Data Processing Information
for the SWATS Instrument

D. Kenneth Fisher

Introduction

In Summer 2000, a new calibration equation was developed for the Campbell Scientific, Inc. Model 229L moisture sensor installed as part of the SWATS instrument. Other steps in the data-processing routine used to obtain water-potential and water-content estimates from the sensors were also re-examined. Modifications were made which were intended to improve the estimates, and to provide a data-processing routine identical to that used by the Oklahoma Mesonet project, which uses the same moisture sensor.

The new calibration was the result of laboratory tests run on the sensor, aimed at verifying or improving the original sensor calibration. A new calibration equation was proposed which was of a simpler form and was easier to use, and which made slight changes to the original curve over much of the measurement range.

Two changes were made to the data-processing routine for the SWATS instrument. One change involves the calculation of the coefficients used to normalize individual sensor response and obtain a reference-sensor response. Field data and laboratory data were re-examined, and the coefficients for each sensor were rederived.

The second change involved the set of coefficients used in the water-retention equations at each ARM site. Several sets of coefficients had been determined by OSU for each of the soils analyzed. A change from the coefficients currently used to another set, which took more information from the soil samples into account and, hence, may be more accurate, was suggested.

More detailed information about these changes, and the resulting method for processing SWATS sensor data, are discussed in the following sections. The method described is almost identical to the method used by the Oklahoma Mesonet moisture-monitoring program, which uses the same moisture sensor.

New sensor calibration

An effort was undertaken in early 2000 to reevaluate the calibration of the 229L sensor, which is installed as part of the SWATS instrument. Several laboratory tests were run on a number of sensors, including imposing a series of known pressures using a pressure-chamber setup, and colocating a number of 229L sensors with other water-potential-measurement instruments. Results from the laboratory analyses indicated that slight adjustments could be made to the calibration method to improve the accuracy of the measurements and to simplify the form of the calibration equation.

A simplified calibration equation was determined in Summer 2000, and is of the form

$$wp = -c * \exp(a * dTref)$$

where

wp = soil-water (or matric) potential (kPa)
dTref = normalized, or reference-sensor, response (C)
a = 1.788
c = 0.717.

The range of useful potential estimates extends from about -10 kPa to -400 kPa. When the soil and sensors are near saturation, in the range of 0 to -10 kPa, the 229L sensor does not respond to changes in soil-water potential. As the soil begins to dry and the water potential decreases (becomes more negative) to around -10 kPa, the sensor begins to dewater and respond to changing soil conditions. Potential estimates which are greater (less negative) than -10 kPa, therefore, indicate that the actual soil-water potential is somewhere in the 0 to -10 kPa region, but the 229L sensor cannot determine the actual value.

At the drier end of the potential scale, beyond about -400 kPa, potential estimates should be viewed as providing an indication of the direction in which the water potential is changing (increasing or decreasing), rather than an absolute value of water potential. For most soil types, the water content in this region is very low, and limited water movement would be expected.

Coefficients used to normalize individual sensor response

In order to remove inherent sensor-to-sensor variability and apply a single, general calibration equation to all sensors, the response from each individual sensor must be normalized. The normalizing routine consists of a linear regression which converts an individual sensor's response (a temperature rise, dT) to that of a hypothetical, "reference" sensor (dTref). The normalized, reference response is then used in the general sensor calibration equation to estimate water potential.

The normalizing routine requires sensor-specific coefficients which are determined based on the maximum and minimum observed dT values for each individual sensor. The maximum dT response was found in the laboratory by placing the sensor in a sealed container and drying the sensor completely using a desiccant pack.

The minimum dT response was originally determined in the laboratory by completely immersing the sensor in water. In some cases, however, a slight change in the minimum response was noted after a sensor had been installed in the field and had undergone several wetting-and-drying cycles. Field data were therefore examined, along with the laboratory data, for each sensor, and the minimum dT response for each sensor was determined.

The maximum and minimum dT values for approximately 350 sensors were determined. The average values for the maximum response and for the minimum response were calculated, and taken as the maximum and minimum values for an idealized "reference" sensor. A linear regression was used to normalize the response of an individual sensor. The regression equation is of the form

$$\mathbf{dT_{ref} = m * dT_{sensor} + b}$$

where

dT_{ref} = normalized, or reference-sensor, response (C)
dT_{sensor} = individual sensor response (C)
m = slope
b = intercept.

The coefficients m and b were determined by substituting the maximum and minimum dT values for an individual sensor, and those for the reference sensor, into the regression equation, and solving for m and b.

At many of the sites, a change in the sensor hardware was made after the systems had been in the field for several months. A new component, called a STUD unit, was installed which affected the operation of the 229L sensors and necesitated a recalculation of the normlaizing (m and b) coefficients. Field data following the modifications were examined and used to determine new m and b values for each sensor using the method described above.

The slope and intercept (m and b) values for each sensor are listed in Tables 1 and 2. Table 1 contains coefficients for the time period from the original field installation to the hardware modification and addition of the STUD unit. Table 2 contains coefficients for the period from the addition of the STUD unit to the current time.

Water-retention equation coefficients

The soil water retention equation describes the relationship between water potential and water content of a soil. The water-retention properties of a soil are unique to that soil, and are functions of soil characteristics such as soil texture, organic matter content, and physical structure.

Soil samples were collected at several depths in the soil profile at each of the ARM sites, and water-retention curves were developed from laboratory analyses of these samples by the OSU Biosystems and Agricultural Engineering Department. Curves were then fit to the laboratory data in order to obtain predictive equations which could be used to estimate water content based on sensor estimates of water potential.

The commonly used water-retention function developed by van Genuchten is of the form

$$\mathbf{vwc = theta_r + \left[(theta_s - theta_r) / (1 + (a * -wp / 100) \wedge n) \wedge (1 - 1 / n)\right]}$$

where

vwc = volumetric water content (m^3_{water}/m^3_{soil}).
wp = water potential (kPa)
$theta_r$ = residual water content (m^3_{water}/m^3_{soil})
$theta_s$ = saturated water content (m^3_{water}/m^3_{soil})
a, n = empirical constants.

The 4 coefficients in the van Genuchten equation ($theta_r$, $theta_s$, a, and n) were determined for each soil. A program called RETC, a non-linear curve-fitting program written specifically for the purpose of estimating these water-retention curve coefficients, was used. The program provided several options, including the ability to estimate all four coefficients, as well the ability of the user to set the value of one or more parameters and estimate values only for the remaining parameters.

Two sets of coefficients for use in the van Genuchten water-retention equation had been determined by OSU for each soil sample. One set had been derived by allowing the RETC program to determine values all four parameters. A second set had been derived by taking an important soil measurement, the soil bulk density, into account. The bulk density was used to estimate the saturated-water content (theta$_S$) for each soil. The values of the theta$_S$ parameter were then fixed, and the RETC program was run to determine values for the remaining three coefficients.

The original data-processing routine for the SWATS instrument used the first set of water-retention coefficients (with all four coefficients determined by the RETC program). However, since the second set of coefficients used an extra piece of information about the soils, the measured bulk density, water-content estimates might be improved by using these coefficients.

The second set of water-retention coefficients, with theta$_S$ values determined from the measured bulk densities, for each depth for each site are listed in Table 3.

Data processing method

The specific steps that are followed in making water-potential and water-content estimates with the 229L sensors are described below.

Step 1. Normalize the response from an individual sensor

The linear regression used to normalize the response of an individual sensor is of the form

$$dT_{ref} = m * dT_{sensor} + b$$

where

dT_{ref} = normalized, or reference-sensor, response (C)
dT_{sensor} = individual sensor response (C)
m = slope
b = intercept.

Slope and intercept (m and b) values for each sensor are listed in Table 1 (for the time period from the original sensor installation to the addition of the STUD unit) and Table 2 (after the addition of the STUD unit.

Step 2. Estimate soil-water potential as a function of reference-sensor response

The updated water-potential calibration equation is of the form

$$wp = - c * \exp (a * dTref)$$

where

wp = soil-water (matric) potential (kPa)
dTref = reference-sensor response (C)
a = 1.788
c = 0.717.

Step 3. Estimate volumetric water content as a function of water potential

The van Genuchten water-retention equation, used to calculate volumetric-water content based on soil-water potential, has the form

$$\mathbf{vwc = theta_r + (theta_s - theta_r) / (1 + (a * -wp / 100) \wedge n) \wedge (1 - 1 / n)}$$

where

vwc = soil water content on a volume basis (m^3_{water}/m^3_{soil}).
wp = matric (soil-water) potential (kPa)
$theta_r$ = residual water content (m^3_{water}/m^3_{soil})
$theta_s$ = saturated water content (m^3_{water}/m^3_{soil})
a, n = empirical constants.

The 4 coefficients, $theta_r$, $theta_s$, a, and n, for each depth for each site are listed in Table 3.

Table 1
Coefficients for normalizing individual sensor response during pre-STUD period

Table 1 contains a list of coefficients used to normalize an individual sensor's response. This set of coefficients applies during the time period from the initial sensor installation to the modification of the system to incorporate the STUD unit.

Larned

(applicable for the period of 25 June 1996 through 21 November 1996)

site ID	*sensor location*	*serial number*	*m*	*b*
1	w5	3333	1.115	-0.488
1	w15	3310	1.153	-0.179
1	w25	3337	1.111	-0.752
1	w35	3321	1.084	-0.192
1	w60	3342	1.144	-0.268
1	w85	3364	1.132	-0.906
1	w125	3320	1.056	-0.076
1	w175	3343	1.176	-0.264
1	e5	3346	1.122	-0.113
1	e15	3339	1.113	-0.090
1	e25	3371	1.091	-0.518
1	e35	3359	1.029	-0.421
1	e60	3368	1.054	-0.578
1	e85	3332	0.982	-0.162
1	e125	3326	1.155	-0.446
1	e175	3317	1.120	-0.465

Hillsboro

(applicable for the period of 26 June 1996 through 18 March 1997)

site ID	*sensor location*	*serial number*	*m*	*b*
2	w5	3314	1.086	-0.391
2	w15	3370	1.095	-0.153
2	w25	3366	1.020	-0.071
2	w35	3373	1.063	0.019
2	w60	3367	0.961	0.082
2	w85	3324	1.084	0.046
2	w125	3330	1.034	-0.420
2	w175	3327	1.014	-0.070
2	e5	3313	1.122	-0.333
2	e15	3334	1.027	0.061
2	e25	3340	1.079	-0.088
2	e35	3311	1.055	-0.097
2	e60	3341	1.077	-0.322
2	e85	3323	1.004	-0.086
2	e125	3329	1.049	-0.114
2	e175	3316	1.117	0.024

Leroy
(applicable for the period of 21 August 1996 through 19 March 1997)

site ID	*sensor location*	*serial number*	*m*	*b*
3	w5	3549	1.060	-0.200
3	w15	3547	1.139	-0.600
3	w25	3548	1.112	0.034
3	w35	3553	1.125	0.108
3	w60	3565	1.047	-0.306
3	w85	3550	1.082	-0.049
3	w125	3557	1.065	-0.026
3	w175	3651	1.076	-0.331
3	e5	3671	1.071	-0.259
3	e15	3679	1.108	-0.116
3	e25	3566	1.057	-0.269
3	e35	3563	1.050	0.277
3	e60	3688	1.051	0.003
3	e85	3669	0.965	-0.222
3	e125	3559	1.080	-0.176
3	e175	3561	1.035	0.158

Plevna
(applicable for the period of 5 March 1996 through 20 November 1996)

site ID	*sensor location*	*serial number*	*m*	*b*
4	w5	1942	0.913	-0.237
4	w15	1967	0.973	-0.097
4	w25	1956	0.939	-0.283
4	w35	1897	1.022	-0.062
4	w60	1993	1.080	-0.230
4	w85	1988	0.952	0.266
4	w125	1944	0.986	-0.109
4	w175	1983	1.061	-0.270
4	e5	1894	1.034	-0.372
4	e15	1892	0.973	-0.401
4	e25	1911	1.060	-0.444
4	e35	1898	1.025	-0.199
4	e60	1899	1.006	0.031
4	e85	1925	1.090	-0.124
4	e125	2008	0.897	0.079
4	e175	1982	1.020	-0.059

Halstead
(applicable for the period of 7 August 1996 through 20 November 1996)

site ID	*sensor location*	*serial number*	*m*	*b*
5	w5	3636	0.980	-0.159
5	w15	3657	1.105	-0.412
5	w25	3642	1.078	-0.397
5	w35	3691	1.046	-0.911
5	w60	3543	1.012	-0.088
5	w85	3631	0.872	0.115
5	w125	3358	1.084	-0.518
5	w175	3356	1.025	-0.147
5	e5	3684	1.199	-0.323
5	e15	3641	1.165	-0.846
5	e25	3686	1.890	-1.928
5	e35	3650	1.067	-0.456
5	e60	3542	1.123	-0.524
5	e85	3678	1.083	-0.271
5	e125	3632	1.075	-0.717
5	e175	3672	1.103	-0.417

Towanda
(applicable for the period of 6 August 1996 through 20 November 1996)

site ID	*sensor location*	*serial number*	*m*	*b*
6	w5	3690	1.126	-0.600
6	w15	3689	1.034	-0.355
6	w25	3655	1.236	-1.130
6	w35	3646	1.088	-0.815
6	w60	3634	0.912	-0.069
6	w85	3335	1.133	-0.073
6	w125	3538	1.137	-0.406
6	w175	3536	1.091	-0.518
6	e5	3554	0.938	-0.239
6	e15	3693	1.096	-0.524
6	e25	3638	1.140	-0.329
6	e35	3318	1.070	-0.158
6	e60	3637	1.123	-0.387
6	e85	3532	0.944	-0.178
6	e125	3478	1.115	-0.416
6	e175	3468	1.020	-0.156

Elk Falls

(applicable for the period of 12 March 1996 through 20 March 1997)

site ID	*sensor location*	*serial number*	*m*	*b*
7	w5	1963	1.200	-0.384
7	w15	1940	1.024	-0.445
7	w25	1936	1.218	-0.560
7	w35	1934	1.166	-0.529
7	w60	1989	1.000	-0.091
7	w85	2007	0.984	0.071
7	w125	1964	1.198	-0.130
7	w175	1935	1.208	-0.396
7	e5	1950	1.127	-0.322
7	e15	1992	1.010	-0.055
7	e25	1949	0.947	-0.183
7	e35	1948	1.048	-0.423
7	e60	1954	0.990	0.083
7	e85	1966	1.107	-0.414
7	e125	1933	1.136	-0.109
7	e175	1962	1.052	0.086

Coldwater

(applicable for the period of 19 June 1996 through 21 November 1996)

site ID	*sensor location*	*serial number*	*m*	*b*
8	w5	3380	1.126	-0.517
8	w15	3382	1.059	-0.213
8	w25	3381	1.025	-0.060
8	w35	3374	1.036	-0.415
8	w60	3377	1.065	-0.352
8	w85	3378	0.940	-0.132
8	w125	3389	1.058	-0.395
8	w175	3393	1.101	-0.005
8	e5	3357	1.059	-0.389
8	e15	3384	1.008	-0.072
8	e25	3376	1.124	-0.255
8	e35	3349	1.053	-0.259
8	e60	3353	0.955	-0.101
8	e85	3385	1.101	-0.818
8	e125	3386	1.167	-0.254
8	e175	3387	1.058	-0.518

Ashton
(applicable for the period of 27 February 1996 through 7 March 1997)

site ID	*sensor location*	*serial number*	*m*	*b*
9	w5	1961	1.137	-0.469
9	w15	1968	1.178	-0.657
9	w25	1939	0.992	-0.213
9	w35	1941	0.905	-0.183
9	w60	1937	0.997	-0.525
9	w85	1938	0.941	-0.220
9	w125	1970	0.948	-0.080
9	w175	1945	1.157	-0.480
9	e5	1955	1.151	-0.485
9	e15	1953	0.987	-0.020
9	e25	1952	1.046	-0.074
9	e35	1951	1.047	-0.390
9	e60	1946	0.944	-0.046
9	e85	1947	1.041	-0.286
9	e125	1957	0.931	-0.008
9	e175	1943	0.956	-0.112

Tyro
(applicable for the period of 11 July 1996 through 20 March 1997)

site ID	*sensor location*	*serial number*	*m*	*b*
10	w5	3469	1.154	-0.375
10	w15	3511	1.116	-0.605
10	w25	3596	1.052	-0.093
10	w35	3545	1.017	0.017
10	w50	3527	1.014	0.193
10	w85	x	x	x
10	w125	x	x	x
10	w175	x	x	x
10	e5	3599	1.088	-0.372
10	e15	3519	1.071	-0.109
10	e25	3534	0.985	-0.068
10	e35	3513	1.057	-0.555
10	e50	3510	0.999	-0.019
10	e85	x	x	x
10	e125	x	x	x
10	e175	x	x	x

Byron
(applicable for the period of 18 June 1996 through 6 March 1997)

site ID	*sensor location*	*serial number*	*m*	*b*
11	w5	3392	1.101	-0.026
11	w15	3354	1.228	-0.478
11	w25	3360	1.058	-0.125
11	w35	3383	1.038	-0.603
11	w60	3388	1.061	0.011
11	w85	3362	1.085	0.067
11	w125	3351	1.113	0.144
11	w175	3355	1.128	-0.290
11	e5	3361	1.081	-0.402
11	e15	3372	1.064	-0.264
11	e25	3352	1.113	-0.179
11	e35	3365	1.075	-0.545
11	e60	3363	0.975	0.093
11	e85	3369	1.012	0.074
11	e125	3391	1.074	-0.607
11	e175	3390	1.095	-0.044

Pawhuska
(applicable for the period of 10 July 1996 through 7 March 1997)

site ID	*sensor location*	*serial number*	*m*	*b*
12	w5	3465	0.991	-0.077
12	w15	3471	1.048	-0.350
12	w25	3470	1.020	-0.375
12	w35	3464	1.103	-0.076
12	w60	3475	1.020	-0.212
12	w85	x	x	x
12	w125	x	x	x
12	w175	x	x	x
12	e5	3492	1.089	-0.102
12	e15	3474	1.104	-0.177
12	e25	3479	1.057	0.005
12	e35	3467	1.026	-0.047
12	e60	3473	1.009	0.249
12	e85	x	x	x
12	e125	x	x	x
12	e175	x	x	x

Central Facility

(applicable for the period of 31 January 1996 through 28 February 1997)

site ID	*sensor location*	*serial number*	*m*	*b*
13	w5	1920	1.032	-0.303
13	w15	1923	0.993	-0.258
13	w25	1904	1.068	-0.415
13	w35	1978	0.988	-0.083
13	w60	1903	0.968	-0.237
13	w85	x	x	x
13	w125	x	x	x
13	w175	x	x	x
13	e5	1908	1.251	-0.645
13	e15	1975	1.086	-0.288
13	e25	1922	1.040	-0.336
13	e35	1914	1.040	-0.118
13	e60	1929	1.029	-0.123
13	e85	x	x	x
13	e125	x	x	x
13	e175	x	x	x

Ringwood

(applicable fror the period of 21 February 1996 through 6 March 1997)

site ID	*sensor location*	*serial number*	*m*	*b*
15	w5	1907	1.016	0.099
15	w15	1985	1.076	-0.401
15	w25	1991	1.011	-0.107
15	w35	1984	1.002	-0.053
15	w60	1986	1.111	0.024
15	w85	2001	0.979	0.076
15	w125	2002	0.975	0.034
15	w175	2009	0.988	-0.151
15	e5	1901	1.023	0.070
15	e15	1893	1.564	-1.264
15	e25	1999	1.069	-0.310
15	e35	1895	1.024	-0.331
15	e60	1990	1.018	-0.351
15	e85	1987	1.134	-0.344
15	e125	1994	1.004	-0.147
15	e175	1995	1.040	-0.447

Vici
(applicable for the period of 23 July 1996 through 6 March 1997)

site ID	*sensor location*	*serial number*	*m*	*b*
16	w5	3515	1.159	-0.611
16	w15	3491	1.095	-0.541
16	w25	3338	1.068	-0.244
16	w35	3507	1.057	-0.619
16	w60	3331	1.162	-0.329
16	w85	3325	1.097	-0.934
16	w125	3493	1.176	-0.738
16	w175	3485	1.020	-0.485
16	e5	3488	1.059	-0.484
16	e15	3516	1.041	-0.010
16	e25	3486	1.100	-0.622
16	e35	3484	1.057	-0.159
16	e60	3529	1.014	-0.212
16	e85	3498	1.150	-0.049
16	e125	3319	1.125	-1.111
16	e175	3487	1.099	-0.235

Morris
(applicable for the period of 20 August 1996 through 20 March 1997)

site ID	*sensor location*	*serial number*	*m*	*b*
18	w5	3683	1.063	-0.194
18	w15	3680	1.591	-1.707
18	w25	3658	0.898	-0.030
18	w35	3555	0.810	0.294
18	w60	3556	0.868	0.216
18	w85	3675	1.075	-0.631
18	w125	3560	0.993	0.377
18	w175	3635	1.011	-0.157
18	e5	3660	0.990	0.172
18	e15	3649	1.076	-0.245
18	e25	3694	0.980	0.106
18	e35	3562	0.828	0.204
18	e60	3558	0.939	0.234
18	e85	3665	0.996	-0.164
18	e125	3552	0.966	-0.118
18	e175	3654	1.056	0.049

El Reno
(no pre-STUD period for this site)

site ID	*sensor location*	*serial number*	*m*	*b*
19	w5	3668	x	x
19	w15	3681	x	x
19	w25	3500	x	x
19	w35	3648	x	x
19	w60	3662	x	x
19	w85	3505	x	x
19	w125	3692	x	x
19	w175	3490	x	x
19	e5	3506	x	x
19	e15	3540	x	x
19	e25	3541	x	x
19	e35	3528	x	x
19	e60	3522	x	x
19	e85	3502	x	x
19	e125	3503	x	x
19	e175	3461	x	x

Meeker
(applicable for the period of 8 Feb 1996 through 4 June 1997)

site ID	*sensor location*	*serial number*	*m*	*b*
20	w5	1906	1.429	-1.821
20	w15	1913	1.142	-0.461
20	w25	1900	1.000	-0.100
20	w35	1928	1.015	0.019
20	w60	1912	1.061	-0.085
20	w85	1921	0.894	0.164
20	w125	1905	0.973	-0.031
20	w175	x	x	x
20	e5	1919	1.093	-0.479
20	e15	1896	1.072	-0.218
20	e25	1909	0.979	-0.079
20	e35	1917	1.234	-0.237
20	e60	1972	1.079	0.009
20	e85	1902	1.136	-0.211
20	e125	1915	1.001	-0.172
20	e175	x	x	x

Cordell
(applicable for the period 15 February 1996 through 10 December 1996)

site ID	*sensor location*	*serial number*	*m*	*b*
22	w5	2004	1.007	-0.096
22	w15	1997	1.029	0.021
22	w25	1996	1.048	-0.337
22	w35	2010	1.013	-0.022
22	w60	2011	1.066	-0.580
22	w85	2006	1.042	-0.014
22	w125	2000	1.013	0.163
22	w175	1976	1.024	0.056
22	e5	2005	1.022	-0.212
22	e15	1916	1.121	-0.396
22	e25	1910	1.165	-0.441
22	e35	1974	1.041	-0.026
22	e60	1918	1.064	-0.419
22	e85	1998	0.967	-0.025
22	e125	1977	1.054	-0.307
22	e175	1980	1.053	-0.420

Cyril
(applicable for the period of 24 July 1996 through 10 December 1996)

site ID	*sensor location*	*serial number*	*m*	*b*
24	w5	3375	1.011	-0.086
24	w15	3482	1.139	-0.750
24	w25	3322	0.974	0.062
24	w35	3336	1.127	-0.615
24	w60	3328	1.311	-0.962
24	w85	3463	1.072	-0.336
24	w125	3477	1.155	-0.526
24	w175	x	x	x
24	e5	3312	1.027	-0.150
24	e15	3508	1.085	-0.356
24	e25	3476	1.103	-0.738
24	e35	3462	1.040	-0.025
24	e60	3315	1.126	-0.704
24	e85	3531	1.156	0.027
24	e125	3514	1.081	-0.134
24	e175	x	x	x

Seminole

(no pre-STUD period for this site)

site ID	*sensor location*	*serial number*	*m*	*b*
25	w5	3633	x	x
25	w15	3544	x	x
25	w25	3495	x	x
25	w35	3494	x	x
25	w60	3677	x	x
25	w85	3639	x	x
25	w125	3551	x	x
25	w175	3645	x	x
25	e5	3687	x	x
25	e15	3664	x	x
25	e25	3644	x	x
25	e35	3661	x	x
25	e60	3652	x	x
25	e85	3674	x	x
25	e125	3682	x	x
25	e175	3653	x	x

Table 2
Coefficients for normalizing individual sensor response during post-STUD period

Table 2 contains a list of coefficients used to normalize an individual sensor's response. This set of coefficients applies during the time period after modification of the system to incorporate the STUD unit.

Larned
starting 21 Nov 1996

site ID	*sensor location*	*serial number*	*m*	*b*
1	w5	3333	1.152	-0.636
1	w15	3310	1.223	-0.431
1	w25	3337	1.141	-0.88
1	w35	3321	1.098	-0.246
1	w60	3342	1.214	-0.526
1	w85	3364	1.174	-1.086
1	w125	3320	1.07	-0.129
1	w175	3343	1.199	-0.347
1	e5	3346	1.142	-0.185
1	e15	3339	1.113	-0.09
1	e25	3371	1.087	-0.501
1	e35	3359	1.046	-0.493
1	e60	3659	0.898	0.095
1	e85	3332	0.997	-0.226
1	e125	3326	1.176	-0.526
1	e175	3317	1.147	-0.57

Hillsboro
starting 18 March 1997

site ID	*sensor location*	*serial number*	*m*	*b*
2	w5	3314	1.113	-0.501
2	w15	3370	1.046	0.030
2	w25	3366	1.011	-0.036
2	w35	3373	1.054	0.051
2	w60	3367	0.927	0.221
2	w85	3324	1.062	0.126
2	w125	3330	1.01	-0.317
2	w175	3327	0.976	0.081
2	e5	3313	1.139	-0.397
2	e15	3334	1.046	-0.012
2	e25	3340	1.061	-0.021
2	e35	3311	1.042	-0.048
2	e60	3341	1.077	-0.322
2	e85	3323	0.974	0.035
2	e125	3329	1.011	0.035
2	e175	3316	1.074	0.177

Leroy
starting 19 March 1997

site ID	*sensor location*	*serial number*	*m*	*b*
3	w5	3549	1.124	-0.453
3	w15	3547	1.135	-0.584
3	w25	3548	1.093	0.101
3	w35	3553	1.11	0.159
3	w60	3565	1.035	-0.256
3	w85	3550	1.082	-0.049
3	w125	3557	1.07	-0.044
3	w175	3651	0.989	0.015
3	e5	3671	1.08	-0.294
3	e15	3679	1.089	-0.047
3	e25	3566	1.049	-0.236
3	e35	3563	1.054	0.262
3	e60	3688	1.077	-0.096
3	e85	3669	0.961	-0.206
3	e125	3559	1.08	-0.176
3	e175	3561	1.035	0.158

Plevna
starting 20 November 1996

site ID	*sensor location*	*serial number*	*m*	*b*
4	w5	1942	0.916	-0.251
4	w15	1967	0.978	-0.117
4	w25	1956	0.95	-0.33
4	w35	1897	1.043	-0.143
4	w60	1993	1.062	-0.16
4	w85	1988	0.97	0.196
4	w125	1944	1.01	-0.206
4	w175	1983	1.013	-0.079
4	e5	1894	1.049	-0.435
4	e15	1892	0.999	-0.519
4	e25	1911	1.083	-0.537
4	e35	1898	1.067	-0.37
4	e60	1899	1.026	-0.047
4	e85	3663	1.011	-0.309
4	e125	2008	0.897	0.079
4	e175	1982	1.012	-0.027

Halstead
starting 20 November 1996

site ID	*sensor location*	*serial number*	*m*	*b*
5	w5	3636	1.003	-0.255
5	w15	3657	1.114	-0.447
5	w25	3642	1.07	-0.365
5	w35	3691	1.041	-0.89
5	w60	3543	1.012	-0.088
5	w85	3631	0.838	0.265
5	w125	3358	1.048	-0.371
5	w175	3356	1.002	-0.053
5	e5	3684	1.221	-0.403
5	e15	3641	1.176	-0.89
5	e25	3686	1.797	-1.639
5	e35	3650	1.089	-0.548
5	e60	3542	1.074	-0.328
5	e85	3678	1.013	0.002
5	e125	3632	1.004	-0.408
5	e175	3672	1.08	-0.327

Towanda
starting 20 November 1996

site ID	*sensor location*	*serial number*	*m*	*b*
6	w5	3690	1.033	-0.222
6	w15	3689	0.965	-0.068
6	w25	3655	1.094	-0.546
6	w35	3646	1.032	-0.571
6	w60	3634	0.866	0.132
6	w85	3335	1.075	0.133
6	w125	3538	1.054	-0.086
6	w175	3536	1.078	-0.464
6	e5	3554	0.936	-0.23
6	e15	3693	1.048	-0.329
6	e25	3638	1.031	0.08
6	e35	3318	1.017	0.047
6	e60	3637	1.032	-0.034
6	e85	3532	0.856	0.207
6	e125	3478	1.038	-0.115
6	e175	3468	1.193	-0.851

Elk Falls

starting 20 March 1997

site ID	*sensor location*	*serial number*	*m*	*b*
7	w5	1963	1.206	-0.405
7	w15	1940	0.991	-0.305
7	w25	1936	1.234	-0.62
7	w35	1934	1.189	-0.618
7	w60	1989	1.019	-0.169
7	w85	2007	0.958	0.172
7	w125	1964	1.177	-0.056
7	w175	1935	1.114	-0.058
7	e5	1950	1.137	-0.36
7	e15	1992	1.014	-0.071
7	e25	1949	0.958	-0.23
7	e35	1948	1.074	-0.532
7	e60	1954	1.03	-0.073
7	e85	1966	1.107	-0.414
7	e125	1933	1.098	0.029
7	e175	1962	1.019	0.208

Coldwater

starting 21 November 1996

site ID	*sensor location*	*serial number*	*m*	*b*
8	w5	3380	1.159	-0.649
8	w15	3382	1.08	-0.294
8	w25	3381	1.057	-0.185
8	w35	3374	1.061	-0.52
8	w60	3377	1.118	-0.566
8	w85	3378	0.965	-0.242
8	w125	3389	1.068	-0.436
8	w175	3393	1.093	0.024
8	e5	3357	1.1	-0.556
8	e15	3384	1.066	-0.305
8	e25	3376	1.141	-0.321
8	e35	3349	1.054	-0.265
8	e60	3353	0.996	-0.274
8	e85	3385	1.066	-0.667
8	e125	3386	1.131	-0.125
8	e175	3387	1.057	-0.513

Ashton
starting 7 March 1997

site ID	*sensor location*	*serial number*	*m*	*b*
9	w5	1961	1.129	-0.438
9	w15	1968	1.195	-0.724
9	w25	1939	0.99	-0.204
9	w35	1941	0.906	-0.188
9	w60	1937	0.994	-0.509
9	w85	1938	0.921	-0.131
9	w125	1970	0.937	-0.035
9	w175	1945	1.104	-0.276
9	e5	1955	1.126	-0.388
9	e15	1953	0.98	0.008
9	e25	1952	1.042	-0.058
9	e35	1951	1.092	-0.575
9	e60	1946	0.958	-0.105
9	e85	1947	1.012	-0.169
9	e125	1957	0.918	0.048
9	e175	1943	0.936	-0.025

Tyro
starting 20 March 1997

site ID	*sensor location*	*serial number*	*m*	*b*
10	w5	3469	1.159	-0.394
10	w15	3511	1.093	-0.511
10	w25	3596	1.043	-0.06
10	w35	3545	1.045	-0.094
10	w50	3527	1.034	0.118
10	w85	x	x	x
10	w125	x	x	x
10	w175	x	x	x
10	e5	3599	1.084	-0.355
10	e15	3519	1.075	-0.125
10	e25	3534	0.989	-0.084
10	e35	3513	1.088	-0.688
10	e50	3510	1.031	-0.146
10	e85	x	x	x
10	e125	x	x	x
10	e175	x	x	x

Byron
starting 6 March 1997

site ID	*sensor location*	*serial number*	*m*	*b*
11	w5	3392	1.136	-0.154
11	w15	3354	1.244	-0.536
11	w25	3360	1.066	-0.156
11	w35	3383	1.033	-0.583
11	w60	3388	1.011	0.197
11	w85	3362	1.033	0.254
11	w125	3351	1.085	0.24
11	w175	3355	1.029	0.083
11	e5	3361	1.115	-0.538
11	e15	3372	1.085	-0.346
11	e25	3352	1.113	-0.179
11	e35	3365	1.102	-0.659
11	e60	3363	0.953	0.179
11	e85	3369	0.966	0.249
11	e125	3391	1.022	-0.389
11	e175	3390	1.05	0.12

Pawhuska
starting 7 March 1997

site ID	*sensor location*	*serial number*	*m*	*b*
12	w5	3465	0.999	-0.109
12	w15	3471	1.007	-0.181
12	w25	3470	1.02	-0.375
12	w35	3464	1.113	-0.112
12	w60	3475	1.012	-0.179
12	w85	x	x	x
12	w125	x	x	x
12	w175	x	x	x
12	e5	3492	1.098	-0.136
12	e15	3474	1.118	-0.23
12	e25	3479	1.065	-0.026
12	e35	3467	1.073	-0.23
12	e60	3473	1.013	0.235
12	e85	x	x	x
12	e125	x	x	x
12	e175	x	x	x

Central Facility
starting 28 February 1997

site ID	*sensor location*	*serial number*	*m*	*b*
13	w5	1920	1.036	-0.320
13	w15	1923	0.99	-0.244
13	w25	1904	1.059	-0.378
13	w35	1978	1.003	-0.145
13	w60	1903	0.95	-0.159
13	w85	3676	1.097	-0.639
13	w125	x	x	x
13	w175	x	x	x
13	e5	1908	1.258	-0.671
13	e15	1975	1.084	-0.279
13	e25	1922	1.044	-0.354
13	e35	1914	1.061	-0.201
13	e60	1929	1.081	-0.328
13	e85	3666	1.071	0.073
13	e125	x	x	x
13	e175	x	x	x

Ringwood
starting 6 March 1997

site ID	*sensor location*	*serial number*	*m*	*b*
15	w5	1907	1.028	0.053
15	w15	1985	1.048	-0.287
15	w25	1991	1.004	-0.076
15	w35	1984	1.01	-0.085
15	w60	1986	1.126	-0.028
15	w85	2001	0.997	0.004
15	w125	2002	1.021	-0.152
15	w175	2009	0.941	0.043
15	e5	1901	1.027	0.055
15	e15	1893	1.573	-1.295
15	e25	1999	1.069	-0.31
15	e35	1895	1.049	-0.435
15	e60	1990	1.051	-0.491
15	e85	1987	1.149	-0.401
15	e125	1994	1.07	-0.418
15	e175	1995	0.985	-0.216

Vici
starting 6 March 1997

site ID	*sensor location*	*serial number*	*m*	*b*
16	w5	3515	1.156	-0.597
16	w15	3491	1.132	-0.692
16	w25	3338	1.077	-0.279
16	w35	3507	1.102	-0.813
16	w60	3331	1.178	-0.387
16	w85	3325	1.036	-0.661
16	w125	3493	1.16	-0.674
16	w175	3485	1.024	-0.505
16	e5	3488	1.077	-0.559
16	e15	3516	1.079	-0.153
16	e25	3486	1.12	-0.704
16	e35	3484	1.09	-0.288
16	e60	3529	1.034	-0.296
16	e85	3498	1.255	-0.415
16	e125	3319	1.037	-0.715
16	e175	3487	1.231	-0.738

Morris
starting 20 March 1997

site ID	*sensor location*	*serial number*	*m*	*b*
18	w5	3683	1.059	-0.177
18	w15	3680	1.473	-1.287
18	w25	3658	0.888	0.012
18	w35	3555	0.815	0.271
18	w60	3556	0.865	0.229
18	w85	3675	1.075	-0.631
18	w125	3560	1.001	0.348
18	w175	3635	0.976	-0.016
18	e5	3660	0.986	0.186
18	e15	3649	1.076	-0.245
18	e25	3694	0.98	0.106
18	e35	3562	0.841	0.143
18	e60	3558	0.967	0.122
18	e85	3665	0.996	-0.164
18	e125	3552	0.966	-0.118
18	e175	3654	1.061	0.032

El Reno
starting 6 May 1997

site ID	*sensor location*	*serial number*	*m*	*b*
19	w5	3668	1.083	-0.516
19	w15	3681	1.117	-0.955
19	w25	3500	1.051	-0.208
19	w35	3648	1.074	-0.146
19	w60	3662	1.151	-0.289
19	w85	3505	1.057	-0.523
19	w125	3692	1.165	-0.38
19	w175	3490	1.192	-0.635
19	e5	3506	1.026	0.076
19	e15	3540	1.146	-0.191
19	e25	3541	1.144	-0.611
19	e35	3528	1.082	-0.655
19	e60	3522	1.019	-0.251
19	e85	3502	1.109	-0.339
19	e125	3503	1.079	-0.023
19	e175	3461	0.991	-0.186

Meeker
starting 4 June 1997

site ID	*sensor location*	*serial number*	*m*	*b*
20	w5	1906	1.405	-1.726
20	w15	1913	1.131	-0.419
20	w25	1900	1.015	-0.163
20	w35	1928	1.015	0.019
20	w60	1912	1.061	-0.085
20	w85	1921	0.894	0.164
20	w125	1905	0.973	-0.031
20	w175	x	x	x
20	e5	1919	1.116	-0.573
20	e15	1896	1.134	-0.458
20	e25	1909	1.029	-0.287
20	e35	1917	1.357	-0.656
20	e60	1972	1.079	0.009
20	e85	1902	1.136	-0.211
20	e125	1915	1.001	-0.172
20	e175	x	x	x

Cordell
starting 10 December 1996

site ID	*sensor location*	*serial number*	*m*	*b*
22	w5	2004	1.046	-0.252
22	w15	1997	1.062	-0.107
22	w25	1996	1.058	-0.377
22	w35	2010	1.012	-0.017
22	w60	2011	1.089	-0.679
22	w85	2006	1.069	-0.117
22	w125	2000	1.033	0.088
22	w175	1976	1.053	-0.053
22	e5	2005	1.032	-0.251
22	e15	1916	1.139	-0.466
22	e25	1910	1.174	-0.475
22	e35	1974	1.071	-0.141
22	e60	1918	1.095	-0.548
22	e85	1998	0.981	-0.082
22	e125	1977	1.046	-0.273
22	e175	1980	1.067	-0.477

Cyril
starting 10 December 1996

site ID	*sensor location*	*serial number*	*m*	*b*
24	w5	3375	1.015	-0.102
24	w15	3482	1.06	-0.422
24	w25	3322	0.973	0.066
24	w35	3336	1.127	-0.615
24	w60	3328	1.34	-1.073
24	w85	3463	1.072	-0.336
24	w125	3477	1.13	-0.428
24	w175	x	x	x
24	e5	3312	1.032	-0.168
24	e15	3508	1.085	-0.356
24	e25	3476	1.108	-0.759
24	e35	3462	1.084	-0.192
24	e60	3315	1.161	-0.85
24	e85	3531	1.146	0.062
24	e125	3514	1.067	-0.082
24	e175	x	x	x

Seminole

starting 12 December 1996

site ID	*sensor location*	*serial number*	*m*	*b*
25	w5	3633	0.969	-0.055
25	w15	3544	0.931	0.151
25	w25	3495	1.07	-0.161
25	w35	3494	1.019	-0.19
25	w60	3677	1.06	-0.316
25	w85	3639	1.161	-0.397
25	w125	3551	1.015	0.141
25	w175	3645	0.929	-0.005
25	e5	3687	1.046	0.041
25	e15	3664	0.999	0.101
25	e25	3644	1.11	-0.452
25	e35	3661	1.002	-0.284
25	e60	3652	0.996	0.234
25	e85	3674	1.115	-0.594
25	e125	3682	1.036	-0.04
25	e175	3653	1.084	0.014

Table 3.
List of coefficients for use in the van Genuchten water-retention equation.

Table 3 contains a list of coefficients used in the van Genuchten soil water retention equation for estimating volumetric water content from the Mesonet 229L soil moisture sensors. These coefficients were obtained

1. from laboratory analysis of soil samples by OSU
2. with coefficient estimation using the RETC curve-fitting program
3. holding the value of theta_s fixed at its saturated-water content

Larned

sensor depth cm	*depth of soil sample cm*	*texture class*	*theta_r m/m*	*theta_s m/m*	*a 1/bar*	*n*
5	15	silt loam	0.240	0.528	23.817	1.938
15	15	silt loam	0.240	0.528	23.817	1.938
25	15	silt loam	0.240	0.528	23.817	1.938
35	15	silt loam	0.240	0.528	23.817	1.938
60	40	silty clay loam	0.236	0.562	24.671	2.114
85	40	silty clay loam	0.236	0.562	24.671	2.114
125	40	silty clay loam	0.236	0.562	24.671	2.114
175	40	silty clay loam	0.236	0.562	24.671	2.114

Hillsboro

sensor depth cm	*depth of soil sample cm*	*texture class*	*theta_r m/m*	*theta_s m/m*	*a 1/bar*	*n*
5	4-9	silty clay loam	0.313	0.592	21.475	3.146
15	4-9	silty clay loam	0.313	0.592	21.475	3.146
25	25-35	silty clay	0.386	0.475	209.295	1.507
35	25-35	silty clay	0.386	0.475	209.295	1.507
60	25-35	silty clay	0.386	0.475	209.295	1.507
85	25-35	silty clay	0.386	0.475	209.295	1.507
125	25-35	silty clay	0.386	0.475	209.295	1.507
175	25-35	silty clay	0.386	0.475	209.295	1.507

LeRoy

sensor depth *cm*	*depth of soil sample* *cm*	*texture class*	*theta_r* *m/m*	*theta_s* *m/m*	*a* *1/bar*	*n*
5	10-15	silty clay loam	0.389	0.513	101.069	1.678
15	10-15	silty clay loam	0.389	0.513	101.069	1.678
25	10-15	silty clay loam	0.389	0.513	101.069	1.678
35	10-15	silty clay loam	0.389	0.513	101.069	1.678
60	40-45	silty clay	0.413	0.494	119.393	2.030
85	40-45	silty clay	0.413	0.494	119.393	2.030
125	40-45	silty clay	0.413	0.494	119.393	2.030
175	40-45	silty clay	0.413	0.494	119.393	2.030

Plevna

sensor depth *cm*	*depth of soil sample* *cm*	*texture class*	*theta_r* *m/m*	*theta_s* *m/m*	*a* *1/bar*	*n*
5	13	loamy sand	0.052	0.332	156.854	1.361
15	13	loamy sand	0.052	0.332	156.854	1.361
25	27	sand	0.069	0.370	64.265	2.480
35	27	sand	0.069	0.370	64.265	2.480
60	52	loamy sand	0.044	0.366	30.725	17.444
85	52	loamy sand	0.044	0.366	30.725	17.444
125	52	loamy sand	0.044	0.366	30.725	17.444
175	52	loamy sand	0.044	0.366	30.725	17.444

Halstead

sensor depth *cm*	*depth of soil sample* *cm*	*texture class*	*theta_r* *m/m*	*theta_s* *m/m*	*a* *1/bar*	*n*
5	2-5	silt loam	0.289	0.547	42.360	1.787
15	2-5	silt loam	0.289	0.547	42.360	1.787
25	2-5	silt loam	0.289	0.547	42.360	1.787
35	30-35	clay loam	0.299	0.483	45.441	1.729
60	30-35	clay loam	0.299	0.483	45.441	1.729
85	30-35	clay loam	0.299	0.483	45.441	1.729
125	30-35	clay loam	0.299	0.483	45.441	1.729
175	30-35	clay loam	0.299	0.483	45.441	1.729

Towanda

sensor depth *cm*	*depth of soil sample* *cm*	*texture class*	*theta_r* *m/m*	*theta_s* *m/m*	*a* *1/bar*	*n*
5	10-20	silty clay loam	0.303	0.498	51.777	1.774
15	10-20	silty clay loam	0.303	0.498	51.777	1.774
25	10-20	silty clay loam	0.303	0.498	51.777	1.774
35	30-40	silty clay	0.397	0.502	22.397	3.031
60	30-40	silty clay	0.397	0.502	22.397	3.031
85	30-40	silty clay	0.397	0.502	22.397	3.031
125	30-40	silty clay	0.397	0.502	22.397	3.031
175	30-40	silty clay	0.397	0.502	22.397	3.031

Elk Falls

sensor depth *cm*	*depth of soil sample* *cm*	*texture class*	*theta_r* *m/m*	*theta_s* *m/m*	*a* *1/bar*	*n*
5	5-10	silt loam	0.000	0.400	138.199	1.057
15	5-10	silt loam	0.000	0.400	138.199	1.057
25	25-30	silty clay	0.000	0.415	8.013	1.048
35	25-30	silty clay	0.000	0.415	8.013	1.048
60	25-30	silty clay	0.000	0.415	8.013	1.048
85	25-30	silty clay	0.000	0.415	8.013	1.048
125	25-30	silty clay	0.000	0.415	8.013	1.048
175	25-30	silty clay	0.000	0.415	8.013	1.048

Coldwater

sensor depth *cm*	*depth of soil sample* *cm*	*texture class*	*theta_r* *m/m*	*theta_s* *m/m*	*a* *1/bar*	*n*
5	12	loamy sand	0.101	0.426	60.024	1.788
15	12	loamy sand	0.101	0.426	60.024	1.788
25	12	loamy sand	0.101	0.426	60.024	1.788
35	12	loamy sand	0.101	0.426	60.024	1.788
60	44	loamy sand	0.096	0.370	52.354	1.899
85	44	loamy sand	0.096	0.370	52.354	1.899
125	44	loamy sand	0.096	0.370	52.354	1.899
175	44	loamy sand	0.096	0.370	52.354	1.899

Ashton

sensor depth	*depth of soil sample*	*texture class*	*theta_r*	*theta_s*	*a*	*n*
cm	*cm*		*m/m*	*m/m*	*1/bar*	
5	20	loam	0.262	0.468	89.983	1.466
15	20	loam	0.262	0.468	89.983	1.466
25	20	loam	0.262	0.468	89.983	1.466
35	20	loam	0.262	0.468	89.983	1.466
60	50	clay loam	0.000	0.430	4342.496	1.020
85	50	clay loam	0.000	0.430	4342.496	1.020
125	50	clay loam	0.000	0.430	4342.496	1.020
175	50	clay loam	0.000	0.430	4342.496	1.020

Tyro

sensor depth	*depth of soil sample*	*texture class*	*theta_r*	*theta_s*	*a*	*n*
cm	*cm*		*m/m*	*m/m*	*1/bar*	
5	5-10	clay loam	0.300	0.438	216.239	1.371
15	5-10	clay loam	0.300	0.438	216.239	1.371
25	5-10	clay loam	0.300	0.438	216.239	1.371
35	5-10	clay loam	0.300	0.438	216.239	1.371
60	40-45	clay loam	0.262	0.494	40.166	1.922
85	x	x	x	x	x	x
125	x	x	x	x	x	x
175	x	x	x	x	x	x

Byron

sensor depth	*depth of soil sample*	*texture class*	*theta_r*	*theta_s*	*a*	*n*
cm	*cm*		*m/m*	*m/m*	*1/bar*	
5	4-8	loam	0.193	0.408	29.794	1.605
15	4-8	loam	0.193	0.408	29.794	1.605
25	4-8	loam	0.193	0.408	29.794	1.605
35	35-40	loam	0.227	0.434	61.247	1.456
60	60-65	clay loam	0.256	0.396	99.525	1.411
85	60-65	clay loam	0.256	0.396	99.525	1.411
125	60-65	clay loam	0.256	0.396	99.525	1.411
175	60-65	clay loam	0.256	0.396	99.525	1.411

Pawhuska

sensor depth	*depth of soil sample*	*texture class*	*theta_r*	*theta_s*	*a*	*n*
cm	*cm*		*m/m*	*m/m*	*1/bar*	
5	3-8	sandy loam	0.226	0.525	50.960	1.560
15	3-8	sandy loam	0.226	0.525	50.960	1.560
25	3-8	sandy loam	0.226	0.525	50.960	1.560
35	30-35	sandy loam	0.190	0.479	26.922	1.820
60	30-35	sandy loam	0.190	0.479	26.922	1.820
85	x	x	x	x	x	x
125	x	x	x	x	x	x
175	x	x	x	x	x	x

Central Facility

sensor depth	*depth of soil sample*	*texture class*	*theta_r*	*theta_s*	*a*	*n*
cm	*cm*		*m/m*	*m/m*	*1/bar*	
5	10	silt loam	0.246	0.434	29.910	1.631
15	10	silt loam	0.246	0.434	29.910	1.631
25	20	clay	0.265	0.483	66.002	1.524
35	30	clay loam	0.297	0.479	92.101	1.284
60	30	clay loam	0.297	0.479	92.101	1.284
85	30	clay loam	0.297	0.479	92.101	1.284
125	x	x	x	x	x	x
175	x	x	x	x	x	x

Ringwood

sensor depth	*depth of soil sample*	*texture class*	*theta_r*	*theta_s*	*a*	*n*
cm	*cm*		*m/m*	*m/m*	*1/bar*	
5	6	sand	0.091	0.415	34.492	4.017
15	6	sand	0.091	0.415	34.492	4.017
25	21	sand	0.099	0.430	31.154	7.493
35	21	sand	0.099	0.430	31.154	7.493
60	50	sand	0.101	0.430	25.847	21.191
85	50	sand	0.101	0.430	25.847	21.191
125	50	sand	0.101	0.430	25.847	21.191
175	50	sand	0.101	0.430	25.847	21.191

Vici

sensor depth	*depth of soil sample*	*texture class*	*theta_r*	*theta_s*	*a*	*n*
cm	*cm*		*m/m*	*m/m*	*1/bar*	
5	6-8	loam	0.200	0.453	22.289	1.975
15	6-8	loam	0.200	0.453	22.289	1.975
25	20-23	loam	0.106	0.408	21.729	2.122
35	20-23	loam	0.106	0.408	21.729	2.122
60	40	loam	0.172	0.457	91.298	1.289
85	40	loam	0.172	0.457	91.298	1.289
125	40	loam	0.172	0.457	91.298	1.289
175	40	loam	0.172	0.457	91.298	1.289

Morris

sensor depth	*depth of soil sample*	*texture class*	*theta_r*	*theta_s*	*a*	*n*
cm	*cm*		*m/m*	*m/m*	*1/bar*	
5	15-25	silt loam	0.310	0.442	86.578	1.522
15	15-25	silt loam	0.310	0.442	86.578	1.522
25	15-25	silt loam	0.310	0.442	86.578	1.522
35	15-25	silt loam	0.310	0.442	86.578	1.522
60	60-70	clay loam	0.290	0.453	108.722	1.427
85	60-70	clay loam	0.290	0.453	108.722	1.427
125	60-70	clay loam	0.290	0.453	108.722	1.427
175	60-70	clay loam	0.290	0.453	108.722	1.427

El Reno

sensor depth	*depth of soil sample*	*texture class*	*theta_r*	*theta_s*	*a*	*n*
cm	*cm*		*m/m*	*m/m*	*1/bar*	
5	10	Silt loam	0.000	0.506	26806.378	1.060
15	10	Silt loam	0.000	0.506	26806.378	1.060
25	10	Silt loam	0.000	0.506	26806.378	1.060
35	10	Silt loam	0.000	0.506	26806.378	1.060
60	40	Silt loam	0.000	0.487	39666.757	1.053
85	40	Silt loam	0.000	0.487	39666.757	1.053
125	40	Silt loam	0.000	0.487	39666.757	1.053
175	40	Silt loam	0.000	0.487	39666.757	1.053

Meeker

sensor depth	*depth of soil sample*	*texture class*	*theta_r*	*theta_s*	*a*	*n*
cm	*cm*		*m/m*	*m/m*	*1/bar*	
5	6	loam	0.247	0.475	233.857	1.299
15	6	loam	0.247	0.475	233.857	1.299
25	6	loam	0.247	0.475	233.857	1.299
35	30	sandy loam	0.235	0.423	523.815	1.152
60	30	sandy loam	0.235	0.423	523.815	1.152
85	30	sandy loam	0.235	0.423	523.815	1.152
125	30	sandy loam	0.235	0.423	523.815	1.152
175	x	x	x	x	x	x

Cordell

sensor depth	*depth of soil sample*	*texture class*	*theta_r*	*theta_s*	*a*	*n*
cm	*cm*		*m/m*	*m/m*	*1/bar*	
5	8-12	silty clay loam	0.135	0.445	206.681	1.178
15	15-25	silty clay	0.265	0.453	321.648	1.263
25	15-25	silty clay	0.265	0.453	321.648	1.263
35	35-40	silty clay loam	0.000	0.426	964.614	1.052
60	35-40	silty clay loam	0.000	0.426	964.614	1.052
85	35-40	silty clay loam	0.000	0.426	964.614	1.052
125	35-40	silty clay loam	0.000	0.426	964.614	1.052
175	35-40	silty clay loam	0.000	0.426	964.614	1.052

Cyril

sensor depth	*depth of soil sample*	*texture class*	*theta_r*	*theta_s*	*a*	*n*
cm	*cm*		*m/m*	*m/m*	*1/bar*	
5	10	silt loam	0.266	0.668	28.162	2.126
15	10	silt loam	0.266	0.668	28.162	2.126
25	10	silt loam	0.266	0.668	28.162	2.126
35	32	loam	0.150	0.502	41.777	1.581
60	32	loam	0.150	0.502	41.777	1.581
85	32	loam	0.150	0.502	41.777	1.581
125	32	loam	0.150	0.502	41.777	1.581
175	x	x	x	x	x	x

Seminole

sensor depth *cm*	*depth of soil sample* *cm*	*texture class*	*theta_r* *m/m*	*theta_s* *m/m*	*a* *1/bar*	*n*
5	2-10	sandy loam	0.000	0.374	68.741	1.105
15	2-10	sandy loam	0.000	0.374	68.741	1.105
25	21-37	sandy loam	0.000	0.423	38.365	1.164
35	21-37	sandy loam	0.000	0.423	38.365	1.164
60	51-60	clay loam	0.088	0.404	5462.897	1.042
85	51-60	clay loam	0.088	0.404	5462.897	1.042
125	51-60	clay loam	0.088	0.404	5462.897	1.042
175	51-60	clay loam	0.088	0.404	5462.897	1.042