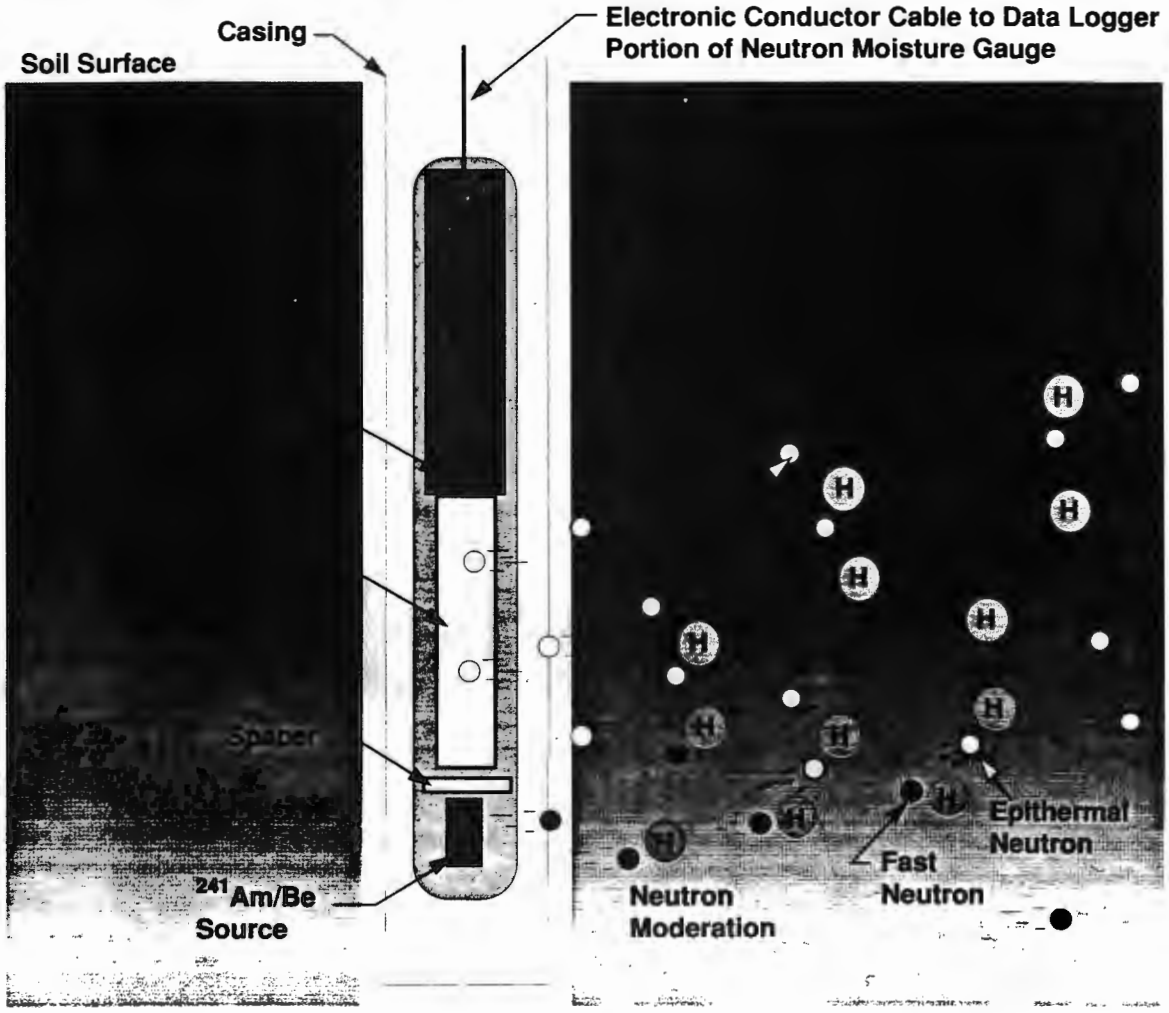
LA-12831-MS

ER Record I.D.

Calibration of Neutron Moisture Gauges and Their Ability to Spatially Determine Soil Water Content in Environmental Studies



4005

Los Alamos
NATIONAL LABORATORY

Los Alamos National Laboratory is operated by the University of California for the United States Department of Energy under contract W-7405-ENG-36.

LA-12831-MS

UC-902
Issued: October 199

Calibration of Neutron Moisture Gauges and Their Ability to Spatially Determine Soil Water Content in Environmental Studies

J. W. Nyhan
J. L. Martinez
G. J. Langhorst

Los Alamos
NATIONAL LABORATORY
Los Alamos, New Mexico 87545

Received by ER-RPF
FEB 0 3 199

CONTENTS

LIST OF FIGURES vii

LIST OF TABLES xi

I. INTRODUCTION 1

II. MATERIALS AND METHODS 3

III. RESULTS AND DISCUSSION 13

A. Radius of Investigation Determinations Performed For Crushed Tuff in 1982 13

B. MCNP Modeling Results for Crushed Tuff 23

C. Calibration of Moisture Gauges in 1994 for Crushed Tuff and Soils Used in Hydrologic Studies 29

IV. SUMMARY AND IMPLICATIONS 62

REFERENCES 67

Appendix A. 1994 NEUTRON MOISTURE GAUGE CALIBRATION DATA 69

Table A-1. Calibration Data for Neutron Probe With Serial Number 4274 (sample count means represent the average of three determinations per depth) 70

Table A-2. Calibration Data for Neutron Probe With Serial Number 4519 (sample count means represent the average of three determinations per depth) 80

Table A-3. Calibration Data for Neutron Probe With Serial Number 5079 (sample count means represent the average of three determinations per depth) 90

Table A-4. Calibration Data for Neutron Probe With Serial Number 5254 (sample count means represent the average of three determinations per depth) 100

List of Figures

Figure 1. Previous studies of Rj determinations and model predictions for neutron moisture gauges.

Figure 2. A typical red-orange Campbell Pacific neutron moisture gauge being used by Barry Drennon to collect (Rj) data for crushed tuff at the top and bottom of a calibration drum.

Figure 3. A typical yellow Troxler neutron moisture gauge used in the 1982 calibration studies.

Figure 4. The Gearhart-Owen neutron moisture gauge (white cylinder, left) consists of a polyethylene shield surrounding the probe. The trailer houses the generator and electronic instrumentation.

Figure 5. Determination of weight of dry crushed tuff to be added to a 15-cm lift in the 1982 calibration study.

Figure 6. Measurement of amount of water to be added to a 15-cm lift of crushed tuff in the 1982 calibration study.

Figure 7. Addition of a fine spray of water to the crushed tuff while it was being mixed in a cement mixer in the 1982 calibration study.

Figure 8. Packing the crushed tuff (known water content) to a known bulk density in a 15-cm lift in a calibration drum in the 1982 calibration study.

Figure 9. X-ray of probe in Campbell Pacific moisture gauge (42% reduction of full size image) showing locations of detector and ^{241}Am/Be source.

Figure 10. X-ray of Troxler Moisture Gauge (42% reduction of full size image) showing locations of detector and ^{241}Am/Be source.

Figure 11. X-ray of the terminal 42.5 cm of the 147-cm-long probe of the Gearhart-Owen moisture gauge (42% reduction of full size image) showing locations of detector and ^{241}Am/Be source.

Figure 12. Midpoint of sensitivity determination for the Campbell Pacific moisture gauge. The relationship of the midpoint of sensitivity to the gauge's ^{241}Am/Be source and detector locations is also shown.

Figure 13. Midpoint of sensitivity determination for the Troxler moisture gauge. The relationship of the midpoint of sensitivity to the gauge's ^{241}Am/Be source and detector locations is also shown.

Figure 23. MCNP shape simulations for calibration drum 4 containing crushed tuff at an average-volumetric water content of 14.9%.

Figure 24. MCNP shape simulations for calibration drum 5 containing crushed tuff at an average-volumetric water content of 33%.

Figure 25. Statistical analysis results for crushed-tuff samples for neutron moisture gauge with serial number 4274.

Figure 26. Statistical analysis results for fine sand and Hackroy clay loam samples for neutron moisture gauge with serial number 4274.

Figure 27. Statistical analysis results for Layton loamy fine sand sample for neutron moisture gauge with serial number 4274.

Figure 28. Statistical analysis results for crushed-tuff samples for neutron moisture gauge with serial number 4519.

Figure 29. Statistical analysis results for fine sand and Hackroy clay loam samples for neutron moisture gauge with serial number 4519.

Figure 30. Statistical analysis results for Layton loamy fine sand sample for neutron moisture gauge with serial number 4519.

Figure 31. Statistical analysis results for crushed-tuff samples for neutron moisture gauge with serial number 5079.

Figure 32. Statistical analysis results for fine sand and Hackroy clay loam samples for neutron moisture gauge with serial number 5079.

Figure 33. Statistical analysis results for Layton loam fine sand for neutron moisture gauge with serial number 5079.

Figure 34. Statistical analysis results for crushed-tuff samples for neutron moisture gauge with serial number 7832.

Figure 35. Statistical analysis results for fine sand and Hackroy clay loam samples for neutron moisture gauge with serial number 7832.

Figure 36. Statistical analysis results for Layton loam fine sand samples for neutron moisture gauge with serial number 7832.

Figure 37. Statistical analysis results for crushed-tuff samples for neutron moisture gauge with serial number 5254.

List of Tables

Table 1. Description of Campbell Pacific neutron moisture probes used in 1991-1994.

Table 2. Soil moisture access-tube data for 1991 field study sites of the Environmental Science Group.

Table 3. Description of soils used in 1991-1994 moisture gauge calibration and access-tube diameter used in calibration drums.

Table 4. Summary of regression results for 1994 neutron probe calibrations on all study soils and moisture gauges (% volumetric water content units).

CALIBRATION OF NEUTRON MOISTURE GAUGES AND THEIR ABILITY TO SPATIALLY DETERMINE SOIL WATER CONTENT IN ENVIRONMENTAL STUDIES

by

J. W. Nyhan, J. L. Martinez, and G. J. Langhorst

ABSTRACT

Several neutron moisture gauges were calibrated, and their ability to spatially determine soil water content was evaluated. In 1982, the midpoint of sensitivity of each neutron probe to the detection of hydrogen was determined, as well as the radius of investigation of each probe in crushed Bandelier Tuff with varying water contents. After determining the response of one of the moisture gauges to changes in soil water at the soil-air interface, a neutron transport model was successfully calibrated to predict spatial variations in soil water content. The model was then used to predict various shapes and volumes of crushed Bandelier Tuff interrogated by the neutron moisture gauge. From 1991 through 1994, six neutron moisture gauges were calibrated for soil water determinations in a local topsoil and crushed Bandelier Tuff, as well as for a sample of fine sand and soils from a field experiment at Hill Air Force Base. Statistical analysis of the calibration results is presented and summarized, and a final summary of practical implications for future neutron moisture gauge studies at Los Alamos is included.

I. INTRODUCTION

Waste management practices at a burial site invariably involve a knowledge of the hydrologic cycle. Since repeated destructive sampling of the burial site environs is undesirable, the use of the neutron moisture gauge represents an attractive method for *in situ* measurement of volumetric soil water content and its change in time and space. Thus, estimation of runoff, evapotranspiration, deep drainage, and change in the soil water storage is usually the objective of the measurement program based on the neutron moisture gauge.

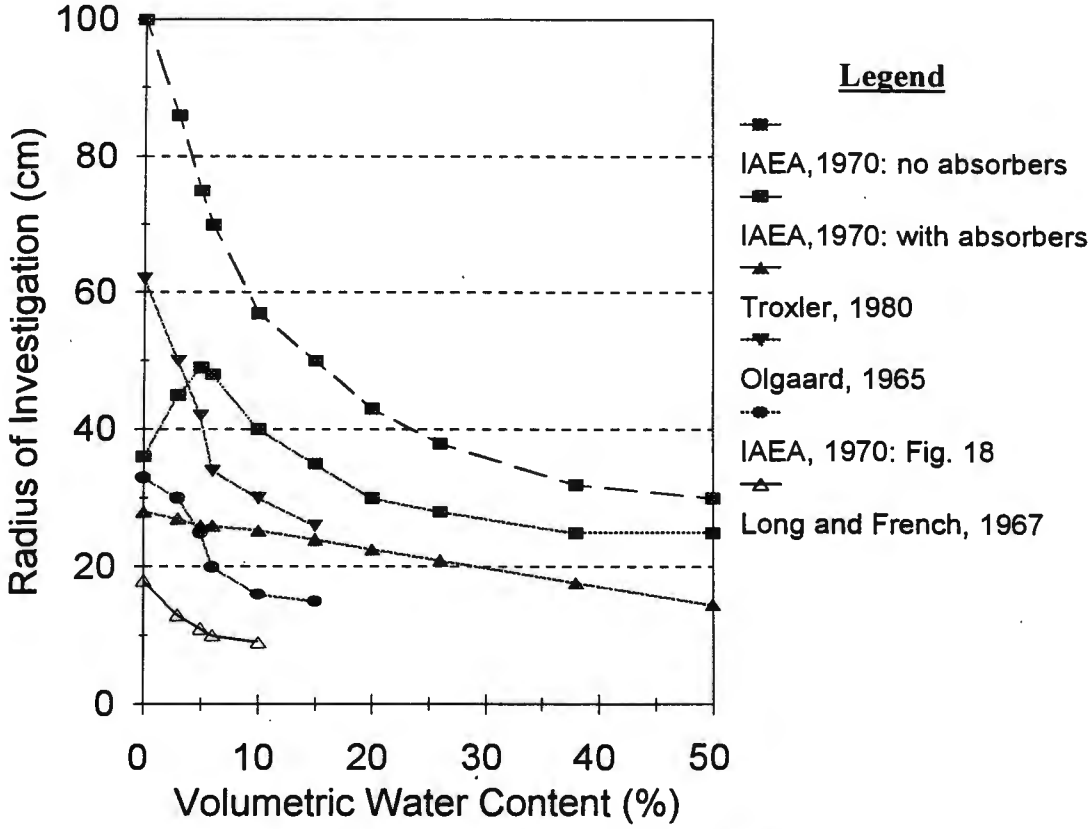


Fig. 1. Previous studies of Rj determinations and model predictions for neutron moisture gauges.

in water content. This data was then used to calibrate a neutron transport model, which was then used to evaluate different shapes and volumes of soil interrogated by the moisture gauges. Because neutron moisture gauge calibrations at the Laboratory have only been performed in crushed Bandelier Tuff between 1991 and 1994, we calibrated six neutron moisture gauges in a local topsoil as well as in several other soil samples used in hydrologic field studies being performed by the Laboratory's Environmental Science Group.

II. MATERIALS AND METHODS

During 1982, three neutron moisture gauges were calibrated to measure the water content of crushed Bandelier Tuff. The Campbell Pacific Model 503 DR moisture

Fig. 2. A typical red-orange Campbell Pacific neutron moisture gauge being used by Barry Drennon to collect Rj data for crushed tuff at the top and bottom of a calibration drum.

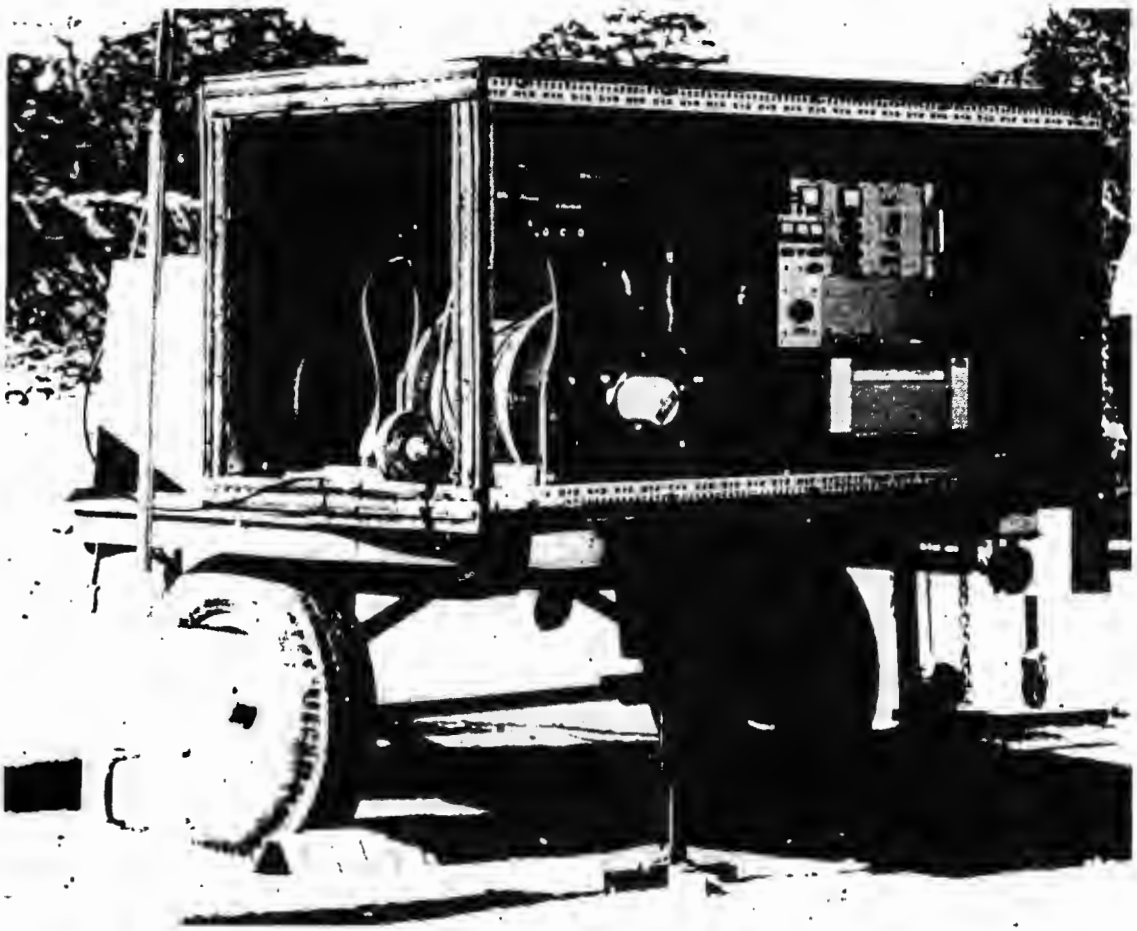


Fig. 4. The Gearhart-Owen neutron moisture gauge (white cylinder, left) consists of a polyethylene shield surrounding the probe. The trailer houses the generator and electronic instrumentation.

8.6, and 15% as determined from the bulk density and the gravimetric water content of samples collected in each 15-cm lift in each drum. To represent saturated conditions in the tuff, a fifth drum was prepared by slowly adding water to the bottom of the tuff-packed drum to result in saturated tuff at the top of the drum. Using only the water contents (Y) and three moisture gauge readings (X) from each 2.5-cm increment of the two 15-cm lifts in the center of each drum, the senior author determined a calibration curve for each moisture gauge using a linear regression model.

Fig. 6. Measurement of amount of water to be added to a 15-cm lift of crushed tuff in the 1982 calibration study.

Fig. 8. Packing the crushed tuff (known water content) to a known bulk density in a 15-cm lift in a calibration drum in the 1982 calibration study.

Table 1. Description of Campbell Pacific neutron moisture probes used in 1991-1994.

Model Number	Serial Number	Outside Diameter of Probe (cm)	Source Type
503DR	H-33095079	3.8	^{241}Am/Be
503DR	H-32024274	3.8	^{241}Am/Be
503DR	H-32074519	3.8	^{241}Am/Be
503DR	H-38098459	3.8	^{241}Am/Be
503DR	H-38098460	3.8	^{241}Am/Be
501DR	H-74015254	4.7	^{137}Cs/^{241}Am/Be

Table 2. Soil Moisture Access Tube Data for 1991 Field Study Sites of the Environmental Science Group.

Study Site Location	Access-Tube Diameter (cm)	Numbers of Access Tubes
MDA-B (TA-21)	5.1	47
Pinyon-Juniper Transect (TA-51)	5.1	21
White Rock Site	5.1	2
Integrated Test Plots (TA-51)	5.1	30
Hill Air Force Base (Ogden, UT)	6.4	36
Cover System Plots (TA-51)	6.4	24
Erosion Plots (TA-51)	5.1	24

III. RESULTS AND DISCUSSION

A. Radius-of-Investigation Determinations Performed For Crushed Tuff in 1982

We were interested in the spatial response of the neutron moisture gauges to hydrogen; therefore, we first determined the exact location of the detector and ^{241}Am/Be source for each neutron moisture gauge, because all of the manufacturers could not provide us with this information (Figs. 9-11). The midpoint of sensitivity for each moisture gauge was then estimated by sliding a plastic disk (hydrogen source) along the length of each probe and determining the sample count rate at each position. The

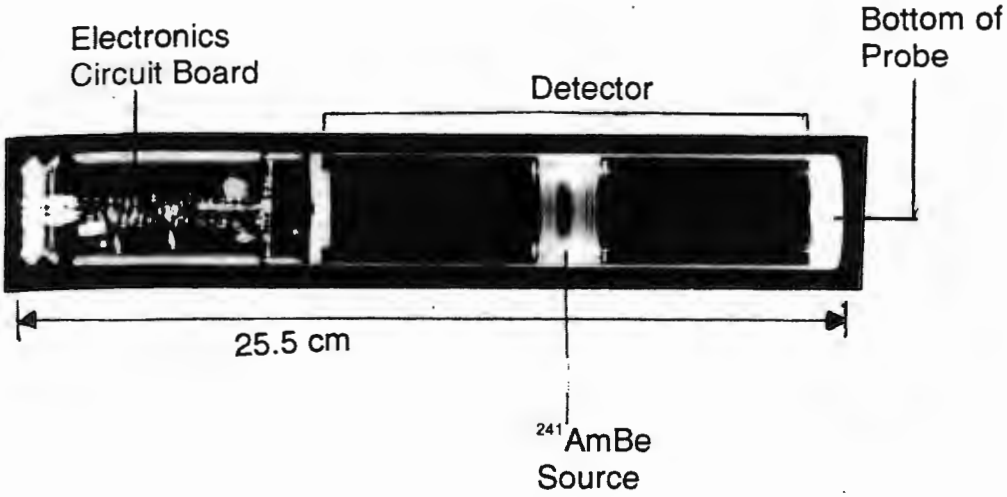


Fig. 10. X-ray of probe in Troxler moisture gauge (42% reduction of full size image) showing locations of detector and ^{241}Am/Be source.

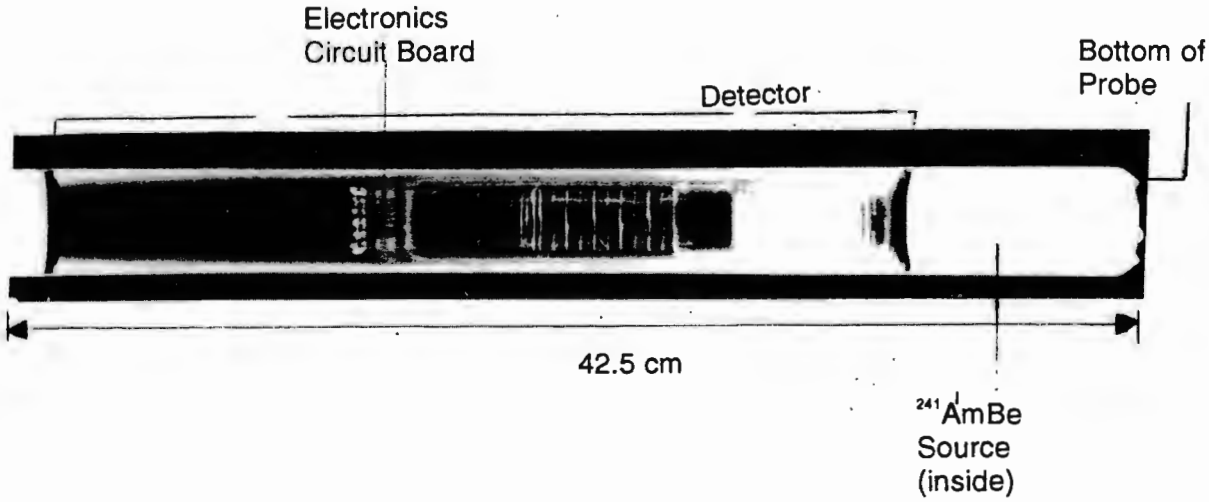


Fig. 11. X-ray of the terminal 42.5 cm of the 147-cm-long probe of the Gearhart-Owen moisutre gauge (42% reduction of full size image) showing locations of detector and ^{241}Am/Be source.

results of this experiment are presented in Figs. 12, 13, and 14 where the average count rate of the plastic disk is expressed as a function of distance from the bottom of each probe. These results are important not only in that they show where the midpoint

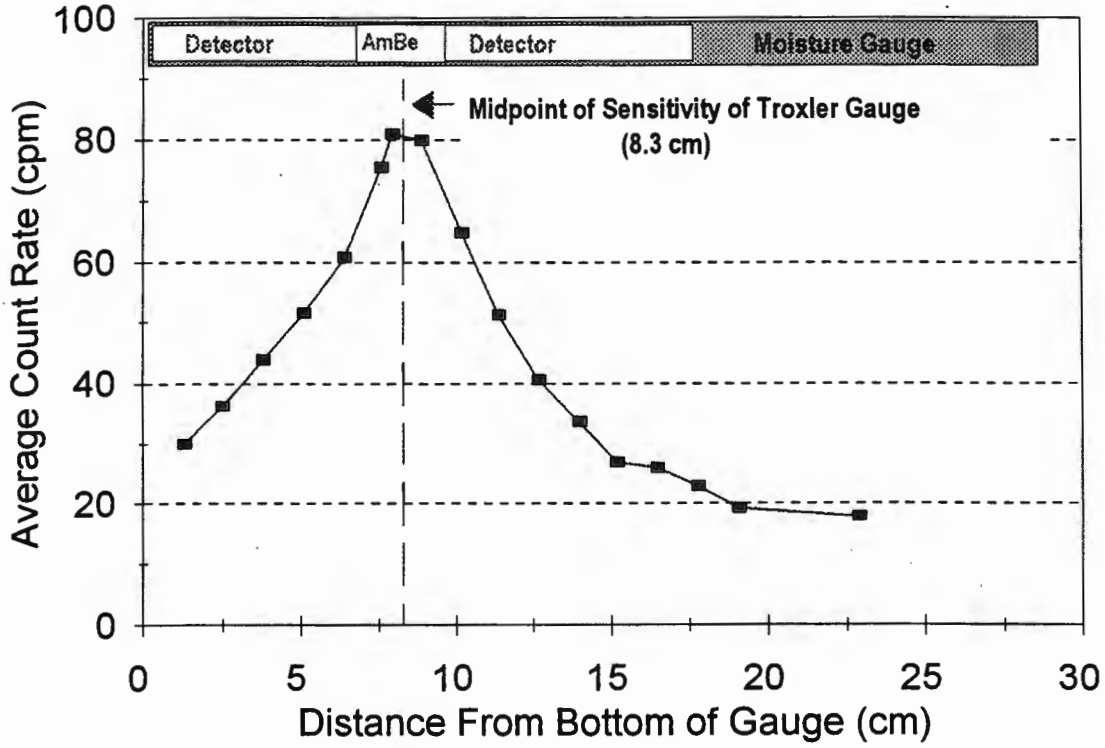


Fig. 13. Midpoint of sensitivity determination for the Troxler moisture gauge. The relationship of the midpoint of sensitivity to the gauge's ^{241}Am/Be source and detector locations is also shown.

directions away from the midpoint of sensitivity along the length of the probe. However, the Campbell Pacific gauge did not exhibit this pattern: background counting rates were reached about 11 cm above the midpoint of sensitivity, but above-background counting rates were still observed with the plastic disk at the bottom of the probe. This observation is important In biasing a probe's response below the midpoint of sensitivity in the field, when layers of varying hydrogen concentrations exist along an access tube.

All three neutron moisture gauges were calibrated using the drums packed with crushed tuff at known bulk densities and soil water contents. After measuring the sample-standard count ratio (X) and calculating volumetric water content (Y) from the

generally showed reduced estimates of volumetric water content upon approaching a soil-air interface. This occurred because increasingly larger amounts of air (with a low water content) were included in the volume of thermalized neutrons sampled by each probe as the interface was approached. The only exception to this pattern occurred in the calibration drum filled with kiln-dried tuff (drum 1), where the moisture gauges detected similar concentrations of hydrogen in the tuff and in the air outside of the drum (Figs. 15, 16, 17).

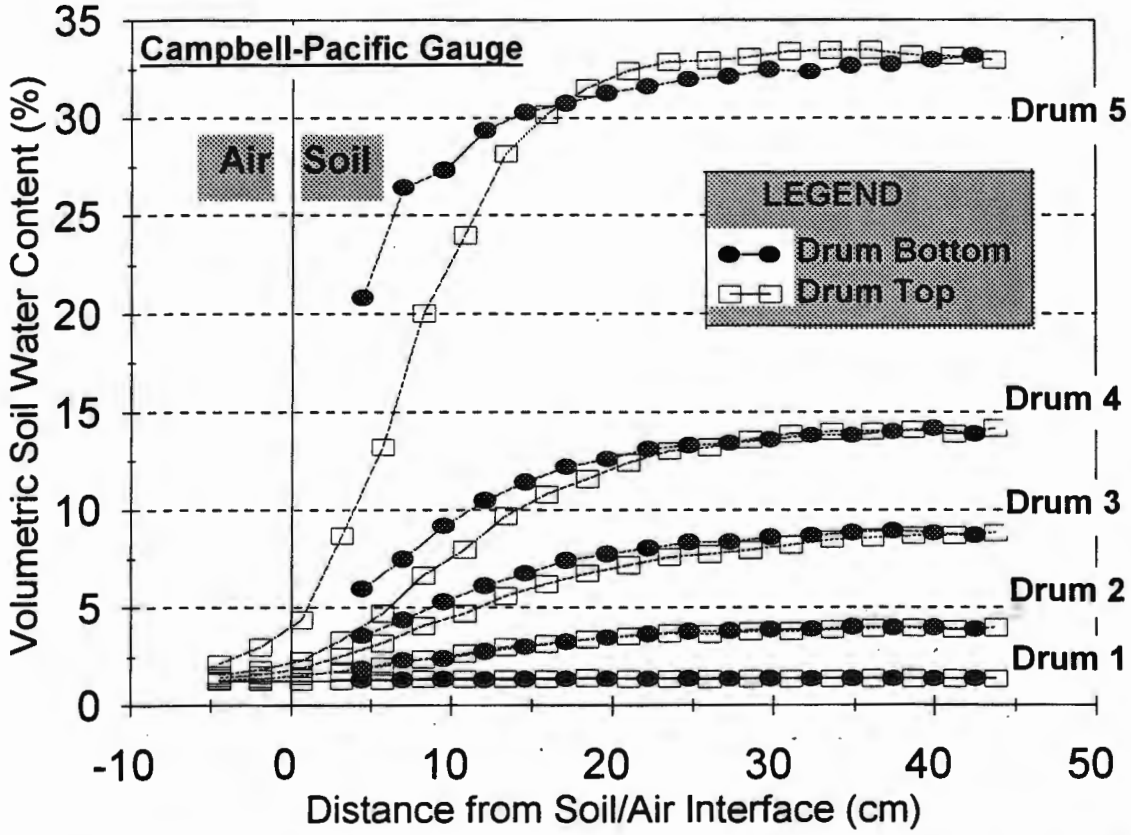


Fig. 15. Estimates of soil water content as a function of distance from the soil-air interface to the midpoint of the probe-sensitive area using the Campbell Pacific moisture gauge. Calibration drums 1, 2, 3, 4, and 5 contained crushed tuff at average volumetric water contents of 0.12, 4.3, 8.6, 14.9 and 33%, respectively.

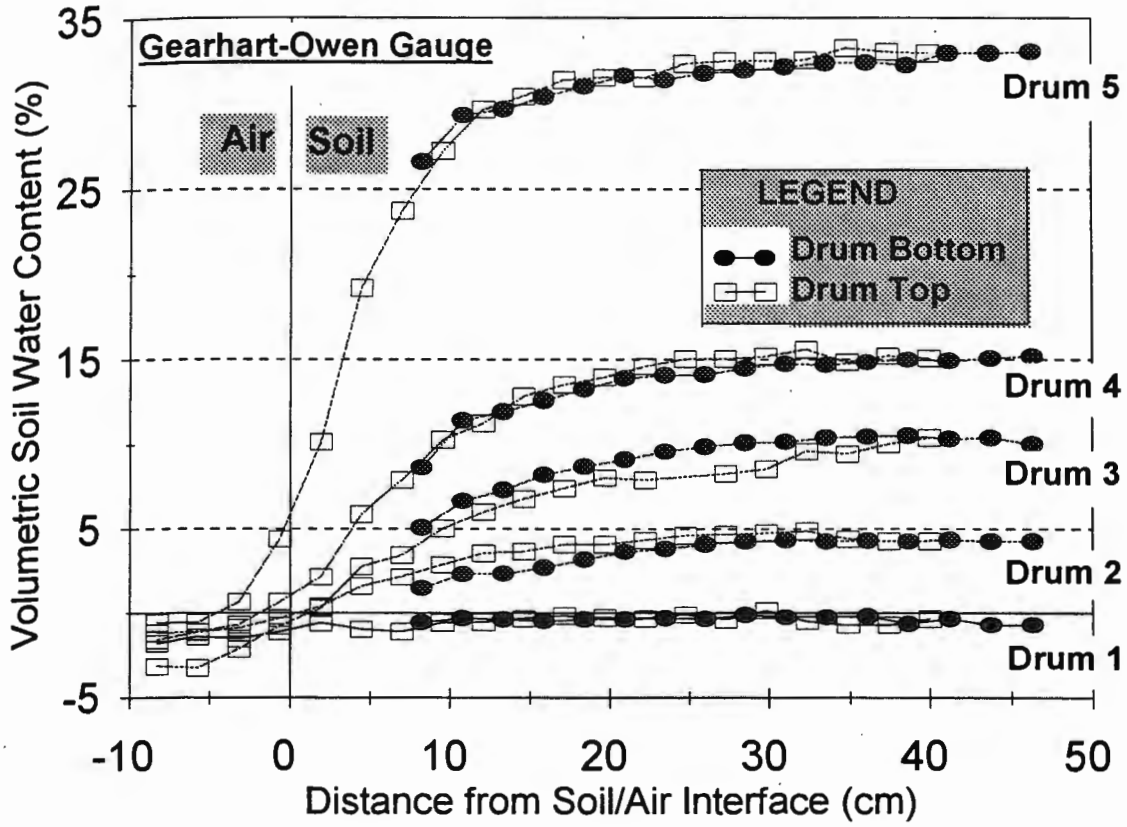


Fig. 17. Estimates of soil water content as a function of distance from the soil-air interface to the midpoint of the probe-sensitive area using the Gearhart-Owen moisture gauge. Calibration drums 1, 2, 3, 4, and 5 contained crushed tuff at average volumetric water contents of 0.12, 4.3, 8.6, 14.9, and 33%, respectively.

approximated the relationship between volumetric water content and distance to the soil-air interface very precisely (R^2 = 0.98 to 0.99, n = 10 to 15) for the interface at the top and the bottom of each drum. The Rj determinations were calculated from these regression equations for all three moisture gauges. Because the Troxler and the Gearhart-Owen gauges both demonstrated similar relationships between water content and distance to the soil-air interface at both the top and bottom of the drum (Figs. 14 and 15), the average Rj is presented in Fig. 16 for these probes as a function of soil water content. This was not the case for the Campbell Pacific moisture gauge

value at intermediate-water content, and then an inverse relationship between these two variables at higher tuff-water contents. This pattern in the data compares quite well with the I.A.E.A. Rj curve with absorbers (Fig. 1), however, Rj values are half as large as the I.A.E.A. modeling estimates.

B. MCNP Modeling Results for Crushed Tuff

After analyzing the calibration drum data describing the behavior of the neutron moisture gauges near the soil surface, we used these data to calibrate an MCNP model to further investigate volumes of tuff interrogated by the Campbell Pacific probe. The MCNP model was calibrated for our specific configurations of access tube, calibration drum, and Campbell Pacific moisture gauge, with its midpoint of sensitivity, source, and detector located in a known position relative to the tuff-air interface. The other specific information required was the approximate atom densities of Si, Al, Fe, O, C, and H in the tuff, and the fast neutron spectra data for an ^{241}Am/Be source.

Using the above information, MCNP simulations (Campbell Pacific moisture gauge) were performed in seven different positions relative to the soil-air interface of our calibration drums (Fig. 19). The average and standard deviation of the three measurements of water content agreed quite well with the model predictions of volumetric water content for each calibration drum. In fact, because a part of MCNP computer output included an estimate of variation of predicted water content, we observed no statistically significant differences between computer predicted and measured water content. We later found that the variation in our MCNP model estimates, which were routinely made with 4-m simulations on a CRAY computer, could be reduced with 10-m computer simulation times, resulting in even better agreement between measured and model-predicted water contents.

of counts coming from each cell was normalized with respect to the volume of the cell, and then expressed as percentage of the total counts observed at the detector.

The MCNP modeling results for the case with the calibration drum divided into a series of concentric rings are presented in Fig. 20. These modeling results show how the neutron moisture gauge's response along the X and Z axes is influenced by the water content of the surrounding tuff. Approximately 90% of the counts arriving at the probe detector came from moist tuff at distances of 25, 23, 20, and 14 cm with corresponding volumetric water contents of 4.3, 8.6, 15, 33%, respectively. These

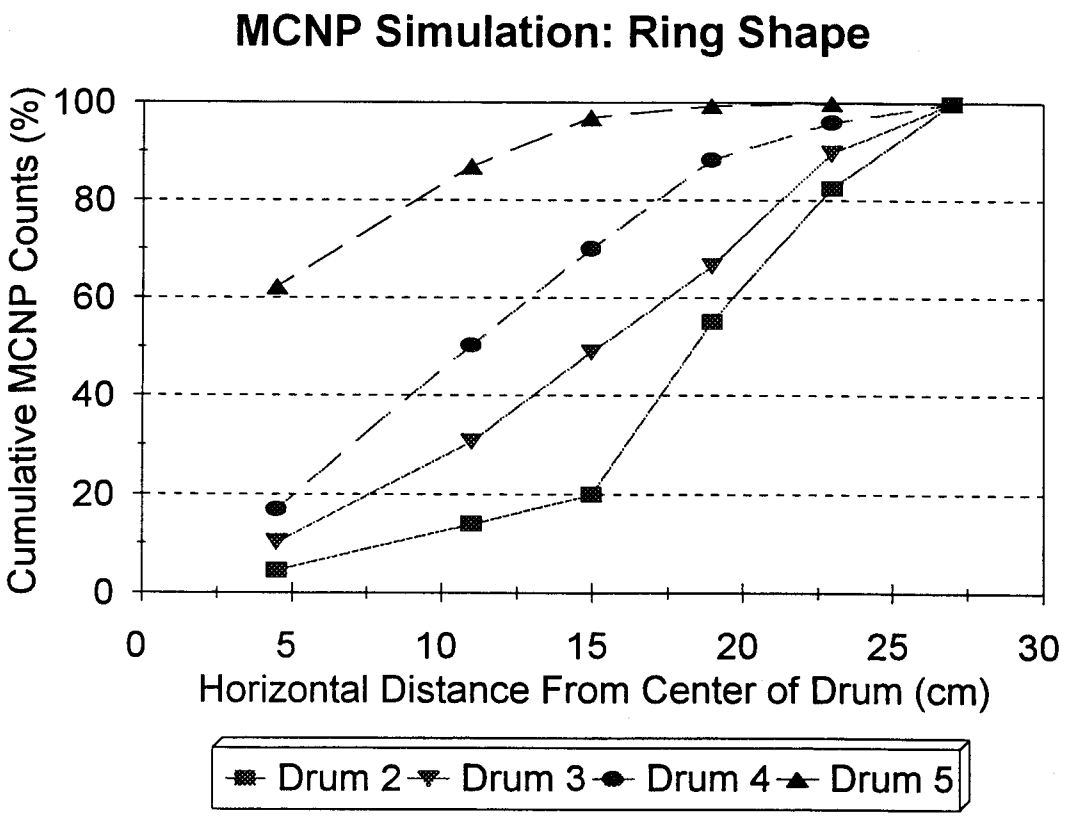


Fig. 20. MCNP modeling results for simulations of crushed tuff in calibration drums with MCNP cells consisting of concentric rings. Calibration drums 2, 3, 4, and 5 contained crushed tuff at average volumetric water contents of 4.3, 8.6, 14.9, and 33%, respectively.

Our overall modeling impressions of the shape of the volume interrogated by the Campbell Pacific moisture gauge thus seemed to vary with the water content of the tuff (Figs. 18 and 19). However, because we considered the ^{241}Am/Be source to be emitting fast neutrons isosymetrically into the tuff in the calibration drums, the principles of the radiation physics involved imply that the modeling should also be designed isosymetrically about the midpoint of sensitivity of the neutron probe. Thus, a concentric series of five different shapes were modeled for three of our calibration drums. The shapes used were 1) spheres, 2) right cylindrical rings as tall as the calibration drums, 3) a spheroid shape with the X and Z axes 30% larger than the Y axis, 4) a spheroid shape with the X and Z axes 20% larger than the Y axis, and 5) a spheroid shape with the values of the X and Z axes equal to the Y axis value divided by 1.3.

Five to six concentric MCNP model cells of each shape were designed around the midpoint of sensitivity of the probe and the total detector counts originating from thermalized neutrons coming from each cell were determined and divided by the cell volume. The detector cpm/cc for each cell was then plotted as function-of-distance from the center of the calibration drum to the cell's midpoint along the X axis.

The MCNP modeling results are presented for the calibration drums at 8.6% (Fig. 22), 15% (Fig. 23), and 33% (Fig. 24) volumetric water contents. The basic assumption of this approach is that maximum cell cpm/cc will be observed relatively close to the center of the drum if the correct shape is approximated in the modeling simulation. Thus, from Fig. 19, it appears that very few thermalized neutrons are detected by the neutron probe from near the top and bottom of the calibration drum. When the ring shapes as tall as the drum were modeled, we observed low cpm/cc in each cell relative to the other shapes investigated (Figs. 20, 21, 22).

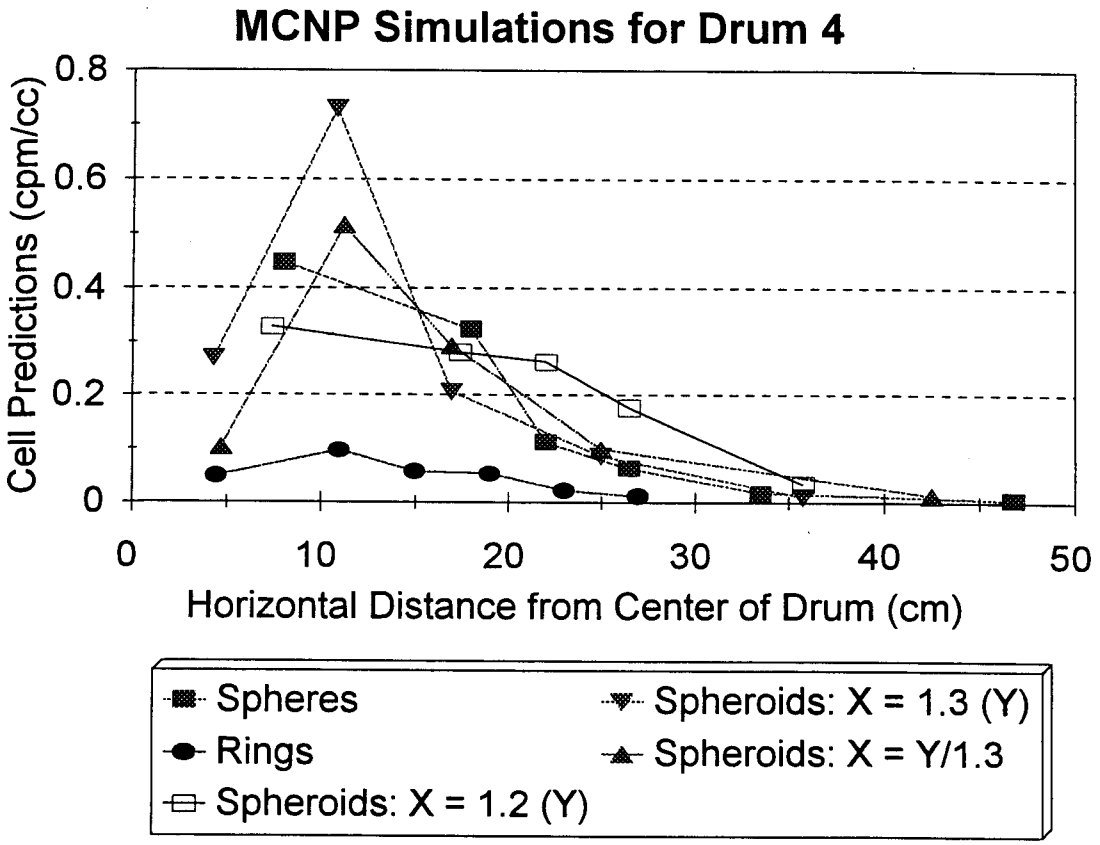
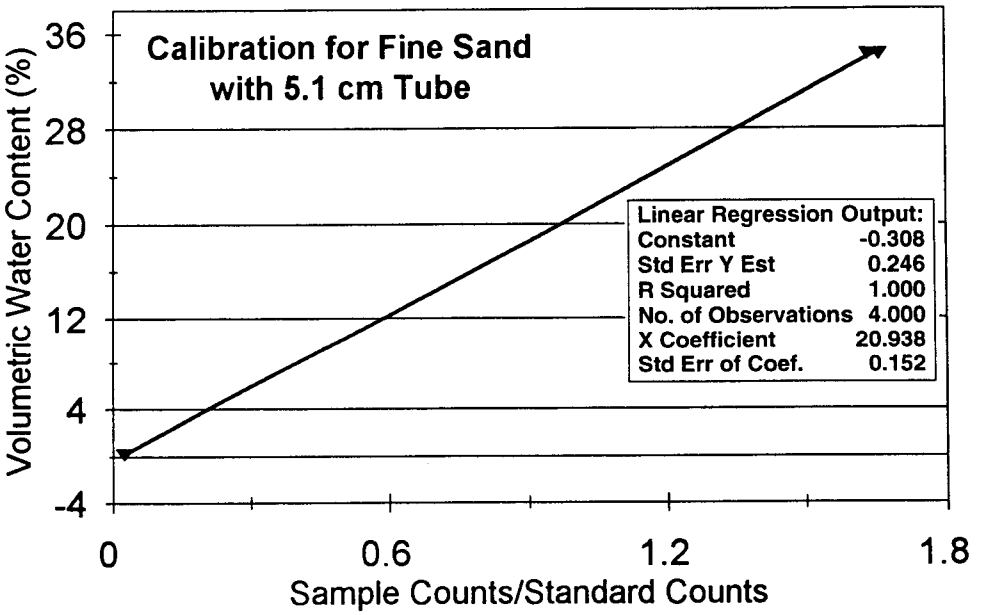


Fig. 23. MCNP shape simulations for calibration drum 4 containing crushed tuff at an average volumetric water content of 14.9%.

C. Calibration of Moisture Gauges in 1994 for Crushed Tuff and Soils Used in Hydrologic Studies

The detailed results of the Campbell Pacific moisture gauge calibrations performed from 1991-1994 are presented in Appendix A. The results of the linear regression analysis of these data are presented in Figures 25 through 44 for each neutron moisture gauge and for each soil studied. The data are then summarized graphically in Figures 45 through 48 by moisture gauge, as well as in a final summary table listing the regression parameters used to calculate volumetric water content (Table 4).

parent material of this soil type (Nyhan et al., 1978). Fewer sample counts were expected since porous materials with relatively higher clay content usually exhibit this trend (CSIRO, 1981). The Layton loamy fine sand always exhibited the smallest sample counts at saturation compared with all of the other soils at saturation. The low count is probably due to the occurrence of strong absorbers of thermal neutrons in this soil such as boron, chlorine, iron, and gadolinium (CSIRO, 1981).



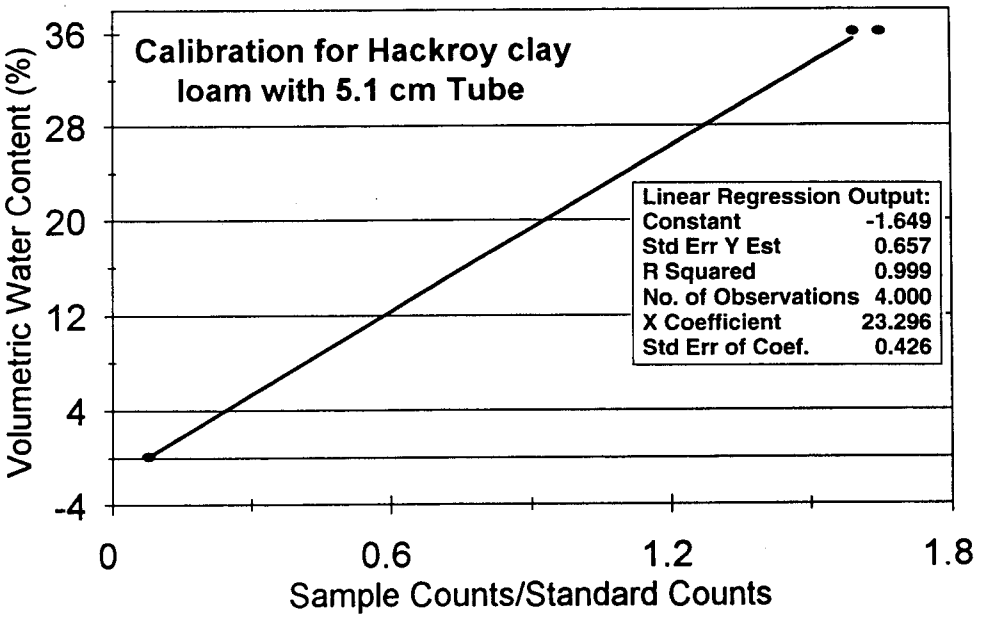
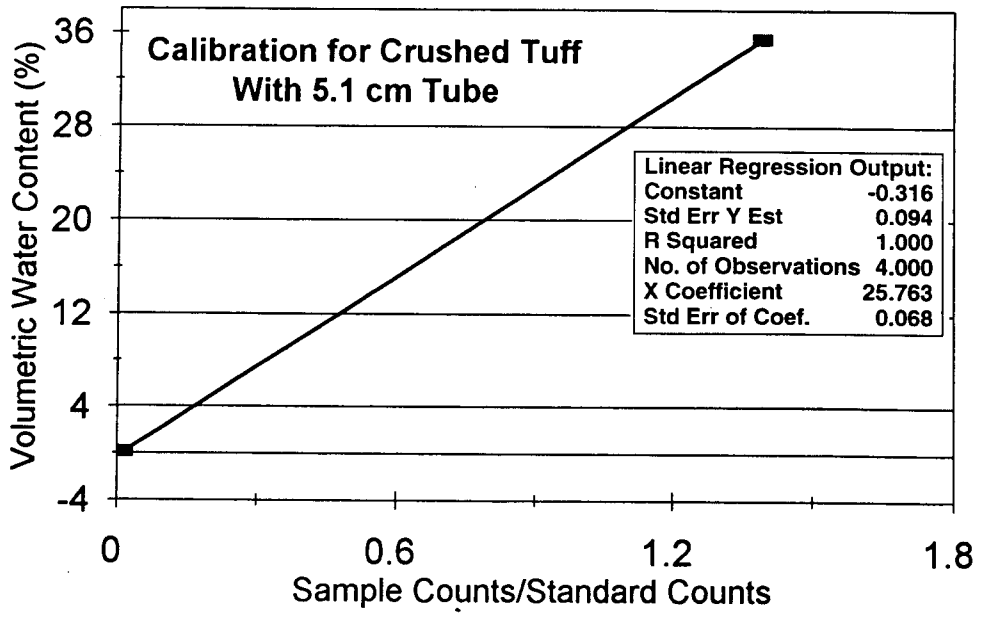


Fig. 26. Statistical analysis results for fine sand and Hackroy clay loam samples for neutron moisture gauge with serial number 4274.



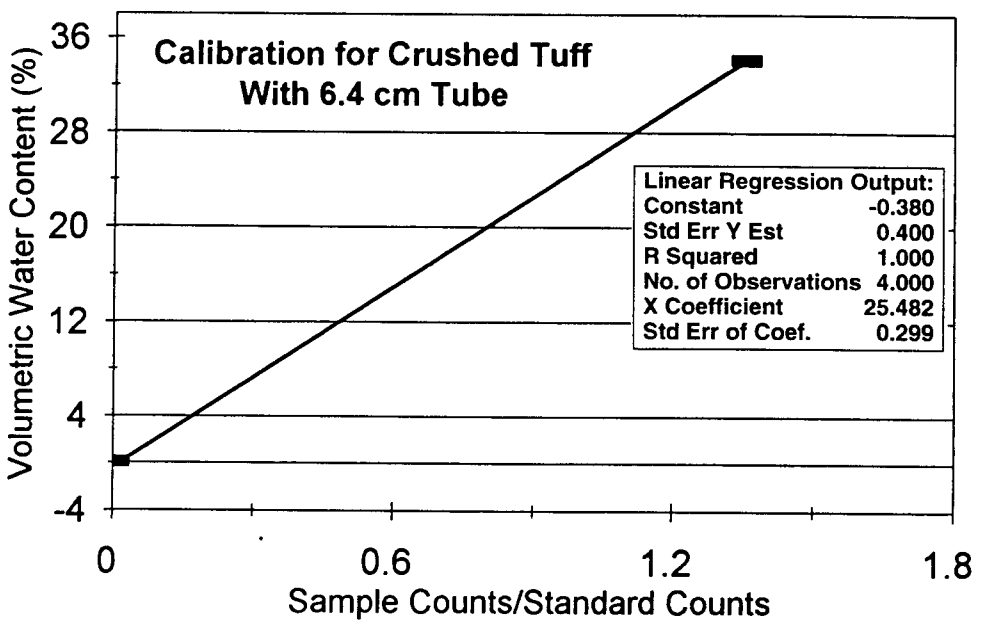


Fig. 28. Statistical analysis results for crushed tuff samples for neutron moisture gauge with serial number 4519.

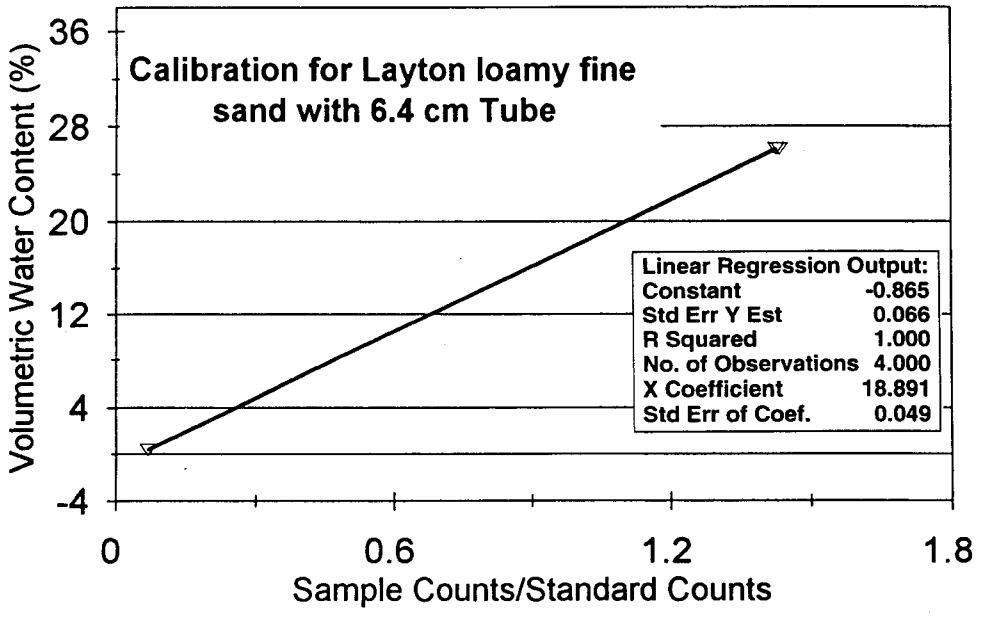
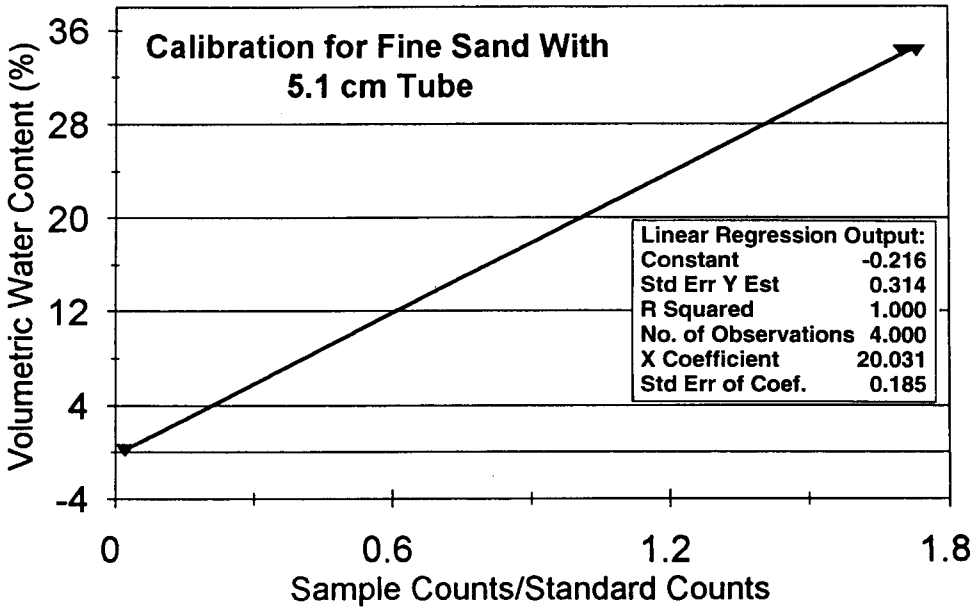


Fig. 30. Statistical analysis results for Layton loamy fine sand sample for neutron moisture gauge with serial number 4519.



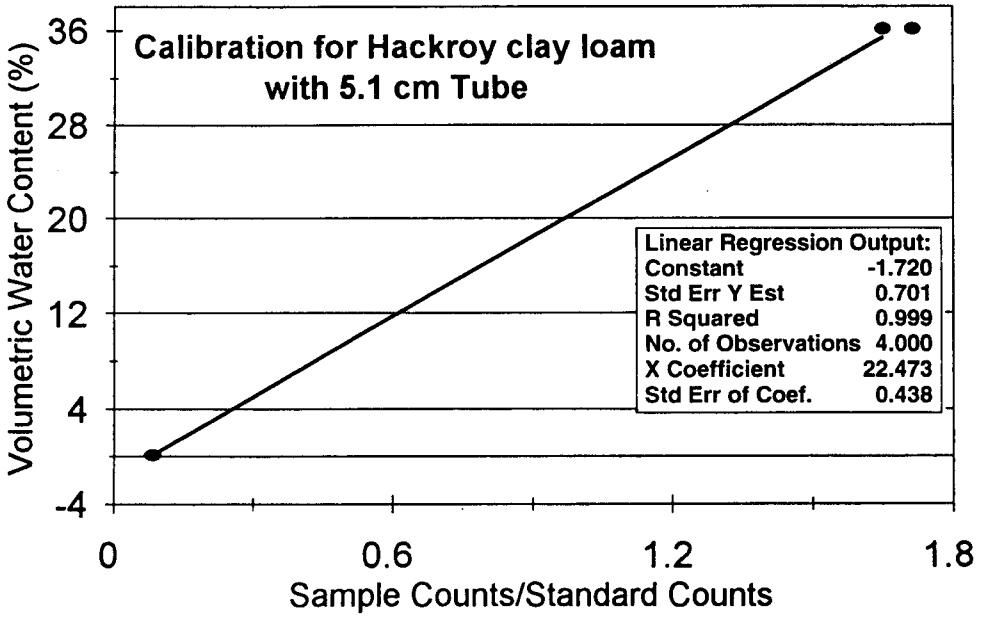
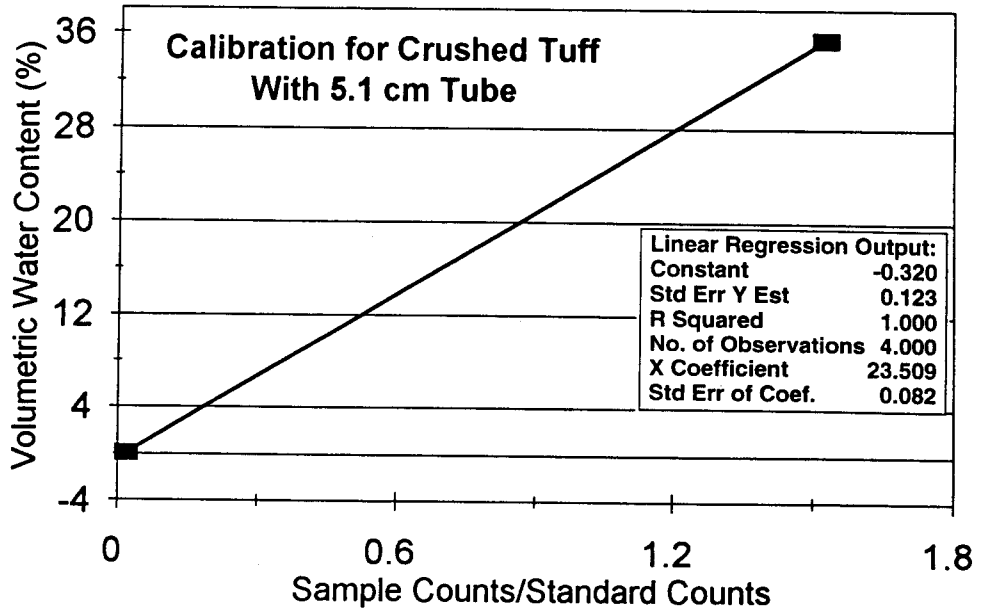


Fig. 32. Statistical analysis results for fine sand and Hackroy clay loam samples for neutron moisture gauge with serial number 5079.



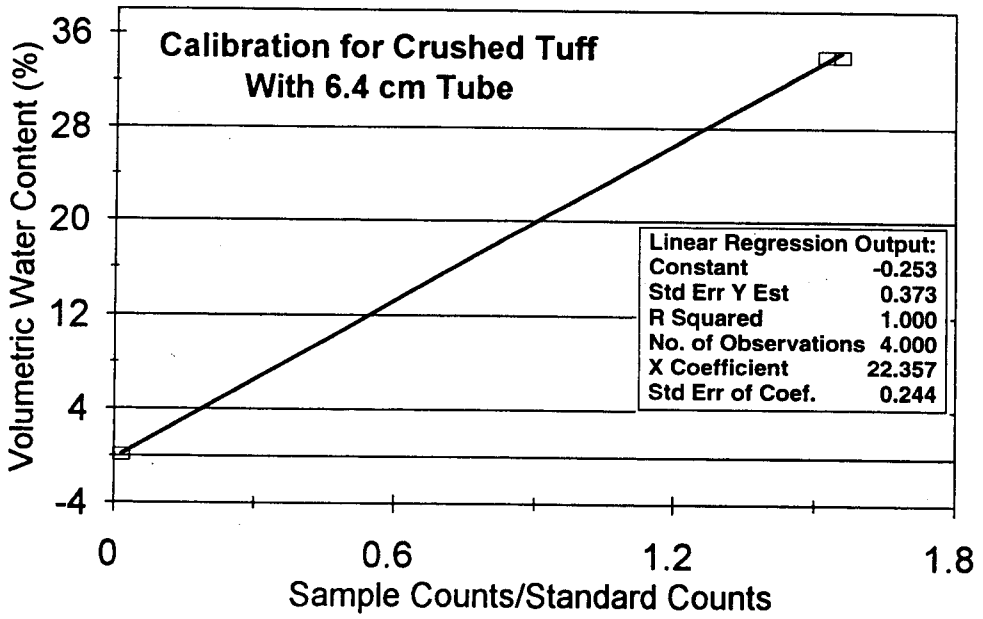


Fig. 34. Statistical analysis results for crushed tuff samples for neutron moisture gauge with serial number 7832.

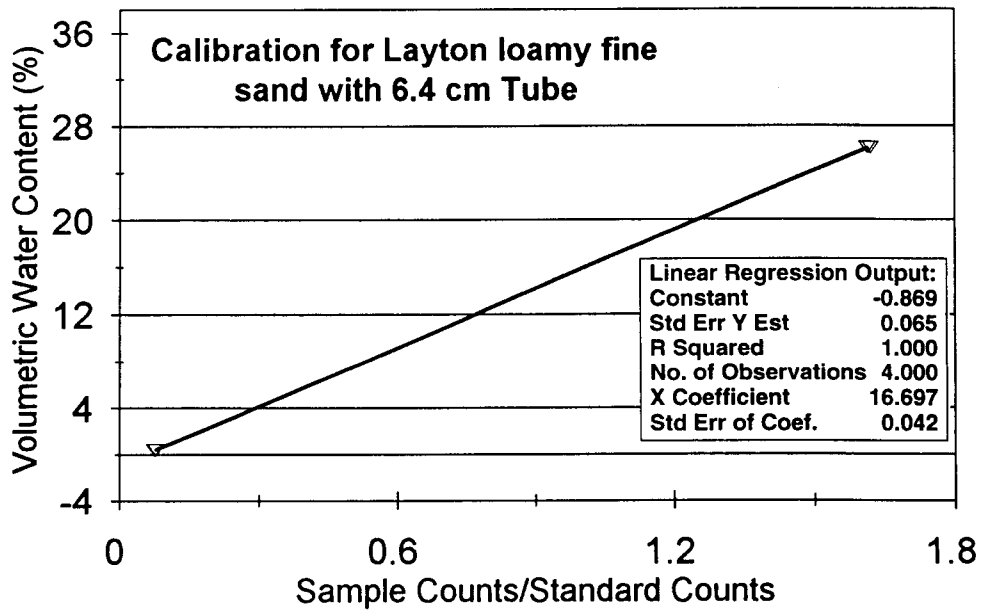
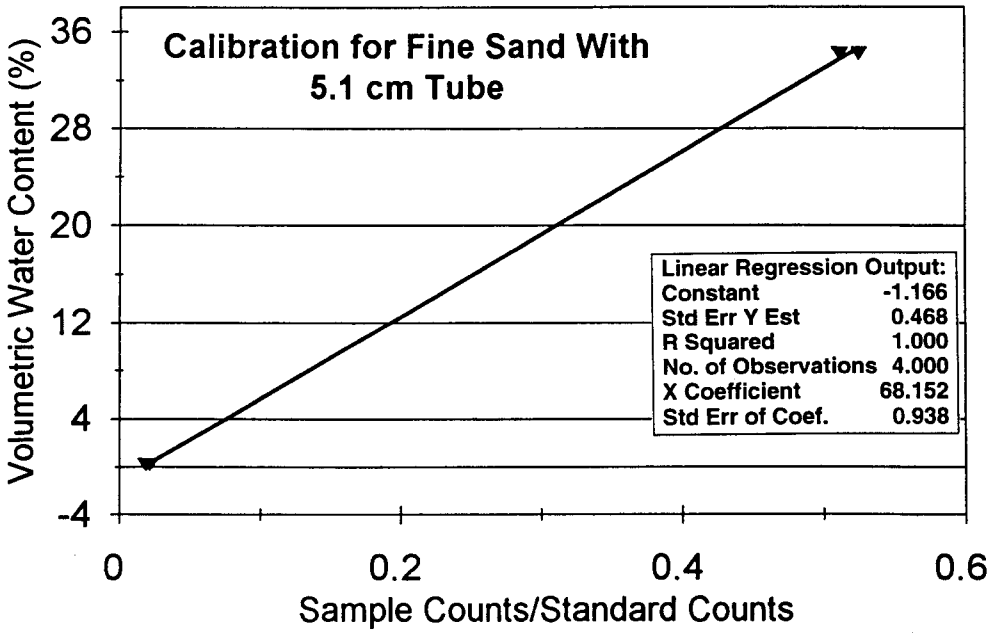


Fig. 36. Statistical analysis results for Layton loamy fine sand samples for neutron moisture gauge with serial number 7832.



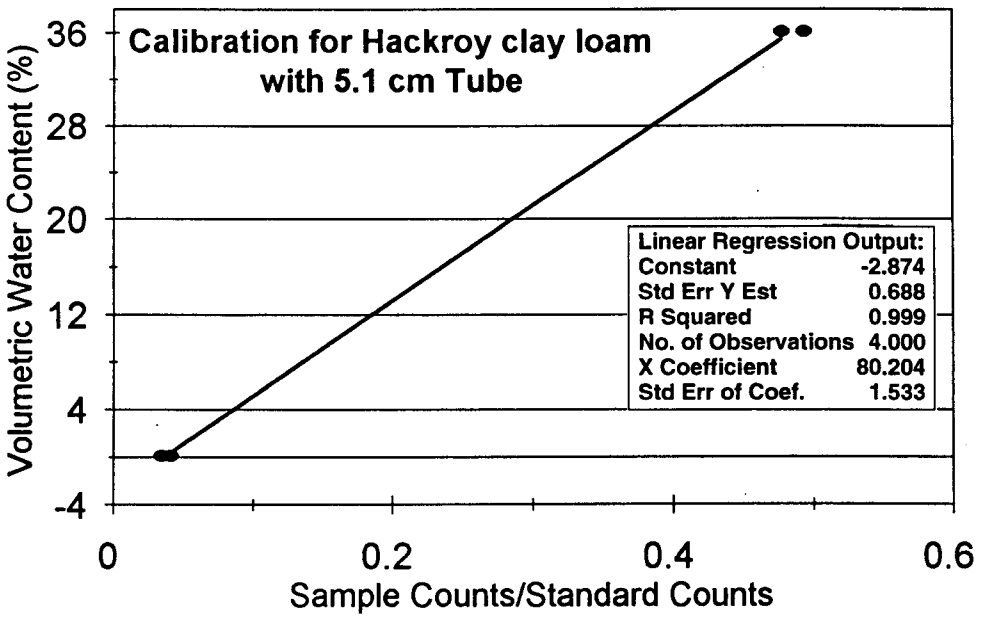
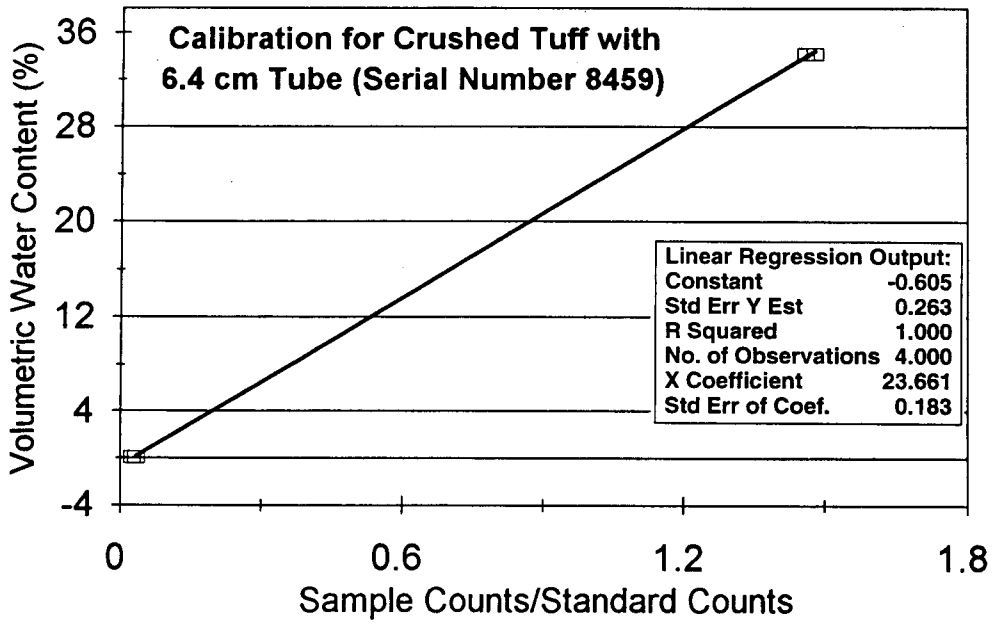


Fig. 38. Statistical analysis results for fine sand and Hackroy clay loam samples for neutron moisture gauge with serial number 5254.



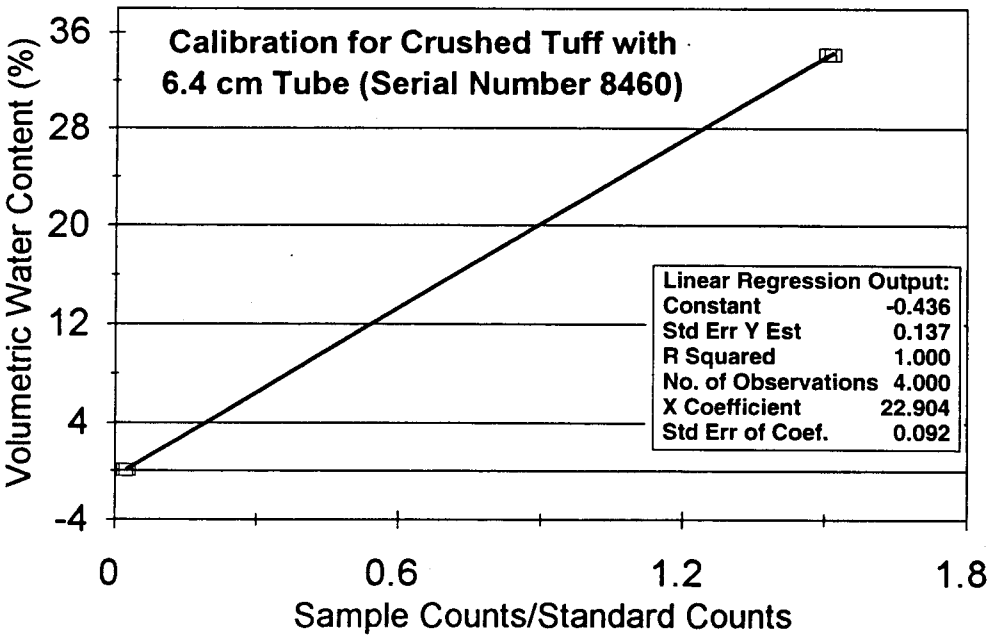
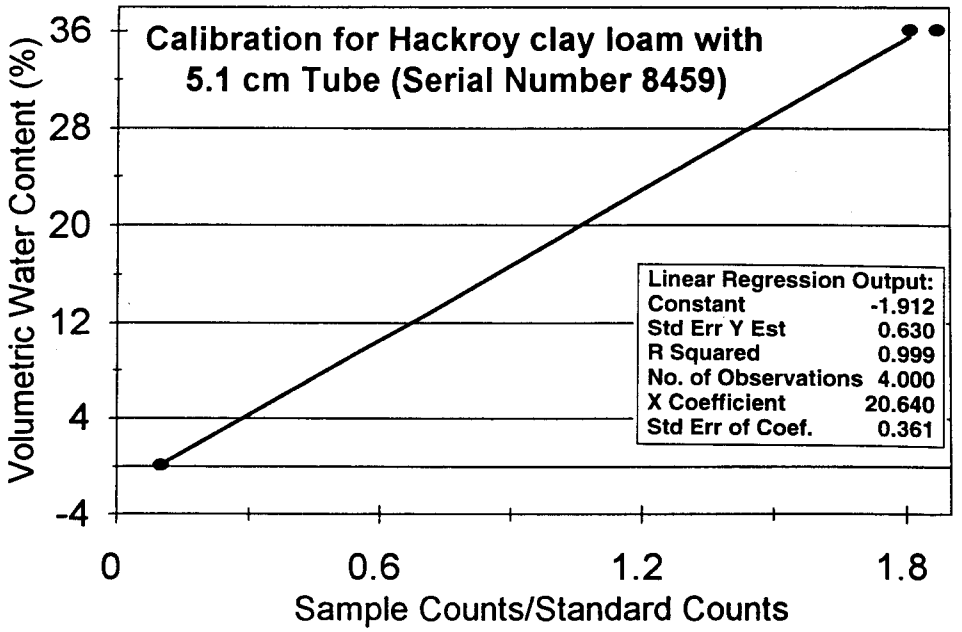


Fig. 40. Statistical analysis results for crushed tuff samples for neutron moisture gauges with serial numbers 8459 and 8460.



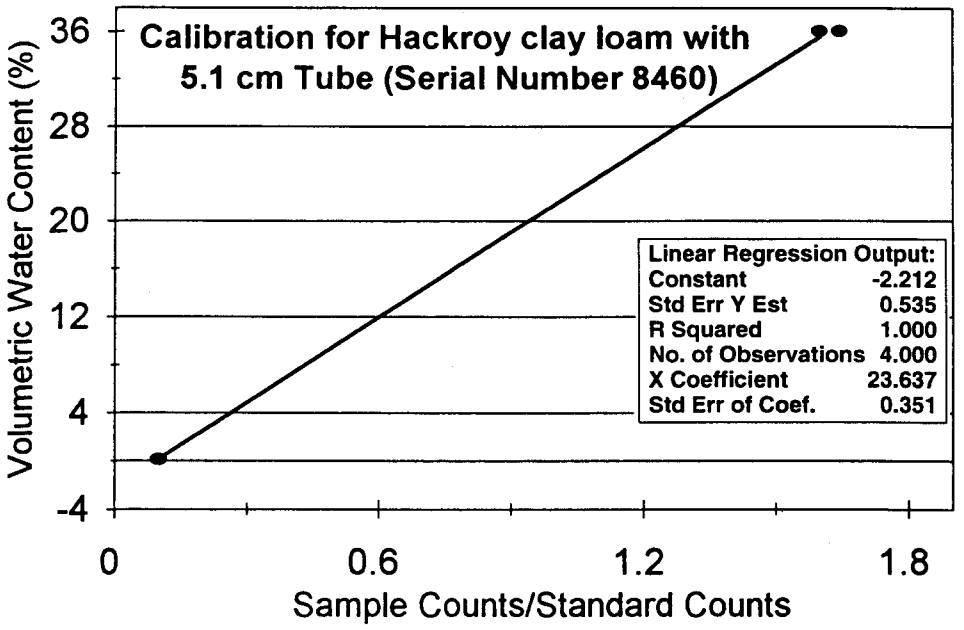
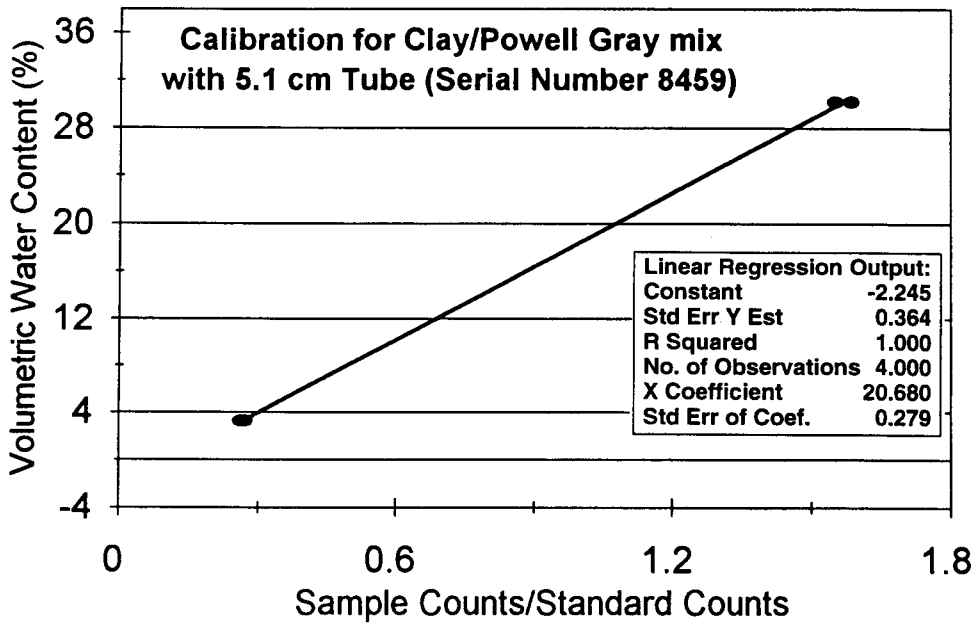


Fig. 42. Summary of regression predictions for all soil samples for neutron moisture gauge with serial number 5254.



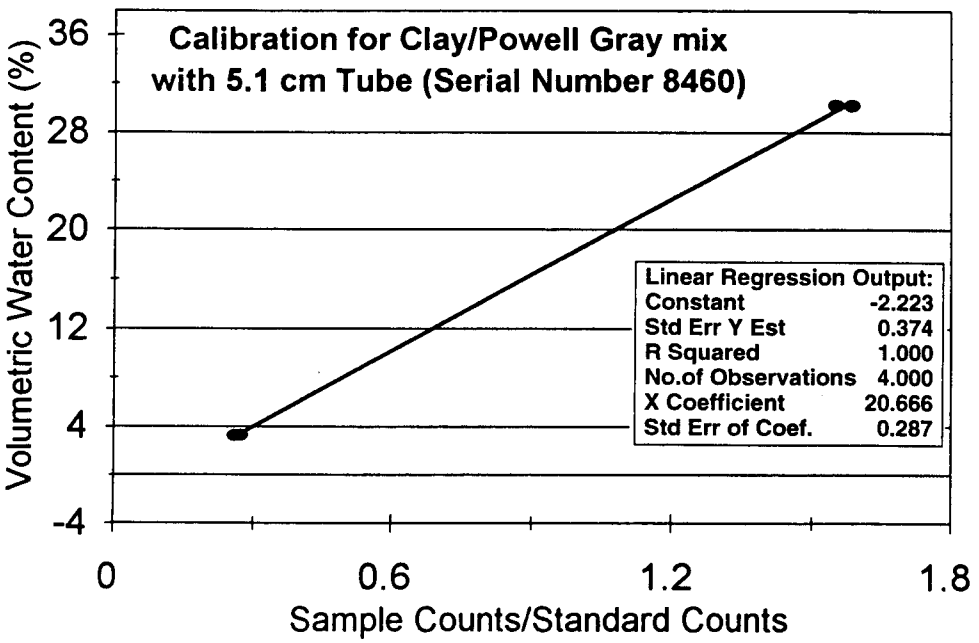
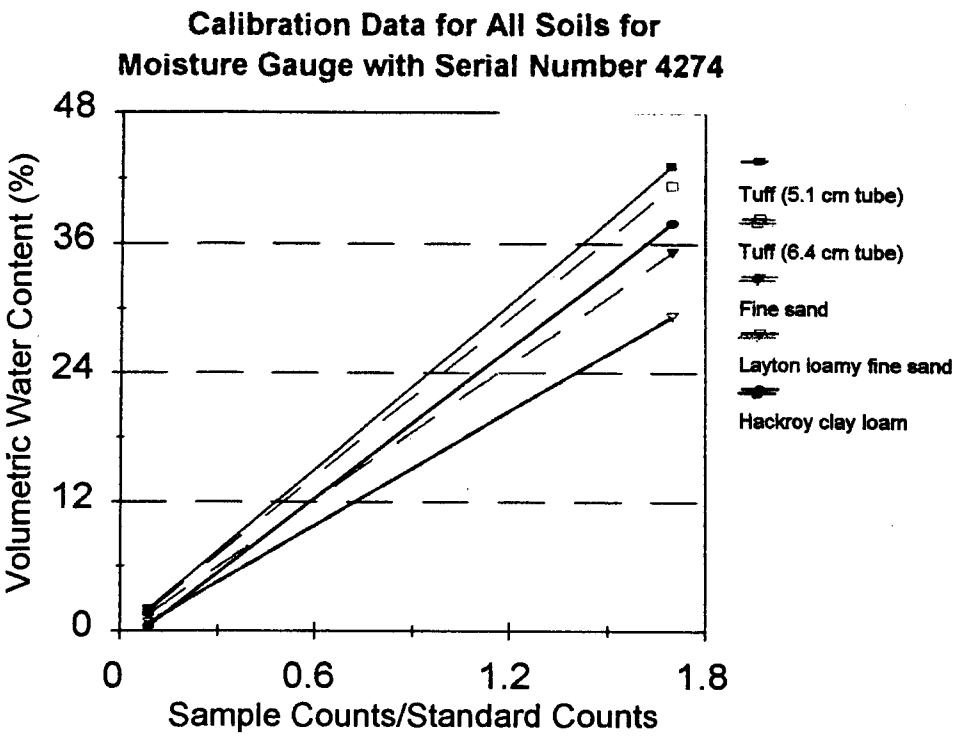


Fig. 44. Statistical analysis results for Bentonite/Powell Gray mixture samples for neutron moisture gauges with serial numbers 8459 and 8460.



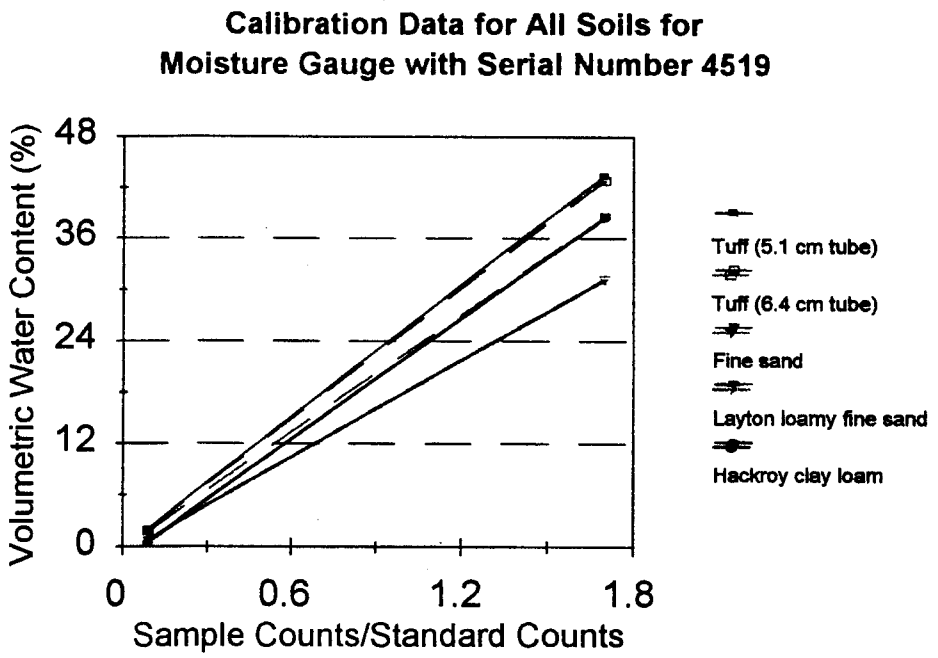
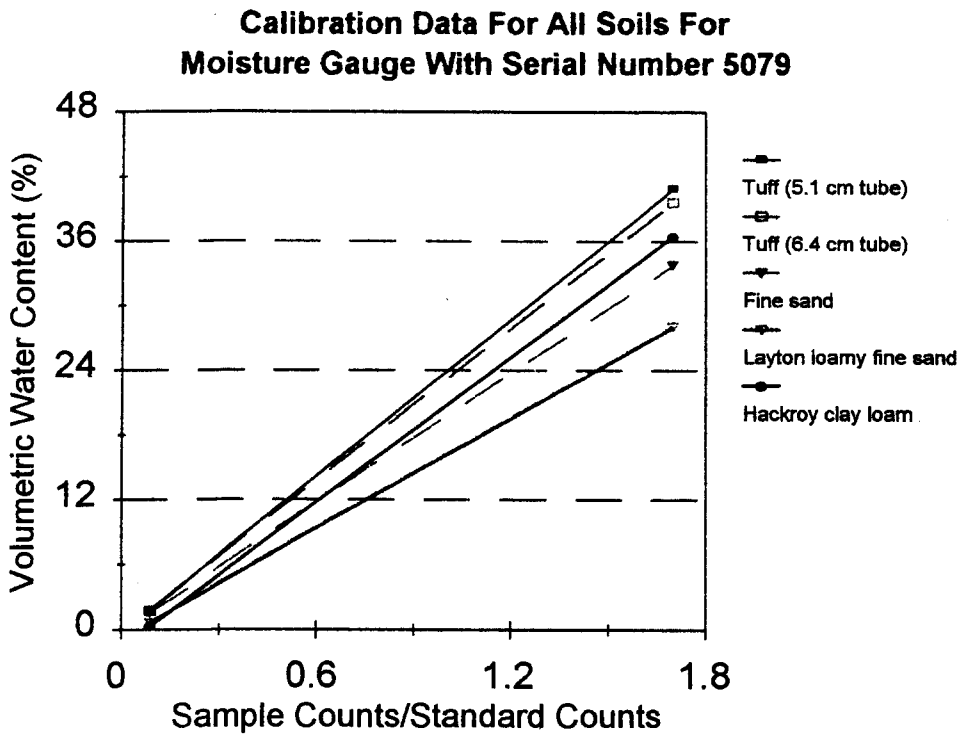


Fig. 45. Summary of regression predictions for all soil samples for neutron moisture gauges with serial numbers 4274 and 4519.



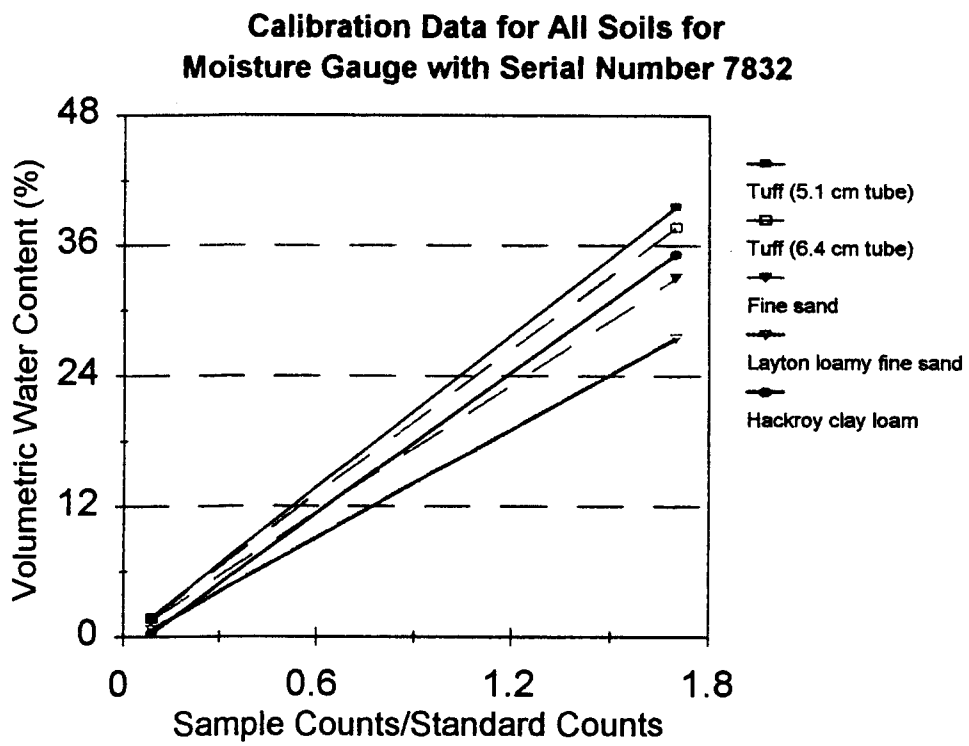


Fig. 46. Summary of regression predictions for all soil samples for neutron moisture gauges with serial numbers 5079 and 7832.

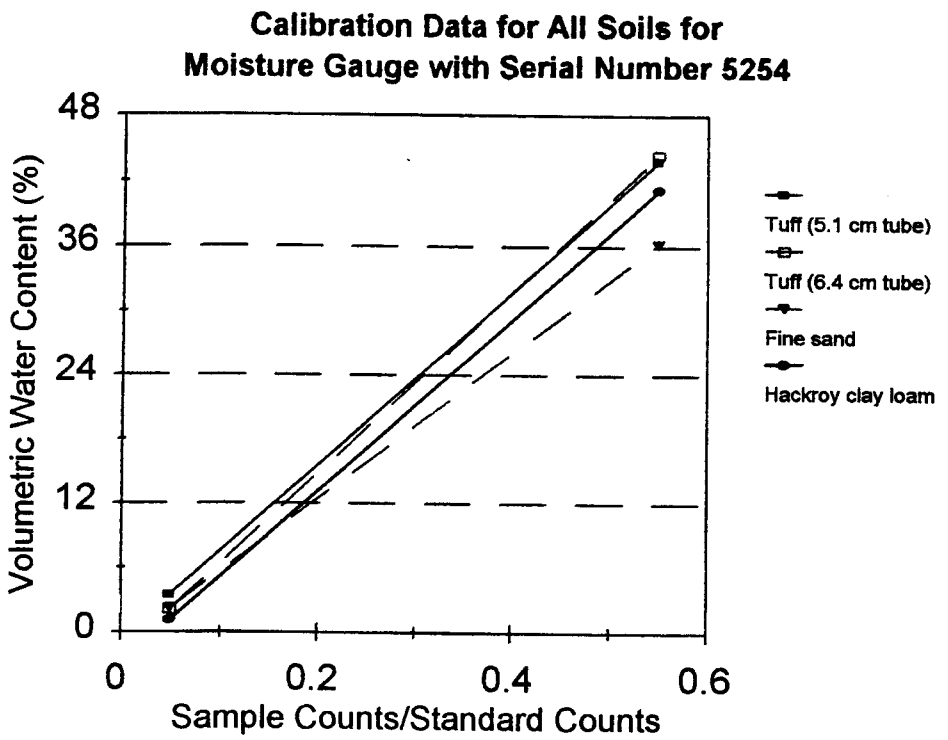
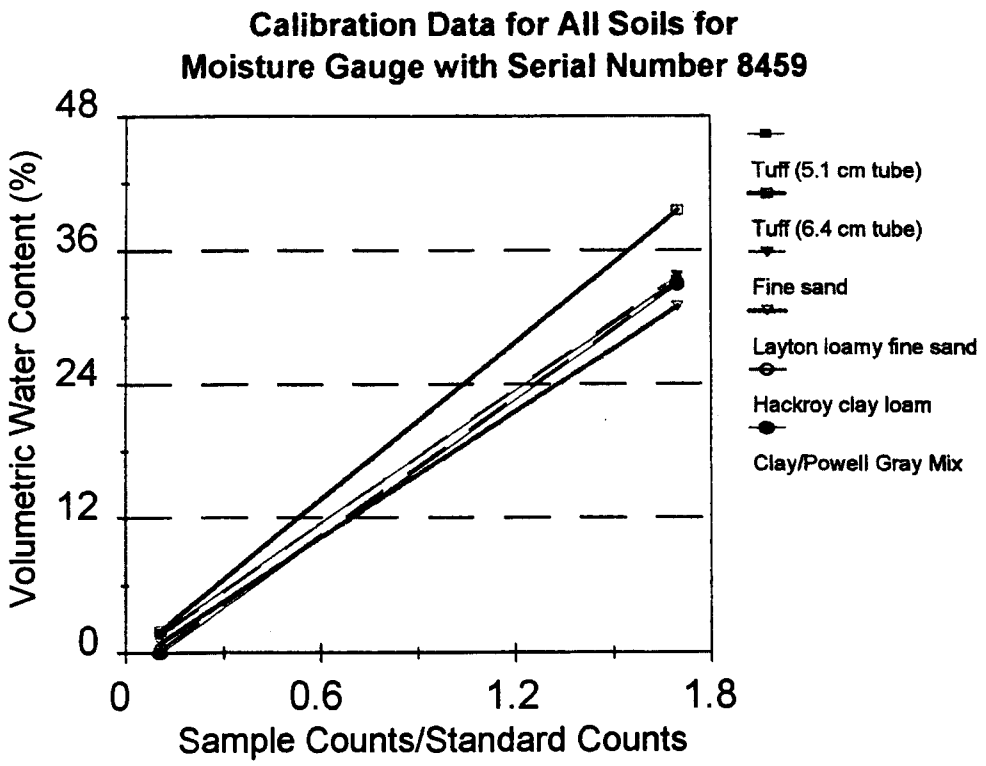


Fig. 47. Summary of regression predictions for all soil samples for neutron moisture gauge with serial number 5254.



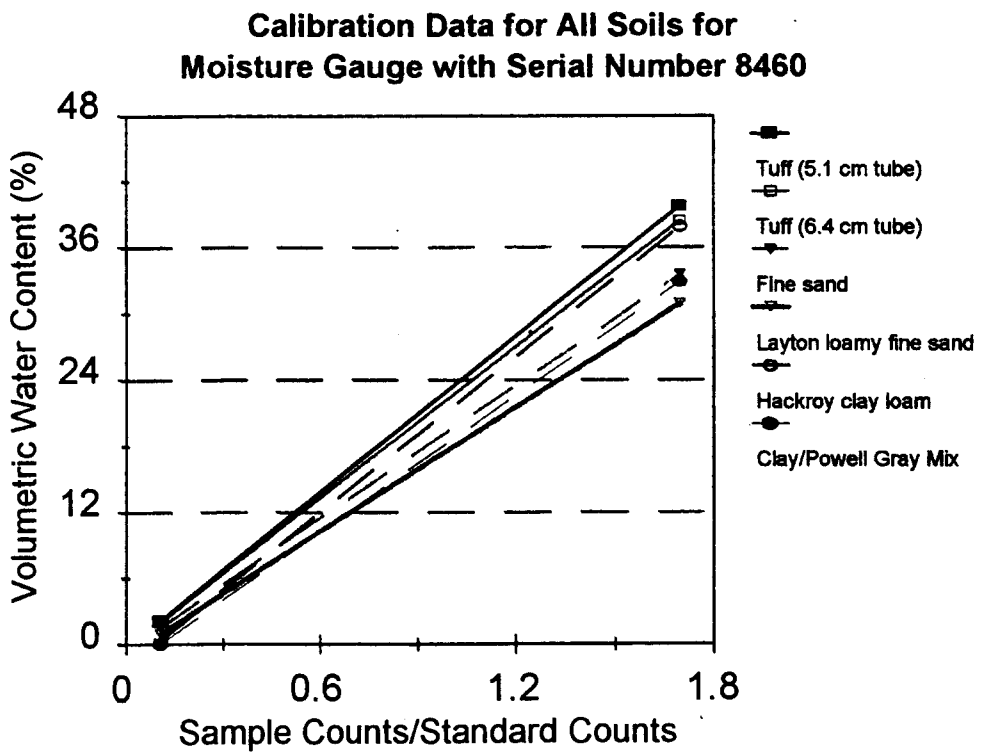


Fig. 48. Summary of regression predictions for all soil samples for neutron moisture gauges with serial numbers 8459 and 8460.

Table 4. Summary of regression results for 1994 neutron probe calibrations on all study soils and moisture gauges (% volumetric water content units)

Soil sample	Access Tube Diam. (cm)	Drum depths (cm) Dry Drum	Wet Drum	Slope[1] A	Y-intercept[1] B
Moisture Gauge Serial Number 4274					
Standard Factory Sand	5.1			21.950	-0.410
Crushed tuff	5.1	20-33,35-48	18-41,43-66	25.562	-0.279
Hackroy clay loam	5.1	33-46,48-61	20-43,46-69	23.296	-1.649
Crushed tuff	6.4	20-33,35-48	18-41,43-66	24.549	-0.324
Fine sand	5.1	20-33,35-48	18-41,43-66	20.938	-0.308
Layton loamy fine sand	6.4	33-46,48-61	33-46,48-61	17.751	-0.812
Moisture Gauge Serial Number 4519					
Standard Factory Sand	5.1			20.070	-0.380
Crushed tuff	5.1	20-33,35-48	18-41,43-66	25.763	-0.316
Hackroy clay loam	5.1	33-46,48-61	20-43,46-69	23.618	-1.617
Crushed tuff	6.4	20-33,35-48	18-41,43-66	25.482	-0.380
Fine sand	5.1	20-33,35-48	18-41,43-66	22.911	-0.285
Layton loamy fine sand	6.4	33-46,48-61	33-46,48-61	18.891	-0.865
Moisture Gauge Serial Number 5079					
Standard Factory Sand	5.1			20.390	-0.470
Crushed tuff	5.1	20-33,35-48	18-41,43-66	24.295	-0.316
Hackroy clay loam	5.1	33-46,48-61	20-43,46-69	22.473	-1.720
Crushed tuff	6.4	20-33,35-48	18-41,43-66	23.530	-0.306
Fine sand	5.1	20-33,35-48	18-41,43-66	20.031	-0.216
Layton loamy fine sand	6.4	33-46,48-61	33-46,48-61	17.027	-0.851
Moisture Gauge Serial Number 7832					
Standard Factory Sand	5.1			18.280	-0.480
Crushed tuff	5.1	20-33,35-48	18-41,43-66	23.509	-0.320
Hackroy clay loam	5.1	33-46,48-61	20-43,46-69	21.709	-1.659
Crushed tuff	6.4	20-33,35-48	18-41,43-66	22.357	-0.253
Fine sand	5.1	20-33,35-48	18-41,43-66	19.567	-0.209
Layton loamy fine sand	6.4	33-46,48-61	33-46,48-61	16.697	-0.869
Moisture Gauge Serial Number 5254					
Standard Factory Sand	5.1			55.940	-1.590
Crushed tuff	5.1	23-38,41-56	23-38,41-56	80.721	-0.509
Hackroy clay loam	5.1	23-38,41-56	23-38,41-56	80.204	-2.874
Crushed tuff	6.4	23-38,41-56	23-38,41-56	84.627	-2.075
Fine sand	5.1	23-38,41-56	23-38,41-56	68.152	-1.166

documentation of how we are performing the measurement of volumetric water content under field conditions using neutron moisture gauges.

The field measurements of the Rj of each neutron probe near the soil surface will contribute greatly to the small amount of field data gathered to date. Since, obviously, neutron moisture probe readings taken near the soil surface underestimate soil water content, we now have quantitative data to evaluate this effect. This information will be used to estimate *in situ* water balance parameters such as evapotranspiration rates from earth covers used in shallow land burial of wastes at Los Alamos. The other major significance of this study involves the new information relating to the neutron probe calibration data collected for a local Los Alamos soil type, instead of having only a calibration curve for crushed tuff, as has been the case to date at the Laboratory.

After the midpoint of sensitivity of each of three currently used neutron moisture gauges to the detection of hydrogen was determined, the behavior of the neutron probes near an soil-air interface was determined. The Rj was determined in the field for each gauge as a function of varying soil water content, and this spatial response of the gauges to varying volumes of soil water was successfully modeled using a neutron transport model. After validating the model, the spatial resolution of soil water was investigated for one of the moisture gauges. These modeling results indicated that both the shape and the volume of soil interrogated by the neutron moisture gauge vary as a function of soil water content. The MCNP neutron transport model used in this study can be used as a very powerful tool in exploring the behavior of the neutron moisture gauge in the soil environment. Future plans for MCNP model investigations should involve investigating the basic design of the neutron moisture gauge, studying the behavior of the gauges near wet-dry soil interfaces, and determining the influence of thermalized neutron absorbers on moisture gauge performance.

There are two other very important practical benefits that can be derived from this calibration study. Electrical service to locations where neutron moisture gauges are

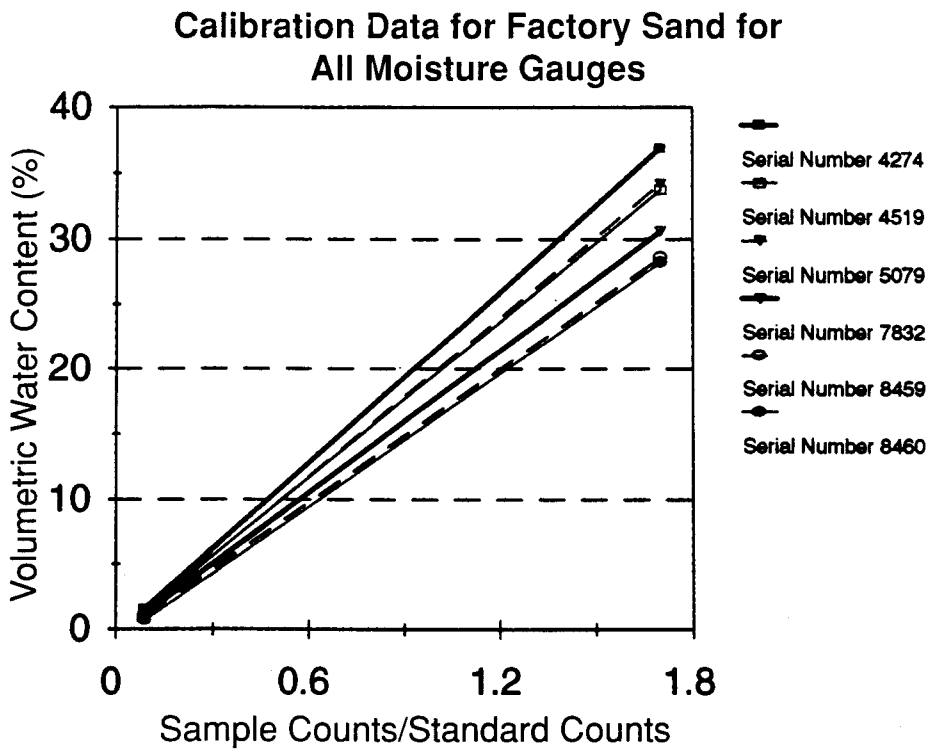


Fig. 49. Summary of regression predictions for the standard factory sand samples for all neutron moisture gauges.

Finally, three practical implications of this neutron moisture gauge calibration study should be taken into account by the user:

(1) The measurement of soil water content with depth in a soil profile should take into account the following:

(a) a precise measurement of the distance between the soil surface and the midpoint of sensitivity of the neutron moisture gauge (Fig. 12) and not the distance between the soil surface and the bottom of the probe

(b) the type of soil at each depth in the soil profile, because calibration curves vary with soil type (Figs. 25-44)

(c) the diameter of the aluminum access tube (Figs. 25-44)

(2) Because we do not have a calibration curve for each of the 61 soils listed in the local soil survey (Nyhan et al., 1978), we suggest

REFERENCES

Christenson, C. W. and R. G. Thomas. "Movement of plutonium through Los Alamos," in "Ground Disposal of Radioactive Wastes," J. M. Morgan, Jr., D. K. Jamison, and J. D. Stevenson Eds., report TID-7628, NTIS, (1962) pp. 248-281.

Commonwealth Scientific and Industrial Research Organization, "Soil water assessment by the neutron method," E.L. Greacen, Ed., ISBN 0 643 00414 9, East Melbourne, Victoria, Australia (1981).

International Atomic Energy Agency, "Neutron moisture gauges: a guidebook on theory and practice," I.A.E.A. techincal report series No. 112, Vienna, Australia (1970).

Long, I. F. and B. K. French, "Measurement of Soil Moisture in the Field by Neutron Moderation," *Jour. Soil Sci.* **18**: 147-158 (1967).

Lorch, E. A. "Neutron Spectra of ^{241}Am/B, ^{241}Am/Be, ^{241}Am/F, ^{242}Cm/Be, ^{238}Pu/^{13}C and ^{252}Cf Isotopic Neutron Sources," *International J. Applied Radiation and Isotopes* **24**: 484-591 (1973).

Los Alamos Radiation Transport Group, "MCNP a General Monte Carlo Code for Neutron and Photon transport," Los Alamos National Laboratory report LA-7396-M (1981).

Nyhan, J.W., L. W. Hacker, T. E. Calhoun, and D. L. Young, "Soil Survey of Los Alamos County, New Mexico," Los Alamos Scientific Laboratory report LA-6779-MS (1978).

Olgaard, P. L. "On the theory of the neutronic method for measuring the water content in soil," Danish Atomic Energy Commission, Riso, Report No. 97 383-397 (1965).

SAS Institute, Inc. *SAS Language: Reference, Version 6, First Edition.* Cary, NC (1990).

Appendix A. 1994 NEUTRON MOISTURE GAUGE CALIBRATION DATA

Crushed Tuff Sample with 5-1 cm diam access tube (saturated sample)

Depth (cm)	Sample Counts Mean	Std Dev	CV
2.5	8556.3	97.4	1.14
5.1	11653.0	61.5	0.53
7.6	14161.3	20.1	0.14
10.2	15954.3	110.3	0.69
12.7	16863.0	46.0	0.27
15.2	17273.0	101.3	0.59
17.8	17590.0	164.6	0.94
20.3	17533.3	9.0	0.05
22.9	17491.0	109.7	0.63
25.4	17556.3	229.2	1.31
27.9	17419.0	118.4	0.68
30.5	17424.7	81.7	0.47
33.0	17554.0	12.1	0.07
35.6	17339.7	114.1	0.66
38.1	17347.7	199.1	1.15
40.6	17288.7	16.3	0.09
43.2	17309.3	130.1	0.75
45.7	17456.0	141.2	0.81
48.3	17417.0	128.7	0.74
50.8	17416.3	29.0	0.17
53.3	17532.7	183.2	1.04
55.9	17710.0	27.7	0.16
58.4	17697.0	64.1	0.36
61.0	17618.0	62.0	0.35
63.5	17516.7	208.1	1.19
66.0	17448.3	154.9	0.89
68.6	17373.0	79.7	0.46
71.1	166.12.7	107.7	0.65
73.7	15513.0	262.0	1.69
76.2	14101.0	140.3	0.99
Standard Counts	12473		

Crushed Tuff sample with 6.4 cm diam access tube (saturated sample).

Depth (cm)	Sample Counts Mean	Std Dev	CV
2.5	7207.0	178.5	2.48
5.1	10336.3	110.0	1.06
7.6	13053.7	276.3	2.12
10.2	15068.3	111.3	0.74
12.7	16296.7	139.0	0.85
15.2	17115.3	104.5	0.61
17.8	17459.3	103.8	0.59
20.3	17630.3	51.4	0.29
22.9	17793.0	107.6	0.60
25.4	17816.3	83.7	0.47
27.9	17911.0	61.2	0.34
30.5	17971.3	135.1	0.75
33.0	17743.0	103.7	0.58
35.6	17809.3	186.7	1.05
38.1	17678.0	187.9	1.06
40.6	17580.0	12.1	0.07
43.2	17549.3	320.3	1.83
45.7	17385.0	36.9	0.21
48.3	17525.7	96.7	0.55
50.8	17413.0	178.5	1.02
53.3	17318.7	173.3	1.00
55.9	17243.0	176.7	1.02
58.4	17167.0	68.8	0.40
61.0	17076.7	51.5	0.30
63.5	17028.0	145.0	0.85
66.0	16699.3	71.4	0.43
68.6	16219.3	122.3	0.75
71.1	15319.7	125.5	0.82
73.7	14210.7	159.1	1.12
76.2	12601.7	107.1	0.85
Standard Counts	12439		

Fine sand sample with 5.1 cm diam access tube (saturated sample).

Depth (cm)	Sample Counts Mean	Std Dev	CV
2.5	7789.3	87.8	1.13
5.1	10179.3	65.0	0.64
7.6	13541.3	212.0	1.57
10.2	16050.0	276.0	1.72
12.7	18189.3	112.0	0.62
15.2	19337.7	182.6	0.94
17.8	20089.0	175.2	0.87
20.3	20371.7	114.2	0.56
22.9	20395.7	194.5	0.95
25.4	20539.7	159.2	0.78
27.9	20441.7	183.6	0.90
30.5	20462.3	168.4	0.82
33.0	20514.0	196.1	0.96
35.6	20669.0	219.6	1.06
38.1	20547.3	83.4	0.41
40.6	20404.3	125.1	0.61
43.2	20462.7	63.5	0.31
45.7	20362.3	168.7	0.83
48.3	20358.3	90.5	0.44
50.8	20130.0	190.1	0.94
53.3	20297.7	322.8	1.59
55.9	20037.7	3.5	0.02
58.4	20010.0	132.6	0.66
61.0	20108.0	144.8	0.72
63.5	20037.7	166.8	0.83
66.0	19734.3	67.6	0.34
68.6	19185.7	169.9	0.89
71.1	18452.0	138.5	0.75
73.7	16972.0	217.1	1.28
76.2	14261.3	49.9	0.35
Standard Counts	12317		

Layton loamy fine sand sample with 6.4 cm diam access tube (saturated sample).

Depth (cm)	Sample Counts Mean	Std Dev	CV
2.5	4099.0	58.9	1.44
5.1	6107.3	81.8	1.34
7.6	8982.3	92.4	1.03
10.2	12038.0	225.0	1.87
12.7	14710.7	178.8	1.22
15.2	16392.3	153.8	0.94
17.8	17385.0	182.2	1.05
20.3	17968.7	121.0	0.67
22.9	18264.3	229.1	1.25
25.4	18493.3	22.5	0.12
27.9	18505.3	156.0	0.84
30.5	18519.7	148.1	0.80
33.0	18444.3	162.7	0.88
35.6	18561.0	133.2	0.72
38.1	18611.0	64.9	0.35
40.6	18603.3	174.3	0.94
43.2	18374.0	96.8	0.53
45.7	18459.3	201.5	1.09
48.3	18591.7	137.5	0.74
50.8	18696.0	90.8	0.49
53.3	18710.3	106.0	0.57
55.9	18548.3	249.4	1.34
58.4	18530.7	150.4	0.81
61.0	18476.0	119.1	0.64
63.5	18445.3	45.3	0.25
66.0	18064.0	232.5	1.29
68.6	17716.3	68.7	0.39
71.1	17330.7	197.3	1.14
73.7	16610.7	104.3	0.63
76.2	15427.0	156.9	1.02
Standard Counts	12213		

Hackroy clay loam sample with 5.1 cm diam access tube (saturated sample).

Depth (cm)	Sample Counts Mean	Std Dev	CV
2.5	8443.0	202.2	2.40
5.1	11349.7	53.3	0.47
7.6	14034.3	250.3	1.78
10.2	16190.3	130.5	0.81
12.7	17361.7	215.0	1.24
15.2	18092.3	44.0	0.24
17.8	18752.7	80.3	0.43
20.3	18972.3	76.4	0.40
22.9	19388.0	42.8	0.22
25.4	19433.7	46.8	0.24
27.9	19460.3	87.8	0.45
30.5	19804.3	136.8	0.69
33.0	19809.3	122.5	0.62
35.6	19877.3	38.7	0.19
38.1	19794.7	143.6	0.73
40.6	19802.7	114.0	0.58
43.2	20060.3	87.2	0.43
45.7	20055.7	45.9	0.23
48.3	20172.0	42.6	0.21
50.8	20144.7	61.1	0.30
53.3	20101.3	56.2	0.28
55.9	20224.3	69.6	0.34
58.4	20482.0	79.8	0.39
61.0	20446.7	50.2	0.25
63.5	20507.7	152.7	0.74
66.0	20575.0	106.4	0.52
68.6	20644.0	22.7	0.11
71.1	20171.7	125.5	0.62
73.7	19773.0	159.0	0.80
76.2	18603.0	69.2	0.37
Standard Counts	12326		

Crushed Tuff sample with 5.1 cm diam access tube (saturated sample)

Depth (cm)	Sample Counts Mean	Std Dev	CV
2.5	6012.3	111.6	1.86
5.1	8692.3	34.6	0.40
7.6	11548.7	20.2	0.17
10.2	13591.0	148.0	1.09
12.7	14843.3	160.0	1.08
15.2	15475.3	165.1	1.07
17.8	15824.7	129.9	0.82
20.3	15920.3	124.1	0.78
22.9	15834.0	127.5	0.81
25.4	15855.7	159.3	1.00
27.9	15787.0	128.2	0.81
30.5	15762.7	132.9	0.84
33.0	15812.7	20.5	0.13
35.6	15840.0	24.3	0.15
38.1	15613.7	107.0	0.69
40.6	15710.7	93.6	0.60
43.2	15721.0	72.1	0.46
45.7	15686.0	131.9	0.84
48.3	15808.0	133.6	0.85
50.8	15829.0	117.6	0.74
53.3	15857.0	154.5	0.97
55.9	16060.7	187.0	1.16
58.4	15989.0	116.1	0.73
61.0	15973.7	57.2	0.36
63.5	16010.7	55.6	0.35
66.0	15843.3	146.8	0.93
68.6	15613.0	59.4	0.38
71.1	15206.0	58.5	0.38
73.7	14689.3	97.3	0.66
76.2	12820.7	78.6	0.61
Standard Counts	11376		

Crushed Tuff sample with 6.4 cm diam access tube (saturated sample)

Depth (cm)	Sample Counts Mean	Std Dev	CV
2.5	5999.0	76.7	1.28
5.1	8517.7	89.8	1.05
7.6	11907.0	80.7	0.68
10.2	14315.0	107.7	0.75
12.7	15733.0	72.5	0.46
15.2	16582.0	191.5	1.15
17.8	17185.0	57.9	0.34
20.3	17451.3	212.0	1.21
22.9	17610.7	189.9	1.08
25.4	17758.0	226.6	1.28
27.9	17683.7	215.9	1.22
30.5	17761.0	117.5	0.66
33.0	17567.7	169.4	0.96
35.6	17562.3	72.8	0.41
38.1	17526.7	149.5	0.85
40.6	17425.0	107.1	0.61
43.2	17298.3	138.2	0.80
45.7	17272.7	88.6	0.51
48.3	17349.0	225.0	1.30
50.8	17371.0	80.1	0.46
53.3	17147.3	134.9	0.79
55.9	17142.7	191.3	1.12
58.4	17147.7	93.4	0.54
61.0	17004.0	93.7	0.55
63.5	16941.7	58.5	0.35
66.0	16846.3	138.0	0.82
68.6	16273.0	97.5	0.60
71.1	15658.0	195.6	1.25
73.7	14757.0	43.6	0.30
76.2	12558.0	152.1	1.21
Standard Counts	12789		

Fine sand sample with 5.1 cm diam access tube (saturated sample).

Depth (cm)	Sample Counts Mean	Std Dev	CV
2.5	5807.7	129.3	2.23
5.1	8164.7	109.3	1.34
7.6	12733.3	273.1	2.14
10.2	15797.7	713.2	4.51
12.7	16495.0	199.8	1.21
15.2	19127.3	46.7	0.24
17.8	19712.3	214.8	1.09
20.3	18546.0	110.7	0.60
22.9	20148.7	112.3	0.56
25.4	20098.0	70.1	0.35
27.9	20058.3	549.5	2.74
30.5	20476.0	133.0	0.65
33.0	18664.0	91.0	0.49
35.6	18678.3	121.5	0.65
38.1	19348.0	998.2	5.16
40.6	18642.0	71.3	0.38
43.2	18379.3	164.9	0.90
45.7	18511.3	79.1	0.43
48.3	20304.3	410.1	2.02
50.8	18604.0	114.5	0.62
53.3	18593.3	127.1	0.68
55.9	18433.3	232.4	1.26
58.4	18289.3	129.3	0.71
61.0	19356.0	1320.8	6.82
63.5	19787.0	78.5	0.40
66.0	19587.7	66.4	0.34
68.6	19168.7	70.9	0.37
71.1	18332.3	139.5	0.76
73.7	16984.0	296.9	1.75
76.2	14205.0	1.0	0.01
Standard Counts	12765		

Layton loamy fine sand sample with 6.4 cm diam access tube (saturated sample).

Depth (cm)	Sample Counts Mean	Std Dev	CV
2.5	4135.3	34.3	0.83
5.1	6613.0	89.4	1.35
7.6	9955.0	146.5	1.47
10.2	12890.3	75.1	0.58
12.7	15245.0	53.7	0.35
15.2	16650.7	62.3	0.37
17.8	17505.0	83.7	0.48
20.3	17865.0	8.0	0.04
22.9	18131.3	156.7	0.86
25.4	18236.0	200.3	1.10
27.9	18287.7	128.8	0.70
30.5	18231.0	71.1	0.39
33.0	18283.3	44.9	0.25
35.6	18317.7	63.1	0.34
38.1	18296.0	248.9	1.36
40.6	18215.3	107.1	0.59
43.2	18202.0	112.9	0.62
45.7	18446.0	41.6	0.23
48.3	18299.3	109.4	0.60
50.8	18481.3	32.0	0.17
53.3	18533.0	33.2	0.18
55.9	18481.0	78.5	0.42
58.4	18283.7	73.1	0.40
61.0	18214.3	49.4	0.27
63.5	18172.7	188.6	1.04
66.0	17798.3	134.0	0.75
68.6	17698.0	106.7	0.60
71.1	17225.3	189.0	1.10
73.7	16529.7	171.3	1.04
76.2	15539.0	81.6	0.52
Standard Counts	12823		

Hackroy clay loam sample with 5.1 cm diam access tube (saturated sample).

Depth (cm)	Sample Counts Mean	Std Dev	CV
2.5	6626.3	46.5	0.70
5.1	9572.3	108.4	1.13
7.6	12374.0	144.0	1.16
10.2	14505.7	121.3	0.84
12.7	15619.0	292.4	1.87
15.2	16274.7	175.9	1.08
17.8	16759.3	11.7	0.07
20.3	17104.0	33.2	0.19
22.9	17505.3	259.2	1.48
25.4	17735.0	33.5	0.19
27.9	17613.7	73.9	0.42
30.5	18020.3	163.7	0.91
33.0	18010.0	117.2	0.65
35.6	18075.0	70.6	0.39
38.1	18077.0	78.2	0.43
40.6	18280.7	122.9	0.67
43.2	18177.7	297.0	1.63
45.7	18185.7	109.0	0.60
48.3	18132.0	36.1	0.20
50.8	18415.7	46.1	0.25
53.3	18565.7	125.4	0.68
55.9	18512.7	235.2	1.27
58.4	18539.0	21.6	0.12
61.0	18637.7	119.8	0.64
63.5	18686.3	122.4	0.66
66.0	18848.7	131.1	0.70
68.6	18700.0	155.2	0.83
71.1	18595.3	28.7	0.15
73.7	18112.3	185.2	1.02
76.2	17130.0	242.5	1.42
Standard Counts	11383		

Crushed Tuff sample with 5.1 cm diam access tube (saturated sample)

Depth (cm)	Sample Counts Mean	Std Dev	CV
2.5	10576.7	99.5	0.94
5.1	15225.0	93.3	0.61
7.6	17682.0	77.1	0.44
10.2	19515.7	123.8	0.63
12.7	20947.7	29.1	0.14
15.2	21484.3	87.8	0.41
17.8	21652.7	219.5	1.01
20.3	21791.7	88.7	0.41
22.9	21714.7	138.0	0.64
25.4	21701.7	137.7	0.63
27.9	21651.3	90.4	0.42
30.5	21630.7	86.9	0.40
33.0	21519.3	44.5	0.21
35.6	21651.0	123.0	0.57
38.1	21458.3	160.0	0.75
40.6	21587.0	165.9	0.77
43.2	21394.0	36.4	0.17
45.7	21684.3	94.6	0.44
48.3	21875.7	80.4	0.37
50.8	21949.7	82.7	0.38
53.3	22091.0	259.0	1.17
55.9	21765.7	28.4	0.13
58.4	21954.3	98.3	0.45
61.0	21953.7	167.5	0.76
63.5	21781.7	83.8	0.38
66.0	21647.3	37.8	0.17
68.6	21162.0	41.6	0.20
71.1	20464.7	64.6	0.32
73.7	19208.0	81.5	0.42
76.2	17385.0	243.6	1.40
Standard Counts	14715		

Crushed Tuff sample with 6.4 cm diam access tube (saturated sample)

Depth (cm)	Sample Counts Mean	Std Dev	CV
2.5	8148.7	174.3	2.14
5.1	11504.7	221.1	1.92
7.6	15157.7	31.1	0.21
10.2	18072.3	144.0	0.80
12.7	19817.3	108.0	0.54
15.2	21005.3	193.0	0.92
17.8	21776.3	117.7	0.54
20.3	21824.7	132.2	0.61
22.9	22049.0	98.9	0.45
25.4	22198.0	155.9	0.70
27.9	22249.0	208.5	0.94
30.5	22211.0	125.9	0.57
33.0	22212.0	298.4	1.34
35.6	21980.7	51.5	0.23
38.1	21885.7	328.0	1.50
40.6	21984.3	175.9	0.80
43.2	21775.0	221.8	1.02
45.7	21714.7	192.0	0.88
48.3	21725.0	78.6	0.36
50.8	21714.7	120.0	0.55
53.3	21488.7	24.0	0.11
55.9	21644.7	101.6	0.47
58.4	21476.7	106.2	0.49
61.0	21428.7	128.8	0.60
63.5	21375.0	59.1	0.28
66.0	21057.7	70.1	0.33
68.6	20575.0	322.5	1.57
71.1	19738.0	216.4	1.10
73.7	18454.7	105.6	0.57
76.2	15788.0	22.5	0.14
Standard Counts	14860		

Fine sand sample with 5.1 cm diam access tube (saturated sample).

Depth (cm)	Sample Counts Mean	Std Dev	CV
2.5	11359.7	235.9	2.08
5.1	15412.7	70.6	0.46
7.6	19639.3	87.0	0.44
10.2	22213.3	327.4	1.47
12.7	23855.0	268.5	1.13
15.2	24600.0	172.7	0.70
17.8	25287.7	37.7	0.15
20.3	25272.7	231.9	0.92
22.9	25125.0	130.4	0.52
25.4	25453.3	222.7	0.88
27.9	25517.0	118.7	0.47
30.5	25473.0	92.5	0.36
33.0	25504.3	22.9	0.09
35.6	25455.0	133.4	0.52
38.1	25384.0	311.0	1.22
40.6	25265.3	188.5	0.75
43.2	25210.0	182.9	0.73
45.7	24964.7	348.1	1.39
48.3	25163.7	280.5	1.11
50.8	25094.0	74.0	0.29
53.3	24982.7	54.1	0.22
55.9	24795.7	53.7	0.22
58.4	24994.7	64.6	0.26
61.0	24838.7	216.4	0.87
63.5	24610.3	127.2	0.52
66.0	24500.3	153.9	0.63
68.6	23521.0	87.9	0.37
71.1	22244.0	112.3	0.50
73.7	20504.7	204.2	1.00
76.2	17739.3	27.6	0.16
Standard Counts	14636		

Layton loamy fine sand sample with 6.4 cm diam access tube (saturated sample).

Depth (cm)	Sample Counts Mean	Std Dev	CV
2.5	4399.0	58.3	1.32
5.1	6684.7	107.3	1.60
7.6	10715.0	13.2	0.12
10.2	14391.7	178.6	1.24
12.7	17742.0	46.1	0.26
15.2	20148.3	142.4	0.71
17.8	21576.7	35.7	0.17
20.3	22380.7	73.0	0.33
22.9	22739.0	73.6	0.32
25.4	22962.0	188.3	0.82
27.9	22925.0	108.7	0.47
30.5	23073.3	101.0	0.44
33.0	22929.3	183.2	0.80
35.6	23044.7	275.5	1.20
38.1	22812.3	139.0	0.61
40.6	22923.7	247.2	1.08
43.2	22793.7	86.2	0.38
45.7	23075.3	109.5	0.47
48.3	23014.3	88.5	0.38
50.8	23141.7	127.8	0.55
53.3	23005.3	64.7	0.28
55.9	23079.7	211.4	0.92
58.4	23075.0	162.8	0.71
61.0	22994.7	152.2	0.66
63.5	22689.7	49.4	0.22
66.0	22485.0	149.0	0.66
68.6	22294.0	161.9	0.73
71.1	21714.3	77.2	0.36
73.7	20578.3	167.6	0.81
76.2	19328.3	135.5	0.70
Standard Counts	14498		

Hackroy clay loam sample with 5.1 cm diam access tube (saturated sample).

Depth (cm)	Sample Counts Mean	Std Dev	CV
2.5	8941.3	164.1	1.84
5.1	13855.0	44.1	0.32
7.6	17912.7	167.0	0.93
10.2	20247.7	316.5	1.56
12.7	21610.3	172.0	0.80
15.2	22569.0	163.8	0.73
17.8	23117.3	69.7	0.30
20.3	23704.0	121.8	0.51
22.9	23715.0	100.2	0.42
25.4	24160.7	188.1	0.78
27.9	24245.3	137.1	0.57
30.5	24391.0	126.0	0.52
33.0	24608.0	186.2	0.76
35.6	24484.3	99.5	0.41
38.1	24586.3	161.0	0.65
40.6	24730.0	56.1	0.23
43.2	24725.0	302.9	1.22
45.7	24793.0	72.0	0.29
48.3	25040.7	235.4	0.94
50.8	25086.0	89.3	0.36
53.3	25140.0	178.1	0.71
55.9	25079.0	166.3	0.66
58.4	25470.0	196.3	0.77
61.0	25472.0	215.2	0.85
63.5	25617.7	44.7	0.17
66.0	25486.7	22.2	0.09
68.6	25334.7	143.0	0.56
71.1	25396.7	49.7	0.20
73.7	24485.3	131.3	0.54
76.2	23191.0	351.5	1.52
Standard Counts	14722		

Crushed Tuff sample with 5.1 cm diam access tube (saturated sample)

Depth (cm)	Sample Counts Mean	Std Dev	CV
2.5	1692.7	87.5	5.17
5.1	2337.7	45.4	1.94
7.6	2608.3	39.5	1.51
10.2	2878.3	14.2	0.49
12.7	2917.3	46.5	1.60
15.2	2989.0	2.6	0.09
17.8	2990.7	72.3	2.42
20.3	3007.0	57.4	1.91
22.9	2972.0	29.0	0.98
25.4	2976.0	57.2	1.92
27.9	2947.0	21.0	0.71
30.5	2916.3	54.7	1.88
33.0	2816.3	51.0	1.81
35.6	2900.7	27.7	0.96
38.1	2976.0	41.1	1.38
40.6	2965.7	23.3	0.79
43.2	2923.7	86.5	2.96
45.7	2955.0	31.6	1.07
48.3	2985.7	5.0	0.17
50.8	2994.0	29.9	1.00
53.3	2984.0	55.2	1.85
55.9	3021.3	61.2	2.02
58.4	2961.3	21.7	0.73
61.0	2947.3	45.9	1.56
63.5	2916.3	9.3	0.32
Standard Counts	6612		

Crushed Tuff sample with 6.4 cm diam access tube (saturated sample)

Depth (cm)	Sample Counts Mean	Std Dev	CV
2.5	1478.0	57.3	3.88
5.1	2017.3	31.8	1.58
7.6	2337.7	46.4	1.98
10.2	2571.7	64.8	2.52
12.7	2758.7	45.2	1.64
15.2	2865.0	55.5	1.94
17.8	2869.0	3.6	0.13
20.3	2843.3	13.0	0.46
22.9	2898.3	14.6	0.50
25.4	2933.3	30.6	1.04
27.9	2890.3	58.4	2.02
30.5	2922.3	64.8	2.22
33.0	2918.7	35.5	1.22
35.6	2852.0	94.4	3.31
38.1	2821.3	33.1	1.17
40.6	2882.0	33.6	1.17
43.2	2821.3	51.2	1.81
45.7	2892.0	65.2	2.25
48.3	2820.3	24.7	0.88
50.8	2866.0	75.7	2.64
53.3	2845.7	32.6	1.14
55.9	2877.7	25.7	0.89
58.4	2859.0	49.4	1.73
61.0	2838.3	51.9	1.83
63.5	2885.3	29.8	1.03
Standard Counts	6706		

Fine sand sample with 5.1 cm diam access tube (saturated sample).

Depth (cm)	Sample Counts Mean	Std Dev	CV
2.5	1912.3	69.2	3.62
5.1	2474.3	17.9	0.72
7.6	2921.0	21.7	0.74
10.2	3205.0	43.3	1.35
12.7	3390.0	99.7	2.94
15.2	3486.7	86.4	2.48
17.8	3488.0	43.6	1.25
20.3	3514.0	70.3	2.00
22.9	3509.3	27.8	0.79
25.4	3634.3	67.1	1.85
27.9	3444.0	10.4	0.30
30.5	3542.0	61.0	1.72
33.0	3501.0	42.5	1.21
35.6	3500.0	21.8	0.62
38.1	3430.3	57.7	1.68
40.6	3503.0	47.7	1.36
43.2	3448.7	60.3	1.75
45.7	3458.7	51.4	1.49
48.3	3373.3	44.9	1.33
50.8	3406.7	64.4	1.89
53.3	3365.0	128.9	3.83
55.9	3375.7	110.1	3.26
58.4	3437.7	30.5	0.89
61.0	3414.0	29.5	0.86
63.5	3491.3	50.5	1.45
Standard Counts	6676		

Hackroy clay loam sample with 5.1 cm diam access tube (saturated sample).

Depth (cm)	Sample Counts Mean	Std Dev	CV
2.5	2315.3	27.5	1.19
5.1	2629.3	20.8	0.79
7.6	2811.7	40.1	1.43
10.2	2939.3	89.1	3.03
12.7	3003.7	30.9	1.03
15.2	3035.7	56.2	1.85
17.8	3082.0	12.8	0.41
20.3	3060.0	73.1	2.39
22.9	3090.3	65.5	2.12
25.4	3138.3	78.6	2.50
27.9	3114.7	32.1	1.03
30.5	3206.7	65.2	2.03
33.0	3240.7	75.3	2.32
35.6	3251.3	98.9	3.04
38.1	3227.3	84.4	2.62
40.6	3253.0	23.5	0.72
43.2	3211.7	42.6	1.33
45.7	3250.0	51.5	1.58
48.3	3287.7	59.3	1.80
50.8	3307.7	59.2	1.79
53.3	3292.3	26.9	0.82
55.9	3407.0	66.4	1.95
58.4	3330.3	14.6	0.44
61.0	3364.3	27.0	0.80
63.5	3413.3	42.1	1.23
Standard Counts	6651		

Crushed Tuff sample with 5.1 cm diam access tube (saturated sample)

Depth (cm)	Sample Counts Mean	Std Dev	CV
2.5	5316.3	144.8	2.72
5.1	7143.3	93.4	1.31
7.6	8642.7	68.5	0.79
10.2	9837.7	8.3	0.08
12.7	10527.0	63.5	0.60
15.2	10732.0	83.4	0.78
17.8	10881.7	28.7	0.26
20.3	10957.3	99.4	0.91
22.9	11047.7	195.1	1.77
25.4	10919.0	188.1	1.72
27.9	10946.0	58.3	0.53
30.5	10832.3	45.7	0.42
33.0	10778.3	59.6	0.55
35.6	10892.3	123.6	1.13
38.1	10833.0	220.6	2.04
40.6	10687.3	48.2	0.45
43.2	10827.7	16.2	0.15
45.7	10920.0	65.2	0.60
48.3	10936.0	137.9	1.26
50.8	11019.7	77.8	0.71
53.3	10958.0	96.7	0.88
55.9	11015.3	79.6	0.72
58.4	10971.3	28.0	0.26
61.0	10972.7	35.1	0.32
63.5	11047.7	29.7	0.27
66.0	10807.0	70.4	0.65
68.6	10763.3	137.5	1.28
71.1	10296.3	126.8	1.23
73.7	9779.3	76.5	0.78
76.2	8793.0	164.8	1.87
Standard Counts	7152		

Crushed Tuff sample with 6.4 cm diam access tube (saturated sample)

Depth (cm)	Sample Counts Mean	Std Dev	CV
2.5	4235.7	114.7	2.71
5.1	5935.3	73.9	1.24
7.6	7775.7	72.4	0.93
10.2	9204.0	123.2	1.34
12.7	10033.3	134.3	1.34
15.2	10521.0	76.7	0.73
17.8	10922.0	52.3	0.48
20.3	11010.3	97.1	0.88
22.9	11128.3	205.8	1.85
25.4	11137.0	110.6	0.99
27.9	11114.0	172.0	1.55
30.5	11072.3	94.1	0.85
33.0	11140.7	63.8	0.57
35.6	11040.7	118.9	1.08
38.1	11093.0	55.8	0.50
40.6	10956.7	36.1	0.33
43.2	10936.0	63.0	0.58
45.7	10914.7	17.0	0.16
48.3	11016.7	94.3	0.86
50.8	10862.0	178.0	1.64
53.3	10926.7	29.3	0.27
55.9	10887.7	88.5	0.81
58.4	10832.3	46.0	0.42
61.0	10703.0	54.1	0.51
63.5	10652.3	83.5	0.78
66.0	10521.0	246.2	2.34
68.6	10235.0	54.8	0.54
71.1	9858.3	67.5	0.68
73.7	9120.7	93.2	1.02
76.2	7796.7	124.3	1.59
Standard Counts	7102		

Fine sand sample with 5.1 cm diam access tube (saturated sample).

Depth (cm)	Sample Counts Mean	Std Dev	CV
2.5	5724.0	36.7	0.64
5.1	7946.7	19.5	0.25
7.6	9945.0	55.9	0.56
10.2	11262.7	80.4	0.71
12.7	11967.3	46.0	0.38
15.2	12242.7	129.2	1.06
17.8	12635.3	75.0	0.59
20.3	12792.7	68.2	0.53
22.9	12692.7	177.0	1.39
25.4	12846.7	10.2	0.08
27.9	12835.0	89.4	0.70
30.5	12802.0	62.2	0.49
33.0	12809.3	122.6	0.96
35.6	12681.3	114.9	0.91
38.1	12743.0	6.1	0.05
40.6	12808.0	191.1	1.49
43.2	12707.3	76.6	0.60
45.7	12629.7	89.8	0.71
48.3	12646.3	160.4	1.27
50.8	12703.7	180.5	1.42
53.3	12612.3	122.3	0.97
55.9	12565.0	126.5	1.01
58.4	12517.7	155.5	1.24
61.0	12530.3	120.3	0.96
63.5	12339.0	72.9	0.59
66.0	12174.3	37.8	0.31
68.6	11830.7	29.6	0.25
71.1	11197.7	95.7	0.85
73.7	10449.7	103.5	0.99
76.2	8805.7	120.1	1.36
Standard Counts	7196		

Layton loamy fine sand sample with 6.4 cm diam access tube (saturated sample).

Depth (cm)	Sample Counts Mean	Std Dev	CV
2.5	2832.0	51.3	1.81
5.1	4673.7	59.1	1.27
7.6	6409.7	20.8	0.33
10.2	8314.7	69.6	0.84
12.7	9688.7	77.2	0.80
15.2	10487.7	7.5	0.07
17.8	11033.0	114.5	1.04
20.3	11303.7	51.7	0.46
22.9	11405.0	103.3	0.91
25.4	11511.7	180.1	1.56
27.9	11509.0	118.2	1.03
30.5	11660.0	96.0	0.82
33.0	11639.7	60.1	0.52
35.6	11500.3	160.2	1.39
38.1	11576.3	97.3	0.84
40.6	11565.0	7.8	0.07
43.2	11491.0	73.7	0.64
45.7	11639.7	42.2	0.36
48.3	11515.7	50.6	0.44
50.8	11623.7	83.2	0.72
53.3	11598.3	203.0	1.75
55.9	11775.0	151.9	1.29
58.4	11668.7	105.6	0.91
61.0	11532.3	73.1	0.63
63.5	11395.3	46.4	0.41
66.0	11202.7	40.1	0.36
68.6	11018.7	91.9	0.83
71.1	10743.0	58.7	0.55
73.7	10087.3	52.7	0.52
76.2	9782.3	156.1	1.60
Standard Counts	7165		

Hackroy clay loam sample with 5.1 cm diam access tube (saturated sample).

Depth (cm)	Sample Counts Mean	Std Dev	CV
2.5	4902.0	137.1	2.80
5.1	6927.7	131.1	1.89
7.6	8858.7	297.1	3.35
10.2	10139.3	105.6	1.04
12.7	10886.7	93.5	0.86
15.2	11330.7	129.4	1.14
17.8	11708.7	54.9	0.47
20.3	11740.3	146.0	1.24
22.9	12093.0	37.0	0.31
25.4	12175.3	86.1	0.71
27.9	12221.0	91.0	0.74
30.5	12203.0	62.4	0.51
33.0	12346.0	75.9	0.61
35.6	12344.0	71.2	0.58
38.1	12438.3	100.9	0.81
40.6	12433.7	170.1	1.37
43.2	12580.7	59.5	0.47
45.7	12355.0	141.2	1.14
48.3	12531.7	84.9	0.68
50.8	12651.7	83.3	0.66
53.3	12660.0	128.3	1.01
55.9	12684.3	105.0	0.83
58.4	12692.3	147.8	1.16
61.0	12695.3	11.9	0.09
63.5	12801.3	23.5	0.18
66.0	12801.7	109.5	0.86
68.6	12747.3	91.3	0.72
71.1	12890.0	90.1	0.70
73.7	12420.0	188.9	1.52
76.2	11714.3	44.1	0.38
Standard Counts	7158		

Crushed Tuff sample with 5.1 cm diam access tube (saturated sample)

Depth (cm)	Sample Counts Mean	Std Dev	CV
2.5	5606.7	93.5	1.67
5.1	7668.7	88.5	1.15
7.6	9674.7	162.4	1.68
10.2	10867.7	100.5	0.93
12.7	11659.3	128.7	1.10
15.2	12020.3	173.1	1.44
17.8	12351.0	88.0	0.71
20.3	12430.0	11.3	0.09
22.9	12490.3	87.8	0.70
25.4	12355.7	129.3	1.05
27.9	12291.7	37.6	0.31
30.5	12302.3	90.8	0.74
33.0	12258.3	44.3	0.36
35.6	12294.7	31.6	0.26
38.1	12253.3	77.9	0.64
40.6	12226.0	81.2	0.66
43.2	12287.3	222.1	1.81
45.7	12369.7	148.2	1.20
48.3	12254.3	46.7	0.38
50.8	12250.3	46.8	0.38
53.3	12301.3	127.1	1.03
55.9	12238.0	110.0	0.90
58.4	12276.3	87.1	0.71
61.0	12269.0	39.1	0.32
63.5	12279.0	43.7	0.36
66.0	12413.0	243.8	1.96
68.6	12535.7	98.2	0.78
71.1	12701.3	189.9	1.50
73.7	12769.3	76.7	0.60
76.2	13071.7	66.5	0.51
Standard Counts	6786		

Crushed Tuff sample with 6.4 cm diam access tube (saturated sample)

Depth (cm)	Sample Counts Mean	Std Dev	CV
2.5	4647.0	83.1	1.79
5.1	6477.0	61.5	0.95
7.6	8695.3	40.1	0.46
10.2	9975.7	150.2	1.51
12.7	10797.7	38.0	0.35
15.2	11454.0	103.1	0.90
17.8	11744.7	22.4	0.19
20.3	11953.0	71.0	0.59
22.9	11897.7	216.8	1.82
25.4	12038.7	86.8	0.72
27.9	12150.7	39.6	0.33
30.5	12029.0	87.8	0.73
33.0	12022.7	32.7	0.27
35.6	12220.7	162.3	1.33
38.1	12123.3	23.2	0.19
40.6	11977.7	66.5	0.56
43.2	12045.0	171.7	1.43
45.7	12093.0	17.8	0.15
48.3	11896.0	85.8	0.72
50.8	11873.0	42.6	0.36
53.3	11841.7	51.1	0.43
55.9	11986.3	18.1	0.15
58.4	11922.7	117.1	0.98
61.0	11979.3	123.8	1.03
63.5	11948.7	119.3	1.00
66.0	12231.7	66.0	0.54
68.6	11965.3	135.7	1.13
71.1	12025.0	73.8	0.61
73.7	11786.3	121.0	1.03
76.2	11533.7	82.0	0.71
Standard Counts	8157		

Fine sand sample with 5.1 cm diam access tube (saturated sample).

Depth (cm)	Sample Counts Mean	Std Dev	CV
2.5	5958.0	39.2	0.66
5.1	8018.0	36.0	0.45
7.6	10403.0	111.5	1.07
10.2	11873.0	76.1	0.64
12.7	12666.3	124.6	0.98
15.2	13457.0	148.7	1.11
17.8	13860.3	124.4	0.90
20.3	14045.0	140.3	1.00
22.9	14156.7	39.3	0.28
25.4	14249.7	118.4	0.83
27.9	14216.3	83.1	0.58
30.5	14304.3	104.4	0.73
33.0	14226.7	51.7	0.36
35.6	14171.3	161.8	1.14
38.1	14041.0	171.5	1.22
40.6	14023.3	100.8	0.72
43.2	14014.7	84.0	0.60
45.7	13916.7	105.3	0.76
48.3	13879.0	139.7	1.01
50.8	13841.3	89.6	0.65
53.3	13874.3	123.0	0.89
55.9	13823.3	95.1	0.69
58.4	13926.7	68.4	0.49
61.0	13945.7	108.9	0.78
63.5	14030.0	115.5	0.82
66.0	14056.0	47.7	0.34
68.6	13969.3	98.5	0.71
71.1	13946.7	36.3	0.26
73.7	13600.7	159.1	1.17
76.2	13640.3	117.3	0.86
Standard Counts	8116		

Hackroy clay loam sample with 5.1 cm diam access tube (saturated sample).

Depth (cm)	Sample Counts Mean	Std Dev	CV
2.5	6694.7	99.4	1.49
5.1	9004.0	104.5	1.16
7.6	10772.0	81.0	0.75
10.2	11543.3	161.0	1.40
12.7	11943.7	25.3	0.21
15.2	12236.7	66.1	0.54
17.8	12372.7	93.7	0.76
20.3	12593.0	163.1	1.30
22.9	12628.3	70.7	0.56
25.4	12640.3	86.0	0.68
27.9	12646.3	109.6	0.87
30.5	12679.3	99.9	0.79
33.0	12755.7	66.0	0.52
35.6	12774.7	82.0	0.64
38.1	12699.3	121.1	0.95
40.6	12959.0	142.6	1.10
43.2	12970.7	63.2	0.49
45.7	13013.7	126.8	0.97
48.3	13129.3	145.1	1.11
50.8	13119.3	179.8	1.37
53.3	13170.0	19.9	0.15
55.9	13386.3	146.8	1.10
58.4	13428.0	100.6	0.75
61.0	13536.3	100.2	0.74
63.5	13652.0	155.2	1.14
66.0	13794.7	99.7	0.72
68.6	13753.7	220.8	1.61
71.1	13888.7	57.0	0.41
73.7	14099.3	96.4	0.68
76.2	14162.0	238.5	1.68
Standard Counts	7096		

Layton loamy fine sand sample with 6.4 cm diam access tube (saturated sample).

Depth (cm)	Sample Counts Mean	Std Dev	CV
2.5	1860.3	42.9	2.31
5.1	3100.0	44.3	1.43
7.6	5241.0	20.3	0.39
10.2	7500.7	101.8	1.36
12.7	9357.7	76.8	0.82
15.2	10862.0	12.1	0.11
17.8	11445.7	136.9	1.20
20.3	11843.7	31.6	0.27
22.9	12046.0	19.1	0.16
25.4	12053.3	78.8	0.65
27.9	11817.0	84.9	0.72
30.5	11855.3	87.8	0.74
33.0	11498.0	33.1	0.29
35.6	11581.0	89.8	0.78
38.1	11422.7	79.2	0.69
40.6	11311.7	29.8	0.26
43.2	11170.3	54.1	0.48
45.7	11236.3	22.1	0.20
48.3	11363.3	53.3	0.47
50.8	11284.0	63.7	0.56
53.3	11242.3	76.8	0.68
55.9	11180.3	141.6	1.27
58.4	11143.0	82.8	0.74
61.0	11143.0	63.5	0.57
63.5	11163.0	108.0	0.97
66.0	11093.7	81.9	0.74
68.6	10827.3	177.3	1.64
71.1	10563.3	83.2	0.79
73.7	10125.7	98.5	0.97
76.2	9437.0	26.5	0.28
Standard Counts	7827		

Bentonite/Powell Gray subsoil mix sample with 6.4 cm diam access tube (saturated sample)

Depth (cm)	Sample Counts Mean	Std Dev	CV
2.5	370.3	10.0	2.71
5.1	468.0	6.2	1.33
7.6	588.7	5.1	0.87
10.2	990.7	53.6	5.41
12.7	1959.7	11.9	0.61
15.2	3644.0	17.0	0.47
17.8	5013.0	66.6	1.33
20.3	7543.7	93.9	1.24
22.9	10009.0	97.7	0.98
25.4	11128.7	98.2	0.88
27.9	11903.0	106.7	0.90
30.5	12229.0	78.8	0.65
33.0	12451.0	43.6	0.35
35.6	12495.7	91.0	0.73
38.1	12576.3	143.6	1.14
40.6	12699.3	104.9	0.83
43.2	12556.3	75.5	0.60
45.7	12496.7	85.4	0.68
48.3	12680.7	110.5	0.87
50.8	12621.3	25.3	0.20
53.3	12810.0	158.4	1.24
55.9	13315.3	118.1	0.89
Standard Counts	8101		

Crushed Tuff sample with 5.1 cm diam access tube (saturated sample)

Depth (cm)	Sample Counts Mean	Std Dev	CV
2.5	5538.0	30.6	0.55
5.1	8131.7	76.5	0.94
7.6	10108.0	82.7	0.82
10.2	11196.0	109.0	0.97
12.7	11938.7	146.6	1.23
15.2	12499.7	203.4	1.63
17.8	12546.7	42.4	0.34
20.3	12735.7	46.3	0.36
22.9	12684.3	68.1	0.54
25.4	12555.3	58.0	0.46
27.9	12609.0	34.7	0.28
30.5	12619.3	15.5	0.12
33.0	12511.0	65.4	0.52
35.6	12567.3	110.6	0.88
38.1	12540.3	118.9	0.95
40.6	12518.0	47.0	0.38
43.2	12423.0	35.6	0.29
45.7	12648.3	74.2	0.59
48.3	12575.0	73.1	0.58
50.8	12532.7	122.0	0.97
53.3	12509.3	66.3	0.53
55.9	12583.3	90.6	0.72
58.4	12554.0	108.4	0.86
61.0	12642.3	39.8	0.32
63.5	12545.7	166.7	1.33
66.0	12634.0	39.6	0.31
68.6	12785.7	62.1	0.49
71.1	12891.0	120.4	0.93
73.7	12997.3	35.2	0.27
76.2	13084.7	129.5	0.99
Standard Counts	8262		

Crushed Tuff sample with 6.4 cm diam access tube (saturated sample)

Depth (cm)	Sample Counts Mean	Std Dev	CV
2.5	5018.7	38.4	0.77
5.1	6991.7	24.1	0.35
7.6	9347.0	65.1	0.70
10.2	10648.3	156.5	1.47
12.7	11117.0	86.5	0.78
15.2	11772.0	77.3	0.66
17.8	11954.3	102.6	0.86
20.3	12217.3	59.8	0.49
22.9	12321.0	67.3	0.55
25.4	12349.3	95.9	0.78
27.9	12448.3	83.2	0.67
30.5	12396.0	69.7	0.56
33.0	12418.7	53.7	0.43
35.6	12347.3	93.2	0.76
38.1	12388.3	134.8	1.09
40.6	12292.0	135.9	1.11
43.2	12386.0	69.2	0.56
45.7	12367.0	74.1	0.60
48.3	12210.7	83.4	0.68
50.8	12214.7	123.4	1.01
53.3	12330.3	129.7	1.05
55.9	12257.3	138.0	1.13
58.4	12318.3	96.3	0.78
61.0	12362.0	143.4	1.16
63.5	12366.7	58.0	0.47
66.0	12369.7	94.3	0.76
68.6	12362.0	85.5	0.69
71.1	12281.3	72.1	0.59
73.7	12072.7	115.1	0.95
76.2	11834.7	77.2	0.65
Standard Counts	8150		

Fine sand sample with 5.1 cm diam access tube (saturated sample).

Depth (cm)	Sample Counts Mean	Std Dev	CV
2.5	6600.3	81.8	1.24
5.1	8878.0	78.6	0.89
7.6	11071.7	71.7	0.65
10.2	12478.3	106.8	0.86
12.7	13328.3	121.1	0.91
15.2	13808.7	79.4	0.58
17.8	14185.0	209.5	1.48
20.3	14338.7	73.1	0.51
22.9	14333.3	191.3	1.34
25.4	14532.0	93.0	0.64
27.9	14470.7	183.7	1.27
30.5	14447.7	39.5	0.27
33.0	14352.0	315.2	2.20
35.6	14385.7	173.1	1.20
38.1	14241.7	165.1	1.16
40.6	14270.0	106.6	0.75
43.2	14156.7	35.6	0.25
45.7	14239.7	205.4	1.44
48.3	14266.7	113.9	0.80
50.8	14136.3	92.7	0.66
53.3	14143.0	167.0	1.18
55.9	14056.0	30.8	0.22
58.4	14291.3	42.4	0.30
61.0	14270.7	89.3	0.63
63.5	14164.0	98.5	0.70
66.0	14263.7	91.4	0.64
68.6	14231.0	98.0	0.69
71.1	14308.7	110.2	0.77
73.7	14043.7	75.0	0.53
76.2	13815.7	133.4	0.97
Standard Counts	8232		

Hackroy clay loam sample with 5.1 cm diam access tube (saturated sample).

Depth (cm)	Sample Counts Mean	Std Dev	CV
2.5	8262.7	143.6	1.74
5.1	10403.0	90.8	0.87
7.6	11378.7	139.8	1.23
10.2	12042.3	142.6	1.18
12.7	12260.0	40.8	0.33
15.2	12505.7	110.8	0.89
17.8	12653.3	75.3	0.60
20.3	12740.0	146.1	1.15
22.9	12809.7	59.3	0.46
25.4	12950.0	121.4	0.94
27.9	12953.0	128.7	0.99
30.5	12990.3	59.0	0.45
33.0	12971.0	101.0	0.78
35.6	13119.3	77.6	0.59
38.1	13206.7	259.2	1.96
40.6	13182.0	99.7	0.76
43.2	13148.7	85.2	0.65
45.7	13334.0	137.8	1.03
48.3	13237.7	195.6	1.48
50.8	13390.7	148.7	1.11
53.3	13533.3	134.8	1.00
55.9	13600.0	135.5	1.00
58.4	13635.7	46.3	0.34
61.0	13792.7	157.1	1.14
63.5	13866.0	225.6	1.63
66.0	14066.7	63.5	0.45
68.6	13993.7	53.0	0.38
71.1	14298.0	134.8	0.94
73.7	14471.3	135.7	0.94
76.2	14413.7	148.7	1.03
Standard Counts	8227		

Layton loamy fine sand sample with 6.4 cm diam access tube (saturated sample).

Depth (cm)	Sample Counts Mean	Std Dev	CV
2.5	1853.7	93.9	5.07
5.1	3551.3	120.8	3.40
7.6	6703.7	440.9	6.58
10.2	8202.0	46.4	0.57
12.7	9953.7	58.0	0.58
15.2	11057.0	122.5	1.11
17.8	11862.7	152.1	1.28
20.3	12210.0	93.2	0.76
22.9	12289.3	38.7	0.31
25.4	12091.0	140.3	1.16
27.9	12056.7	54.2	0.45
30.5	11884.0	185.0	1.56
33.0	11760.3	42.4	0.36
35.6	11630.7	12.6	0.11
38.1	11518.0	80.5	0.70
40.6	11462.0	75.4	0.66
43.2	11286.7	74.5	0.66
45.7	11356.0	139.6	1.23
48.3	11438.3	66.9	0.58
50.8	11388.3	146.7	1.29
53.3	11501.7	66.5	0.58
55.9	11463.3	268.4	2.34
58.4	11308.0	123.0	1.09
61.0	11328.0	57.8	0.51
63.5	11343.7	137.8	1.22
66.0	11150.0	145.5	1.30
68.6	11077.0	56.6	0.51
71.1	10824.3	171.2	1.58
73.7	10403.3	119.5	1.15
76.2	9362.0	94.3	1.01
Standard Counts	7921		

Bentonite/Powell Gray subsoil mix sample with 6.4 cm diam access tube (saturated sample)

Depth (cm)	Sample Counts Mean	Std Dev	CV
2.5	446.3	29.6	6.63
5.1	579.0	13.5	2.34
7.6	735.0	14.8	2.01
10.2	1123.0	29.6	2.64
12.7	1773.7	15.5	0.88
15.2	3577.0	54.4	1.52
17.8	5924.3	58.6	0.99
20.3	8472.3	65.3	0.77
22.9	10460.3	83.1	0.79
25.4	11742.0	13.5	0.12
27.9	12356.0	56.7	0.46
30.5	12634.7	125.9	1.00
33.0	12849.7	156.7	1.22
35.6	12846.7	99.5	0.78
38.1	12761.0	69.5	0.55
40.6	12926.7	73.8	0.57
43.2	12819.0	84.3	0.66
45.7	12972.7	88.7	0.68
48.3	12870.3	17.0	0.13
50.8	13094.0	90.6	0.69
53.3	13540.0	44.8	0.33
55.9	13656.3	69.0	0.51
Standard Counts	8250		

☆ U.S. Government Printing Office 1994–573-192/93179

This report has been reproduced directly from the
best available copy.

It is available to DOE and DOE contractors from the
Office of Scientific and Technical Information,
P.O. Box 62,
Oak Ridge, TN 37831.
Prices are available from
(615) 576-8401.

It is available to the public from the
National Technical Information Service,
US Department of Commerce,
5285 Port Royal Rd.,
Springfield, VA 22161.