan	200	-22.38	-22.74	0.09	0.08	-21.29	0.58	235.3	0	-24.08	-10.35	-5.75
01-Jan	300	-23.64	-23.96	0.08	0.07	-20.27	0.71	204.8	0	-24.97	-10.72	-5.96
01-Jan	400	-23.78	-24.13	0.08	0.07	-21.33	0.45	201.4	0	-25.92	-11.09	-6.15
01-Jan	500	-23.37	-23.99	0.08	0.07	-20.13	0.45	182.9	0	-26.82	-11.49	-6.34
01-Jan	600	-23.25	-23.83	0.08	0.07	-20.16	0.45	110	0	-27.59	-11.88	-6.53
01-Jan	700	-24.74	-25.16	0.07	0.06	-19.1	0.6	206.2	0	-28.22	-12.25	-6.7
01-Jan	800	-25.52	-25.71	0.06	0.06	-18.81	0.63	200.3	0	-28.68	-12.58	-6.87
01-Jan	900	-25.48	-25.66	0.06	0.06	-16.91	0.86	265.2	0	-29.03	-12.89	-7.03
01-Jan	1000	-24.87	-25	0.07	0.06	4.7	0.94	276.6	0	-29.28	-13.16	-7.2
01-Jan	1100	-20.9	-20.54	0.09	0.09	64.29	0.62	169.9	0	-29.32	-13.5	-7.35
01-Jan	1200	-16.21	-15.91	0.13	0.12	93.9	2.51	70.3	0	-28.41	-13.59	-7.31
01-Jan	1300	-13.94	-13.69	0.14	0.14	116.4	3.82	46.3	0	-25.41	-13.29	-7.27
01-Jan	1400	-12.14	-11.89	0.15	0.15	115.5	4.17	50	0	-20.88	-12.57	-7.12
01-Jan	1500	-11	-10.76	0.16	0.16	101.3	4.27	46	0	-16.57	-11.32	-6.89
01-Jan	1600	-10.35	-10.15	0.16	0.16	76.5	4.16	45.4	0	-13.51	-9.99	-6.65
01-Jan	1700	-10.26	-10.14	0.17	0.16	35.91	4.16	44.6	0	-11.91	-8.83	-6.42
01-Jan	1800	-10.92	-10.99	0.16	0.16	-21.38	3.46	47.9	0	-11.77	-7.95	-6.24
01-Jan	1900	-15.15	-15.71	0.14	0.13	-46.55	1.26	38.8	0	-12.88	-7.44	-6.09
01-Jan	2000	-18.32	-18.95	0.12	0.11	-38.71	0.46	110.2	0	-15.19	-7.38	-6.15
01-Jan	2100	-20.34	-21.26	0.1	0.09	-31.5	0.69	242.8	0	-18.15	-7.79	-6.37
01-Jan	2200	-21.46	-21.75	0.09	0.09	-26.85	0.92	261.7	0	-20.7	-8.47	-6.64
01-Jan	2300	-22.25	-22.5	0.08	0.08	-24.32	0.94	272.1	0	-22.54	-9.23	-6.88
01-Jan	2400	-23.15	-23.37	0.08	0.07	-24.56	0.67	206.2	0	-23.86	-9.97	-7.1
02-Jan	100	-24.3	-24.74	0.07	0.06	-24.17	0.47	214.5	0	-24.86	-10.58	-7.32
02-Jan	200	-24.81	-25.27	0.07	0.06	-22.83	0.48	218.6	0	-25.78	-11.09	-7.54
02-Jan	300	-24.7	-25.34	0.07	0.06	-21.28	0.56	246.9	0	-26.59	-11.55	-7.74
02-Jan	400	-25.04	-25.52	0.07	0.06	-20.85	0.45	191	0	-27.26	-11.99	-7.92
02-Jan	500	-25.69	-26.08	0.06	0.06	-20.24	0.49	177.1	0	-27.78	-12.37	-8.09
02-Jan	600	-25.8	-26.07	0.06	0.06	-20.15	0.64	195.3	0	-28.17	-12.71	-8.26
02-Jan	700	-25.3	-25.94	0.06	0.06	-20.22	0.46	172.5	0	-28.42	-12.98	-8.41
02-Jan	800	-25.24	-25.78	0.06	0.06	-20.22	0.55	183.4	0	-28.6	-13.22	-8.56
02-Jan	900	-26.57	-26.72	0.06	0.05	-20.05	0.7	193.2	0	-28.72	-13.4	-8.7
02-Jan	1000	-25.52	-25.85	0.06	0.06	-2.82	0.55	223.8	0	-28.81	-13.57	-8.84
02-Jan	1100	-20	-19.59	0.09	0.09	61.54	0.71	183.1	0	-28.83	-13.86	-9.01