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Cover Performance Enhancement Tests at the Grand Junction, Colorado, Disposal Site: Construction Documentation, Material Testing, and Instrument Calibration

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Abbreviations

ACAP	Alternative Cover Assessment Program
ASTM	American Society for Testing and Materials
cm	centimeter
DOE	U.S. Department of Energy
ECAP	Enhanced Cover Assessment Project
EPA	U.S. Environmental Protection Agency
kN/m^3	kilonewton per cubic meter
kPa	kilopascal
LLDPE	linear low-density polyethylene
m	meter
m^3	cubic meter
m/s	meter per second
mm	millimeter
mm/yr	millimeter per year
PVC	polyvinyl chloride
SWCC	soil water characteristic curve
USCS	Unified Soil Classification System
WCR	water content reflectometer

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Executive Summary

The U.S. Department of Energy's Office of Legacy Management (LM) initiated the Enhanced Cover Assessment Project (ECAP) in September 2007 to evaluate the hydraulic performance of a disposal cell cover at an LM site, and to test an approach for improving the performance and sustainability of LM covers. The objectives include (1) directly measure the water balance and percolation flux in a low-conductivity cover at a site regulated under the Uranium Mill Tailings Radiation Control Act (UMTRCA), and (2) accelerate and enhance natural processes that may be transforming existing low-conductivity covers, which rely on earthen hydraulic barriers, into water balance covers, which store water in soil and release it as soil evaporation and plant transpiration. Covers employing the store-and-release principle have been shown to function well—to limit percolation—in semiarid to arid regions, whereas covers similar to UMTRCA covers with compacted earthen barrier layers have performed unsatisfactorily with respect to limiting percolation.

A low-conductivity cover could be enhanced, or modified, by deliberately blending the upper layers of the cover profile using soil furrowing or ripping machinery and planting native vegetation. A test facility was constructed at the LM Grand Junction, Colorado, Disposal Site to evaluate the soil water balance of both the existing cover and an enhanced cover. The facility includes two test sections containing matching Grand Junction disposal cell covers; one will be enhanced using the proposed method and the other will be left to evolve without intervention. The test covers are being evaluated by monitoring hydrologic conditions within the cover profile (water content and matric potential) as well as boundary fluxes (runoff, evapotranspiration, and percolation). This report describes the historical experience of final covers employing earthen barrier layers, the ECAP test facility, testing conducted to characterize the as-built engineering properties of the ECAP test sections, and calibration of instruments installed at the ECAP test facility. Performance monitoring results for the test sections will be reported separately.

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1.0 Introduction

Final covers at many disposal sites managed by the U.S. Department of Energy (DOE) and others rely on a compacted earthen barrier to limit radon flux from the cell and percolation of water into underlying waste. These barriers are generally constructed of clayey soils using methods that result in low saturated hydraulic conductivity (less than 10^{-9} meters per second [m/s]) when the barrier is constructed. However, field investigations of actual covers have shown that the in-service saturated hydraulic conductivity of soil barriers can be much higher than the saturated hydraulic conductivity attained during construction (Benson et al. 2011).

The percolation rate into the waste is also much higher than anticipated, sometimes by several orders of magnitude (Albrecht and Benson 2001; Albright et al. 2006a, 2006b; DOE 1999; Gee et al. 2009). For example, at the Lakeview, Oregon, Disposal Site, the saturated hydraulic conductivity of the compacted soil barrier was about 3.0×10^{-7} m/s (Waugh et al. 2007). Beginning in 2005, percolation rates measured at the lower end of the top slope of the Lakeview disposal cell cover exceeded 200 millimeters per year (mm/yr) (Waugh et al. 2007). In contrast, the percolation rate for a cover with a barrier layer having saturated hydraulic conductivity less than 1×10^{-9} m/s should be no greater than 32 mm/yr.

These findings are not unique to covers constructed for disposal sites managed by DOE. Similar findings have been reported in a nationwide study conducted by the U.S. Environmental Protection Agency (EPA) (Albright et al. 2006a, 2006b) and case studies reported by Albrecht and Benson (2001). The higher-than-expected saturated hydraulic conductivity generally can be attributed to (1) unanticipated ecological consequences of biointrusion, desiccation, and freeze-thaw cycling; (2) the retention of borrow soil structure (clods) during construction; and (3) natural soil formation processes after construction.

Studies by DOE and EPA have shown that water balance covers can be very effective at limiting percolation at arid and semiarid sites (Dwyer 2001; Albright et al. 2004; Scanlon et al. 2005a, 2005b; Waugh et al. 2009). Water balance covers consist of thick, fine-textured soil layers that store precipitation in the root zone where water can be removed seasonally by plants (Albright et al. 2010). For example, the average percolation rate from the water balance cover at the Monticello, Utah, Disposal Site has been about 0.6 mm/yr over more than 9 years, with a maximum annual percolation rate of 3.2 mm/yr occurring during one of the wettest years on record (Waugh et al. 2009). The design target was an average percolation rate less than 3.0 mm/yr. The climate, soils, and plant ecology of the Monticello and Lakeview disposal cells are similar. However, the water balance cover at Monticello has performed, hydraulically, much better than the conventional cover with a compacted soil layer at Lakeview. Water balance covers also are *not* prone to significant changes in engineering properties caused by biointrusion, desiccation, and freeze-thaw cycling (Benson et al. 2008; Benson et al. 2011).

Maintenance of conventional covers at DOE disposal sites can be costly. For example, herbicides are applied periodically to control plant establishment and root intrusion in final covers. The costs of herbicide spraying have increased at many sites and will likely continue to do so as ecological conditions become more favorable for plant growth. Replacement or rehabilitation of the hydraulic barrier layer at these sites could also be very expensive. Without intervention, however, ecological succession and soil development processes may, over time, effectively transform existing conventional covers with soil barriers into water balance covers. Thus, one option is to enhance this transformation process by anthropogenic means. The goal would be to accommodate ecological processes and, thereby, sustain a high level of performance while reducing long-term maintenance costs.

In September 2007, the DOE Office of Legacy Management initiated the Enhanced Cover Assessment Project (ECAP) to demonstrate an inexpensive way to improve long-term surveillance and maintenance of final covers for disposal cells. A test facility was constructed at the Grand Junction, Colorado, Disposal Site to evaluate a method to enhance, or modify, conventional covers with soil barriers in a manner that deliberately accelerates their transformation to water balance covers. The goal is to enhance protectiveness over the long term by providing more effective control of percolation.

This report describes historical experience with final covers employing soil barrier layers at sites managed by DOE and others, the ECAP test facility, testing conducted to characterize the as-built engineering properties of the ECAP test sections, and calibration of instruments installed at the ECAP test facility.

2.0 Existing Caps and Natural Analogs

The Grand Junction disposal site was originally constructed for the disposal of uranium mill tailings and other materials associated with the cleanup of the processing site and vicinity properties in the city of Grand Junction, Colorado (http://www.lm.doe.gov/Grand_Junction_All). All contaminated materials from the old processing site and all vicinity property materials temporarily stored at the site had been transported to the disposal cell by the end of 1994. About 4.4 million cubic yards of contaminated materials were placed in the cell. Part of the Grand Junction disposal cell was completed in 1994; the remainder of the cell will remain open until 2023 to receive additional low-level radioactive materials expected from such sources as tailings material buried along utility lines.

The final cover at the Grand Junction disposal site consists of four layers (Figure 1): a radon barrier constructed with compacted, fine-grained soil that has low hydraulic conductivity; a frost protection layer constructed with fine-grained soil; a sand-and-gravel bedding layer; and a layer of basalt riprap. Saturated hydraulic conductivity values for the radon barrier, measured at two locations with air-entry permeameters (Stephens et al. 1988) in 2003, were 7×10^{-7} and 2×10^{-6} m/s, 2 to 3 orders of magnitude above the design target.

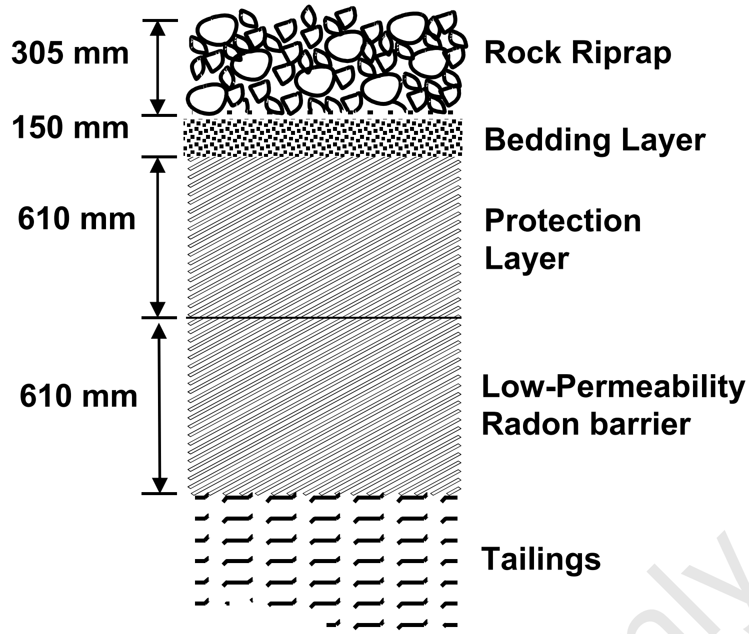


Figure 1. Profile of final cover for the Grand Junction disposal cell.

A Long-Term Surveillance Plan serves as the regulatory framework guiding the maintenance of the disposal cell and, at many sites, includes a provision to cut and spray plants that may be considered to be a threat to the integrity of the disposal cell. Deep-rooted plants may transmit percolation into the underlying waste at much higher rates than originally anticipated. At present there is a requirement to eliminate deep-rooted plants at least annually. In addition, the cost of controlling vegetation on the Grand Junction disposal cell cover has increased as the cover has provided a more favorable habitat for fourwing saltbush and other plants. The riprap layer acts as a mulch that retains water within the underlying fine-textured soil, enhancing the establishment and growth of vegetation. Soil from eolian deposition is filling voids in the riprap, providing a more suitable habitat for vegetation. As a result of these conditions, LM is concerned that the hydraulic performance of the disposal cell cover may be diminishing, and the costs of maintenance may increase in the long term.

The conditions observed at the Grand Junction disposal site are not unique. Deep-rooted plants began growing on conventional uranium mill tailings covers within a few years after construction (DOE 1992). Roots of woody plants were excavated and found to grow down into or through compacted soil barriers at the Grand Junction; Lakeview; Burrell, Pennsylvania; Durango, Colorado; Shiprock, New Mexico; and Tuba City, Arizona, disposal sites (DOE 1992, 1999; Waugh et al. 2007). Taproots typically extended vertically through the riprap and bedding layers and then branched and spread laterally at the surface of the compacted soil barrier, following both the source of water and the path of least resistance to penetration and growth. Secondary and tertiary roots extended vertically into the compacted soil barrier, where they became fibrous root mats following cracks and soil structural planes.

In a follow-up investigation of root intrusion, DOE evaluated the effects of plant roots and soil development on in situ saturated hydraulic conductivity of compacted soil layers at Burrell, Lakeview, Shiprock, and Tuba City using air-entry permeameters (Stephens et al. 1988). At

Burrell, the mean saturated hydraulic conductivity was 3.0×10^{-7} m/s where Japanese knotweed roots penetrated the compacted soil barrier, and 2.9×10^{-9} m/s at locations with no plants (Waugh 1999; DOE 1999). The weighted-average saturated hydraulic conductivity for the entire cover, calculated using the community leaf area index for Japanese knotweed, was 4.4×10^{-8} m/s. At Lakeview, the mean saturated hydraulic conductivity for the compacted soil barrier both with and without sagebrush and bitterbrush roots was 3.0×10^{-7} m/s (Waugh et al. 2007). The highest saturated hydraulic conductivity values occurred near the top of the compacted soil barrier; the lowest values occurred deeper in the barrier. The mean saturated hydraulic conductivity in the top of the Shiprock compacted soil barrier was 4.4×10^{-7} m/s (Glenn and Waugh 2001). Results were highly variable, and where tamarisk and Russian thistle were rooted in the barrier, the saturated hydraulic conductivity was lower. The Shiprock compacted soil barrier was nearly saturated, as measured monthly for 16 months at four locations using a neutron hydroprobe. At Tuba City, the mean saturated hydraulic conductivity of the compacted soil barrier was 8.7×10^{-8} m/s, with values ranging from a low of 9.8×10^{-11} to a high of 1.18×10^{-6} m/s. In all of the tests mentioned above, dyes indicated that water moved through macropore cracks in the soil structure of compacted soil barriers.

Short-term changes in cover soil properties are not unique to Uranium Mill Tailings Radiation Control Act disposal cells. Exhumations of the test sections in EPA's Alternative Cover Assessment Program (ACAP) (Albright et al. 2004) show changes to saturated and unsaturated hydraulic properties over the 4- to 8-year life of the test sections. Benson et al. (2011) reported in-service saturated hydraulic conductivities of storage and barrier layers between 7.5×10^{-8} and 6.0×10^{-6} m/s regardless of the initial saturated hydraulic conductivity. Alterations in saturated hydraulic conductivity occurred in all climates and for barrier and storage layers in all cover types. Wet-dry cycling appears to play a major role in altering hydraulic conductivity. Smaller changes in saturated hydraulic conductivity occurred in storage and barrier layers constructed with soils that have lower clay content, soils that have a fines fraction with a greater proportion of silt-size particles, and soils compacted to lower dry unit weight. Changes in the soil water characteristic curve (SWCC) parameters (α and n) typically were smaller than the changes in saturated hydraulic conductivity (2.2 times smaller for α and 1.1 times smaller for n, on average). Benson et al. (2011) reported that the porosity of most earthen storage and barrier layers evaluated in the ACAP study was between 0.35 and 0.45 when exhumed, and predicted that densely compacted earthen storage and barrier layers would loosen over time and become more permeable.

Geomorphological and ecological evidence from a natural analog site, called Beaver Gulch, near the Grand Junction disposal site (Smith et al. 1997) supports the concept of ripping and blending the riprap, bedding layer, and underlying frost protection layer, and planting native shrubs in the rip rows. Studies of natural analogs provide clues, from present and past environments, that point to possible long-term changes in engineered covers (Waugh et al. 1994). Analog studies involve the use of logical analogy to investigate natural materials, conditions, or processes that are similar to those known or predicted to occur in some component of an engineered cover system. Thus, analogs can be thought of as uncontrolled, long-term experiments. Evidence or clues from Beaver Gulch suggest that a vegetated rock and soil cover would be adequate to control erosion and limit percolation over hundreds to thousands of years. Rock varnish, lichenometry, soil morphology, and plant community characteristics indicate the slope's stability and relative age, long-term water movement through the soil profile, and the trajectories of plant succession.

3.0 Test Sections

This study is evaluating whether the existing cover design at the Grand Junction disposal site can be enhanced so that it functions as an effective store-and-release cover. The objective is to accelerate and enhance the natural processes occurring in the field, where fine-textured soil is slowly filling in the riprap. This will be accomplished by deliberately blending the riprap and underlying fine-textured soil by furrowing or ripping and mixing the rock, drainage, and frost protection layers and planting native shrubs in the rip rows. The treatment's effectiveness will be evaluated by monitoring hydrologic conditions within the cover profile (water content and matric potential) as well as boundary fluxes (runoff, evapotranspiration, and percolation).

Testing the procedure on the existing cap was not practical. Thus, two identical large-scale test sections simulating the cover were constructed adjacent to the Grand Junction disposal site (Figure 2). One of these test sections (Test Section R) will be modified, and the other (Test Section C) will be monitored as a control that simulates the existing cover. Both test sections were constructed in late summer and fall 2007 and have since acclimated to ambient environmental conditions. The cover enhancement treatment will be selected and applied to Test Section R based on test results for different soil furrowing and ripping implements at a nearby test pad.

The ECAP test sections are modeled after the test sections used in EPA's ACAP (Albright et al. 2004). Figure 3 shows a cross section of an ACAP test section. Each test section contains a pan lysimeter (10 m × 20 m) that is used for monitoring percolation from the base of the cover, a runoff collection system, a collection of instruments used to monitor state variables within the cover profile, and a weather station to monitor meteorological conditions. This system permits quantification of all components of the water balance, namely precipitation, runoff, soil water storage, percolation, and evapotranspiration. Evapotranspiration is quantified by closing the water balance. Each test section includes a 10 m wide buffer zone around the lysimeter.

The test sections were constructed using the same earthen materials employed for the full-scale cover. (In 1992, the earthen materials were stockpiled for future closure activities.) Therefore, all cover materials used to construct the ECAP test facility are identical to those in the cover over the disposal cell. The radon barrier and the frost protection layer were constructed with moderately plastic clay having a Unified Soil Classification System (USCS) designation of CL. The radon barrier was underlain with a 460 mm thick layer of road base gravel (broadly graded alluvium with a USCS classification of SW) that was stockpiled onsite when the full-scale cover was constructed. This lower layer of road base gravel simulates the transition layer in the disposal cell. The bedding layer beneath the riprap was also constructed with road base gravel. Riprap for the surface was obtained from a stockpile onsite left over from the construction of the full-scale cell. Heavy equipment similar to that used for the full-scale cover was employed for construction.

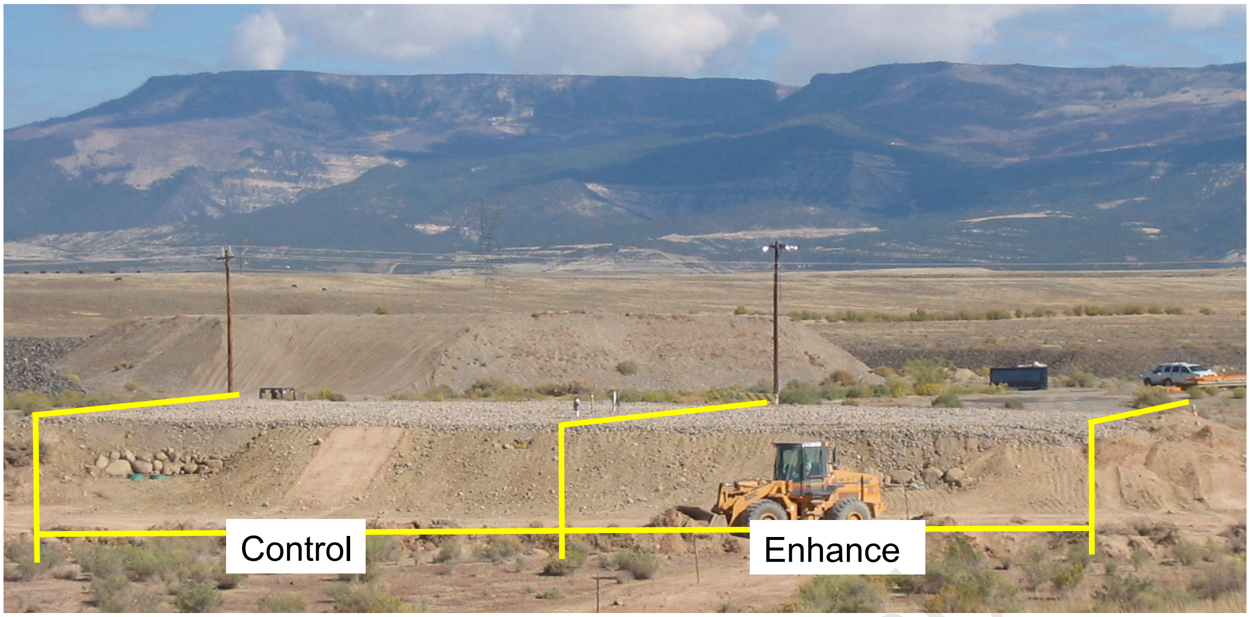


Figure 2. Photograph of the ECAP test facility, with Test Section C ("control") and Test Section R ("enhance") labeled.

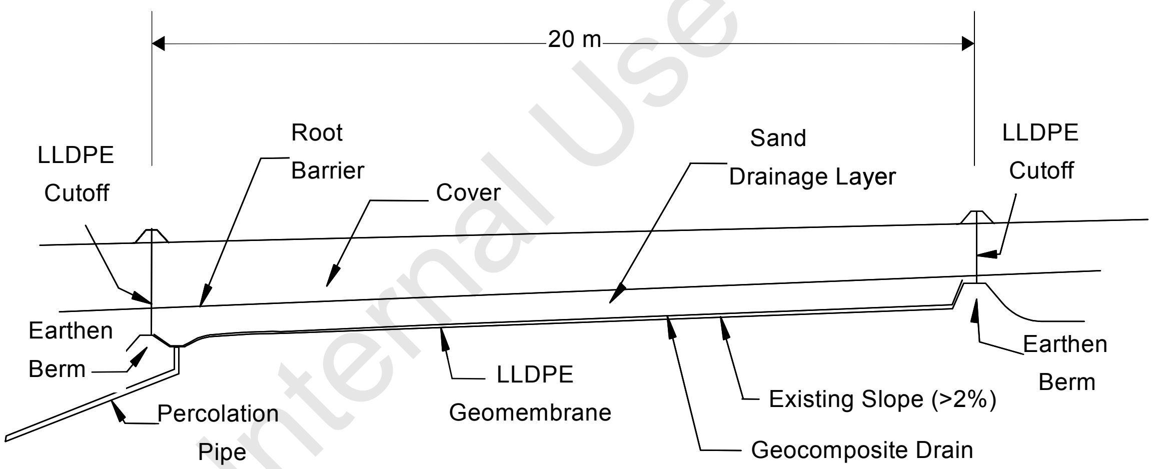
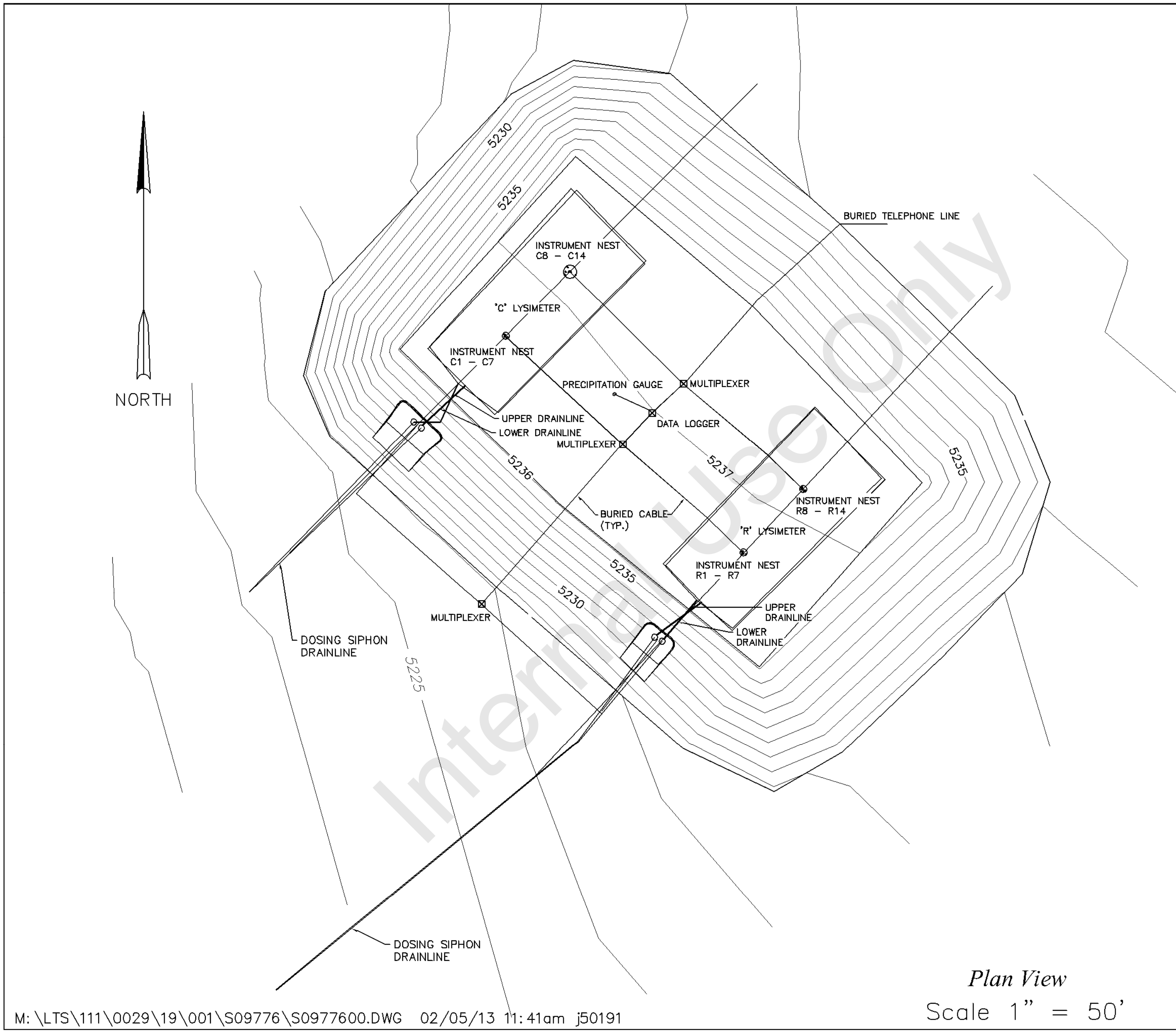


Figure 3. Cross section of the lysimeter used to monitor water balance variables.

3.1 Construction

The construction of two identical ACAP-style lysimeters required an area approximately 65 m by 45 m (approximately 0.3 hectare). The completed test facility was approximately 3 m tall and was sloped at 3H:1V around the perimeter (Figure 2). The top deck was sloped at 2 percent, a slope identical to that of the full-scale cover. Figure 4 shows a plan view of the completed test facility. Procedures described in Benson et al. (1999a) were followed for construction. As-built cross sections are in Appendix A. The control point for surveying test facility corners, instrument locations, and sampling points, as noted in the figures and appendixes, is elevation 5,231.91 ft; N12,964.68' E 92,455.96'.



C Lysimeter Corner Coordinates

location	Northing (ft)	Easting (ft)
C–N,liner	12,972.97	92,261.26
C–E,liner	12,950.17	92,283.62
C–S,liner	12,904.82	92,238.98
C–W,liner	12,924.96	92,218.06
C–N,upper	12,972.49	92,262.82
C–E,upper	12,951.02	92,283.97
C–S,upper	12,904.25	92,238.03
C–W,upper	12,924.35	92,217.69
liner area (sqr. ft) = 1,982.93		
upper area (sqr. ft) = 1,931.61		

R Lysimeter Corner Coordinates

location	Northing (ft)	Easting (ft)
R–N,liner	12,906.59	92,335.28
R–E,liner	12,884.75	92,355.59
R–S,liner	12,839.21	92,310.21
R–W,liner	12,858.81	92,289.31
R–N,upper	12,906.05	92,335.19
R–E,upper	12,884.41	92,356.79
R–S,upper	12,838.42	92,310.27
R–W,upper	12,858.41	92,289.89
liner area (sqr. ft) = 1,930.42		
upper area (sqr. ft) = 1,943.84		

Figure 4. Plan view drawing of the ECAP test facility.

Before the test facility was constructed, its dimensions were staked out in an area north of the existing disposal cell. This area was cleared and grubbed, and approximately 0.3 m of topsoil was stripped using a Case 821 front-end loader. The stripped soil was stockpiled in an adjacent area for use in revegetation after construction. After stripping, the exposed subgrade was proof-rolled, and the dry unit weight and water content were measured. Table 1 summarizes the dry unit weight and water content data.

Table 1. Water Content and Dry Unit Weight of Each Layer of ECAP Test Sections

Layer	Water Content (%)		Dry Unit Weight (kN/m^3)	
	Test Section C	Test Section R	Test Section C	Test Section R
Frost Protection	16.8 ± 1.5	16.1 ± 0.6	16.9 ± 0.5	17.0 ± 0.1
Radon Barrier	14.6 ± 0.2	17.1 ± 0.5	18.1 ± 0.1	17.5 ± 0.2
Transition	2.9 ± 0.2	2.9 ± 0.2	19.9 ± 0.3	19.2 ± 1.0

Note: No measurements made on riprap or bedding layers.

Silty clay with cobbles, which had been stockpiled nearby during full-scale construction, was used as compacted random fill for the foundation of the test facility. Moisture was added to the stockpile beforehand to improve compaction. The moisture-conditioned material was transported to the test pad in 10-cubic-meter (m^3) dump trucks, spread with a Bobcat T250 skid loader, and compacted with a Rhino 66 vibratory padfoot compacter (75 mm shank). Approximately 0.6 m of the silty clay fill was placed. This layer was overlain with a veneer of granular road base to provide a smooth working platform for the construction of the lysimeter.

3.1.1 Lysimeter

One ACAP-style lysimeter was constructed in each test section using 1.5 mm thick linear low-density polyethylene (LLDPE) geomembrane with texturing on both sides. LLDPE geomembrane was used to form the base and sidewalls of each lysimeter. However, the upper portion of the sidewalls of Test Section R was constructed with 0.1 mm polyethylene sheet to ensure that ripping through the sidewalls could be accomplished during the soil-ripping phase of the project. LLDPE geomembrane was used because of its flexibility, ductility, and puncture resistance. Methods described in Benson et al. (1999a) were used to form and weld the lysimeter walls and to install the sump in the base for the collection of percolation.

The floor of the lysimeter was overlain with geocomposite drainage layer (geonet sandwiched between two non-woven geotextiles) that collects percolation from the base of the cover profile and directs the percolation to a collection sump and a collection basin. Pipes used to convey percolation from the sump to the basin were placed in trenches and buried in road base.

3.1.2 Placement of Cover Soils

The cover soils were placed in the same sequence used for the construction of the actual cover on the disposal cell. Table 2 compares the actual cover profile on the Grand Junction disposal cell and the as-built ECAP test sections.

Table 2. Comparison of Cover at Grand Junction Disposal Cell and ECAP Test Facility

Component	Grand Junction Disposal Cell	ECAP Test Facility
Riprap Layer	305 mm cobbles	305 mm cobbles
Bedding Layer	150 mm coarse material	150 mm road base
Frost Protection Layer	610 mm Mancos Shale or clay from stockpiles (CL); compacted to dry unit weight >95% of ASTM D 698; no water content specification	Clay from stockpile (CL); compacted to dry unit weight corresponding to 93% of ASTM D 698; no water content specification
Radon Barrier	610 mm clay from stockpiles (CL); 95% <25 mm and >70% fines; compacted to dry unit weight >ASTM D 698 with water content 0% to +3% wet of optimum water content	610 mm clay stockpile (CL), 100% <25 mm and fines = 93%; compacted to 103% of maximum dry unit weight at 1.5% wet of optimum water content
Transition Layer	915 mm of non-contaminated fill finer than 150 mm diameter, no density specification	915 mm road base with 100% finer than 150 mm, no density measurements

Road base material for the transition layer was transported from stockpiles to the test pad in 10 m^3 dump trucks and spread in 0.3 m loose lifts with a Bobcat skid loader (Figure 5a). Lift thickness was monitored with a laser level set to a 2 percent grade. The material was placed over the entire test facility (i.e., within the lysimeters, between the lysimeters, and in the perimeter area). The final thickness of the transition layer was determined using conventional surveying techniques and a transit equipped with an electronic distance meter.

Clay for the radon barrier was moisture-conditioned at the stockpile, using a water truck, and transported to the test facility in 10 m^3 dump trucks. The clay was spread in 200 mm loose lifts, using a skid loader, and compacted with a Rhino compactor (Figure 5b). Vibration was not used when compacting the clay. Loose lift and final placement thickness were controlled during construction with a laser level set to a 2 percent grade. Identical methods were used to place and compact the clay within, between, and around the perimeter of the lysimeters. The final thickness was determined by elevation difference between the surveyed ground surface elevations obtained after each layer was constructed, using conventional surveying techniques.

The frost protection layer was constructed using methods similar to those used to construct the radon barrier. However, the loose lifts were more than 300 mm thick, and compaction was achieved by driving dump trucks over the frost protection layer. The same methods were used inside, between, and around the perimeter area of the lysimeters. The final layer thickness was determined by elevation differences, using conventional surveying techniques.

The bedding layer was constructed with granular road base that was placed using the same methods employed for the transition layer (Figure 5c). The bedding layer was 150 mm thick. Riprap from onsite stockpiles was placed directly on the bedding layer and spread to a final lift thickness of 300 mm (Figure 5d).

Figure 5. (a) Spreading road base for the transition layer, (b) compacting the radon barrier, (c) placing the bedding layer, and (d) placing riprap.

Figure 5 (continued). (a) Spreading road base for the transition layer, (b) compacting the radon barrier, (c) placing the bedding layer, and (d) placing riprap.

3.1.3 Compaction

The as-built dry unit weight and water content of each layer were measured using a nuclear gage in accordance with American Society for Testing and Materials (ASTM) D 6938. A technician from a local geotechnical testing laboratory conducted the nuclear gage testing. Table 1 summarizes the compaction test data. Results of laboratory compaction testing and field density data are in Appendix B.

The geotechnical laboratory determined compaction curves for the road base and clay corresponding to standard Proctor (ASTM D 698) (see Appendix B). The clay has a maximum dry unit weight of 17.3 kilonewtons per cubic meter (kN/m^3) and optimum water content (14.5 percent). The road base has a maximum dry unit weight of 18.2 kN/m^3 and optimum water content (13.6 percent).

To mimic full-scale construction, compaction control was not conducted on the transition or bedding layers. The radon barrier was compacted to 103 percent of maximum dry unit weight and 1.5 percent wet of optimum, on average. These conditions are ideal for remolding clay clods, eliminating interclod voids, and achieving a barrier with low saturated hydraulic conductivity (Benson and Daniel 1990). The frost protection layer was compacted to 93 percent of maximum dry unit weight without a water content criterion.

3.2 Materials Characterization

Samples were collected from the transition layer, radon barrier, frost protection layer, and bedding layer during construction. Disturbed samples of the coarse-grained road base in the transition layer were collected with shovels and placed in sealed 20-liter buckets. Undisturbed block samples were collected from the radon barrier and frost protection layer using the procedure in ASTM D 7015. Cylindrical polyvinyl chloride (PVC) sampling rings, with a height and diameter of 360 mm, were used to collect the block samples. Large block samples were collected to provide a realistic assessment of the field saturated hydraulic conductivity at the time of construction (Benson et al. 1994, Trast and Benson 1995, Benson et al. 1999a).

All of the samples were shipped to the Wisconsin Geotechnics Laboratory at the University of Wisconsin–Madison for analysis. Locations where the samples were collected are shown in Appendix C. Particle size distributions, Atterberg limits, and compaction characteristics for the materials are summarized in Table 3 and listed in Appendix B. The clay is moderately to highly plastic, consists almost entirely of fines (94 percent), and contains no gravel or cobbles. The road base is a very broadly graded, coarse-grained material with comparable amounts of sand and gravel, a modest amount of fines, and no cobbles.

Table 3. Compaction and Index Properties of Soils Used for ECAP Test Sections

Property		Bedding/ Transition	Frost Protection/ Radon Barrier
Compaction	Maximum Dry Unit Weight (kN/m^3)	18.2	17.3
	Optimum Water Content (%)	13.6	14.5
Atterberg Limits	Liquid Limit	NP	43
	Plasticity Index	NP	27
Particle Size Distribution	% Cobbles	0	0
	% Gravel	39	0
	% Sand	46	6
	% Fines	15	94

3.2.1 Saturated Hydraulic Conductivity

The saturated hydraulic conductivity of each block sample was measured in a flexible-wall permeameter using the falling-headwater/rising-tailwater method described in ASTM D 5084. Prior to testing, disturbed soil was trimmed from the surfaces until the specimen had a diameter of 305 mm and an aspect ratio of 1.0. Testing was conducted using an average effective stress of 35 kilopascal (kPa), a hydraulic gradient of 10, and a backpressure of 350 kPa. Table 4 summarizes the saturated hydraulic conductivities of the block samples from the radon barrier and frost protection layer. Data sheets from these tests are in Appendix D.

Table 4. Saturated Hydraulic Conductivity of Samples from ECAP Test Sections

Test Section	Layer	Water Content (%)	Dry Unit Weight (kN/m^3)	Sat. Hydraulic Conductivity (m/s)
C	Bedding	-	19.6	1.5×10^{-3}
R	Bedding	-	19.6	1.5×10^{-3}
C	Frost Protection	22.4	15.2	1.8×10^{-6}
C	Frost Protection	21.7	16.4	1.6×10^{-10}
R	Frost Protection	15.1	18.1	1.3×10^{-10}
R	Frost Protection	19.4	16.3	3.8×10^{-8}
C	Radon Barrier	21.3	16.2	6.3×10^{-10}
C	Radon Barrier	14.6	17.8	7.4×10^{-9}
R	Radon Barrier	19.0	17.0	7.4×10^{-11}
R	Radon Barrier	20.6	16.3	9.6×10^{-11}
C	Transition	-	19.6	1.1×10^{-3}
R	Transition	-	19.6	1.4×10^{-3}

The saturated hydraulic conductivity of the road base was measured in a large-scale rigid-wall permeameter custom made for this study. Tests were conducted using the constant-head method described in ASTM D 5856 using a hydraulic gradient of 1. The permeameter had a diameter of 356 mm to accommodate the large particles contained in the road base. Test specimens were prepared by compacting the road base in the permeameter in three lifts of equal thickness using a wooden tamper until the dry unit weight of the test specimen was equal to the average dry unit weight measured in the field (19.6 kN/m^3). For a given layer, the two field samples were composited due to the similarity in the particle size distribution (Appendix B). Table 4 summarizes the saturated hydraulic conductivities of the road base. Data sheets from the tests are in Appendix D.

As expected, the fine-grained radon barrier and frost protection layer have much lower saturated hydraulic conductivity than the coarse-grained road base used in the transition and bedding layers (Table 4). The saturated hydraulic conductivity of the frost protection layer ranged from 1.3×10^{-10} to 1.8×10^{-6} m/s, while the saturated hydraulic conductivity of the radon barrier ranged from 7.4×10^{-11} to 7.4×10^{-9} m/s; hence, the frost protection layer is also more permeable and more variable than the radon barrier. The frost protection layer's greater permeability and variability is due to its lower in-place dry unit weight and its lack of water content control. The highest saturated hydraulic conductivity in the frost protection layer corresponded to the specimen with the lowest dry unit weight.

Three of the four specimens from the radon barrier had very low hydraulic conductivity (less than 10^{-10} m/s), which reflects the high compaction water content and moderate to high plasticity of the clay (Benson and Daniel 1990, Benson et al. 1994). One specimen had saturated hydraulic conductivity greater than 10^{-9} m/s. This specimen had compaction water content less than optimum water content, a condition that is known to result in macrostructure and higher hydraulic conductivity (Benson and Daniel 1990). However, the geometric mean hydraulic conductivity of the four block samples from the radon barrier (both test sections) is 4.3×10^{-10} m/s, which is less than the target saturated hydraulic conductivity (10^{-9} m/s) and close to the average saturated hydraulic conductivity reported in a survey of more than 100 as-built clay barriers in North America (4.8×10^{-10} m/s, Benson et al. 1999b).

The saturated hydraulic conductivity of the road base material was very uniform (1.1×10^{-3} to 1.5×10^{-3} m/s). The similarity of the hydraulic conductivities is consistent with the similarity in the particle size distributions of the road base samples (Appendix B). Thus, compositing samples from a given layer in a test section was appropriate.

3.2.2 Soil Water Characteristic Curves

SWCCs for the radon barrier, the frost protection layer, and the road base were measured using the procedures described in ASTM D 6836. SWCCs for the radon barrier and the frost protection layer were measured in pressure plate extractors custom-made for this project. The test specimens were trimmed from specimens used for saturated hydraulic conductivity testing. For the road base material, test specimens were compacted into large-scale hanging columns, which were 300 mm in diameter and custom made for this study, until the average dry unit weight measured in the field was achieved.

All of the custom-made equipment conformed to the criteria in ASTM D 6836. Tests conducted on specimens from the radon barrier and the frost protection layer used Methods B and D in ASTM D 6836. Tests conducted on the road base used Method A in ASTM D 6836. Data from the SWCC tests are in Appendix E.

All of the SWCCs were parameterized using van Genuchten's equation:

$$\frac{\theta-\theta_r}{\theta_s-\theta_r}=\left[\frac{1}{1+(\alpha\psi)^n}\right]^m \tag{1}$$

where θ_s is the saturated hydraulic conductivity, θ_r is the residual water content, α and *n* are the van Genuchten shape parameters, and $m = 1 - 1/n$. The SWCCs are shown in Figure 6 (road base for transition and bedding layers) and Figure 7 (frost protection layer and radon barrier), and the parameters are summarized in Table 5.

Table 5. van Genuchten Parameters for Samples from ECAP Test Sections

Test Section	Layer	θ_s	θ_r	α (kPa^{-1})	n
C	Bedding	0.25	0.05	0.81	1.60
R	Bedding	0.25	0.00	1.91	1.28
C	Frost Protection	0.43	0.00	0.013	1.24
C	Frost Protection	0.38	0.00	0.036	1.20
R	Frost Protection	0.46	0.00	0.0092	1.28
R	Frost Protection	0.41	0.00	0.0073	1.26
C	Radon Barrier	0.38	0.00	0.0071	1.26
C	Radon Barrier	0.41	0.00	0.0057	1.30
R	Radon Barrier	0.35	0.00	0.0087	1.22
R	Radon Barrier	0.36	0.00	0.0092	1.24
C	Transition	0.25	0.04	1.13	1.42
R	Transition	0.25	0.05	0.88	1.56

The difference between α in the road base (transition and bedding layers) and α in the clay (frost protection layer and radon barrier) reflects the different pore size distributions of these materials (Table 5). The clay has much smaller pores and, therefore, much higher air entry suction (lower α) than the road base material. The radon barrier also has lower α than the frost protection layer, which reflects the smaller pores obtained when compacting clay with a higher water content to a higher dry unit weight The control on compaction water content employed during the radon barrier's construction also resulted in a narrower range of α relative to the frost protection layer (0.0071–0.0092 kPa^{-1} vs. 0.0073–0.013 kPa^{-1}). Both the clay and the road base have an *n* value that is less than 2, which indicates the broad distribution of pores characteristic of compacted clays (Tinjum et al. 1997) and broadly graded, coarse-grained soils. The low residual water content obtained for both materials (0.00 for clay; 0.04–0.05 for the road base) indicates that sufficient equilibration time was permitted when measuring points on the dry end of the SWCC.

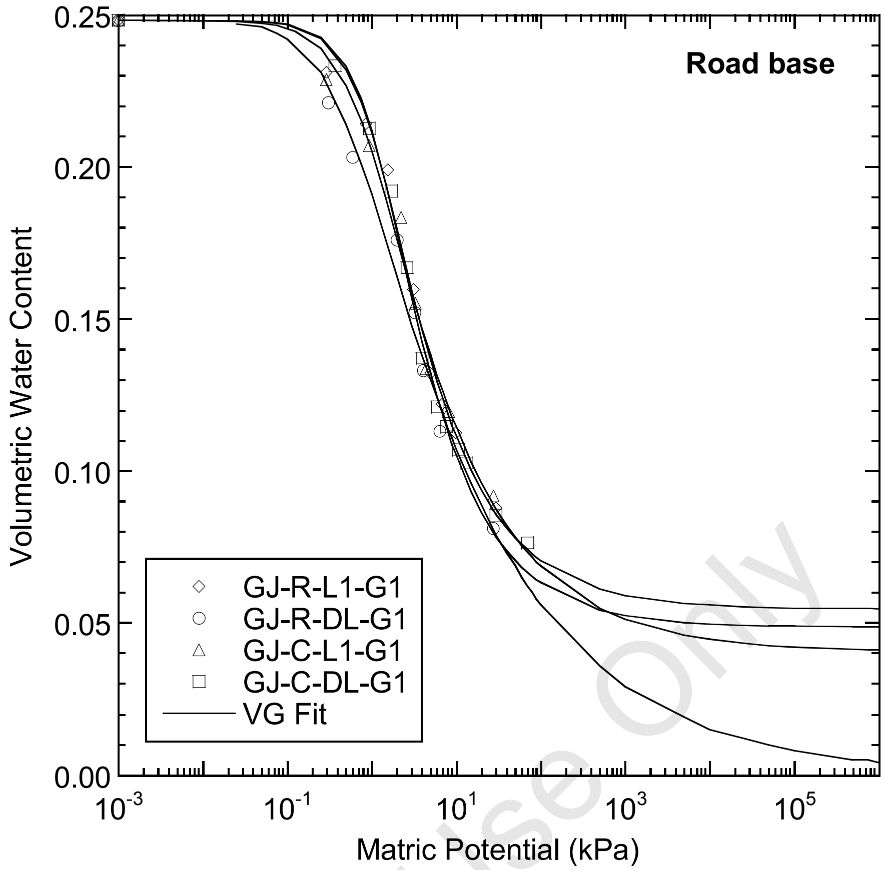


Figure 6. SWCC for road base used for the transition layer and bedding layer. SWCCs marked "L1" are for samples from the transition layer. "DL" designates the bedding layer, "R" designates Test Section R, and "C" designates Test Section C.

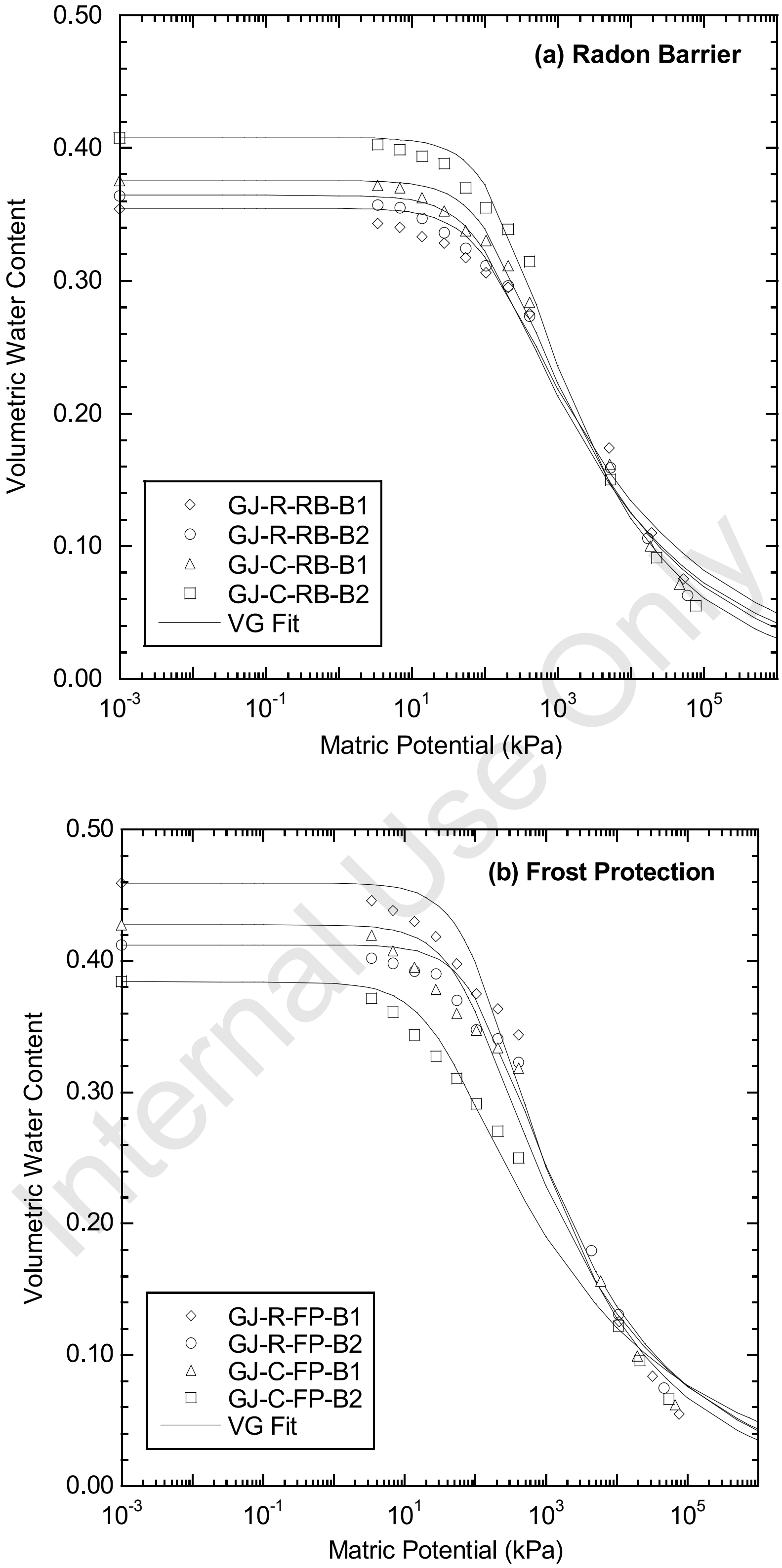


Figure 7. SWCCs for (a) the radon barrier and (b) the frost protection layer.
SWCCs marked "RB" are for samples from the radon barrier. "FP" designates the frost protection layer, "R" designates Test Section R, and "C" designates Test Section C.

3.2.3 Edaphic Properties

The success of cover modification will depend, in part, on the edaphic properties of cover soil layers (Albright, Benson, and Waugh 2010). Edaphology is the branch of soil science concerned with the influence of soils on living things, particularly plants. Initiating a favorable plant succession trajectory, and reliable transpiration rates, will require the characterization and possible enhancement of edaphic properties. Soils excavated and stockpiled to construct the Grand Junction disposal cell cover and the test sections were formed in colluvium and alluvium derived from basalt residuum and weathered clayey shale. The native soils, classified as aridisols, include typic natrargids (soil profiles include a horizon with columnar structure and >15 percent of the cation exchange capacity [CEC] saturated with sodium) and typic calciorthids (soil profiles include a horizon with >15 percent calcium carbonate and/or at least 5 percent calcium sulfate). Below is a summary of physical and chemical properties of test section soils that may influence plant establishment and succession. Values (Table 6) are for soil layers sampled during construction of test sections and analyzed by the Colorado State University Soil Testing Laboratory.

Table 6. Summary of Key Edaphic Properties of Test Section Soil Layers[a]

Soil Layer	pH	Salts (mmho/cm)	CEC meq/100 g	Nitrate-N (ppm)	Phosphorus (ppm)	Potassium (ppm)
Bedding	7.8–8.7	1.4–3.5	15.1–21.5	0.6–12.5	3	62–81
Frost protection	7.8–8.2	2.7–4.9	30.6–34.5	0.7–4.2	2–5	170–246
Radon Barrier	7.8–8.4	1.7–4.8	43.3–48.2	1.2–16.5	2–9	198–310
Soil Layer	**% Sand**	**% Silt**	**% Clay**	**Texture[b]**	**SAR[c]**	**Bulk Density (g cm^{-3})**
Bedding	81–83	12–15	4–5	Loamy sand	2–8	–
Frost protection	15–23	56–67	10–25	Silt loam	6–21	1.73
Radon Barrier	8–19	33–35	47–59	Clay	6–12	1.79

[a] Value ranges for *n*=4 samples taken from test sections during construction.
[b] USDA soil texture classification system.
[c] Sodium absorption ratio = $Na/(Ca+Mg/2)^{1/2}$ in meq/L.

Soil physical properties that most influence plant ecology are particle size distribution (texture), dry unit weight (bulk density), and particle aggregation (structure). In general, soil texture and structure influence the distribution and availability of water for plants, root growth, and CEC—the quantity of cations that can be adsorbed on negatively charged soil solids. CEC influences the availability of plant nutrients. Blending the loamy sand bedding layer with the silt loam protection layer should produce a layer with favorable plant-available water (see above discussion of soil water retention characteristics). High bulk density values for frost protection and radon barrier layers may hinder root growth. Achieving a bulk density similar to that of the undisturbed borrow source (1.3–1.4 g cm^{-3}) is a goal of this test work. Frost protection and radon barrier layers initially had massive structure—few cracks within soil aggregates—as reflected in low saturated hydraulic conductivity values (see above). A goal of furrowing and ripping is to create a more blocky structure, which should enhance permeability, root development, and plant health.

Soil chemical properties that most influence plant establishment and development are pH, type and concentration of soluble salts, and availability of plant nutrients. Frost protection and radon barrier soils are slightly alkaline, typical for the area, and variably sodic. Sodic soils can adversely affect plant metabolism and indirectly affect root growth by increasing soil dispersion and hindering structural development. Effects of elevated sodium on soil aggregate structure may be offset by the presence of gypsum. Salinity levels are well within tolerance limits for native vegetation in the area, and high CEC values reflect the high clay content. Nitrate levels appear to be variably elevated, phosphorus levels are low, and potassium levels are typical for the area.

Overall, high bulk density, which we hope to lower by ripping, and elevated sodium levels, which may be offset by the presence of gypsum, could otherwise adversely influence the establishment and development of a favorable plant community. We will continue to evaluate these and other edaphic properties during the course of the study.

3.3 Monitoring System

The test sections were equipped with a monitoring system that was similar to the systems used in the ACAP. Surface runoff collected by diversion berms and percolation collected in the lysimeter sump are conveyed via Schedule 40 PVC pipe to collection basins (Figure 8a). Water being collected in the percolation and runoff basins is monitored with a pressure transducer and a float switch. The flow of water into the percolation tank is monitored with a high-capacity tipping bucket (Figure 8b). The tipping buckets and the pressure transducers were calibrated in accordance with the methods in Benson et al. (1999a), which are summarized in Appendix F.

Water content (θ) is measured using CS 616 water content reflectometers (WCRs) manufactured by Campbell Scientific, Inc. The WCRs are installed in two nests located along the centerline at the upper and lower quarter points of each test section. Each nest contains seven probes (Figure 9) that are used to monitor the transition layer (two probes), radon barrier (two probes), frost protection layer (two probes), and bedding layer (one probe). The soil-specific calibration of the WCRs was conducted using the method described in Benson and Wang (2006), which includes temperature compensation. The calibration equation has the form:

$$\theta = \frac{-(b_1 - a_1T) + \sqrt{(b_1 + a_1T)^2 - 4a_2T(a_0T + b_0 - P)}}{2a_2T} \tag{2}$$

where P is the period reported by the WCR, T is the soil temperature at the probe location, and a_0, a_1, a_2, b_0, and b_1 are calibration parameters. Calibration was conducted on samples of the radon barrier, frost protection layer, and road base that were composited after conducting the hydraulic properties tests. Specimens used for calibration were prepared at the average dry unit weight of each material that was measured in the field. Table 7 summarizes the parameters for Equation 2. Appendix G summarizes the calibration data.

Figure 8. (a) Piping to drainage basins and (b) the high-capacity tipping bucket in the drainage basin for Test Section R.

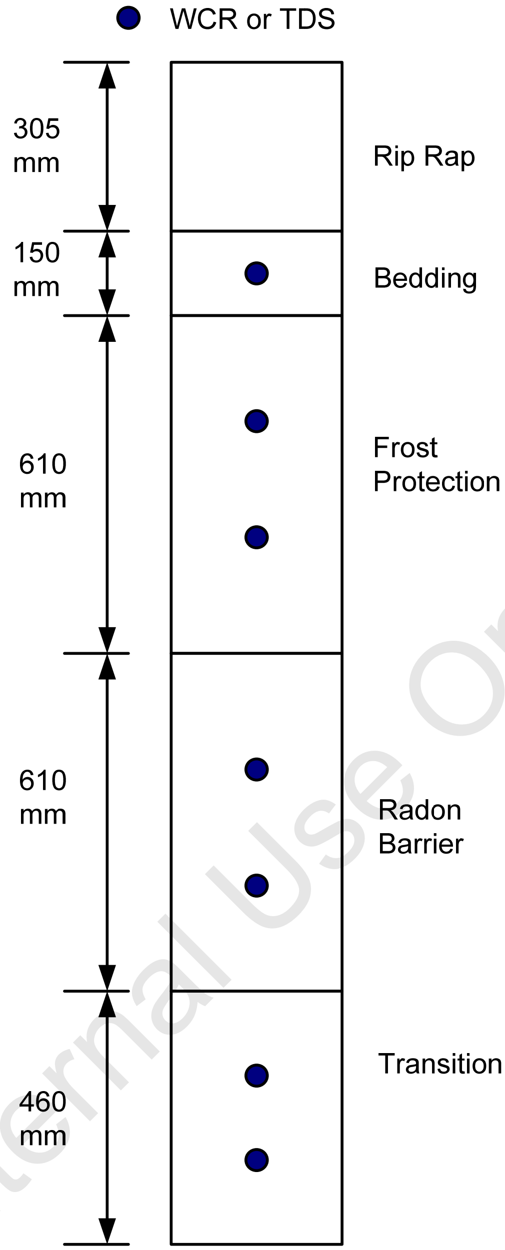


Figure 9. Location of WCR and TDS sensors in a monitoring nest.

Table 7. Summary of Parameters a_o, a_1, a_2, b_o, *and* b_1 *in WCR Calibration Equation*

Parameter	Radon Barrier	Frost Protection Layer	Bedding and Transition Layers
a_o (µs/°C)	-0.0066	-0.0468	-0.0120
a_1 (µs/°C)	0.0172	0.0287	0.0135
a_2 (µs/°C)	-0.0004	-0.0009	-0.0005
b_o (µs)	16.70	15.63	17.36
b_1 (µs)	0.681	0.828	0.399

Matric suction (ψ) in the cover profile was monitored with CS 229 thermal dissipation sensors (TDSs) manufactured by Campbell Scientific, Inc. The TDSs were calibrated following the procedure in Sawangsuriya et al. (2009), which is based on the non-dimensional parameterization proposed by Flint et al. (2002). The calibration equation has the form:

$$\psi = \psi_o \qquad T^* = 1 \tag{3a}$$

$$\psi = \frac{\psi_o}{T^{*\frac{1}{\lambda}}} \qquad T^* < 1 \tag{3b}$$

where T^* is the normalized temperature drop and ψ_o is the air entry suction for the ceramic element in the TDS, and λ is a fitting parameter (Sawangsuriya et al. 2009). The normalized temperature drop is computed as:

$$T^* = \frac{\Delta T_d - \Delta T}{\Delta T_d - \Delta T_s} \tag{4}$$

where ΔT_d is the temperature drop for a dry TDS, ΔT_s is the temperature drop for a saturated TDS, and ΔT is the temperature drop at a given ψ. A unique calibration for each TDS was conducted (Appendix H). However, compilation of the data showed that a single calibration could be applied to all sensors, as Figure 10 illustrates. This calibration has ΔT_d = 3.94 °C, ΔT_s = 1.41 °C, ψ_o = 12 kPa, and λ = 0.43.

Meteorological data (precipitation, air temperature, relative humidity, wind speed and direction, and solar radiation) are measured with a meteorological station mounted on the test facility. A Campbell Scientific, Inc., CR21X datalogger mounted at the meteorological station is used to collect data from the meteorological sensors as well as all other sensors installed at the test facility. Data are recorded hourly under quiescent conditions. However, when water elevations in the basins change more rapidly (e.g., during heavy precipitation), data are recorded as frequently as every 15 seconds. A comprehensive data quality assurance review is conducted quarterly to ensure the integrity of the data and to identify problems (potential and actual) in the monitoring system. The quality assurance report for the first quarter of 2009 is in Appendix I. Wiring for the datalogger and sensors was oriented to facilitate the ripping of Test Section R without damaging the instrumentation. The layout of the sensors, multiplexors, datalogger, and wiring is in Figure 4.

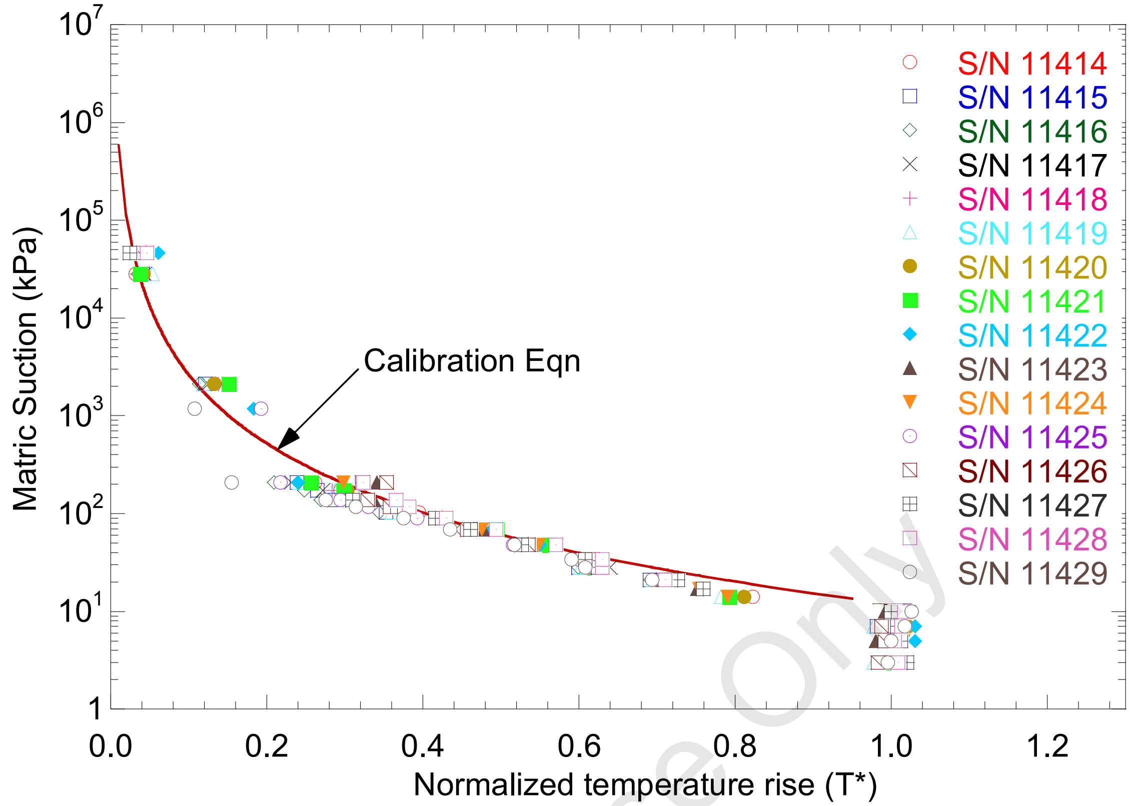


Figure 10. Calibration data for thermal dissipation sensors (TDSs) with the calibration equation. Appendix H includes the correspondence between the TDSs' serial numbers and locations in the test sections.

Acknowledgments

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Appendix A

Construction Drawings of Lysimeters

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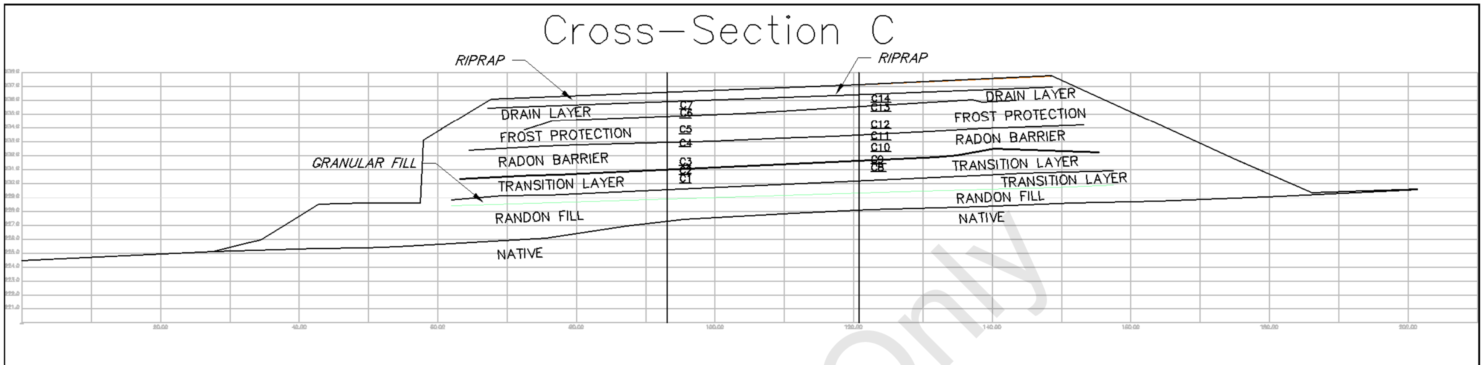
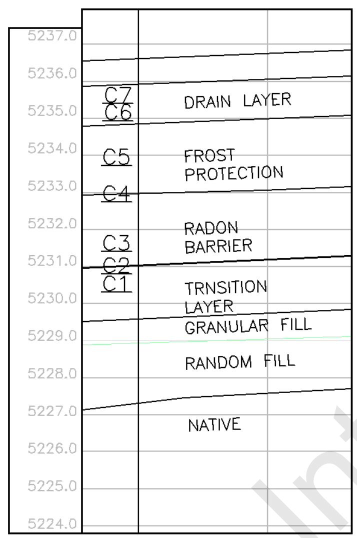
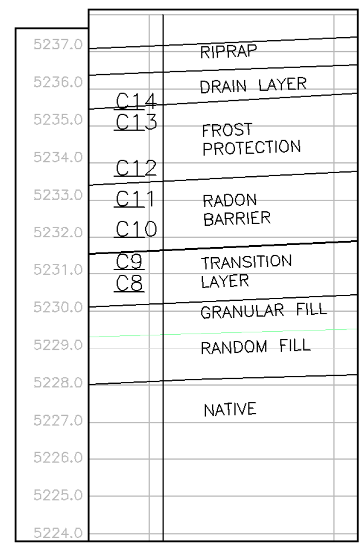




Instrument	elevation (ft)	layer	depth bgs (ft)	interval distance (ft)	(centimeters)
C1-C7 surface	5236.61		0		
C7	5235.33	drain	1.33	1.33	40.5
C6	5234.74	frost protection	1.92	0.59	18.0
C5	5233.60	frost protection	3.06	1.14	34.7
C4	5232.61	radon barrier	4.05	0.99	30.2
C3	5231.41	radon barrier	5.25	1.20	36.6
C2	5230.79	transition layer	5.87	0.62	18.9
C1	5230.30	transition layer	6.36	0.49	14.9
C8-C14 surface	5237.16		0		
C14	5235.80	drain	0.86	0.86	26.2
C13	5235.24	frost protection	1.42	0.56	17.1
C12	5234.00	frost protection	2.66	1.24	37.8
C11	5233.17	radon barrier	3.49	0.83	25.3
C10	5232.35	radon barrier	4.31	0.82	25.0
C9	5231.47	transition layer	5.19	0.88	26.8
C8	5230.88	transition layer	5.78	0.59	18.0



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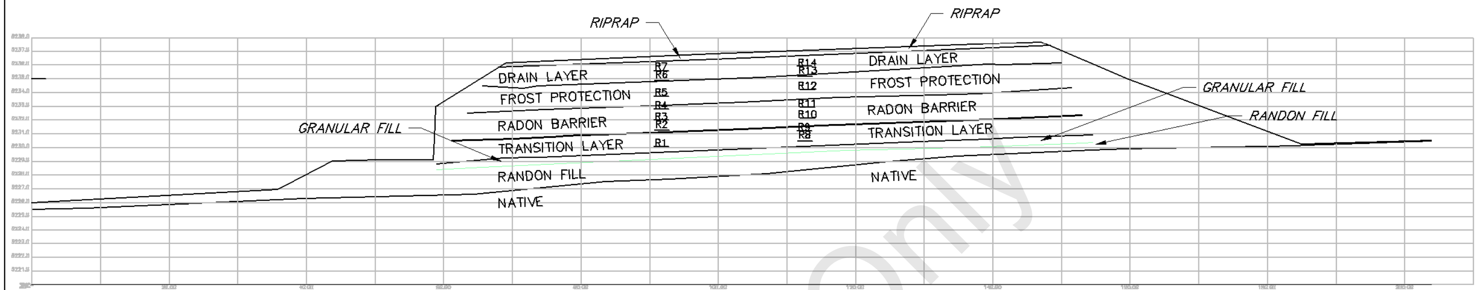
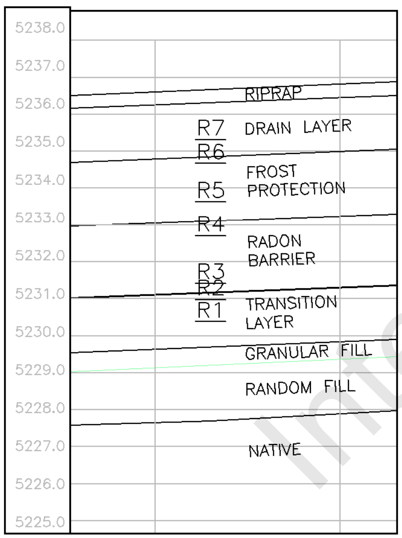
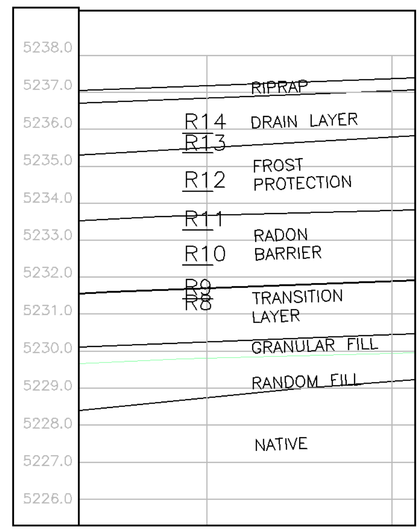
Cross-Section R





Instrument	elevation (ft)	layer	depth bgs (ft)	interval distance (ft)	interval distance (centimeters)
R1-R7 surface	5236.66		0		
R7	5235.32	drain	1.34	1.34	40.8
R6	5234.67	frost protection	1.99	0.65	19.8
R5	5233.63	frost protection	3.03	1.04	31.7
R4	5232.71	radon barrier	3.95	0.92	28.0
R3	5231.42	radon barrier	5.24	1.29	39.3
R2	5230.98	transition layer	5.68	0.44	13.4
R1	5230.38	transition layer	6.28	0.60	18.3
R8-R14 surface			0		
R14	5235.9	drain	0.76	0.76	23.2
R13	5235.37	frost protection	1.29	0.53	16.2
R12	5234.33	frost protection	2.33	1.04	31.7
R11	5233.27	radon barrier	3.39	1.06	32.3
R10	5232.32	radon barrier	4.34	0.95	29.0
R9	5231.41	transition layer	5.25	0.91	27.7
R8	5230.96	transition layer	5.7	0.45	13.7



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Appendix B

Laboratory Compaction, Field Density, Atterberg Limits, and Particle Size Distributions

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Native

Overall pad area		
test	**dry density (pcf)**	**water content (%)**
south corner	104.4	9.1
west center	103.0	8.5
north center	102.7	9.2
mean	103.4	8.9
std. dev.	0.907	0.379
n	3	3
std. error	0.524	0.219
95% conf. (+)	104.4	9.4
95% conf. (-)	102.3	8.5

Random Fill

max dd (pcf)	108.0
opt. w_c (%)	18.5

Overall pad—final lift		
test	**dry density (pcf)**	**water content (%)**
NE area	120.8	9.3
West middle	122.5	12.7
SE area	117.8	12.4
mean	120.4	11.5
std. dev.	2.380	1.882
n	3	3
std. error	1.374	1.087
95% conf. (+)	123.1	13.6
95% conf. (-)	117.7	9.3
Overall pad—initial lift		
test	**dry density (pcf)**	**water content (%)**
Center	113.9	15.1
South[a]	124.7	12.6
West	112.9	12.7
East[a]	121.0	12.0
mean	118.1	13.1
std. dev.	5.676	1.369
n	4	4
std. error	2.838	0.684
95% conf. (+)	123.7	14.4
95% conf. (-)	112.6	11.8

[a] excessive rock at tested location

Transition Layer (Base)

Test Pad "C"

test	**dry density (pcf)**	**water content (%)**		***"C" dry density***		***"C" water content***	
A	125.1	3.0		Mean	126.9	Mean	2.9
B	128.6	2.8		Std Error	1.085	Std Error	0.248
C	124.9	3.5		Median	126.9	Median	2.9
D	128.9	2.3		Mode	#N/A	Mode	#N/A
				Std Dev	2.170	Variance	4.709
layer statistics						Variance	0.247
mean	126.9	2.9		Minimum	124.9	Minimum	2.3
std. dev.	2.17	0.50		Maximum	128.9	Maximum	3.5
n	4	4		Sum	507.5	Sum	11.6
std. error	1.085	0.248		Count	4	Count	4
95% conf. (+)	129.0	3.4					
95% conf. (-)	124.7	2.4					

Test Pad "R"

test	**dry density (pcf)**	**water content (%)**		***"R" dry density***		***"R" water content***	
A	123.9	3.1		**Mean**	**122.5**	**Mean**	**2.9**
B	130.5	2.7		Std Error	3.100	Std Error	0.103
C	116.3	3.1		Median	121.6	Median	3.0
D	119.2	2.8		Mode	#N/A	Mode	3.1
				Std Dev	6.199	Std Dev	0.206
				Variance	38.429	Variance	0.043
layer statistics				Minimum	116.3	Minimum	2.7
mean	122.5	2.9		Maximum	130.5	Maximum	3.1
std. dev.	6.20	0.21		Sum	489.9	Sum	11.7
n	4	4		Count	4	Count	4
std. error	3.100	0.103					
95% conf. (+)	128.6	3.1					
95% conf. (-)	116.4	2.7					

Initial Lift—Radon Barrier

max dd (pcf)	110.0
opt. w_c (%)	14.5

Test Pad "C"						
test	**dry density (pcf)**	**water content (%)**	***"C" dry density***		***"C" water content***	
A	114.0	16.0				
B	110.7	17.8	Mean	111.7	Mean	17.0
C	110.8	16.6	Std Error	0.778	Std Error	0.437
D	111.3	17.7	Median	111.1	Median	17.2
			Mode	#N/A	Mode	#N/A
mean	111.7	17.0	Std Dev	1.556	Std Dev	0.873
std. dev.	1.556	0.873	Variance	2.420	Variance	0.763
n	4	4	Minimum	110.7	Minimum	16
std. error	0.778	0.437	Maximum	114	Maximum	17.8
95% conf. (+)	113.2	17.9	Sum	446.8	Sum	68.1
95% conf. (-)	110.2	16.2	Count	4	Count	4

Test Pad "R"						
test	**dry density (pcf)**	**water content (%)**	***"R" dry density***		***"R" water content***	
A	110.8	18.2				
B	111.7	17.4	Mean	111.8	Mean	18.0
C	111.4	18.8	Std Error	0.511	Std Error	0.307
D	113.2	17.7	Median	111.6	Median	18.0
			Mode	#N/A	Mode	#N/A
mean	111.8	18.0	Std Dev	1.021	Std Dev	0.613
std. dev.	1.021	0.613	Variance	1.043	Variance	0.376
n	4	4	Minimum	110.8	Minimum	17.4
std. error	0.511	0.307	Maximum	113.2	Maximum	18.8
95% conf. (+)	112.8	18.6	Sum	447.1	Sum	72.1
95% conf. (-)	110.8	17.4	Count	4	Count	4

Test Pad "M"						
test	**dry density (pcf)**	**water content (%)**	***"M" dry density***		***"M" water content***	
A	112.4	18.3				
B	111.2	17.4	Mean	112.3	Mean	18.0
C	114.1	17.4	Std Error	0.663	Std Error	0.347
D	111.4	18.8	Median	111.9	Median	17.9
			Mode	#N/A	Mode	17.4
mean	112.3	18.0	Std Dev	1.325	Std Dev	0.695
std. dev.	1.325	0.695	Variance	1.756	Variance	0.482
n	4	4	Minimum	111.2	Minimum	17.4
std. error	0.663	0.347	Maximum	114.1	Maximum	18.8
95% conf. (+)	113.6	18.7	Sum	449.1	Sum	71.9
95% conf. (-)	111.0	17.3	Count	4	Count	4

Final Lift—Radon Barrier

max dd (pcf) 110.0
opt. w_c (%) 14.5

Test Pad "C"

test	dry density (pcf)	water content (%)	*"C" dry density*		*"C" water content*	
A	115.3	14.4				
B	115.5	14.6	Mean	115.5	Mean	14.6
C	116.5	14.3	Std Error	0.392	Std Error	0.132
D	114.6	14.9	Median	115.4	Median	14.5
			Mode	#N/A	Mode	#N/A
mean	115.5	14.6	Std Dev	0.785	Std Dev	0.265
std. dev.	0.785	0.265	Variance	0.616	Variance	0.070
n	4	4	Minimum	114.6	Minimum	14.3
std. error	0.392	0.132	Maximum	116.5	Maximum	14.9
95% conf. (+)	116.2	14.8	Sum	461.9	Sum	58.2
95% conf. (-)	114.7	14.3	Count	4	Count	4

Test Pad "R"

test	dry density (pcf)	water content (%)	*"R" dry density*		*"R" water content*	
A	111.0	17.5				
B	110.8	17.6	Mean	111.7	Mean	17.1
C	114.2	16.6	Std Error	0.844	Std Error	0.275
D	110.7	16.6	Median	110.9	Median	17.1
			Mode	#N/A	Mode	16.6
mean	111.7	17.1	Std Dev	1.688	Std Dev	0.550
std. dev.	1.688	0.550	Variance	2.849	Variance	0.302
n	4	4	Minimum	110.7	Minimum	16.6
std. error	0.844	0.275	Maximum	114.2	Maximum	17.6
95% conf. (+)	113.3	17.6	Sum	446.7	Sum	68.3
95% conf. (-)	110.0	16.5	Count	4	Count	4

Test Pad "M"

test	dry density (pcf)	water content (%)	*"M" dry density*		*"M" water content*	
A	111.4	15.6				
B	112.7	17.7	Mean	112.7	Mean	16.4
C	113.0	16.6	Std Error	0.464	Std Error	0.501
D	113.6	15.6	Median	112.9	Median	16.1
			Mode	#N/A	Mode	15.6
mean	112.7	16.4	Std Dev	0.929	Std Dev	1.001
std. dev.	0.929	1.001	Variance	0.862	Variance	1.002
n	4	4	Minimum	111.4	Minimum	15.6
std. error	0.464	0.501	Maximum	113.6	Maximum	17.7
95% conf. (+)	113.6	17.4	Sum	450.7	Sum	65.5
95% conf. (-)	111.8	15.4	Count	4	Count	4

Atterberg Limits Test

Sample I.D. GJ-C-FP-B1 **Test Date**

Liquid Limit

Can #	WT of Can (g)	WT of Can + Wet Soil (g)	WT of Can + Dry Soil (g)	Water Content (%)	Blow Number
k1	28.9	46.5	40.94	46.2	40
10	31.8	50.3	44.28	48.2	30
21	28.7	50.8	43.37	50.6	21

Plastic Limit

Can #	WT of Can (g)	WT of Can + Wet Soil (g)	WT of Can + Dry Soil (g)	Water Content (%)
a1	31.8	41.9	40.34	18.3

Atterberg Limits Test

Sample I.D. GJ-C-RB-B2 **Test Date**

Liquid Limit

Can #	WT of Can (g)	WT of Can + Wet Soil (g)	WT of Can + Dry Soil (g)	Water Content (%)	Blow Number
c	31.7	52.6	45.56	50.8	34
24	31.3	49.2	43.09	51.8	28
41	31	51.1	43.81	56.9	18

Plastic Limit

Can #	WT of Can (g)	WT of Can + Wet Soil (g)	WT of Can + Dry Soil (g)	Water Content (%)
6	31.2	39.9	38.47	19.7

Atterberg Limits Test

Sample I.D.	GJ-R-RB-B2	Test Date

Liquid Limit

Can #	WT of Can (g)	WT of Can + Wet Soil (g)	WT of Can + Dry Soil (g)	Water Content (%)	Blow Number
2	31.6	55.5	47.47	50.6	31
5	31.7	57	48.48	50.8	24
7	31.3	51.3	44.35	53.3	18

Plastic Limit

Can #	WT of Can (g)	WT of Can + Wet Soil (g)	WT of Can + Dry Soil (g)	Water Content (%)
f1	31.1	39.6	38.3	18.1

Atterberg Limits Test

Sample I.D.	GJ-R-FP-B1	Test Date

Liquid Limit

Can #	WT of Can (g)	WT of Can + Wet Soil (g)	WT of Can + Dry Soil (g)	Water Content (%)	Blow Number
L	31.3	56.5	48.3	48.2	32
22	31.6	60.1	50.63	49.8	26
190	32	56.5	48.05	52.6	18

Plastic Limit

Can #	WT of Can (g)	WT of Can + Wet Soil (g)	WT of Can + Dry Soil (g)	Water Content (%)
0	29.4	38.2	36.91	17.2

Atterberg Limits Test

Sample I.D.	GJ-R-FP-B2	Test Date	

Liquid Limit

Can #	WT of Can (g)	WT of Can + Wet Soil (g)	WT of Can + Dry Soil (g)	Water Content (%)	Blow Number
j	31.3	57.2	48.72	48.7	30
3	31	57.3	48.53	50.0	25
23	31.4	57.7	48.47	54.1	14

Plastic Limit

Can #	WT of Can (g)	WT of Can + Wet Soil (g)	WT of Can + Dry Soil (g)	Water Content (%)
k	31.5	39.9	38.58	18.6

Atterberg Limits Test

Sample I.D.	GJ-R-RB-B1	Test Date	

Liquid Limit

Can #	WT of Can (g)	WT of Can + Wet Soil (g)	WT of Can + Dry Soil (g)	Water Content (%)	Blow Number
y1	30.9	67.6	55.43	49.6	30
y	31.1	60.7	50.47	52.8	22
x1	30.6	58.8	48.95	53.7	15

Plastic Limit

Can #	WT of Can (g)	WT of Can + Wet Soil (g)	WT of Can + Dry Soil (g)	Water Content (%)
z1	30.9	42.3	40.59	17.6

Atterberg Limits Test

Sample I.D.	GJ-C-FP-B2	Test Date

Liquid Limit

Can #	WT of Can (g)	WT of Can + Wet Soil (g)	WT of Can + Dry Soil (g)	Water Content (%)	Blow Number
x3	30.4	62.8	51.86	51.0	32
2	30.9	66.2	54.15	51.8	28
12	30.8	60.9	50.27	54.6	18

Plastic Limit

Can #	WT of Can (g)	WT of Can + Wet Soil (g)	WT of Can + Dry Soil (g)	Water Content (%)
h1	30.8	45.2	42.86	19.4

Atterberg Limits Test

Sample I.D.	GJ-C-RB-B1	Test Date

Liquid Limit

Can #	WT of Can (g)	WT of Can + Wet Soil (g)	WT of Can + Dry Soil (g)	Water Content (%)	Blow Number
A3	25.1	61.8	49.58	49.9	29
H2	30.8	65.6	53.88	50.8	17
MC6	31	65.2	53.32	53.2	20

Plastic Limit

Can #	WT of Can (g)	WT of Can + Wet Soil (g)	WT of Can + Dry Soil (g)	Water Content (%)
8	24.5	34.8	33.29	17.2

Wisconsin Geotechnics Laboratory

Mechanical Particle Size Analysis - ASTM D 422

Sample ID:	#1_WTS/3'/2P_A			Test Date:	8/8/12
Weight of Air Dry Sample =		4266	g	Initials:	

Sieve No.	Sieve Opening	Weight Retained on Each Sieve	Percent Retained on Each Sieve	Cumulative Percent Retained	Percent Finer
	(mm)	(g)	(%)	(%)	(%)
2"	50.8	0.00	0	0	100
1"	25.4	578.00	13.55	13.55	86
3/4"	19.0	60.42	1.42	14.97	85.03
5/8"	15.9	43.00	1.01	15.97	84.03
1/2"	12.7	122.46	2.87	17.84	82.16
3/8"	9.52	136.80	3.21	21.04	78.96
4	4.75	264.10	6.19	27.23	72.77
10	2.00	433.30	10.16	37.39	62.61
20	0.85	151.23	3.55	40.94	59.06
40	0.425	206.25	4.83	45.77	54.23
60	0.250	222.52	5.22	50.99	49.01
100	0.150	153.97	3.61	54.60	45.40
200	0.075	155.02	3.63	58.23	41.77
Sieve Pan		29.01	0.68	58.91	41.09
Wet Sieve P_{200}		1709.90	40.08		
	R_{200}	2556.08			
	P_{200}	1709.90			
	Total Weight (g) =	**4266**			

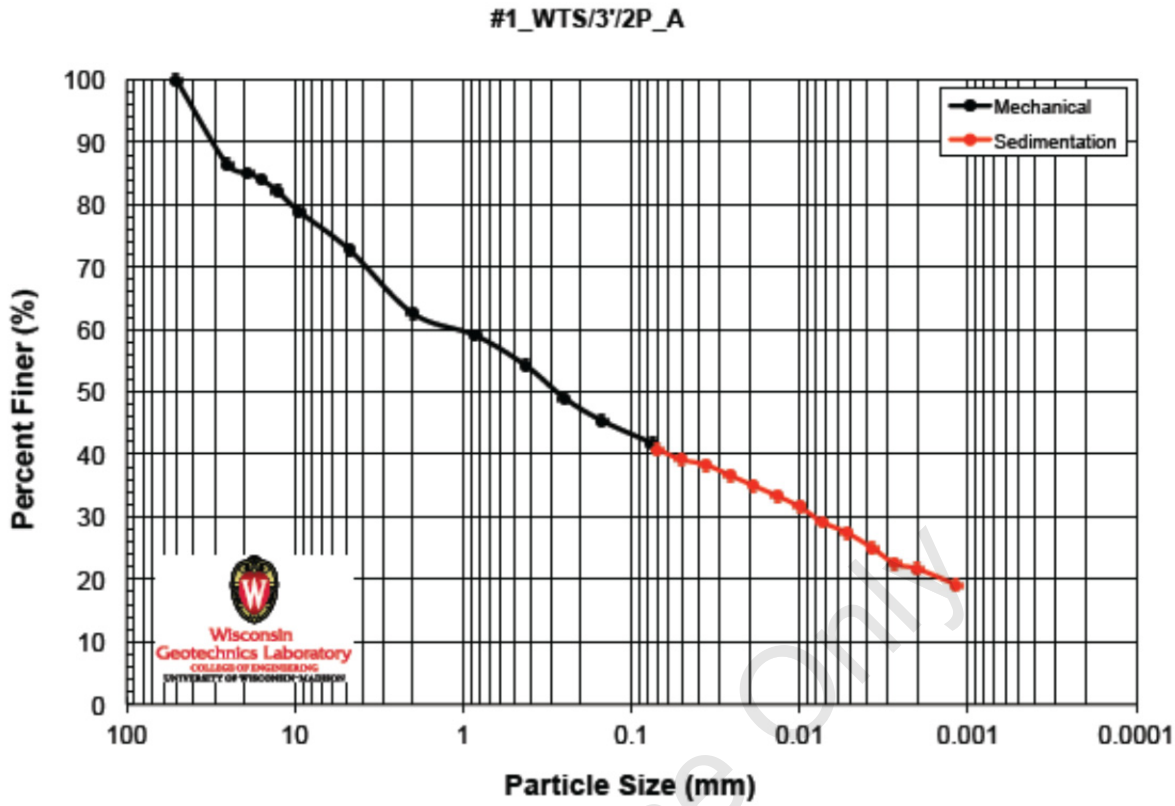
Wisconsin Geotechnics Laboratory

Sedimentation Particle Size Analysis - ASTM D 422

Sample ID:	#1_WTS/3'/2P_A
Specific Gravity, G_s =	2.65
Dry Weight of Soil, W (g) =	50
Meniscus Correction, F_m =	0.5
Temperature Correction, F_T =	0.9
Material Max. Size and Percentage (%)	P200 41.77

Temp. Correction, A	0.0129
Hydrometer Type:	ASTM 152H
Temperature of Test, C	23
Zero Correction, F_z	6
a	1.000

Time (min)	Hydrometer Reading, R	R_{cp}	R_{cl}	L (cm)	D (mm)	Final Percent Finer (%)	Percent Finer
0.0	0				0.425	41.77	
0.2	54	48.90	83.90	7.45	0.0703	40.86	97.81
0.5	52	46.90	81.90	7.78	0.0508	39.18	93.81
1.0	51	45.90	80.90	7.94	0.0363	38.35	91.81
2.0	49	43.90	78.90	8.27	0.0262	36.68	87.81
4.0	47	41.90	76.90	8.60	0.0189	35.01	83.81
8.0	45	39.90	74.90	8.92	0.0136	33.34	79.81
15.0	43	37.90	72.90	9.25	0.0101	31.66	75.81
30.0	40	34.90	69.90	9.74	0.0073	29.16	69.81
60.0	38	32.90	67.90	10.07	0.0053	27.49	65.81
128.0	35	29.90	64.90	10.56	0.0037	24.98	59.81
249.0	32	26.90	61.90	11.05	0.0027	22.47	53.81
468.3	31	25.90	60.90	11.21	0.0020	21.64	51.81
1409.0	28	22.90	57.90	11.70	0.0012	19.13	45.80
-59328522.0	0	-5.10	29.90	16.28	#NUM!	-4.26	-10.20
-59328522.0	0	-5.10	29.90	16.28	#NUM!	-4.26	-10.20
-59328522.0	0	-5.10	29.90	16.28	#NUM!	-4.26	-10.20



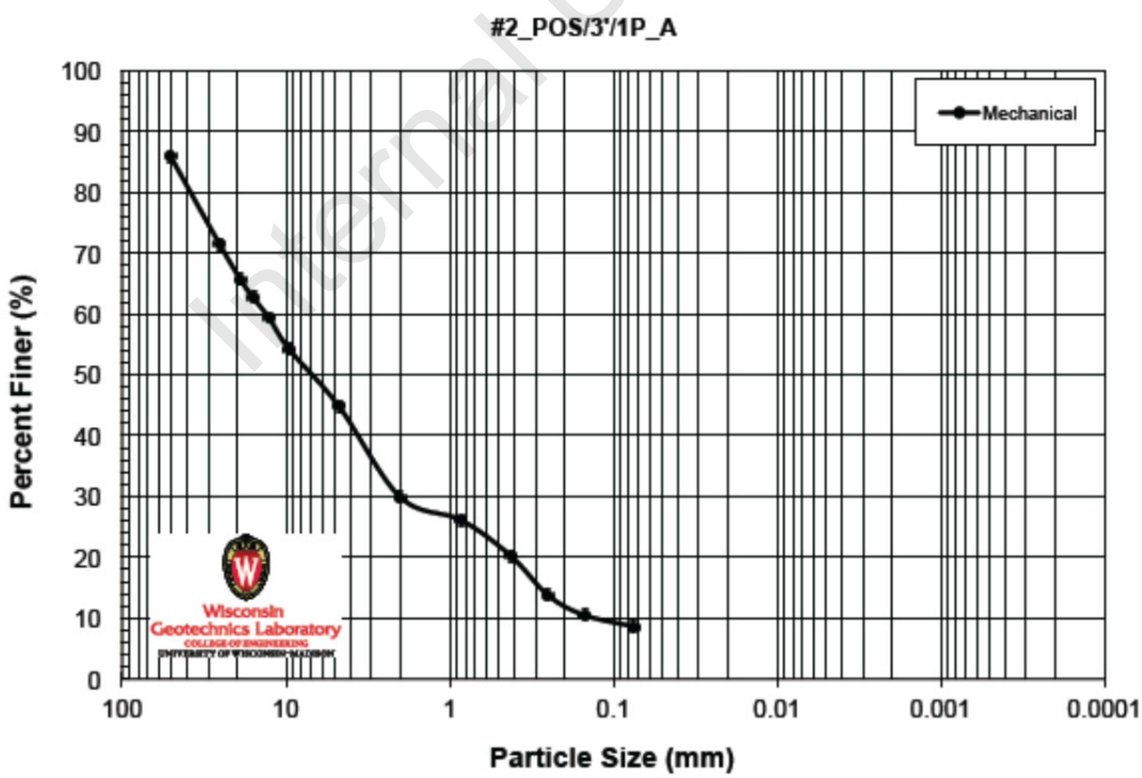
#1_WTS/3'/2P_A
Mechanical
Sedimentation
Percent Finer (%)
100
90
80
70
60
50
40
30
20
10
0
100
10
1
0.1
0.01
0.001
0.0001
Particle Size (mm)
Wisconsin
Geotechnics Laboratory

Wisconsin Geotechnics Laboratory

Mechanical Particle Size Analysis - ASTM D 422

Sample ID:	#2_POS/3'/1P_A			Test Date:	8/8/12
Weight of Air Dry Sample =		6828	g	Initials:	

Sieve No.	Sieve Opening	Weight Retained on Each Sieve	Percent Retained on Each Sieve	Cumulative Percent Retained	Percent Finer
	(mm)	(g)	(%)	(%)	(%)
2"	50.8	958.08	14.03	14.03	85.97
1"	25.4	989.58	14.49	28.52	71
3/4"	19.0	392.62	5.75	34.27	65.73
5/8"	15.9	204.79	3.00	37.27	62.73
1/2"	12.7	228.62	3.35	40.62	59.38
3/8"	9.52	356.18	5.22	45.84	54.16
4	4.75	636.20	9.32	55.16	44.84
10	2.00	1022.52	14.98	70.13	29.87
20	0.85	258.65	3.79	73.92	26.08
40	0.425	397.55	5.82	79.74	20.26
60	0.250	447.32	6.55	86.29	13.71
100	0.150	222.12	3.25	89.55	10.45
200	0.075	127.87	1.87	91.42	8.58
Sieve Pan		12.48	0.18	91.60	8.40
Wet Sieve P_{200}		560.94			
	R_{200}	6254.58			
	P_{200}	573.42			
	Total Weight (g) =	**6828**			



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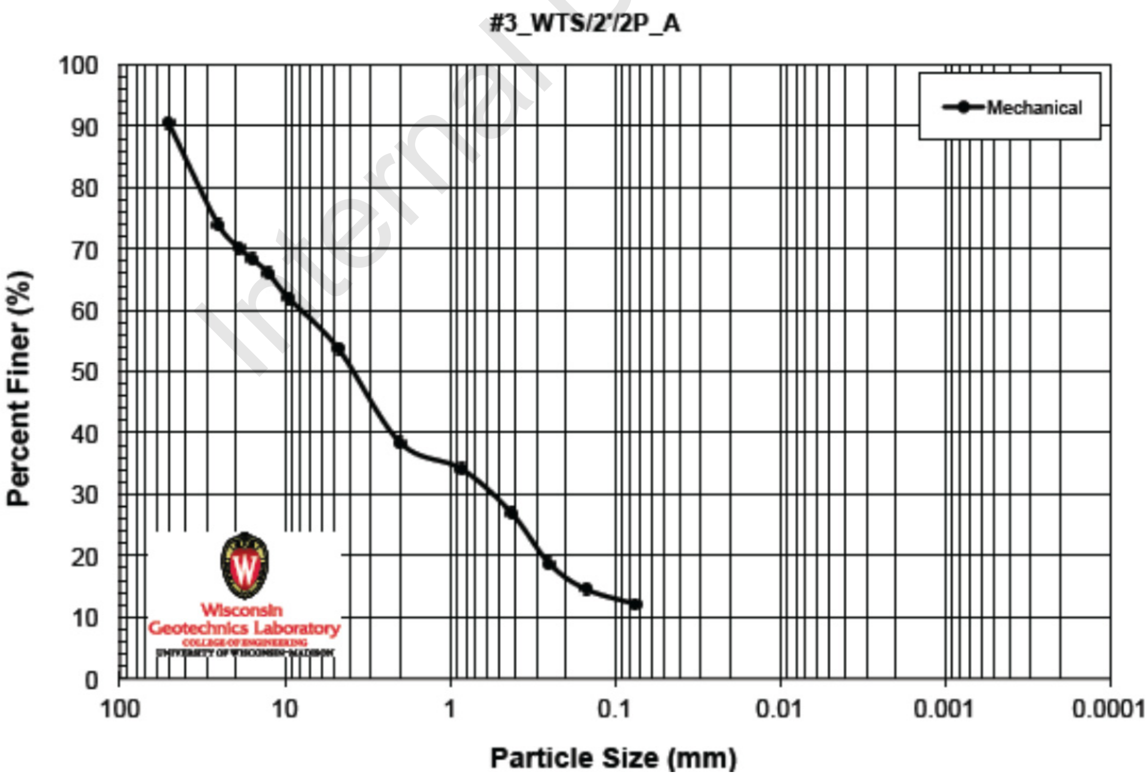
Mechanical Particle Size Analysis - ASTM D 422

Sample ID:	#3_WTS/2'/2P_A			Test Date:	8/8/12
Weight of Air Dry Sample =		5585	g	Initials:	

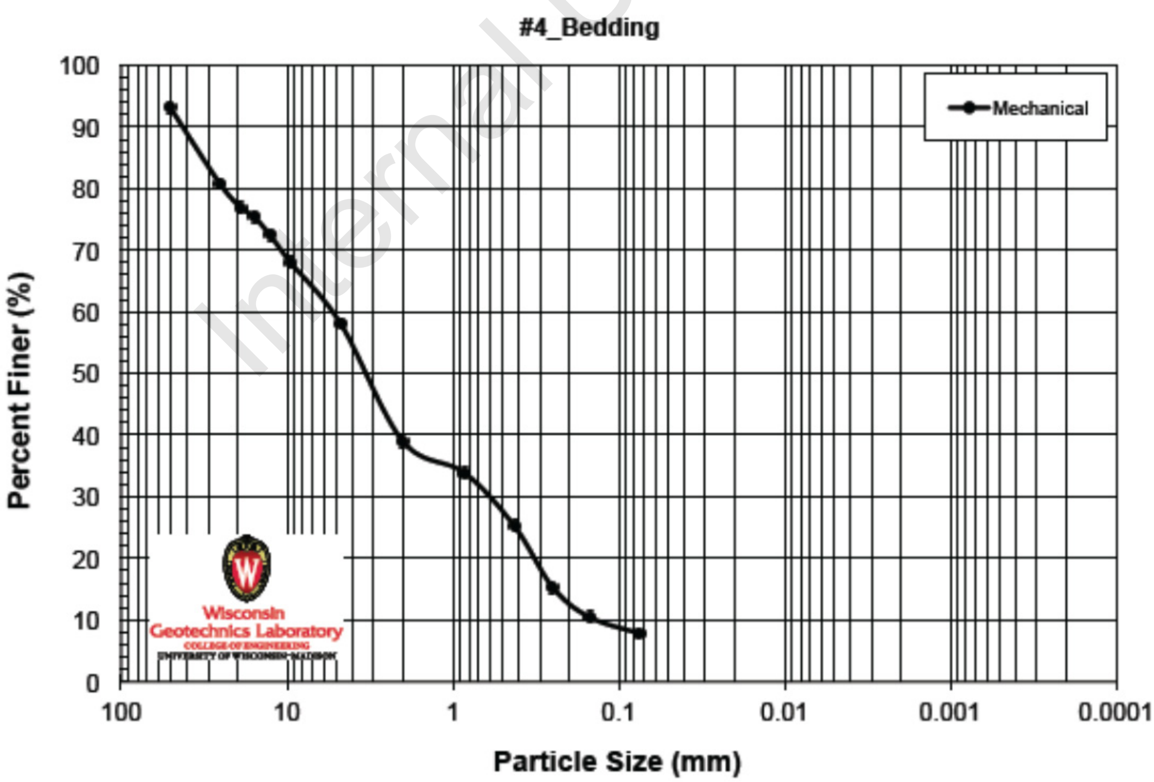
Sieve No.	Sieve Opening	Weight Retained on Each Sieve	Percent Retained on Each Sieve	Cumulative Percent Retained	Percent Finer
	(mm)	(g)	(%)	(%)	(%)
2"	50.8	527.84	9.451029543	9.451029543	90.54897046
1"	25.4	923.45	16.53	25.99	74
3/4"	19.0	214.59	3.84	29.83	70.17
5/8"	15.9	98.46	1.76	31.59	68.41
1/2"	12.7	125.33	2.24	33.83	66.17
3/8"	9.52	232.81	4.17	38.00	62.00
4	4.75	461.34	8.26	46.26	53.74
10	2.00	855.31	15.31	61.58	38.42
20	0.85	240.07	4.30	65.88	34.12
40	0.425	398.25	7.13	73.01	26.99
60	0.250	461.80	8.27	81.28	18.72
100	0.150	234.05	4.19	85.47	14.53
200	0.075	137.81	2.47	87.93	12.07
Sieve Pan		13.99	0.25	88.18	11.82
Wet Sieve P_{200}		645.91			
	R_{200}	4925.10			
	P_{200}	659.90			
	Total Weight (g) =	5585			



Wisconsin Geotechnics Laboratory

Mechanical Particle Size Analysis - ASTM D 422

Sample ID:	#4_Bedding			Test Date:	8/8/12
Weight of Air Dry Sample =		5970	g	Initials:	
Sieve No.	**Sieve Opening**	**Weight Retained on Each Sieve**	**Percent Retained on Each Sieve**	**Cumulative Percent Retained**	**Percent Finer**
	(mm)	(g)	(%)	(%)	(%)
2"	50.8	404.77	6.780067002	6.780067002	93.219933
1"	25.4	742.05	12.43	19.21	81
3/4"	19.0	231.65	3.88	23.09	76.91
5/8:	15.9	85.86	1.44	24.53	75.47
1/2"	12.7	177.52	2.97	27.50	72.50
3/8"	9.52	267.75	4.48	31.99	68.01
4	4.75	593.00	9.93	41.92	58.08
10	2.00	1140.67	19.11	61.03	38.97
20	0.85	305.76	5.12	66.15	33.85
40	0.425	516.42	8.65	74.80	25.20
60	0.250	592.10	9.92	84.72	15.28
100	0.150	289.20	4.84	89.56	10.44
200	0.075	159.30	2.67	92.23	7.77
Sieve Pan		22.26	0.37	92.60	7.40
Wet Sieve P_{200}		419.43			
	R_{200}	5528.31			
	P_{200}	441.69			
	Total Weight (g) =	**5970**			



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Mechanical Particle Size Analysis - ASTM D 422

Sample ID:	#5_POS/3'/1P_B			Test Date:	8/14/12
Weight of Air Dry Sample =		3906	g	Initials:	

Sieve No.	Sieve Opening	Weight Retained on Each Sieve	Percent Retained on Each Sieve	Cumulative Percent Retained	Percent Finer
	(mm)	(g)	(%)	(%)	(%)
2"	50.8	337.62	8.64	8.64	91.36
1"	25.4	127.73	3.27	11.91	88
3/4"	19.0	118.85	3.04	14.96	85.04
5/8:	15.9	23.37	0.60	15.55	84.45
1/2"	12.7	67.01	1.72	17.27	82.73
3/8"	9.52	92.61	2.37	19.64	80.36
4	4.75	149.13	3.82	23.46	76.54
10	2.00	292.24	7.48	30.94	69.06
20	0.85	125.77	3.22	34.16	65.84
40	0.425	155.91	3.99	38.15	61.85
60	0.250	156.79	4.01	42.17	57.83
100	0.150	116.05	2.97	45.14	54.86
200	0.075	134.59	3.45	48.58	51.42
Sieve Pan		23.31	0.60	49.18	50.82
Wet Sieve P_{200}		1984.97	50.82		
	R_{200}	1897.67			
	P_{200}	2008.28			
	Total Weight (g) =	**3906**			

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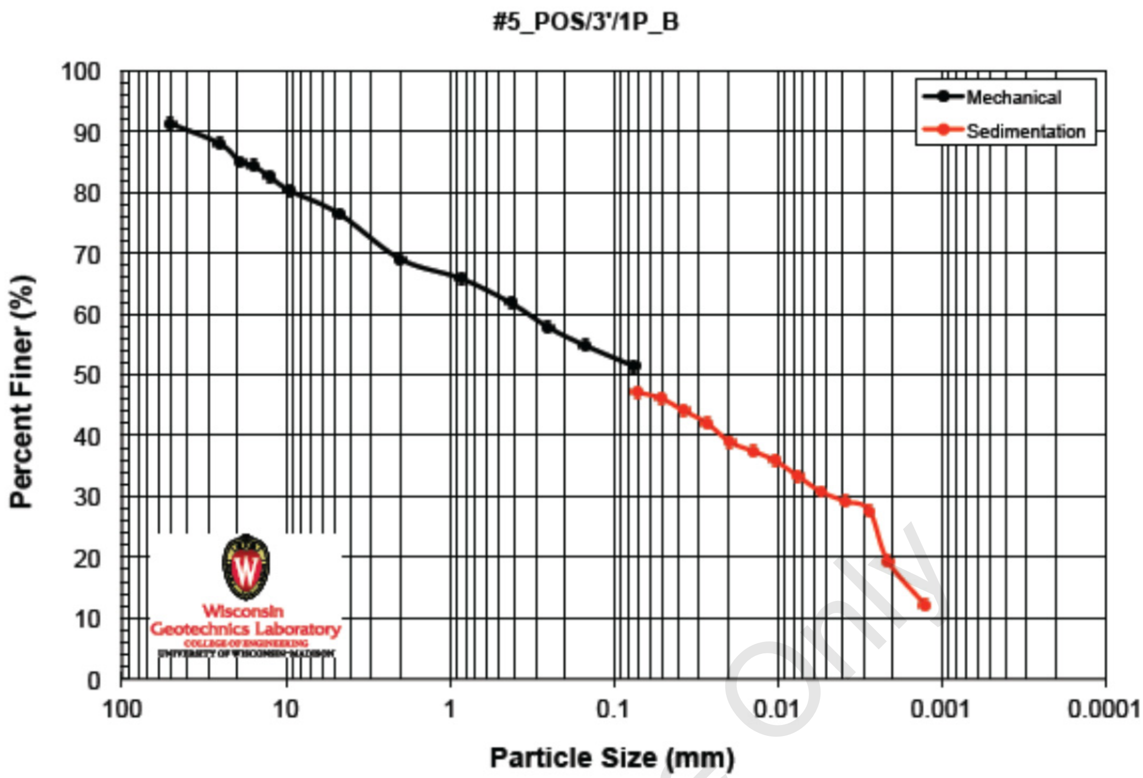
Sedimentation Particle Size Analysis - ASTM D 422

Sample ID:	#5_POS/3'/1P_B
Specific Gravity, G_s =	2.65
Dry Weight of Soil, W (g) =	50
Meniscus Correction, F_m =	0.5
Temperature Correction, F_T =	0.9
Material Max. Size and Percentage (%)	P200 51.42

Temp. Correction, A	0.0129
Hydrometer Type:	ASTM 152H
Temperature of Test, C	23
Zero Correction, F_z	6
a	1.000

Time (min)	Hydrometer Reading, R	R_{cp}	R_{cl}	L (cm)	D (mm)	Final Percent Finer (%)	Percent Finer
0.0	0				0.425	51.42	
0.2	51	45.90	79.40	7.94	0.0725	47.20	91.81
0.5	50	44.90	78.40	8.11	0.0518	46.18	89.81
1.0	48	42.90	76.40	8.43	0.0374	44.12	85.81
2.0	46	40.90	74.40	8.76	0.0269	42.06	81.81
4.0	43	37.90	71.40	9.25	0.0196	38.98	75.81
8.0	41.5	36.40	69.90	9.50	0.0140	37.43	72.81
15.0	40	34.90	68.40	9.74	0.0104	35.89	69.81
30.0	37.5	32.40	65.90	10.15	0.0075	33.32	64.81
60.0	35	29.90	63.40	10.56	0.0054	30.75	59.81
120.0	33.5	28.40	61.90	10.80	0.0039	29.21	56.81
242.0	32	26.90	60.40	11.05	0.0028	27.66	53.81
452.7	24	18.90	52.40	12.36	0.0021	19.44	37.80
1394.0	17	11.90	45.40	13.50	0.0013	12.24	23.80
-59328538.0	0	-5.10	28.40	16.28	#NUM!	-5.24	-10.20
-59328538.0	0	-5.10	28.40	16.28	#NUM!	-5.24	-10.20
-59328538.0	0	-5.10	28.40	16.28	#NUM!	-5.24	-10.20



#5_POS/3'/1P_B
Percent Finer (%)
100
90
80
70
60
50
40
30
20
10
0
100
10
1
0.1
0.01
0.001
0.0001
Particle Size (mm)
Mechanical
Sedimentation
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Mechanical Particle Size Analysis - ASTM D 422

Sample ID:	#6_POS/2'/1P_B			Test Date:	8/14/12
Weight of Air Dry Sample =		5221	g	Initials:	

Sieve No.	Sieve Opening	Weight Retained on Each Sieve	Percent Retained on Each Sieve	Cumulative Percent Retained	Percent Finer
	(mm)	(g)	(%)	(%)	(%)
2"	50.8	1075.93	20.61	20.61	79.39
1"	25.4	290.18	5.56	26.17	74
3/4"	19.0	129.91	2.49	28.65	71.35
5/8:	15.9	51.42	0.98	29.64	70.36
1/2"	12.7	55.67	1.07	30.71	69.29
3/8"	9.52	66.77	1.28	31.98	68.02
4	4.75	140.22	2.69	34.67	65.33
10	2.00	184.35	3.53	38.20	61.80
20	0.85	108.00	2.07	40.27	59.73
40	0.425	114.20	2.19	42.46	57.54
60	0.250	101.54	1.94	44.40	55.60
100	0.150	104.84	2.01	46.41	53.59
200	0.075	159.22	3.05	49.46	50.54
Sieve Pan		25.55	0.49	49.95	50.05
Wet Sieve P_{200}		2613.17	50.05		
	R_{200}	2582.25			
	P_{200}	2638.72			
	Total Weight (g) =	5221			

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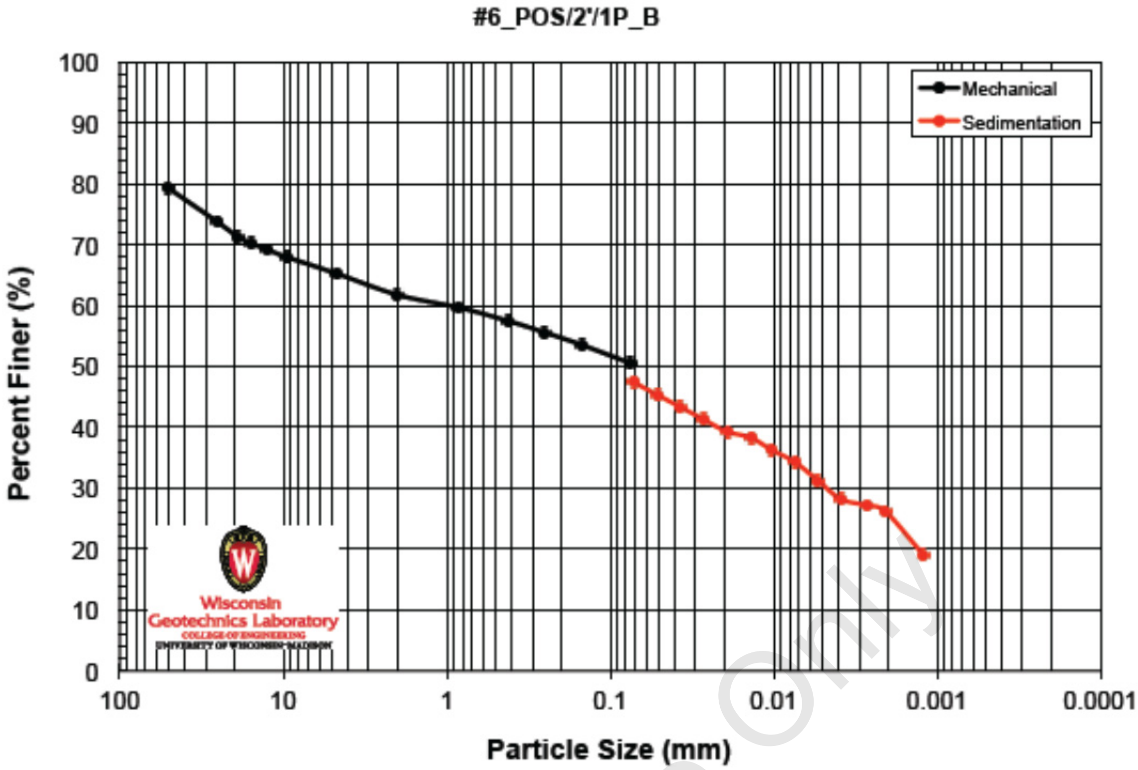
Sedimentation Particle Size Analysis - ASTM D 422

Sample ID:	#6_POS/2'/1P_B
Specific Gravity, G_s =	2.65
Dry Weight of Soil, W (g) =	50
Meniscus Correction, F_m =	0.5
Temperature Correction, F_T =	0.9
Material Max. Size and Percentage (%)	P200 50.54

Temp. Correction, A	0.0129
Hydrometer Type:	ASTM 152H
Temperature of Test, C	23
Zero Correction, F_z	6
a	1.000

Time (min)	Hydrometer Reading, R	R_{cp}	R_{cl}	L (cm)	D (mm)	Final Percent Finer (%)	Percent Finer
0.0	0				0.425	50.54	
0.3	52	46.90	79.90	7.78	0.0718	47.41	93.81
0.5	50	44.90	77.90	8.11	0.0518	45.39	89.81
1.0	48	42.90	75.90	8.43	0.0374	43.37	85.81
2.0	46	40.90	73.90	8.76	0.0269	41.35	81.81
4.0	44	38.90	71.90	9.09	0.0194	39.32	77.81
8.0	43	37.90	70.90	9.25	0.0138	38.31	75.81
15.0	41	35.90	68.90	9.58	0.0103	36.29	71.81
30.0	39	33.90	66.90	9.90	0.0074	34.27	67.81
60.0	36	30.90	63.90	10.40	0.0054	31.24	61.81
120.0	33	27.90	60.90	10.89	0.0039	28.20	55.81
251.0	32	26.90	59.90	11.05	0.0027	27.19	53.81
433.3	31	25.90	58.90	11.21	0.0021	26.18	51.81
1374.0	24	18.90	51.90	12.36	0.0012	19.11	37.80
-59328558.0	0	-5.10	27.90	16.28	#NUM!	-5.16	-10.20
-59328558.0	0	-5.10	27.90	16.28	#NUM!	-5.16	-10.20
-59328558.0	0	-5.10	27.90	16.28	#NUM!	-5.16	-10.20


#6_POS/2'/1P_B
Percent Finer (%)
Particle Size (mm)
Mechanical
Sedimentation
100
90
80
70
60
50
40
30
20
10
0
100
10
1
0.1
0.01
0.001
0.0001
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Mechanical Particle Size Analysis - ASTM D 422

Sample ID:	#7_POS/4'/2P_A			Test Date:	8/16/12
Weight of Air Dry Sample =		4149	g	Initials:	

Sieve No.	Sieve Opening	Weight Retained on Each Sieve	Percent Retained on Each Sieve	Cumulative Percent Retained	Percent Finer
	(mm)	(g)	(%)	(%)	(%)
2"	50.8	296.86	7.15	7.15	92.85
1"	25.4	223.46	5.39	12.54	87
3/4"	19.0	122.12	2.94	15.48	84.52
5/8:	15.9	36.83	0.89	16.37	83.63
1/2"	12.7	92.53	2.23	18.60	81.40
3/8"	9.52	92.23	2.22	20.83	79.17
4	4.75	174.04	4.19	25.02	74.98
10	2.00	288.89	6.96	31.98	68.02
20	0.85	120.92	2.91	34.90	65.10
40	0.425	147.38	3.55	38.45	61.55
60	0.250	155.64	3.75	42.20	57.80
100	0.150	127.04	3.06	45.26	54.74
200	0.075	155.70	3.75	49.02	50.98
Sieve Pan		34.88	0.84	49.86	50.14
Wet Sieve P_{200}		2080.48	50.14		
	R_{200}	2033.64			
	P_{200}	2115.36			
	Total Weight (g) =	**4149**			

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Sedimentation Particle Size Analysis - ASTM D 422

Sample ID:	#7_POS/4'/2P_A
Specific Gravity, G_s =	2.65
Dry Weight of Soil, W (g) =	50
Meniscus Correction, F_m =	0.5
Temperature Correction, F_T =	0.9
Material Max. Size and Percentage (%)	P200 50.98

Temp. Correction, A	0.0129
Hydrometer Type:	ASTM 152H
Temperature of Test, C	23
Zero Correction, F_z	6
a	1.000

Time (min)	Hydrometer Reading, R	R_{cp}	R_{cl}	L (cm)	D (mm)	Final Percent Finer (%)	Percent Finer
0.0	0				0.425	50.98	
0.2	52	46.90	81.90	7.78	0.0718	47.83	93.81
0.5	50	44.90	79.90	8.11	0.0518	45.79	89.81
1.0	48.5	43.40	78.40	8.35	0.0372	44.26	86.81
2.0	47	41.90	76.90	8.60	0.0267	42.73	83.81
4.0	45	39.90	74.90	8.92	0.0192	40.69	79.81
8.0	44	38.90	73.90	9.09	0.0137	39.67	77.81
15.0	42	36.90	71.90	9.41	0.0102	37.63	73.81
30.0	41	35.90	70.90	9.58	0.0073	36.61	71.81
60.0	39	33.90	68.90	9.90	0.0052	34.57	67.81
122.0	35	29.90	64.90	10.56	0.0038	30.49	59.81
234.0	18	12.90	47.90	13.34	0.0031	13.16	25.80
415.8	10	4.90	39.90	14.65	0.0024	5.00	9.80
1357.0	7	1.90	36.90	15.14	0.0014	1.94	3.80
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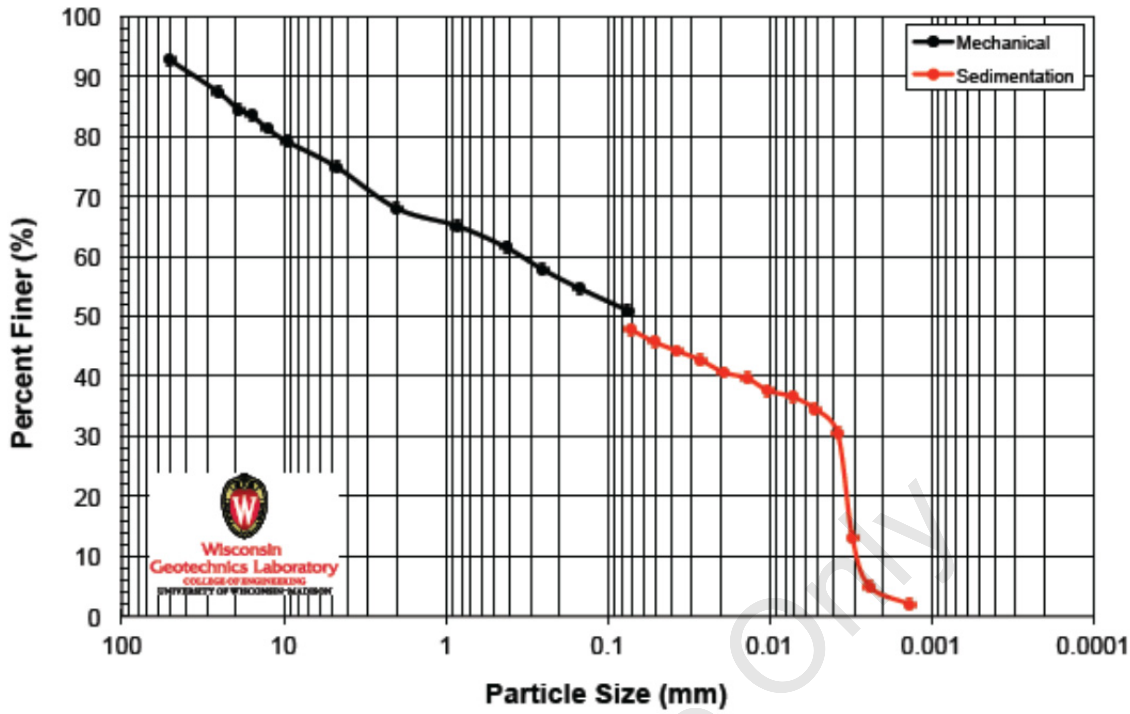
-59328576.0	0	-5.10	29.90	16.28	#NUM!	-5.20	-10.20
-59328576.0	0	-5.10	29.90	16.28	#NUM!	-5.20	-10.20

#7_POS/4'/2P_A


Mechanical
Sedimentation
Percent Finer (%)
Particle Size (mm)
100
90
80
70
60
50
40
30
20
10
0
100
10
1
0.1
0.01
0.001
0.0001
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Mechanical Particle Size Analysis - ASTM D 422

Sample ID:	#8_POS/3'/2P_B			Test Date:	8/20/12
Weight of Air Dry Sample =		5178	g	Initials:	

Sieve No.	Sieve Opening	Weight Retained on Each Sieve	Percent Retained on Each Sieve	Cumulative Percent Retained	Percent Finer
	(mm)	(g)	(%)	(%)	(%)
2"	50.8	1022.42	19.75	19.75	80.25
1"	25.4	285.67	5.52	25.26	75
3/4"	19.0	126.86	2.45	27.71	72.29
5/8:	15.9	8.02	0.15	27.87	72.13
1/2"	12.7	85.29	1.65	29.51	70.49
3/8"	9.52	155.74	3.01	32.52	67.48
4	4.75	276.35	5.34	37.86	62.14
10	2.00	518.39	10.01	47.87	52.13
20	0.85	168.59	3.26	51.13	48.87
40	0.425	256.25	4.95	56.08	43.92
60	0.250	294.65	5.69	61.77	38.23
100	0.150	183.26	3.54	65.30	34.70
200	0.075	163.88	3.16	68.47	31.53
Sieve Pan		24.02	0.46	68.93	31.07
Wet Sieve P_{200}		1608.61	31.07		
	R_{200}	3545.37			
	P_{200}	1632.63			
	Total Weight (g) =	**5178**			

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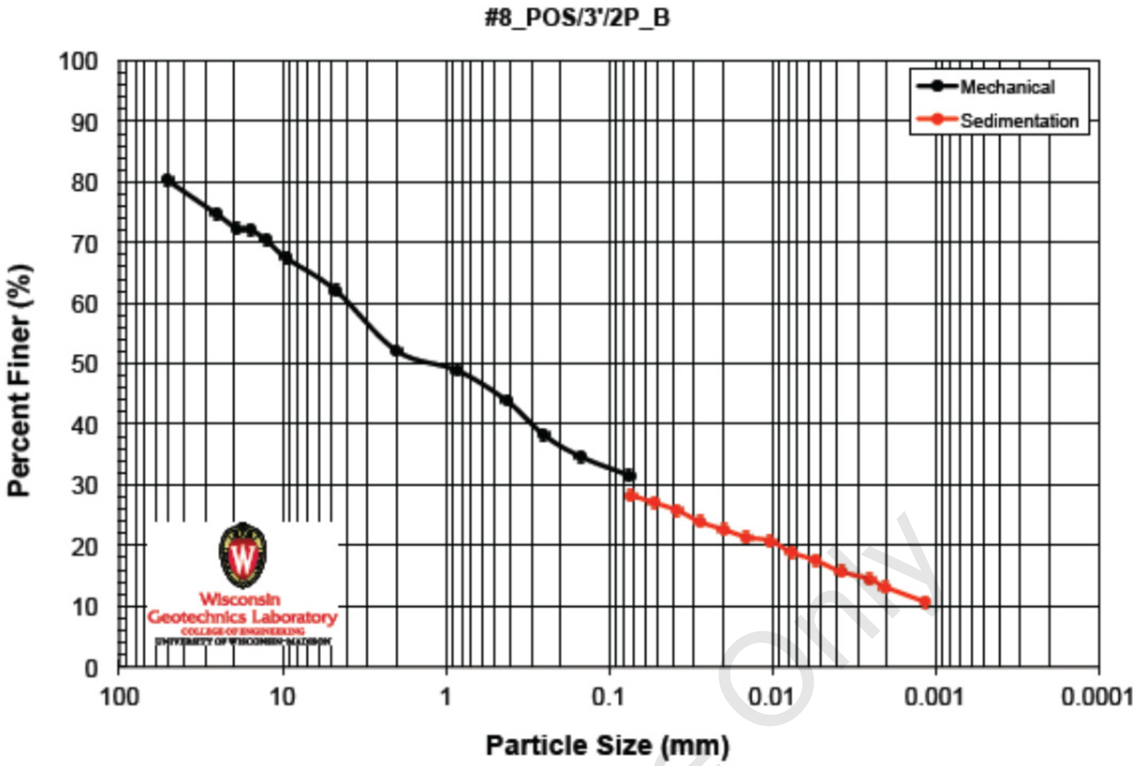
Sedimentation Particle Size Analysis - ASTM D 422

Sample ID:	#8_POS/3'/2P_B	Temp. Correction, A	0.0129
Specific Gravity, G_s =	2.65	Hydrometer Type:	ASTM 152H
Dry Weight of Soil, W (g) =	50	Temperature of Test, C	23
Meniscus Correction, F_m =	0.5	Zero Correction, F_z	6
Temperature Correction, F_T =	0.9	a	1.000
Material Max. Size and Percentage (%)	P200 31.53		

Time (min)	Hydrometer Reading, R	R_{cp}	R_{cl}	L (cm)	D (mm)	Final Percent Finer (%)	Percent Finer
0.0	0				0.425	31.53	
0.3	50	44.90	74.90	8.11	0.0733	28.32	89.81
0.5	48	42.90	72.90	8.43	0.0529	27.06	85.81
1.0	46	40.90	70.90	8.76	0.0381	25.79	81.81
2.0	43	37.90	67.90	9.25	0.0277	23.90	75.81
4.0	41	35.90	65.90	9.58	0.0199	22.64	71.81
8.0	39	33.90	63.90	9.90	0.0143	21.38	67.81
16.0	38	32.90	62.90	10.07	0.0102	20.75	65.81
30.0	35	29.90	59.90	10.56	0.0076	18.86	59.81
60.0	33	27.90	57.90	10.89	0.0055	17.60	55.81
130.0	30	24.90	54.90	11.38	0.0038	15.70	49.80
307.0	28	22.90	52.90	11.70	0.0025	14.44	45.80
477.0	26	20.90	50.90	12.03	0.0020	13.18	41.80
1585.0	22	16.90	46.90	12.69	0.0012	10.66	33.80
-59329970.0	0	-5.10	24.90	16.28	#NUM!	-3.22	-10.20
-59329970.0	0	-5.10	24.90	16.28	#NUM!	-3.22	-10.20
-59329970.0	0	-5.10	24.90	16.28	#NUM!	-3.22	-10.20



#8_POS/3'/2P_B
Mechanical
Sedimentation
Percent Finer (%)
Particle Size (mm)
100
90
80
70
60
50
40
30
20
10
0
100
10
1
0.1
0.01
0.001
0.0001
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Mechanical Particle Size Analysis - ASTM D 422

Sample ID:	#9_WTS/2'/2P_B	Test Date:	8/20/12
Weight of Air Dry Sample =	5938 g	Initials:	

Sieve No.	Sieve Opening	Weight Retained on Each Sieve	Percent Retained on Each Sieve	Cumulative Percent Retained	Percent Finer
	(mm)	(g)	(%)	(%)	(%)
	81	323.67	5.45	5.45	94.55
	75.0	757.44	12.76	18.21	81.79
1"	25.4	1267.12	21.34	39.55	60
3/4"	19.0	108.22	1.82	41.37	58.63
5/8:	15.9	22.22	0.37	41.74	58.26
1/2"	12.7	88.46	1.49	43.23	56.77
3/8"	9.52	120.13	2.02	45.26	54.74
4	4.75	236.20	3.98	49.23	50.77
10	2.00	366.46	6.17	55.40	44.60
20	0.85	139.01	2.34	57.75	42.25
40	0.425	181.90	3.06	60.81	39.19
60	0.250	205.81	3.47	64.27	35.73
100	0.150	152.25	2.56	66.84	33.16
200	0.075	160.25	2.70	69.54	30.46
Sieve Pan		20.90	0.35	69.89	30.11
Wet Sieve P_{200}		1787.96	30.11		
	R_{200}	4129.14			
	P_{200}	1808.86			
	Total Weight (g) =	**5938**			

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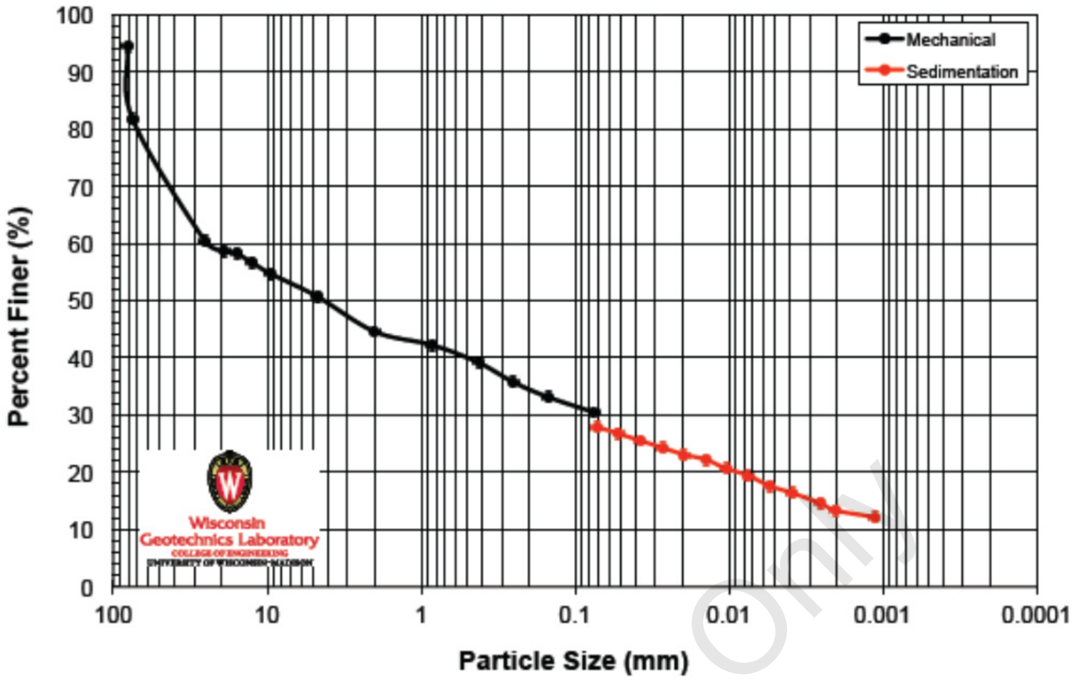
Sedimentation Particle Size Analysis - ASTM D 422

Sample ID:	#9_WTS/2'/2P_B
Specific Gravity, G_s =	2.65
Dry Weight of Soil, W (g) =	50
Meniscus Correction, F_m =	0.5
Temperature Correction, F_T =	0.9
Material Max. Size and Percentage (%)	P200 30.46

Temp. Correction, A	0.0129
Hydrometer Type:	ASTM 152H
Temperature of Test, C	23
Zero Correction, F_z	6
a	1.000

Time (min)	Hydrometer Reading, R	R_{cp}	R_{cl}	L (cm)	D (mm)	Final Percent Finer (%)	Percent Finer
0.0	0				0.425	30.46	
0.2	51	45.90	77.90	7.94	0.0725	27.97	91.81
0.5	49	43.90	75.90	8.27	0.0523	26.75	87.81
1.0	47	41.90	73.90	8.60	0.0377	25.53	83.81
2.0	45	39.90	71.90	8.92	0.0272	24.31	79.81
4.0	43	37.90	69.90	9.25	0.0196	23.09	75.81
8.0	41.5	36.40	68.40	9.50	0.0140	22.18	72.81
15.0	39	33.90	65.90	9.90	0.0105	20.66	67.81
30.0	37	31.90	63.90	10.23	0.0075	19.44	63.81
60.0	34	28.90	60.90	10.72	0.0054	17.61	57.81
120.0	32	26.90	58.90	11.05	0.0039	16.39	53.81
296.0	29	23.90	55.90	11.54	0.0025	14.56	47.80
466.0	27	21.90	53.90	11.87	0.0021	13.34	43.80
1575.0	25	19.90	51.90	12.19	0.0011	12.13	39.80

#9_WTS/2'/2P_B


Percent Finer (%)
100
90
80
70
60
50
40
30
20
10
0
100
10
1
0.1
0.01
0.001
0.0001
Particle Size (mm)
Mechanical
Sedimentation
Wisconsin
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Mechanical Particle Size Analysis - ASTM D 422

Sample ID:	#10_CS/3'/1P_B			Test Date:	8/20/12
Weight of Air Dry Sample =		6055	g	Initials:	
Sieve No.	Sieve Opening	Weight Retained on Each Sieve	Percent Retained on Each Sieve	Cumulative Percent Retained	Percent Finer
	(mm)	(g)	(%)	(%)	(%)
	72	712.15	11.76	11.76	88.24
2"	50.8	548.52	9.06	20.82	79.18
1"	25.4	1262.55	20.85	41.67	58
3/4"	19.0	198.12	3.27	44.94	55.06
5/8:	15.9	50.48	0.83	45.78	54.22
1/2"	12.7	127.66	2.11	47.89	52.11
3/8"	9.52	145.78	2.41	50.29	49.71
4	4.75	251.52	4.15	54.45	45.55
10	2.00	453.61	7.49	61.94	38.06
20	0.85	149.51	2.47	64.41	35.59
40	0.425	208.94	3.45	67.86	32.14
60	0.250	233.04	3.85	71.71	28.29
100	0.150	151.58	2.50	74.21	25.79
200	0.075	143.61	2.37	76.58	23.42
Sieve Pan		18.21	0.30	76.88	23.12
Wet Sieve P_{200}		1399.72	23.12		
	R_{200}	4637.07			
	P_{200}	1417.93			
	Total Weight (g) =	6055			

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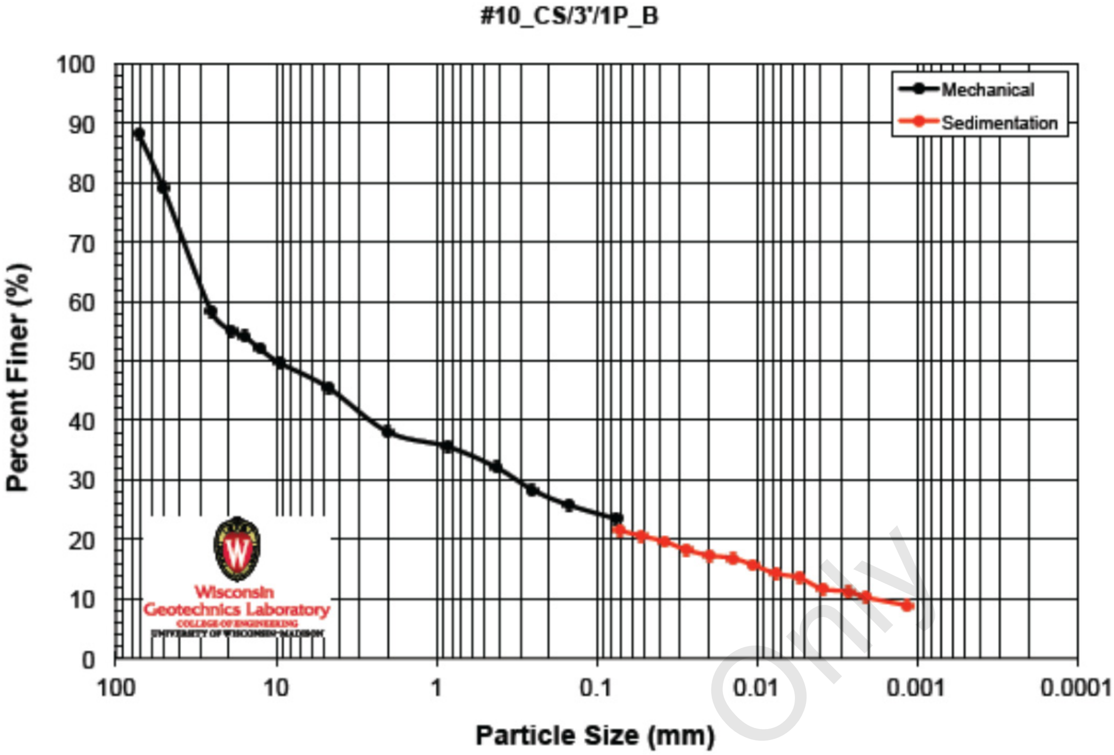
Sedimentation Particle Size Analysis - ASTM D 422

Sample ID:	#10_CS/3'/1P_B	Temp. Correction, A	0.0129
Specific Gravity, G_s =	2.65	Hydrometer Type:	ASTM 152H
Dry Weight of Soil, W (g) =	50	Temperature of Test, C	23
Meniscus Correction, F_m =	0.5	Zero Correction, F_z	6
Temperature Correction, F_T =	0.9	a	1.000
Material Max. Size and Percentage (%)	P200 23.42		

Time (min)	Hydrometer Reading, R	R_{cp}	R_{cl}	L (cm)	D (mm)	Final Percent Finer (%)	Percent Finer
0.0	0				0.425	23.42	
0.3	51	45.90	75.90	7.94	0.0725	21.50	91.81
0.5	49	43.90	73.90	8.27	0.0523	20.56	87.81
1.0	47	41.90	71.90	8.60	0.0377	19.63	83.81
2.0	44	38.90	68.90	9.09	0.0274	18.22	77.81
4.0	42	36.90	66.90	9.41	0.0197	17.28	73.81
8.0	41	35.90	65.90	9.58	0.0141	16.82	71.81
15.0	38.5	33.40	63.40	9.99	0.0105	15.64	66.81
30.0	35.5	30.40	60.40	10.48	0.0076	14.24	60.81
60.0	34	28.90	58.90	10.72	0.0054	13.54	57.81
124.0	30	24.90	54.90	11.38	0.0039	11.66	49.80
273.0	29	23.90	53.90	11.54	0.0026	11.19	47.80
442.0	27	21.90	51.90	11.87	0.0021	10.26	43.80
1551.0	24	18.90	48.90	12.36	0.0011	8.85	37.80


#10_CS/3'/1P_B
Percent Finer (%)
100
90
80
70
60
50
40
30
20
10
0
100
10
1
0.1
0.01
0.001
0.0001
Particle Size (mm)
Mechanical
Sedimentation
Wisconsin
Geotechnics Laboratory

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Mechanical Particle Size Analysis - ASTM D 422

Sample ID:	#11_POS/4'/2P_B	Test Date:	8/28/12
Weight of Air Dry Sample =	7086 g	Initials:	

Sieve No.	Sieve Opening	Weight Retained on Each Sieve	Percent Retained on Each Sieve	Cumulative Percent Retained	Percent Finer
	(mm)	(g)	(%)	(%)	(%)
	120	2452.21	34.61	34.61	65.39
2"	50.8	513.38	7.24	41.85	58.15
1"	25.4	320.07	4.52	46.37	54
3/4"	19.0	56.04	0.79	47.16	52.84
5/8:	15.9	58.92	0.83	47.99	52.01
1/2"	12.7	68.31	0.96	48.95	51.05
3/8"	9.52	100.58	1.42	50.37	49.63
4	4.75	223.91	3.16	53.53	46.47
10	2.00	367.40	5.18	58.72	41.28
20	0.85	140.04	1.98	60.70	39.30
40	0.425	170.85	2.41	63.11	36.89
60	0.250	180.89	2.55	65.66	34.34
100	0.150	136.88	1.93	67.59	32.41
200	0.075	164.71	2.32	69.92	30.08
Sieve Pan		28.01	0.40	70.31	29.69
Wet Sieve P_{200}		2103.80	29.69		
	R_{200}	4954.19			
	P_{200}	2131.81			
	Total Weight (g) =	**7086**			

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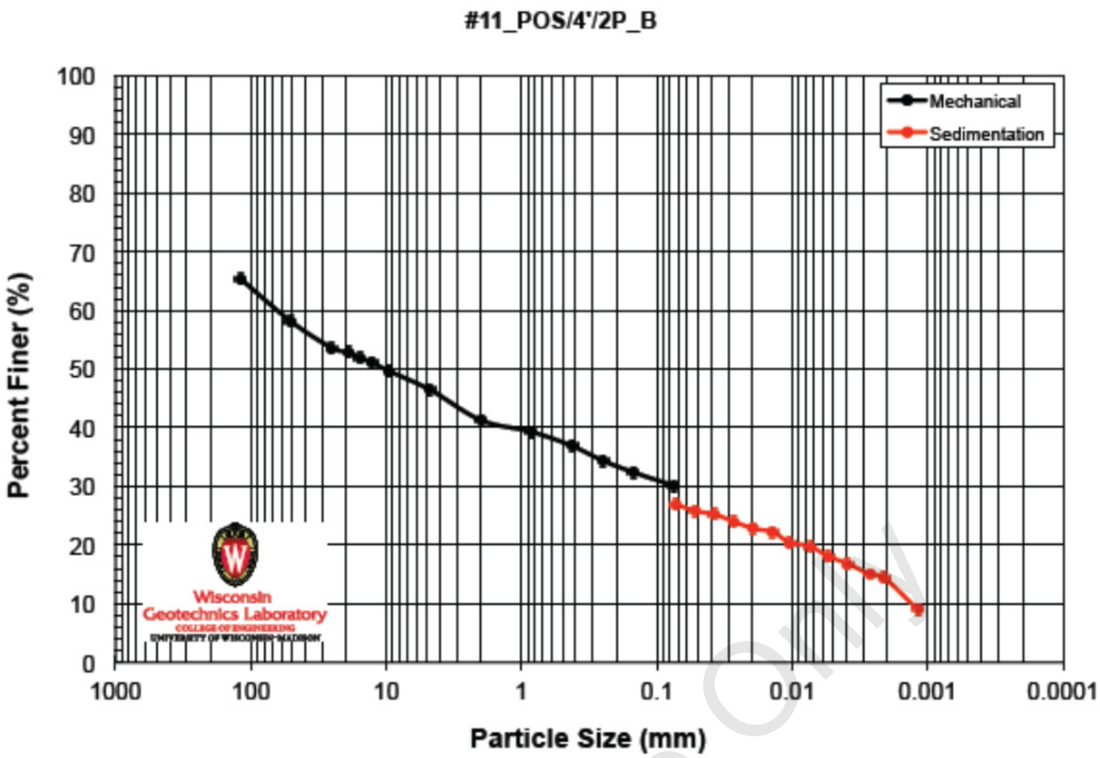
Sedimentation Particle Size Analysis - ASTM D 422

Sample ID:	#11_POS/4'/2P_B	Temp. Correction, A	0.0129
Specific Gravity, G_s =	2.65	Hydrometer Type:	ASTM 152H
Dry Weight of Soil, W (g) =	50	Temperature of Test, C	23
Meniscus Correction, F_m =	0.5	Zero Correction, F_z	6
Temperature Correction, F_T =	0.9	a	1.000
Material Max. Size and Percentage (%)	P200 30.08		

Time (min)	Hydrometer Reading, R	R_{cp}	R_{cl}	L (cm)	D (mm)	Final Percent Finer (%)	Percent Finer
0.0	0				0.425	30.08	
0.2	50	44.90	77.90	8.11	0.0733	27.02	89.81
0.5	48	42.90	75.90	8.43	0.0529	25.82	85.81
1.0	47	41.90	74.90	8.60	0.0377	25.21	83.81
2.0	45	39.90	72.90	8.92	0.0272	24.01	79.81
4.0	43	37.90	70.90	9.25	0.0196	22.81	75.81
8.0	42	36.90	69.90	9.41	0.0140	22.20	73.81
15.0	39	33.90	66.90	9.90	0.0105	20.40	67.81
30.0	38	32.90	65.90	10.07	0.0075	19.80	65.81
60.0	35	29.90	62.90	10.56	0.0054	17.99	59.81
120.0	33	27.90	60.90	10.89	0.0039	16.79	55.81
262.0	30	24.90	57.90	11.38	0.0027	14.98	49.80
432.0	29	23.90	56.90	11.54	0.0021	14.38	47.80
1541.0	20	14.90	47.90	13.01	0.0012	8.97	29.80
-59330016.0	0	-5.10	27.90	16.28	#NUM!	-3.07	-10.20
-59330016.0	0	-5.10	27.90	16.28	#NUM!	-3.07	-10.20
-59330016.0	0	-5.10	27.90	16.28	#NUM!	-3.07	-10.20


#11_POS/4'/2P_B
Percent Finer (%)
Particle Size (mm)
Mechanical
Sedimentation
100
90
80
70
60
50
40
30
20
10
0
1000
100
10
1
0.1
0.01
0.001
0.0001
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Mechanical Particle Size Analysis - ASTM D 422

Sample ID:	#12_POS/2'/1P_A			Test Date:	8/28/12
Weight of Air Dry Sample =		6113	g	Initials:	

Sieve No.	Sieve Opening	Weight Retained on Each Sieve	Percent Retained on Each Sieve	Cumulative Percent Retained	Percent Finer
	(mm)	(g)	(%)	(%)	(%)
2"	50.8	323.66	5.29	5.29	94.71
1"	25.4	893.92	14.62	19.92	80
3/4"	19.0	169.30	2.77	22.69	77.31
5/8:	15.9	114.94	1.88	24.57	75.43
1/2"	12.7	162.07	2.65	27.22	72.78
3/8"	9.52	207.01	3.39	30.61	69.39
4	4.75	399.49	6.54	37.14	62.86
10	2.00	681.09	11.14	48.28	51.72
20	0.85	210.75	3.45	51.73	48.27
40	0.425	302.58	4.95	56.68	43.32
60	0.250	329.62	5.39	62.07	37.93
100	0.150	199.46	3.26	65.33	34.67
200	0.075	167.20	2.74	68.07	31.93
Sieve Pan		25.96	0.42	68.49	31.51
Wet Sieve P_{200}		1925.95	31.51		
	R_{200}	4161.09			
	P_{200}	1951.91			
	Total Weight (g) =	6113			

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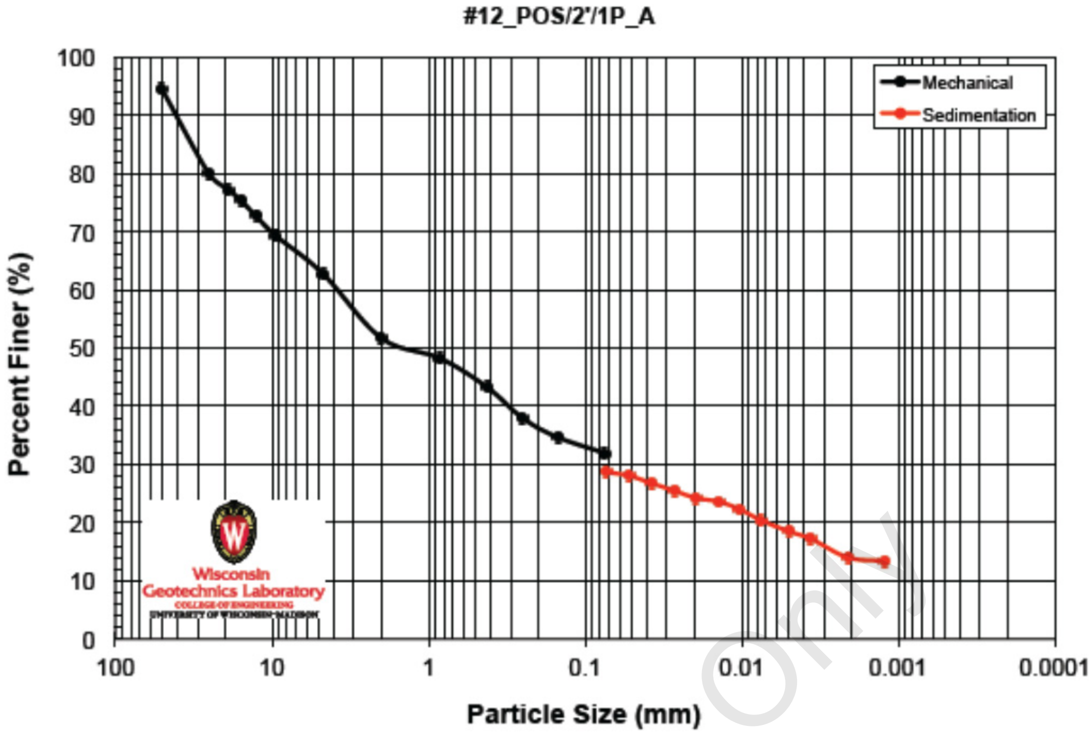
Sedimentation Particle Size Analysis - ASTM D 422

Sample ID:	#12_POS/2'/1P_A		Temp. Correction, A	0.0129
Specific Gravity, G_s =	2.65		Hydrometer Type:	ASTM 152H
Dry Weight of Soil, W (g) =	50		Temperature of Test, C	23
Meniscus Correction, F_m =	0.5		Zero Correction, F_z	6
Temperature Correction, F_T =	0.9		a	1.000
Material Max. Size and Percentage (%)	P200 31.93			

Time (min)	Hydrometer Reading, R	R_{cp}	R_d	L (cm)	D (mm)	Final Percent Finer (%)	Percent Finer
0.0	0				0.425	31.93	
0.3	50	44.90	76.90	8.11	0.0733	28.68	89.81
0.5	49	43.90	75.90	8.27	0.0523	28.04	87.81
1.0	47	41.90	73.90	8.60	0.0377	26.76	83.81
2.0	45	39.90	71.90	8.92	0.0272	25.48	79.81
4.0	43	37.90	69.90	9.25	0.0196	24.21	75.81
8.0	42	36.90	68.90	9.41	0.0140	23.57	73.81
15.0	40	34.90	66.90	9.74	0.0104	22.29	69.81
30.0	37	31.90	63.90	10.23	0.0075	20.37	63.81
71.0	34	28.90	60.90	10.72	0.0050	18.46	57.81
140.0	32	26.90	58.90	11.05	0.0036	17.18	53.81
442.0	27	21.90	53.90	11.87	0.0021	13.99	43.80
1300.0	26	20.90	52.90	12.03	0.0012	13.35	41.80
-59335822.0	0	-5.10	26.90	16.28	#NUM!	-3.26	-10.20
-59335822.0	0	-5.10	26.90	16.28	#NUM!	-3.26	-10.20
-59335822.0	0	-5.10	26.90	16.28	#NUM!	-3.26	-10.20
-59335822.0	0	-5.10	26.90	16.28	#NUM!	-3.26	-10.20


#12_POS/2'/1P_A
Percent Finer (%)
Particle Size (mm)
Mechanical
Sedimentation
Wisconsin
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100
90
80
70
60
50
40
30
20
10
0
100
10
1
0.1
0.01
0.001
0.0001

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Mechanical Particle Size Analysis - ASTM D 422

Sample ID:	#13_CS/3'/1P_A			Test Date:	8/28/12
Weight of Air Dry Sample =		6379	g	Initials:	

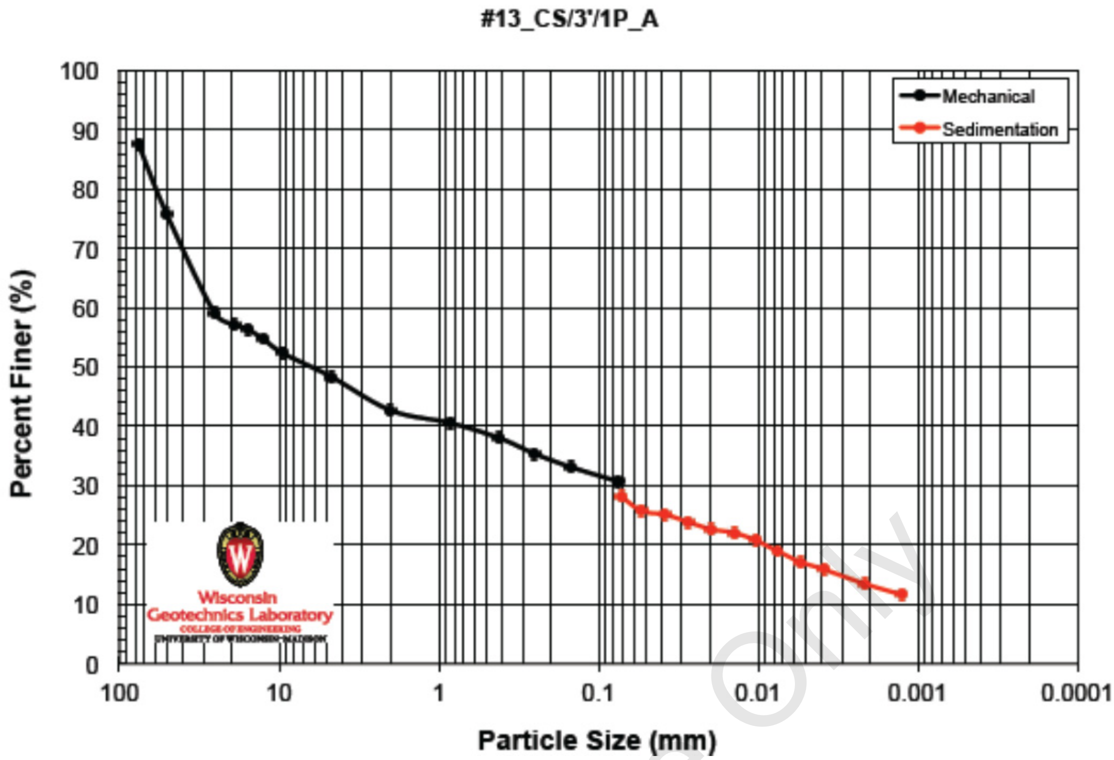
Sieve No.	Sieve Opening	Weight Retained on Each Sieve	Percent Retained on Each Sieve	Cumulative Percent Retained	Percent Finer
	(mm)	(g)	(%)	(%)	(%)
3"	76.2	790.75	12.40	12.40	87.60
2"	50.8	745.15	11.68	24.08	75.92
1"	25.4	1071.69	16.80	40.88	59
3/4"	19.0	125.56	1.97	42.85	57.15
5/8:	15.9	47.55	0.75	43.59	56.41
1/2"	12.7	100.96	1.58	45.17	54.83
3/8"	9.52	156.08	2.45	47.62	52.38
4	4.75	253.36	3.97	51.59	48.41
10	2.00	364.51	5.71	57.31	42.69
20	0.85	135.37	2.12	59.43	40.57
40	0.425	157.59	2.47	61.90	38.10
60	0.250	174.40	2.73	64.63	35.37
100	0.150	140.99	2.21	66.84	33.16
200	0.075	158.30	2.48	69.33	30.67
Sieve Pan		25.91	0.41	69.73	30.27
Wet Sieve P_{200}		1930.80	30.27		
	R_{200}	4422.26			
	P_{200}	1956.71			
	Total Weight (g) =	**6379**			

Wisconsin Geotechnics Laboratory

Sedimentation Particle Size Analysis - ASTM D 422

Sample ID:	#13_CS/3'/1P_A	Temp. Correction, A	0.0129
Specific Gravity, G_s =	2.65	Hydrometer Type:	ASTM 152H
Dry Weight of Soil, W (g) =	50	Temperature of Test, C	23
Meniscus Correction, F_m =	0.5	Zero Correction, F_z	6
Temperature Correction, F_T =	0.9	a	1.000
Material Max. Size and Percentage (%)	P200 30.67		

Time (min)	Hydrometer Reading, R	R_{cp}	R_{cl}	L (cm)	D (mm)	Final Percent Finer (%)	Percent Finer
0.0	0				0.425	30.67	
0.2	51	45.90	76.90	7.94	0.0725	28.16	91.81
0.5	47	41.90	72.90	8.60	0.0534	25.71	83.81
1.0	46	40.90	71.90	8.76	0.0381	25.09	81.81
2.0	44	38.90	69.90	9.09	0.0274	23.87	77.81
4.0	42	36.90	67.90	9.41	0.0197	22.64	73.81
8.0	41	35.90	66.90	9.58	0.0141	22.03	71.81
15.0	39	33.90	64.90	9.90	0.0105	20.80	67.81
30.0	36	30.90	61.90	10.40	0.0076	18.96	61.81
61.0	33	27.90	58.90	10.89	0.0054	17.12	55.81
122.0	31	25.90	56.90	11.21	0.0039	15.89	51.81
423.0	27	21.90	52.90	11.87	0.0022	13.44	43.80
1281.0	24	18.90	49.90	12.36	0.0013	11.60	37.80


#13_CS/3'/1P_A
Percent Finer (%)
Particle Size (mm)
Mechanical
Sedimentation
100
90
80
70
60
50
40
30
20
10
0
100
10
1
0.1
0.01
0.001
0.0001
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Mechanical Particle Size Analysis - ASTM D 422

Sample ID:	#14_WTS/3'/2P_B			Test Date:	8/28/12
Weight of Air Dry Sample =		5416	g	Initials:	
Sieve No.	Sieve Opening	Weight Retained on Each Sieve	Percent Retained on Each Sieve	Cumulative Percent Retained	Percent Finer
	(mm)	(g)	(%)	(%)	(%)
2"	50.8	1214.18	22.42	22.42	77.58
1"	25.4	574.12	10.60	33.02	67
3/4"	19.0	69.30	1.28	34.30	65.70
5/8:	15.9	15.22	0.28	34.58	65.42
1/2"	12.7	97.56	1.80	36.38	63.62
3/8"	9.52	126.28	2.33	38.71	61.29
4	4.75	248.51	4.59	43.30	56.70
10	2.00	415.00	7.66	50.96	49.04
20	0.85	151.07	2.79	53.75	46.25
40	0.425	201.02	3.71	57.46	42.54
60	0.250	220.66	4.07	61.54	38.46
100	0.150	141.01	2.60	64.14	35.86
200	0.075	142.24	2.63	66.77	33.23
Sieve Pan		16.20	0.30	67.07	32.93
Wet Sieve P_{200}		1783.60	32.93		
	R_{200}	3616.17			
	P_{200}	1799.80			
	Total Weight (g) =	**5416**			

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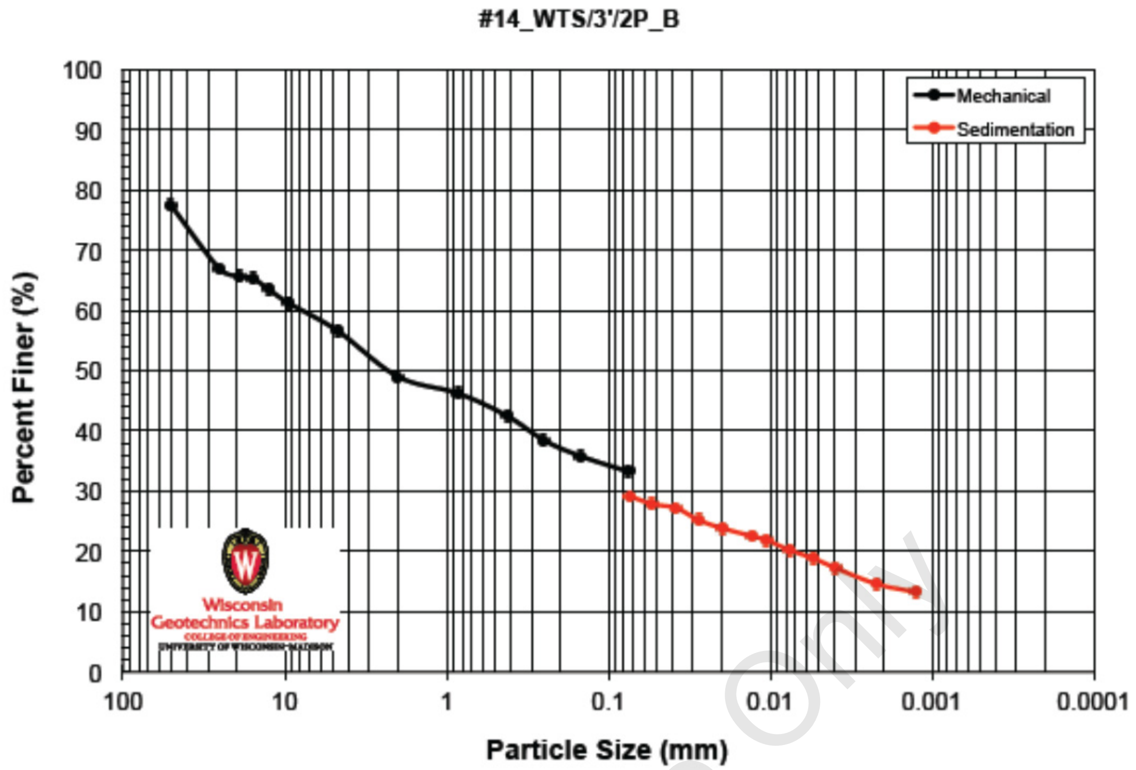
Sedimentation Particle Size Analysis - ASTM D 422

Sample ID:	#14_WTS/3'/2P_B	Temp. Correction, A	0.0129
Specific Gravity, G_s =	2.65	Hydrometer Type:	ASTM 152H
Dry Weight of Soil, W (g) =	50	Temperature of Test, C	23
Meniscus Correction, F_m =	0.5	Zero Correction, F_z	6
Temperature Correction, F_T =	0.9	a	1.000
Material Max. Size and Percentage (%)	P200 33.23		

Time (min)	Hydrometer Reading, R	R_{cp}	R_{cl}	L (cm)	D (mm)	Final Percent Finer (%)	Percent Finer
0.0	0				0.425	33.23	
0.2	49	43.90	74.90	8.27	0.0740	29.18	87.81
0.5	47	41.90	72.90	8.60	0.0534	27.85	83.81
1.0	46	40.90	71.90	8.76	0.0381	27.19	81.81
2.0	43	37.90	68.90	9.25	0.0277	25.19	75.81
4.0	41	35.90	66.90	9.58	0.0199	23.86	71.81
9.7	39	33.90	64.90	9.90	0.0130	22.53	67.81
15.0	38	32.90	63.90	10.07	0.0105	21.87	65.81
30.0	35.5	30.40	61.40	10.48	0.0076	20.21	60.81
60.0	33.5	28.40	59.40	10.80	0.0055	18.88	56.81
120.0	31	25.90	56.90	11.21	0.0039	17.22	51.81
408.0	27	21.90	52.90	11.87	0.0022	14.56	43.80
1266.0	25	19.90	50.90	12.19	0.0013	13.23	39.80


#14_WTS/3'/2P_B
Mechanical
Sedimentation
Percent Finer (%)
Particle Size (mm)
100
90
80
70
60
50
40
30
20
10
0
100
10
1
0.1
0.01
0.001
0.0001
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Mechanical Particle Size Analysis - ASTM D 422

Sample ID:	#15_POS/3'/2P_A			Test Date:	8/28/12
Weight of Air Dry Sample =		5850	g	Initials:	

Sieve No.	Sieve Opening	Weight Retained on Each Sieve	Percent Retained on Each Sieve	Cumulative Percent Retained	Percent Finer
	(mm)	(g)	(%)	(%)	(%)
4.5	114	1067.77	18.25	18.25	81.75
3	76.2	525.26	8.98	27.23	72.77
2"	50.8	0.00	0.00	27.23	72.77
1"	25.4	1004.78	17.18	44.41	56
3/4"	19.0	141.45	2.42	46.83	53.17
5/8:	15.9	78.81	1.35	48.18	51.82
1/2"	12.7	118.71	2.03	50.20	49.80
3/8"	9.52	189.20	3.23	53.44	46.56
4	4.75	286.09	4.89	58.33	41.67
10	2.00	408.83	6.99	65.32	34.68
20	0.85	122.81	2.10	67.42	32.58
40	0.425	180.09	3.08	70.50	29.50
60	0.250	208.30	3.56	74.06	25.94
100	0.150	116.80	2.00	76.05	23.95
200	0.075	107.84	1.84	77.90	22.10
Sieve Pan		17.88	0.31	78.20	21.80
Wet Sieve P_{200}		1275.00	21.80		
	R_{200}	4556.74			
	P_{200}	1292.88			
	Total Weight (g) =	5850			

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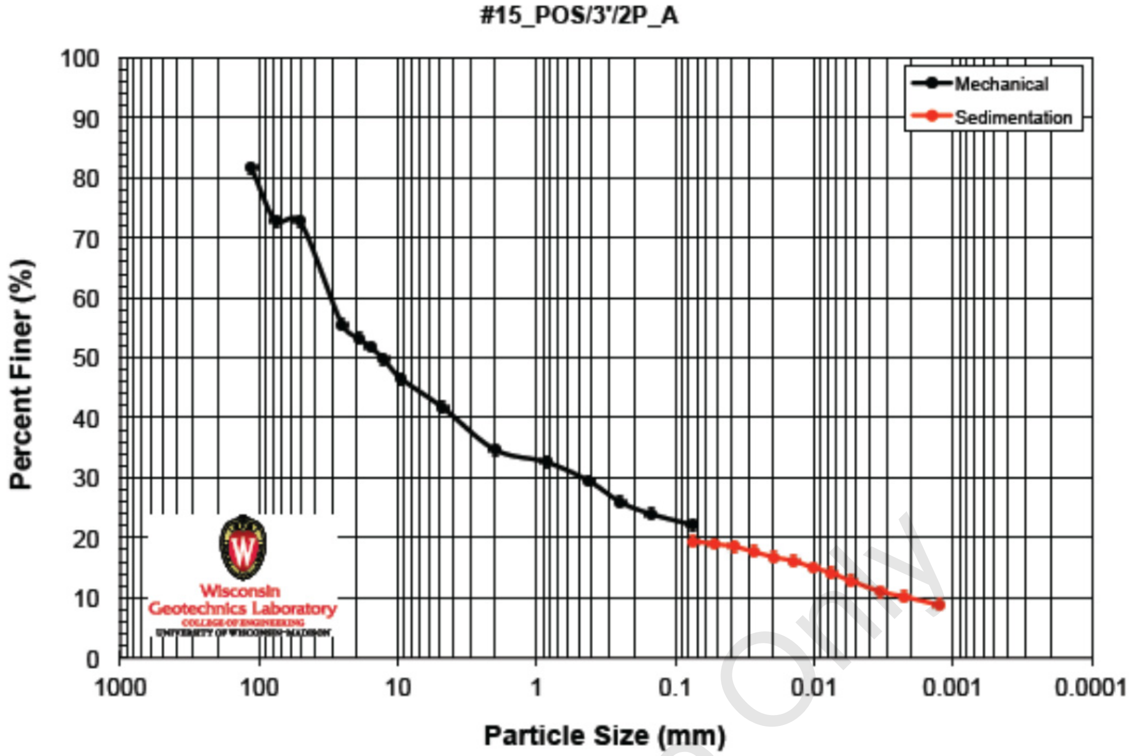
Sedimentation Particle Size Analysis - ASTM D 422

Sample ID:	#15_POS/3'/2P_A
Specific Gravity, G_s =	2.65
Dry Weight of Soil, W (g) =	50
Meniscus Correction, F_m =	0.5
Temperature Correction, F_T =	0.9
Material Max. Size and Percentage (%)	P200 22.10

Temp. Correction, A	0.0129
Hydrometer Type:	ASTM 152H
Temperature of Test, C	23
Zero Correction, F_z	6
a	1.000

Time (min)	Hydrometer Reading, R	R_{cp}	R_{cl}	L (cm)	D (mm)	Final Percent Finer (%)	Percent Finer
0.0	0				0.425	22.10	
0.2	49	43.90	73.90	8.27	0.0740	19.41	87.81
0.5	48	42.90	72.90	8.43	0.0529	18.97	85.81
1.0	47	41.90	71.90	8.60	0.0377	18.52	83.81
2.0	45	39.90	69.90	8.92	0.0272	17.64	79.81
4.0	43	37.90	67.90	9.25	0.0196	16.75	75.81
8.0	41.5	36.40	66.40	9.50	0.0140	16.09	72.81
16.0	39	33.90	63.90	9.90	0.0101	14.99	67.81
30.0	37	31.90	61.90	10.23	0.0075	14.10	63.81
60.0	34	28.90	58.90	10.72	0.0054	12.78	57.81
172.0	30	24.90	54.90	11.38	0.0033	11.01	49.80
390.0	28	22.90	52.90	11.70	0.0022	10.12	45.80
1248.0	25	19.90	49.90	12.19	0.0013	8.80	39.80


#15_POS/3'/2P_A
Mechanical
Sedimentation
Percent Finer (%)
100
90
80
70
60
50
40
30
20
10
0
1000
100
10
1
0.1
0.01
0.001
0.0001
Particle Size (mm)
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Mechanical Particle Size Analysis - ASTM D 422

Sample ID:	#16_POS/3'/2P_B			Test Date:	8/28/12
Weight of Air Dry Sample =		7062	g	Initials:	

Sieve No.	Sieve Opening	Weight Retained on Each Sieve	Percent Retained on Each Sieve	Cumulative Percent Retained	Percent Finer
	(mm)	(g)	(%)	(%)	(%)
5.5	140	2905.3	41.14	41.14	58.86
2"	50.8	222.24	3.15	44.29	55.71
1"	25.4	328.11	4.65	48.93	51
3/4"	19.0	74.82	1.06	49.99	50.01
5/8:	15.9	44.04	0.62	50.62	49.38
1/2"	12.7	66.45	0.94	51.56	48.44
3/8"	9.52	105.43	1.49	53.05	46.95
4	4.75	165.28	2.34	55.39	44.61
10	2.00	271.61	3.85	59.24	40.76
20	0.85	120.50	1.71	60.94	39.06
40	0.425	144.87	2.05	62.99	37.01
60	0.250	158.56	2.25	65.24	34.76
100	0.150	123.31	1.75	66.99	33.01
200	0.075	141.28	2.00	68.99	31.01
Sieve Pan		15.14	0.21	69.20	30.80
Wet Sieve P_{200}		2175.06	30.80		
	R_{200}	4871.80			
	P_{200}	2190.20			
	Total Weight (g) =	**7062**			

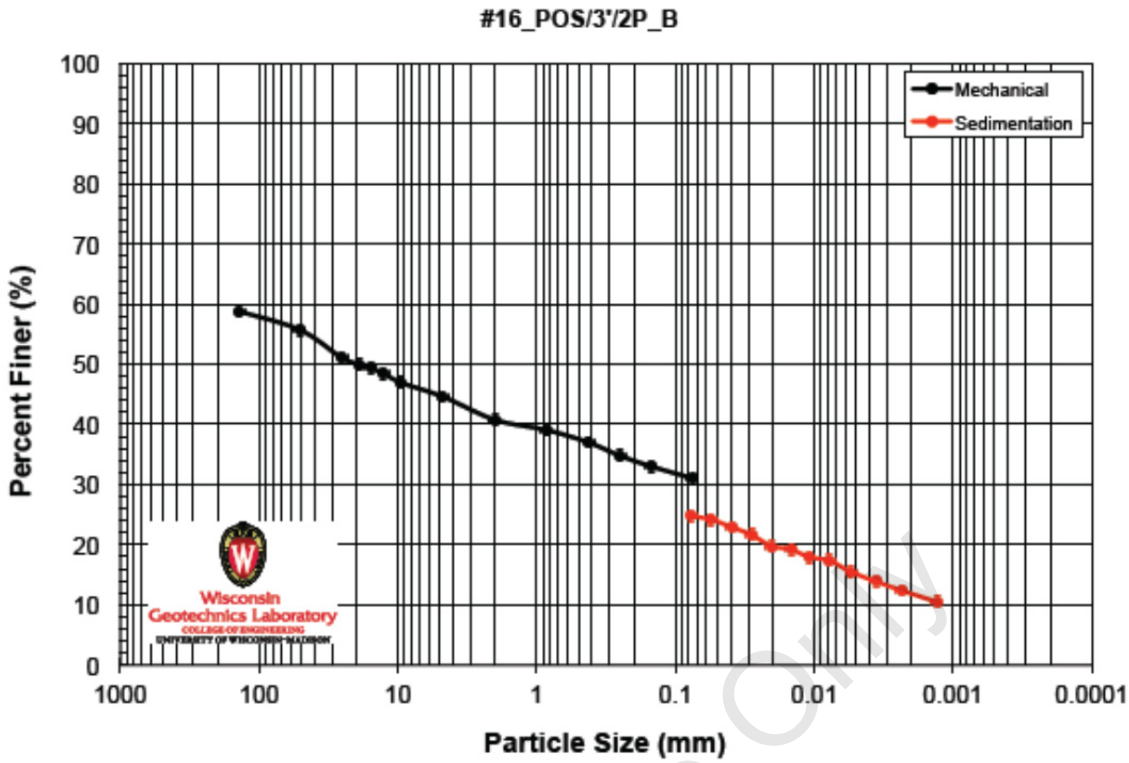
Wisconsin Geotechnics Laboratory

Sedimentation Particle Size Analysis - ASTM D 422

Sample ID:	#16_POS/3'/2P_B
Specific Gravity, G_s =	2.65
Dry Weight of Soil, W (g) =	50
Meniscus Correction, F_m =	0.5
Temperature Correction, F_T =	0.9
Material Max. Size and Percentage (%)	P200 / 31.01

Temp. Correction, A	0.0129
Hydrometer Type:	ASTM 152H
Temperature of Test, C	23
Zero Correction, F_z	6
a	1.000

Time (min)	Hydrometer Reading, R	R_{cp}	R_{cl}	L (cm)	D (mm)	Final Percent Finer (%)	Percent Finer
0.0	0				0.425	31.01	
0.2	45	39.90	67.40	8.92	0.0769	24.75	79.81
0.5	44	38.90	66.40	9.09	0.0549	24.13	77.81
1.0	42	36.90	64.40	9.41	0.0395	22.89	73.81
2.0	40	34.90	62.40	9.74	0.0284	21.65	69.81
4.0	37	31.90	59.40	10.23	0.0206	19.79	63.81
8.0	36	30.90	58.40	10.40	0.0147	19.17	61.81
15.0	34	28.90	56.40	10.72	0.0109	17.93	57.81
30.0	33	27.90	55.40	10.89	0.0078	17.31	55.81
64.0	30	24.90	52.40	11.38	0.0054	15.45	49.80
149.0	27.5	22.40	49.90	11.79	0.0036	13.90	44.80
368.0	25	19.90	47.40	12.19	0.0023	12.34	39.80
1226.0	22	16.90	44.40	12.69	0.0013	10.48	33.80


#16_POS/3'/2P_B
Percent Finer (%)
100
90
80
70
60
50
40
30
20
10
0
1000
100
10
1
0.1
0.01
0.001
0.0001
Particle Size (mm)
Mechanical
Sedimentation
Wisconsin
Geotechnics Laboratory
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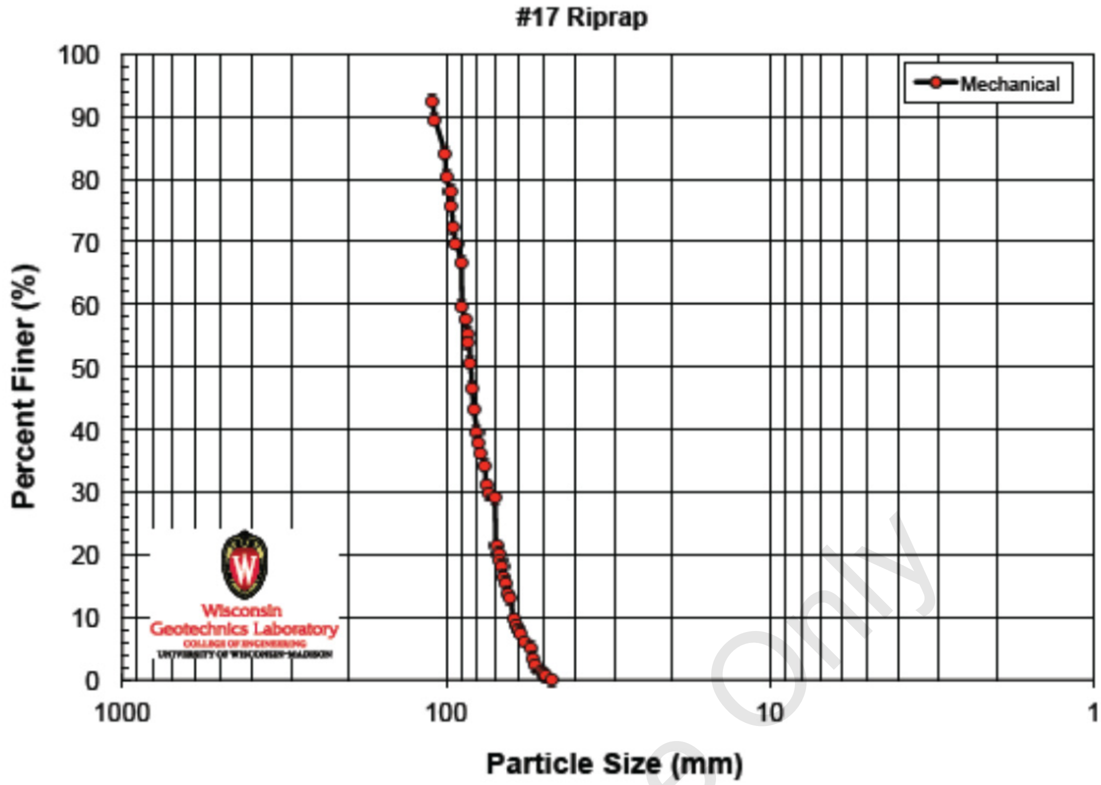
Wisconsin Geotechnics Laboratory

Mechanical Particle Size Analysis - ASTM D 422

Sample ID:	#17_RipRap			Test Date:	8/7/12
Weight of Air Dry Sample =		27154	g	Initials:	

Measured Grain Size	Measured Weight at this size	Percentage at this size	Cumulative Percent Retained	Percent Finer
(mm)	(g)	(%)	(%)	(%)
110.0	2042.00	7.52	7.52	92.48
108.0	799.00	2.94	10.46	90
101.0	1442.50	5.31	15.77	84.23
100.0	1024.00	3.77	19.55	80.45
97.00	650.80	2.40	21.94	78.06
96.0	615.50	2.27	24.21	75.79
95.0	956.00	3.52	27.73	72.27
93.0	705.80	2.60	30.33	69.67
90.0	791.00	2.91	33.24	66.76
89.0	1902.10	7.00	40.25	59.75
87.0	614.50	2.26	42.51	57.49
86.0	556.00	2.05	44.56	55.44
85.0	427.60	1.57	46.13	53.87
84.0	846.90	3.12	49.25	50.75
83.0	1119.00	4.12	53.37	46.63
82.0	923.50	3.40	56.77	43.23
80.0	986.00	3.63	60.40	39.60
79.0	448.30	1.65	62.06	37.94
78.0	485.50	1.79	63.84	36.16
76.0	508.00	1.87	65.71	34.29
75.0	884.70	3.26	68.97	31.03
74.0	332.30	1.22	70.20	29.80
71.0	204.60	0.75	70.95	29.05
70.0	2047.90	7.54	78.49	21.51
69.0	351.30	1.29	79.78	20.22
68.0	331.90	1.22	81.01	18.99
67.0	181.10	0.67	81.67	18.33
66.0	472.00	1.74	83.41	16.59
65.0	286.00	1.05	84.47	15.53
64.0	438.80	1.62	86.08	13.92
63.0	252.20	0.93	87.01	12.99
62.0	911.40	3.36	90.37	9.63
61.0	239.00	0.88	91.25	8.75
60.0	177.40	0.65	91.90	8.10
59.0	149.90	0.55	92.45	7.55
57.0	393.10	1.45	93.90	6.10
55.0	240.30	0.88	94.78	5.22
54.0	458.30	1.69	96.47	3.53
53.0	330.20	1.22	97.69	2.31
51.0	269.00	0.99	98.68	1.32
50.0	103.80	0.38	99.06	0.94
49.0	89.60	0.33	99.39	0.61
47.0	165.30	0.61	100.00	0.00
Total Weight (g)		27154.10		



#17 Riprap
Mechanical
Percent Finer (%)
Particle Size (mm)
100
90
80
70
60
50
40
30
20
10
0
1000
100
10
1
Wisconsin
Geotechnics Laboratory

Appendix C

Soil Sampling Locations

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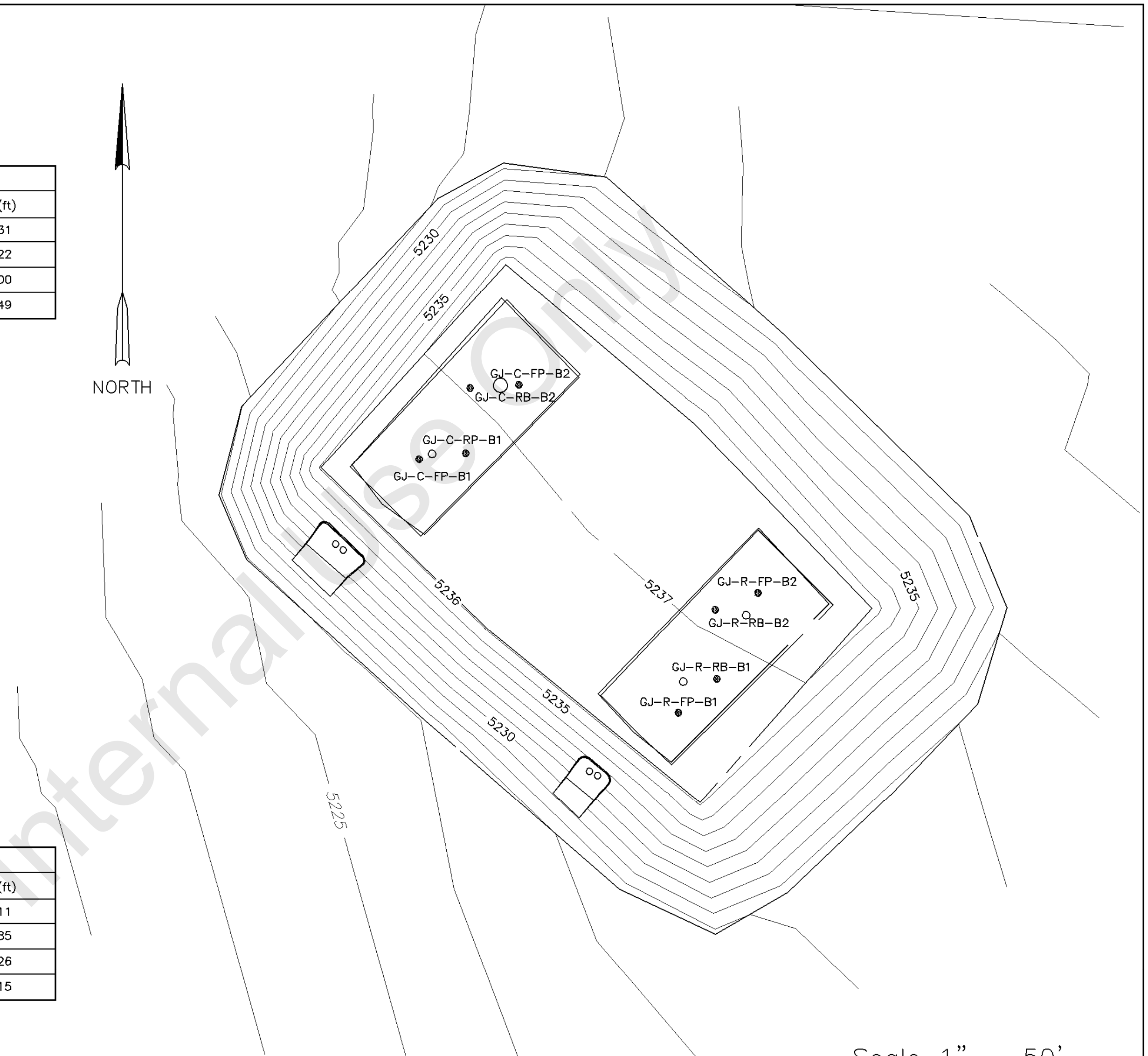
Soil Block Sample Locations		
Number	Northing (ft)	Easting (ft)
GJ–C–FP–B2	12,947.94	92,266.31
GJ–C–RB–B2	12,947.01	92,252.22
GJ–C–RP–B1	12,928.24	92,251.00
GJ–C–FP–B1	12,926.46	92,237.49



Soil Block Sample Locations		
Number	Northing (ft)	Easting (ft)
GJ–R–FP–B2	12,887.88	92,335.11
GJ–R–RB–B2	12,883.01	92,322.85
GJ–R–RP–B1	12,863.03	92,323.26
GJ–R–FP–B1	12,853.31	92,312.15

M:\LTS\111\0029\19\001\S09773\S0977300.DWG 02/05/13 11:05am j50191

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Appendix D

Data from Saturated Hydraulic Conductivity Tests

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Constant Head—Rigid Wall Hydraulic Conductivity Test On Sandy Soil					
Sample I.D.		GJ-C-DL-G1, G2		Test Date	2/20/2008
Sample Diameter, D =		14	inch		
Sample Length, L =		7.5	inch		
Sample Area, A =		993.15	cm^2		
Sample Volume, V =		0.668	ft^3		
Dry WT of Material, WT =		83.3	lb		
Dry Density, γ_d =		124.7	pcf		
Head Lost, ΔH =		7.5	inch		
Hydraulic Gradient, i =		1			
Stand Pipe Area, a =		281.1	cm^2		
Time	**Reading**	**ΔT**	**V**	**Elapsed Time**	**Hydraulic Conductivity**
(mm:ss)	**(cm)**	**(sec)**	**(cm^3)**	**(sec)**	**(cm/sec)**
0:00:00	0	0		0	
0:00:18	10	18	2811	18	1.57×10^{-1}
0:00:37	20	19	2811	37	1.49×10^{-1}
0:00:55	30	18	2811	55	1.57×10^{-1}
0:01:14	40	19	2811	74	1.49×10^{-1}
0:01:32	50	18	2811	92	1.57×10^{-1}
0:01:51	60	19	2811	111	1.49×10^{-1}
0:02:09	70	18	2811	129	1.57×10^{-1}
0:02:29	80	20	2811	149	1.42×10^{-1}
0:02:47	90	18	2811	167	1.57×10^{-1}
0:03:05	100	18	2811	185	1.57×10^{-1}
				Last 4 Average:	1.53E-01

Constant Head—Rigid Wall Hydraulic Conductivity Test On Sandy Soil					
Sample I.D.		GJ-R-DL-G1, G2		Test Date	2/21/2008
Sample Diameter, D =		14	inch		
Sample Length, L =		7.5	inch		
Sample Area, A =		993.15	cm^2		
Sample Volume, V =		0.668	ft^3		
Dry WT of Material, WT =		83.3	lb		
Dry Density, γ_d =		124.7	pcf		
Head Lost, ΔH =		7.5	inch		
Hydraulic Gradient, i =		1			
Stand Pipe Area, a =		281.1	cm^2		
Time	**Reading**	**ΔT**	**V**	**Elapsed Time**	**Hydraulic Conductivity**
(mm:ss)	**(cm)**	**(sec)**	**(cm^3)**	**(sec)**	**(cm/sec)**
0:00:00	0	0		0	
0:00:21	10	21	2811	21	1.35×10^{-1}
0:00:40	20	19	2811	40	1.49×10^{-1}
0:01:00	30	20	2811	60	1.42×10^{-1}
0:01:18	40	18	2811	78	1.57×10^{-1}
0:01:36	50	18	2811	96	1.57×10^{-1}
0:01:56	60	20	2811	116	1.42×10^{-1}
0:02:16	70	20	2811	136	1.42×10^{-1}
0:02:34	80	18	2811	154	1.57×10^{-1}
0:02:53	90	19	2811	173	1.49×10^{-1}
0:03:13	100	20	2811	193	1.42×10^{-1}
				Last 4 Average:	1.47E-01

Constant Head—Rigid Wall Hydraulic Conductivity Test On Sandy Soil					
	Sample I.D.	GJ-C-L1-G1, G2		Test Date	2/22/2008
	Sample Diameter, D =	14	inch		
	Sample Length, L =	7.5	inch		
	Sample Area, A =	993.15	cm^2		
	Sample Volume, V =	0.668	ft^3		
	Dry WT of Material, WT =	83.3	lb		
	Dry Density, γ_d =	124.7	pcf		
	Head Lost, ΔH =	7.5	inch		
	Hydraulic Gradient, i =	1			
	Stand Pipe Area, a =	281.1	cm^2		
Time	**Reading**	**ΔT**	**V**	**Elapsed Time**	**Hydraulic Conductivity**
(mm:ss)	**(cm)**	**(sec)**	**(cm^3)**	**(sec)**	**(cm/sec)**
0:00:00	0	0		0	
0:00:33	10	33	2811	33	8.58×10^{-2}
0:01:01	20	28	2811	61	1.01×10^{-1}
0:01:29	30	28	2811	89	1.01×10^{-1}
0:01:55	40	26	2811	115	1.09×10^{-1}
0:02:21	50	26	2811	141	1.09×10^{-1}
0:02:46	60	25	2811	166	1.13×10^{-1}
0:03:12	70	26	2811	192	1.09×10^{-1}
0:03:36	80	24	2811	216	1.18×10^{-1}
0:04:01	90	25	2811	241	1.13×10^{-1}
0:04:27	100	26	2811	267	1.09×10^{-1}
				Last 4 Average:	1.12E-01

Constant Head—Rigid Wall Hydraulic Conductivity Test On Sandy Soil					
	Sample I.D.	GJ-R-L1-G1, G2		Test Date	2/25/2008
	Sample Diameter, D =	14	inch		
	Sample Length, L =	7.5	inch		
	Sample Area, A =	993.15	cm^2		
	Sample Volume, V =	0.668	ft^3		
	Dry WT of Material, WT =	83.3	lb		
	Dry Density, γ_d =	124.7	pcf		
	Head Lost, ΔH =	7.5	inch		
	Hydraulic Gradient, i =	1			
	Stand Pipe Area, a =	281.1	cm^2		
Time	**Reading**	**ΔT**	**V**	**Elapsed Time**	**Hydraulic Conductivity**
(mm:ss)	**(cm)**	**(sec)**	**(cm^3)**	**(sec)**	**(cm/sec)**
0:00:00	0	0		0	
0:00:30	10	30	2811	30	9.43×10^{-2}
0:00:57	20	27	2811	57	1.05×10^{-1}
0:01:23	30	26	2811	83	1.09×10^{-1}
0:01:47	40	24	2811	107	1.18×10^{-1}
0:02:11	50	24	2811	131	1.18×10^{-1}
0:02:33	60	22	2811	153	1.29×10^{-1}
0:02:55	70	22	2811	175	1.29×10^{-1}
0:03:16	80	21	2811	196	1.35×10^{-1}
0:03:36	90	20	2811	216	1.42×10^{-1}
0:03:56	100	20	2811	236	1.42×10^{-1}
				Last 4 Average:	1.37E-01

Hydraulic Conductivity Test

ASTM D 5084 - 00

Sample I.D.	**R-FP-B1**			**Test Date :**	**1/25/08**		
Cell Pressure =	56.1	psi	Diameter of Sample, D =	30.5	cm		
Inflow Pressure =	52.2	psi	Length of Sample, L =	15.2	cm		
Outflow Pressre =	50.0	psi	Area of Sample, A =	729.66	cm^2		
Pressure Difference =	2.2	psi	Sample Volume, V =	11120.0	cm^3		
Effective Stress =	5.0	psi	a_{in} =	1	cm^2		
Hydraulic Gradient, i =	10.2		a_{out} =	1	cm^2		
Weight of wet sample =	21999.6	(g)	Sample Water Content =	19.4	(%)		
Wet Density =	2.0	g/cm^3	Dry Density =	1.66	g/cm^3	103.5	

$$K_s = \frac{a_{in} * a_{out}}{(a_{in} + a_{out})} \frac{L}{A * \Delta t} Ln\left\{\frac{(\Delta H_1)}{(\Delta H_2)}\right\}$$

Can #	WT of Can	WT of Can + Wet Soil	WT of Can + Dry Soil	Water Content
	(g)	(g)	(g)	(%)
874	35.08	305.27	261.39	19.39

Date, Time	Inflow	OutFlow	Δt	H	Time	K	Q_{out} / Q_{in}	Q_{in}	Q_{out}
			(sec)	(cm)	(min)	(cm/sec)			
0:00:00	0.7	21.6	0.0	20.9	0.0				
0:01:13	10.0	17.6	73.0	7.6	1.2	1.13E-05	0.4	9.3	4
0:03:23	15.0	13.0	130.0	-2.0	3.4	4.90E-06	0.9	5	4.6
0:05:49	20.0	8.2	146.0	-11.8	5.8	4.74E-06	1.0	5	4.8
0:08:28	24.5	3.8	159.0	-20.7	8.5	4.22E-06	1.0	4.5	4.4
0:00:00	0.0	24.2	0.0	24.2	8.5				
0:01:19	5.0	19.5	79.0	14.5	9.8	7.37E-06	0.9	5	4.7
0:06:41	15.0	9.4	322.0	-5.6	15.2	4.10E-06	1.0	10	10.1
0:09:59	20.0	4.2	198.0	-15.8	18.5	3.74E-06	1.0	5	5.2
0:12:47	24.0	0.5	168.0	-23.5	21.3	3.54E-06	0.9	4	3.7
0:00:00	0.0	24.3	0.0	24.3	21.3				
0:01:45	5.0	18.7	105.0	13.7	23.0	6.07E-06	1.1	5	5.6
0:05:12	11.0	12.8	207.0	1.8	26.5	3.70E-06	1.0	6	5.9
0:08:20	16.0	7.8	188.0	-8.2	29.6	3.67E-06	1.0	5	5
0:12:37	22.0	1.8	257.0	-20.2	33.9	3.47E-06	1.0	6	6
0:00:00	0.0	24.5	0.0	24.5	33.9				
0:01:57	5.0	19.3	117.0	14.3	35.8	5.23E-06	1.0	5	5.2
0:04:55	10.0	14.0	178.0	4.0	38.8	3.69E-06	1.1	5	5.3
0:08:11	15.0	9.0	196.0	-6.0	42.1	3.47E-06	1.0	5	5
0:11:00	19.0	5.0	169.0	-14.0	44.9	3.42E-06	1.0	4	4
0:15:16	24.5	0.0	256.0	-24.5	49.1	3.16E-06	0.9	5.5	5
0:00:00	0.0	24.5	0.0	24.5	49.1				
0:01:56	5.0	19.5	116.0	14.5	51.1	5.17E-06	1.0	5	5
0:05:05	10.0	14.0	189.0	4.0	54.2	3.54E-06	1.1	5	5.5
0:08:26	15.0	9.0	201.0	-6.0	57.6	3.38E-06	1.0	5	5
0:12:08	20.0	4.0	222.0	-16.0	61.3	3.27E-06	1.0	5	5
0:15:31	24.0	0.0	203.0	-24.0	64.7	3.06E-06	1.0	4	4
0:00:00	0.0	24.5	0.0	24.5	64.7				
0:05:18	10.0	14.5	318.0	4.5	70.0	3.89E-06	1.0	10	10
0:10:59	18.0	6.5	341.0	-11.5	75.6	3.24E-06	1.0	8	8
0:16:37	25.0	-0.5	338.0	-25.5	81.3	3.18E-06	1.0	7	7
0:00:00	0.0	24.5	0.0	24.5	81.3				
0:05:03	10.0	14.0	303.0	4.0	86.3	4.19E-06	1.1	10	10.5
0:11:14	19.0	5.0	371.0	-14.0	92.5	3.39E-06	1.0	9	9
0:15:19	24.0	0.0	245.0	-24.0	96.6	3.14E-06	1.0	5	5
0:00:00	1.0	21.5	0.0	20.5	96.6				
0:02:06	5.0	16.5	126.0	11.5	98.7	4.37E-06	1.3	4	5
0:05:09	10.0	11.3	183.0	1.3	101.7	3.61E-06	1.0	5	5.2
0:07:34	14.0	7.3	145.0	-6.7	104.2	3.79E-06	1.0	4	4
0:10:14	18.0	3.3	160.0	-14.7	106.8	3.63E-06	1.0	4	4
0:12:26	21.0	0.3	132.0	-20.7	109.0	3.46E-06	1.0	3	3
				Last 4 Average:		**3.77E-06**			

Hydraulic Conductivity Test

ASTM D 5084 - 00

Sample I.D.	R-FP-B2		Test Date :	1/25/08	
Cell Pressure =	56.1	psi	Diameter of Sample, D =	30.5	cm
Inflow Pressure =	52.2	psi	Length of Sample, L =	15.2	cm
Outflow Pressre =	50.0	psi	Area of Sample, A =	729.66	cm^2
Pressure Difference =	2.2	psi	Sample Volume, V =	11120.0	cm^3
Effective Stress =	5.0	psi	a_{in} =	1	cm^2
Hydraulic Gradient, i =	10.2		a_{out} =	1	cm^2
Weight of wet sample =	23650.7	(g)	Sample Water Content =	15.1	(%)
Wet Density =	2.1	g/cm^3	Dry Density =	1.85	g/cm^3 115.5

$$K_s = \frac{a_{in} * a_{out}}{(a_{in} + a_{out})} \frac{L}{A * \Delta t} Ln\left\{\frac{(\Delta H_1)}{(\Delta H_2)}\right\}$$

Can #	WT of Can	WT of Can + Wet Soil	WT of Can + Dry Soil	Water Content
	(g)	(g)	(g)	(%)
5	50.44	330.11	293.5	15.08

Time	Inflow	OutFlow	Δt (sec)	H (cm)	Time (min)	K (cm/sec)	Q_{out} / Q_{in}	Q_{in}	Q_{out}
14:23:19	0.0	23.4	0.0	23.4	0.0				
15:30:00	1.8	19.9	4001.0	18.1	1.1	7.88E-08	1.9	1.8	3.5
16:52:00	2.9	19.0	4920.0	16.1	2.5	2.47E-08	0.8	1.1	0.9
8:41:00	2.7	20.8	0.0	18.1	2.5				
9:42:00	3.1	19.5	3660.0	16.4	3.5	2.82E-08	3.3	0.4	1.3
11:52:00	4.4	19.4	7800.0	15.0	5.7	1.10E-08	0.1	1.3	0.1
16:25:00	8.4	19.0	16380.0	10.6	10.2	1.67E-08	0.1	4	0.4
9:01:00	17.4	11.0	59760.0	-6.4	26.8	1.90E-08	0.9	9	8
13:13:00	19.5	9.3	15120.0	-10.2	31.0	1.79E-08	0.8	2.1	1.7
14:22:00	20.0	8.9	4140.0	-11.1	32.2	1.58E-08	0.8	0.5	0.4
16:01:00	20.8	8.4	5940.0	-12.4	33.8	1.60E-08	0.6	0.8	0.5
16:01:00	4.0	22.3	0.0	18.3	33.8				
8:11:00	22.2	4.1	231000.0	-18.1	98.0	1.07E-08	1.0	18.2	18.2
8:11:00	0.4	23.6	0.0	23.2	98.0				
13:41:00	6.4	20.8	19800.0	14.4	103.5	2.68E-08	0.5	6	2.8
8:32:00	14.0	16.4	67860.0	2.4	122.3	1.13E-08	0.6	7.6	4.4
12:43:00	15.6	15.5	15060.0	-0.1	126.5	1.11E-08	0.6	1.6	0.9
11:18:00	22.7	11.0	81300.0	-11.7	149.1	1.00E-08	0.6	7.1	4.5
11:18:00	0.4	23.4	0.0	23.0	149.1				
14:50:00	3.4	21.9	12720.0	18.5	152.6	2.11E-08	0.5	3	1.5
9:31:00	10.6	17.6	67260.0	7.0	171.3	1.07E-08	0.6	7.2	4.3
12:58:00	11.7	16.8	12420.0	5.1	174.8	9.94E-09	0.7	1.1	0.8
16:08:00	12.8	16.0	11400.0	3.2	177.9	1.10E-08	0.7	1.1	0.8
8:54:00	18.3	12.3	60360.0	-6.0	194.7	1.04E-08	0.7	5.5	3.7
12:01:00	19.2	11.6	11220.0	-7.6	197.8	1.01E-08	0.8	0.9	0.7
16:10:00	20.2	10.6	14940.0	-9.6	202.0	9.57E-09	1.0	1	1
16:30:00	0.5	23.0	0.0	22.5	202.0				
11:05:00	8.0	17.3	66900.0	9.3	220.5	1.21E-08	0.8	7.5	5.7
8:19:00	23.0	6.8	162840.0	-16.2	265.8	1.08E-08	0.7	15	10.5
8:19:00	0.5	22.0	0.0	21.5	265.8				
11:20:00	2.9	20.5	10860.0	17.6	268.8	2.15E-08	0.6	2.4	1.5
13:02:00	3.5	19.9	6120.0	16.4	270.5	1.19E-08	1.0	0.6	0.6
16:09:00	4.4	18.9	11220.0	14.5	273.6	1.04E-08	1.1	0.9	1
8:37:00	9.8	13.9	59280.0	4.1	290.1	1.12E-08	0.9	5.4	5
12:38:00	11.0	12.6	14460.0	1.6	294.1	1.15E-08	1.1	1.2	1.3
				Last 4 Average:		**1.33E-08**			

Hydraulic Conductivity Test

ASTM D 5084 - 00

Sample I.D.	GJ-C-FP-B1	Test Date :	2/11/08

Cell Pressure =	56.1	psi	Diameter of Sample, D =	30.5	cm	
Inflow Pressure =	52.2	psi	Length of Sample, L =	15.2	cm	
Outflow Pressre =	50.0	psi	Area of Sample, A =	729.66	cm^2	
Pressure Difference =	2.2	psi	Sample Volume, V =	11120.0	cm^3	
Effective Stress =	5.0	psi	a_{in} =	5	cm^2	
Hydraulic Gradient, i =	10.2		a_{out} =	5	cm^2	
Weight of wet sample =	21092.4	(g)	Sample Water Content =	22.4	(%)	
Wet Density =	1.9	g/cm^3	Dry Density =	1.55	g/cm^3	96.8

$$K_s = \frac{a_{in} * a_{out}}{\left(a_{in} + a_{out}\right)} \frac{L}{A * \Delta t} Ln\left\{\frac{\left(\Delta H_1\right)}{\left(\Delta H_2\right)}\right\}$$

Can #	WT of Can	WT of Can + Wet Soil	WT of Can + Dry Soil	Water Content
	(g)	(g)	(g)	(%)
	30.84	195.39	165	22.44

Time	Inflow	OutFlow	Δt (sec)	H (cm)	Time (min)	K (cm/sec)	Q_{out} / Q_{in}	Q_{in}	Q_{out}
0:00:00	0.3	24.1	0.0	23.8	0.0				
0:00:13	5.0	19.1	13.0	14.1	0.2	2.24E-04	1.1	24	25
0:00:29	10.0	14.1	16.0	4.1	0.5	1.99E-04	1.0	25	25
0:00:49	15.0	9.1	20.0	-5.9	0.8	1.70E-04	1.0	25	25
0:01:09	20.0	4.1	20.0	-15.9	1.2	1.82E-04	1.0	25	25
0:01:24	23.0	0.2	15.0	-22.8	1.4	1.77E-04	1.3	15	19.5
0:00:00	0.0	24.5	0.0	24.5	1.4				
0:00:14	5.0	19.5	14.0	14.5	1.6	2.14E-04	1.0	25	25
0:00:32	10.0	14.5	18.0	4.5	1.9	1.77E-04	1.0	25	25
0:00:51	15.0	9.5	19.0	-5.5	2.3	1.78E-04	1.0	25	25
0:01:12	20.0	4.5	21.0	-15.5	2.6	1.72E-04	1.0	25	25
0:01:27	23.0	1.5	15.0	-21.5	2.9	1.53E-04	1.0	15	15
0:00:00	0.0	24.5	0.0	24.5	2.9				
0:00:13	5.0	19.5	13.0	14.5	3.1	2.31E-04	1.0	25	25
0:00:31	10.0	14.5	18.0	4.5	3.4	1.77E-04	1.0	25	25
0:00:51	15.0	9.5	20.0	-5.5	3.7	1.69E-04	1.0	25	25
0:01:11	20.0	4.5	20.0	-15.5	4.0	1.81E-04	1.0	25	25
0:01:29	23.8	0.5	18.0	-23.3	4.3	1.67E-04	1.1	19	20
0:00:00	0.1	24.6	0.0	24.5	4.3				
0:00:14	5.0	19.6	14.0	14.6	4.6	2.12E-04	1.0	25	25
0:00:32	10.0	14.6	18.0	4.6	4.9	1.77E-04	1.0	25	25
0:00:51	15.0	9.6	19.0	-5.4	5.2	1.78E-04	1.0	25	25
0:01:12	20.0	4.6	21.0	-15.4	5.5	1.72E-04	1.0	25	25
0:01:29	23.8	0.2	17.0	-23.6	5.8	1.86E-04	1.2	19	22
0:00:00	0.0	24.0	0.0	24.0	5.8				
0:00:14	5.0	19.0	14.0	14.0	6.1	2.15E-04	1.0	25	25
0:00:33	10.0	14.0	19.0	4.0	6.4	1.68E-04	1.0	25	25
0:00:52	15.0	9.0	19.0	-6.0	6.7	1.79E-04	1.0	25	25
0:01:13	20.0	4.0	21.0	-16.0	7.0	1.73E-04	1.0	25	25
					Last 4 Average:	**1.84E-04**			

Hydraulic Conductivity Test

ASTM D 5084 - 00

Sample I.D.	GJ-C-FP-B2			Test Date :	3/5/08	
Cell Pressure =	56.1	psi	Diameter of Sample, D =	30.5	cm	
Inflow Pressure =	52.2	psi	Length of Sample, L =	15.2	cm	
Outflow Pressre =	50.0	psi	Area of Sample, A =	729.66	cm^2	
Pressure Difference =	2.2	psi	Sample Volume, V =	11120.0	cm^3	
Effective Stress =	5.0	psi	a_{in} =	5	cm^2	
Hydraulic Gradient, i =	10.2		a_{out} =	5	cm^2	
Weight of wet sample =	23042.9	(g)	Sample Water Content =	14.6	(%)	
Wet Density =	2.1	g/cm^3	Dry Density =	1.81	g/cm^3	113.0

$$K_s = \frac{a_{in} * a_{out}}{(a_{in} + a_{out})} \frac{L}{A * \Delta t} Ln\left\{\frac{(\Delta H_1)}{(\Delta H_2)}\right\}$$

Can #	WT of Can	WT of Can + Wet Soil	WT of Can + Dry Soil	Water Content
	(g)	(g)	(g)	(%)
X1	30.87	169.45	151.84	14.56

Time	Inflow	OutFlow	Δt (sec)	H (cm)	Time (min)	K (cm/sec)	Q_{out} / Q_{in}	Q_{in}	Q_{out}
10:26:00	0.5	23.2	0.0	22.7	0.0				
10:55:00	3.6	19.7	1740.0	16.1	29.0	1.14E-06	1.1	15.5	17.5
11:33:00	7.1	16.0	2280.0	8.9	67.0	9.86E-07	1.1	17.5	18.5
12:22:00	11.7	11.5	2940.0	-0.2	116.0	1.02E-06	1.0	23	22.5
13:07:00	15.4	7.7	2700.0	-7.7	161.0	9.62E-07	1.0	18.5	19
13:57:00	19.2	3.7	3000.0	-15.5	211.0	9.49E-07	1.1	19	20
14:37:00	22.0	0.9	2400.0	-21.1	251.0	8.93E-07	1.0	14	14
14:37:00	0.3	23.8	0.0	23.5	251.0				
15:50:00	6.6	16.6	4380.0	10.0	324.0	9.39E-07	1.1	31.5	36
16:46:00	11.1	12.0	3360.0	0.9	380.0	8.83E-07	1.0	22.5	23
8:42:00	0.8	23.6	0.0	22.8	380.0				
9:34:00	6.0	18.1	3120.0	12.1	432.0	1.04E-06	1.1	26	27.5
10:37:00	11.2	12.8	3780.0	1.6	495.0	8.98E-07	1.0	26	26.5
11:35:00	15.7	8.4	3480.0	-7.3	553.0	8.80E-07	1.0	22.5	22
13:29:00	23.0	1.0	6840.0	-22.0	667.0	8.02E-07	1.0	36.5	37
13:29:00	0.2	24.0	0.0	23.8	667.0				
14:33:00	5.1	18.2	3840.0	13.1	731.0	8.40E-07	1.2	24.5	29
16:28:00	13.7	9.6	6900.0	-4.1	846.0	8.18E-07	1.0	43	43
17:02:00	15.9	7.2	2040.0	-8.7	880.0	7.94E-07	1.1	11	12
7:54:00	0.5	24.0	0.0	23.5	880.0				
8:46:00	5.2	18.9	3120.0	13.7	932.0	9.47E-07	1.1	23.5	25.5
9:31:00	8.7	15.4	2700.0	6.7	977.0	8.21E-07	1.0	17.5	17.5
10:28:00	12.8	11.3	3420.0	-1.5	1034.0	7.96E-07	1.0	20.5	20.5
11:20:00	16.3	7.8	3120.0	-8.5	1086.0	7.83E-07	1.0	17.5	17.5
12:04:00	19.0	5.0	2640.0	-14.0	1130.0	7.58E-07	1.0	13.5	14
13:04:00	22.5	1.6	3600.0	-20.9	1190.0	7.29E-07	1.0	17.5	17
13:04:00	0.1	23.7	0.0	23.6	1190.0				
13:58:00	4.2	19.3	3240.0	15.1	1244.0	7.87E-07	1.1	20.5	22
16:14:00	13.0	10.1	8160.0	-2.9	1380.0	7.17E-07	1.0	44	46
17:06:00	16.1	7.0	3120.0	-9.1	1432.0	6.98E-07	1.0	15.5	15.5
8:48:00	0.7	24.0	0.0	23.3	1432.0				
9:53:00	5.8	18.6	3900.0	12.8	1497.0	8.14E-07	1.1	25.5	27
11:22:00	11.7	12.7	5340.0	1.0	1586.0	7.14E-07	1.0	29.5	29.5
				Last 4 Average:		**7.36E-07**			

Hydraulic Conductivity Test

ASTM D 5084 - 00

Sample I.D.	GJ-R-RB-B1			Test Date :	3/3/08		
Cell Pressure =	56.1	psi		Diameter of Sample, D =	30.5	cm	
Inflow Pressure =	52.2	psi		Length of Sample, L =	15.2	cm	
Outflow Pressre =	50.0	psi		Area of Sample, A =	729.66	cm^2	
Pressure Difference =	2.2	psi		Sample Volume, V =	11120.0	cm^3	
Effective Stress =	5.0	psi		a_{in} =	1	cm^2	
Hydraulic Gradient, i =	10.2			a_{out} =	1	cm^2	
Weight of wet sample =	22900.0	(g)		Sample Water Content =	19.0	(%)	
Wet Density =	2.1	g/cm^3		Dry Density =	1.73	g/cm^3	108.1

$$K_s = \frac{a_{in} * a_{out}}{(a_{in} + a_{out})} \frac{L}{A * \Delta t} Ln\left\{\frac{(\Delta H_1)}{(\Delta H_2)}\right\}$$

Can #	WT of Can	WT of Can + Wet Soil	WT of Can + Dry Soil	Water Content
	(g)	(g)	(g)	(%)
A3	50.37	380.37	327.7	19.00

Time	Inflow	OutFlow	Δt (sec)	H (cm)	Time (min)	K (cm/sec)	Q_{out} / Q_{in}	Q_{in}	Q_{out}
9:24:00	1.3	23.8	0.0	22.5	0.0				
11:30:00	4.1	22.1	7560.0	18.0	126.0	3.55E-08	0.6	2.8	1.7
14:38:00	5.3	21.0	11280.0	15.7	314.0	1.24E-08	0.9	1.2	1.1
16:45:00	6.1	20.2	7620.0	14.1	441.0	1.29E-08	1.0	0.8	0.8
8:40:00	10.8	16.1	57300.0	5.3	1396.0	9.76E-09	0.9	4.7	4.1
13:31:00	11.9	15.3	17460.0	3.4	1687.0	7.14E-09	0.7	1.1	0.8
17:08:00	12.8	14.6	13020.0	1.8	1904.0	8.16E-09	0.8	0.9	0.7
7:53:00	16.3	12.3	53100.0	-4.0	2789.0	7.43E-09	0.7	3.5	2.3
12:04:00	17.3	11.5	15060.0	-5.8	3040.0	8.33E-09	0.8	1	0.8
16:14:00	18.2	10.7	15000.0	-7.5	3290.0	7.99E-09	0.9	0.9	0.8
8:47:00	21.8	7.7	59580.0	-14.1	4283.0	8.04E-09	0.8	3.6	3
12:55:00	25.0	3.5	101280.0	-21.5	5971.0	5.57E-09	1.3	3.2	4.2
12:55:00	1.6	23.3	0.0	21.7	5971.0				
12:00:00	8.7	18.4	83100.0	9.7	7356.0	8.85E-09	0.7	7.1	4.9
9:36:00	13.7	14.6	77760.0	0.9	8652.0	7.39E-09	0.8	5	3.8
17:08:00	15.2	13.3	27120.0	-1.9	9104.0	6.99E-09	0.9	1.5	1.3
9:11:00	18.7	10.9	57780.0	-7.8	10067.0	7.12E-09	0.7	3.5	2.4
9:24:00	23.3	7.3	87180.0	-16.0	11520.0	6.88E-09	0.8	4.6	3.6
				Last 4 Average:		7.45E-09			

Hydraulic Conductivity Test

ASTM D 5084 - 00

Sample I.D.	GJ-R-RB-B2		Test Date :		
Cell Pressure =	56.1	psi	Diameter of Sample, D =	30.5	cm
Inflow Pressure =	52.2	psi	Length of Sample, L =	15.2	cm
Outflow Pressre =	50.0	psi	Area of Sample, A =	729.66	cm^2
Pressure Difference =	2.2	psi	Sample Volume, V =	11120.0	cm^3
Effective Stress =	5.0	psi	a_{in} =	1	cm^2
Hydraulic Gradient, i =	10.2		a_{out} =	1	cm^2
Weight of wet sample =	22276.3	(g)	Sample Water Content =	20.6	(%)
Wet Density =	2.0	g/cm^3	Dry Density =	1.66	g/cm^3 103.8

$$K_s = \frac{a_{in} * a_{out}}{(a_{in} + a_{out})} \frac{L}{A * \Delta t} Ln \left\{ \frac{(\Delta H_1)}{(\Delta H_2)} \right\}$$

Can #	WT of Can	WT of Can + Wet Soil	Can + Dry	Content
	(g)	(g)	(g)	(%)
NA	50.8	320.5	274.44	20.60

Time	Inflow	OutFlow	Δt (sec)	H (cm)	Time (min)	K (cm/sec)	Q_{out} / Q_{in}	Q_{in}	Q_{out}
13:57:00	1.5	23.5	0.0	22.0	0.0				
14:53:00	2.8	21.4	3360.0	18.6	56.0	6.04E-08	1.6	1.3	2.1
9:49:00	12.0	12.8	68160.0	0.8	1192.0	1.66E-08	0.9	9.2	8.6
17:02:00	13.2	8.4	25980.0	-4.8	1625.0	1.47E-08	3.7	1.2	4.4
8:07:00	17.9	3.8	54300.0	-14.1	2530.0	1.23E-08	1.0	4.7	4.6
14:59:00	19.7	2.1	24720.0	-17.6	2942.0	1.06E-08	0.9	1.8	1.7
14:59:00	0.9	23.1	0.0	22.2	2942.0				
9:19:00	7.2	16.4	66000.0	9.2	4042.0	1.21E-08	1.1	6.3	6.7
8:35:00	13.8	10.7	83760.0	-3.1	5438.0	9.72E-09	0.9	6.6	5.7
16:56:00	15.7	8.6	30060.0	-7.1	5939.0	9.29E-09	1.1	1.9	2.1
16:56:00	0.6	24.0	0.0	23.4	5939.0				
10:45:00	13.5	12.4	#######	-1.1	8448.0	1.03E-08	0.9	12.9	11.6
8:49:00	18.9	7.0	79440.0	-11.9	9772.0	9.58E-09	1.0	5.4	5.4
16:40:00	20.7	5.3	28260.0	-15.4	10243.0	9.17E-09	0.9	1.8	1.7
9:14:00	24.2	2.3	59640.0	-21.9	11237.0	8.37E-09	0.9	3.5	3
9:14:00	1.0	23.2	0.0	22.2	11237.0				
9:35:00	9.2	16.1	87660.0	6.9	12698.0	1.08E-08	0.9	8.2	7.1
16:42:00	11.2	14.2	25620.0	3.0	13125.0	9.96E-09	1.0	2	1.9
8:36:00	15.6	10.9	57240.0	-4.7	14079.0	9.13E-09	0.8	4.4	3.3
				Last 4 Average:		**9.56E-09**			

Hydraulic Conductivity Test

ASTM D 5084 - 00

Sample I.D.	GJ - C - RB - B1		Test Date :	3/28/08		
Cell Pressure =	56.1	psi	Diameter of Sample, D =	30.5	cm	
Inflow Pressure =	52.2	psi	Length of Sample, L =	15.2	cm	
Outflow Pressre =	50.0	psi	Area of Sample, A =	729.66	cm^2	
Pressure Difference =	2.2	psi	Sample Volume, V =	11120.0	cm^3	
Effective Stress =	5.0	psi	a_{in} =	1	cm^2	
Hydraulic Gradient, i =	10.2		a_{out} =	1	cm^2	
Veight of wet sample =	22317.1	(g)	Sample Water Content =	21.3	(%)	
Wet Density =	2.0	g/cm^3	Dry Density =	1.65	g/cm^3	103.3

$$K_s = \frac{a_{in} * a_{out}}{\left(a_{in} + a_{out}\right)} \frac{L}{A * \Delta t} Ln\left\{\frac{\left(\Delta H_1\right)}{\left(\Delta H_2\right)}\right\}$$

Can #	WT of Can	WT of Can + Wet Soil	Can + Dry Soil	Water Content
	(g)	(g)	(g)	(%)
H1	30.88	175.43	150.02	21.33

Time	Inflow	OutFlow	Δt (sec)	H (cm)	Time (min)	K (cm/sec)	Q_{out} / Q_{in}	Q_{in}	Q_{out}
8:43:00	1.0	24.4	0.0	23.4	0.0				
9:03:00	2.8	21.7	1200.0	18.9	20.0	2.23E-07	1.5	1.8	2.7
10:05:00	5.9	18.3	3720.0	12.4	82.0	1.07E-07	1.1	3.1	3.4
11:15:00	8.8	16.3	4200.0	7.5	152.0	7.40E-08	0.7	2.9	2
12:32:00	11.6	12.5	4620.0	0.9	229.0	9.39E-08	1.4	2.8	3.8
13:40:00	13.9	10.1	4080.0	-3.8	297.0	7.85E-08	1.0	2.3	2.4
15:18:00	16.9	7.0	5880.0	-9.9	395.0	7.33E-08	1.0	3	3.1
16:10:00	18.4	5.4	3120.0	-13.0	447.0	7.24E-08	1.1	1.5	1.6
8:20:00	1.5	23.8	0.0	22.3	447.0				
10:16:00	7.1	17.3	6960.0	10.2	563.0	1.06E-07	1.2	5.6	6.5
11:27:00	9.4	14.9	4260.0	5.5	634.0	7.09E-08	1.0	2.3	2.4
13:31:00	13.3	11.1	7440.0	-2.2	758.0	6.91E-08	1.0	3.9	3.8
15:08:00	16.0	8.3	5820.0	-7.7	855.0	6.59E-08	1.0	2.7	2.8
16:09:00	17.6	6.7	3660.0	-10.9	916.0	6.28E-08	1.0	1.6	1.6
17:00:00	18.8	5.4	3060.0	-13.4	967.0	5.98E-08	1.1	1.2	1.3
8:49:00	1.0	24.2	0.0	23.2	967.0				
9:44:00	4.1	20.3	3300.0	16.2	1022.0	1.27E-07	1.3	3.1	3.9
11:32:00	7.6	16.6	6480.0	9.0	1130.0	6.94E-08	1.1	3.5	3.7
12:17:00	8.9	15.2	2700.0	6.3	1175.0	6.43E-08	1.1	1.3	1.4
14:10:00	12.0	12.0	6780.0	0.0	1288.0	6.15E-08	1.0	3.1	3.2
15:21:00	13.7	10.1	4260.0	-3.6	1359.0	5.77E-08	1.1	1.7	1.9
				Last 4 Average:		6.32E-08			

Hydraulic Conductivity Test

ASTM D 5084 - 00

Sample I.D.	GJ-C-RB-B2		Test Date :	2/14/08	
Cell Pressure =	56.1	psi	Diameter of Sample, D =	30.5	cm
Inflow Pressure =	52.2	psi	Length of Sample, L =	15.2	cm
Outflow Pressre =	50.0	psi	Area of Sample, A =	729.66	cm^2
Pressure Difference =	2.2	psi	Sample Volume, V =	11120.0	cm^3
Effective Stress =	5.0	psi	a_{in} =	1	cm^2
Hydraulic Gradient, i =	10.2		a_{out} =	1	cm^2
Weight of wet sample =	22634.6	(g)	Sample Water Content =	21.7	(%)
Wet Density =	2.0	g/cm^3	Dry Density =	1.67	g/cm^3 104.5

$$K_s = \frac{a_{in} * a_{out}}{(a_{in} + a_{out})} \frac{L}{A * \Delta t} Ln\left\{\frac{(\Delta H_1)}{(\Delta H_2)}\right\}$$

Can #	WT of Can	WT of Can + Wet Soil	Can + Dry Soil	Water Content
	(g)	(g)	(g)	(%)
2	30.99	211.4	179.2	21.73

Time	Inflow	OutFlow	Δt (sec)	H (cm)	Time (min)	K (cm/sec)	Q_{out} / Q_{in}	Q_{in}	Q_{out}
13:55:00	2.0	22.8	0.0	20.8	0.0				
14:53:00	5.9	20.4	3480.0	14.5	58.0	1.10E-07	0.6	3.9	2.4
9:48:00	22.1	9.7	68100.0	-12.4	1193.0	2.65E-08	0.7	16.2	10.7
9:48:00	0.7	23.7	0.0	23.0	1193.0				
14:16:00	4.9	20.2	16080.0	15.3	1461.0	2.88E-08	0.8	4.2	3.5
17:02:00	6.7	18.4	9960.0	11.7	1627.0	2.24E-08	1.0	1.8	1.8
8:07:00	18.2	10.8	54300.0	-7.4	2532.0	2.34E-08	0.7	11.5	7.6
9:17:00	24.0	0.3	90600.0	-23.7	4042.0	1.35E-08	1.8	5.8	10.5
9:17:00	0.5	24.0	0.0	23.5	4042.0				
8:35:00	14.9	10.9	83880.0	-4.0	5440.0	2.09E-08	0.9	14.4	13.1
16:56:00	18.7	7.1	30060.0	-11.6	5941.0	1.80E-08	1.0	3.8	3.8
16:56:00	1.0	23.6	0.0	22.6	5941.0				
10:44:00	22.3	4.0	150480.0	-18.3	8449.0	1.82E-08	0.9	21.3	19.6
10:44:00	1.2	23.5	0.0	22.3	8449.0				
8:49:00	12.9	11.8	79500.0	-1.1	9774.0	1.86E-08	1.0	11.7	11.7
16:40:00	15.8	8.1	28260.0	-7.7	10245.0	1.62E-08	1.3	2.9	3.7
9:12:00	22.5	1.8	59520.0	-20.7	11237.0	1.62E-08	0.9	6.7	6.3
9:12:00	1.1	23.1	0.0	22.0	11237.0				
9:35:00	14.0	11.4	87780.0	-2.6	12700.0	1.78E-08	0.9	12.9	11.7
16:41:00	17.0	8.5	25560.0	-8.5	13126.0	1.62E-08	1.0	3	2.9
8:36:00	23.1	3.0	57300.0	-20.1	14081.0	1.51E-08	0.9	6.1	5.5
					Last 4 Average:	**1.63E-08**			

Appendix E

Data from Saturated SWCC Tests

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Pressure Plate Extractor Test

ASTM D 6836 - 02 (Method B)

Sample I.D.	GJ-C-FP-B1		Test Date	
WT of Sample Ring =	71.18	g		
WT of Sample Ring + Soil =	287.53	g		
Water Content =	22.4	%		
Diameter of Sample Ring, D =	2.86	in		
Height of Sample Ring, L =	1.0	in		
Volume, V =	3.72E-03	ft^3	105.3	cm^3
Dry Unit Weight =	104.82	pcf	1.68	Mg/m^3
Water WT =	39.59	g		
Solid WT =	176.76	g		
Add Water for saturation =	5.37	g	Sr	114.48
Saturated Water Content =	25.44	%		
Tube Area, A =	0.19	cm^2		

Applied Pressure	Reading	Water out from soil sample	Suction	Water Content	Volumetric Water Content
(psi)	(cm)	(cc)	(kPa)		
0	13.2	0.000	0.001	0.254	0.427
0.5	17.6	0.836	3.449	0.250	0.419
1	24.3	2.109	6.897	0.242	0.407
2	31	3.382	13.794	0.235	0.395
4	40.4	5.168	27.588	0.225	0.378
8	50.5	7.087	55.176	0.214	0.360
15	57.7	8.455	103.455	0.207	0.347
30	65	9.842	206.910	0.199	0.334
60	73.7	11.495	413.820	0.189	0.318
		-2.508	0.000	0.269	0.451
		Activity Meter Test	5950.00	0.093	0.156
			19800.00	0.059	0.099
			67200.00	0.037	0.062

Activity Meter Test

Suction	Wt of Can	Wt of Can + Wet Soil	Wt of Can + Dry Soil	Gravimetric Water Content	Volumetric Water Content
(Mpa)	(g)	(g)	(g)	(%)	(%)
67.2	7.6559	15.5037	15.2263	0.037	0.062
19.8	7.9814	15.6275	15.2019	0.059	0.099
5.95	7.3871	13.7838	13.2407	0.093	0.156

Pressure Plate Extractor Test

ASTM D 6836 - 02 (Method B)

Sample I.D.	GJ-C-FP-B2		Test Date	
WT of Sample Ring =	69.7	g		
WT of Sample Ring + Soil =	283.1	g		
Water Content =	20.5	%		
Diameter of Sample Ring, D =	2.86	in		
Height of Sample Ring, L =	1.0	in		
Volume, V =	3.72E-03	ft^3	105.3	cm^3
Dry Unit Weight =	105.02	pcf	1.68	Mg/m^3
Water WT =	36.30	g		
Solid WT =	177.10	g		
Add Water for saturation =	4.1	g	Sr	103.21
Saturated Water Content =	22.82	%		
Tube Area, A =	0.19	cm^2		

Applied Pressure (psi)	Reading (cm)	Water out from soil sample (cc)	Suction (kPa)	Water Content	Volumetric Water Content
0	17.6	0.000	0.001	0.228	0.384
0.5	24.5	1.311	3.449	0.221	0.372
1	30.3	2.413	6.897	0.215	0.361
2	40.1	4.275	13.794	0.204	0.343
4	49.2	6.004	27.588	0.194	0.327
8	58.5	7.771	55.176	0.184	0.310
15	69.2	9.804	103.455	0.173	0.291
30	80.6	11.970	206.910	0.161	0.270
60	92	14.136	413.820	0.148	0.250
		Activity Meter Test	10700.00	0.072	0.122
			21300.00	0.057	0.095
			54600.00	0.039	0.066

Activity Meter Test

Suction (Mpa)	Wt of Can (g)	Wt of Can + Wet Soil (g)	Wt of Can + Dry Soil (g)	Gravimetric Water Content (%)	Volumetric Water Content (%)
54.6	7.584	14.7081	14.4376	0.039	0.066
21.3	8.4801	15.0092	14.6593	0.057	0.095
10.7	7.7687	13.9971	13.5766	0.072	0.122

Pressure Plate Extractor Test

ASTM D 6836 - 02 (Method B)

Sample I.D.	GJ-C-RB-B1		Test Date	
WT of Sample Ring =	71.53	g		
WT of Sample Ring + Soil =	291.9	g		
Water Content =	21.3	%		
Diameter of Sample Ring, D =	2.86	in		
Height of Sample Ring, L =	1.0	in		
Volume, V =	3.72E-03	ft^3	105.3	cm^3
Dry Unit Weight =	107.73	pcf	1.73	Mg/m^3
Water WT =	38.70	g		
Solid WT =	181.67	g		
Add Water for saturation =	0.8	g	Sr	105.49
Saturated Water Content =	21.74	%		
Tube Area, A =	0.19	cm^2		

Applied Pressure (psi)	Reading (cm)	Water out from soil sample (cc)	Suction (kPa)	Water Content	Volumetric Water Content
0	16	0.000	0.001	0.217	0.375
0.5	18	0.380	3.449	0.215	0.372
1	19.1	0.589	6.897	0.214	0.370
2	23.1	1.349	13.794	0.210	0.363
4	28.7	2.413	27.588	0.204	0.352
8	37	3.990	55.176	0.195	0.337
15	41.1	4.769	103.455	0.191	0.330
30	51.5	6.745	206.910	0.180	0.311
60	67	9.690	413.820	0.164	0.283
		Activity Meter Test	5150.00	0.094	0.162
			18400.00	0.058	0.100
			47000.00	0.041	0.071

Activity Meter Test

Suction (Mpa)	Wt of Can (g)	Wt of Can + Wet Soil (g)	Wt of Can + Dry Soil (g)	Gravimetric Water Content (%)	Volumetric Water Content (%)
47	7.7181	15.1533	14.859	0.041	0.071
18.4	7.6415	14.2766	13.914	0.058	0.100
5.15	7.7967	14.2967	13.74	0.094	0.162

Pressure Plate Extractor Test

ASTM D 6836 - 02 (Method B)				
Sample I.D.	**GJ-C-RB-B2**		**Test Date**	
WT of Sample Ring =	71.34	g		
WT of Sample Ring + Soil =	289.26	g		
Water Content =	21.7	%		
Diameter of Sample Ring, D =	2.86	in		
Height of Sample Ring, L =	1.0	in		
Volume, V =	3.72E-03	ft^3	105.3	cm^3
Dry Unit Weight =	106.18	pcf	1.70	Mg/m^3
Water WT =	38.86	g		
Solid WT =	179.06	g		
Add Water for saturation =	4.04	g	Sr	111.67
Saturated Water Content =	23.96	%		
Tube Area, A =	0.19	cm^2		

Applied Pressure (psi)	Reading (cm)	Water out from soil sample (cc)	Suction (kPa)	Water Content	Volumetric Water Content
0	14.3	0.000	0.001	0.240	0.408
0.5	17	0.513	3.449	0.237	0.403
1	19.2	0.931	6.897	0.234	0.399
2	22	1.463	13.794	0.231	0.394
4	25	2.033	27.588	0.228	0.388
8	35.3	3.990	55.176	0.217	0.370
15	43.5	5.548	103.455	0.209	0.355
30	52.7	7.296	206.910	0.199	0.338
60	66	9.823	413.820	0.185	0.314
		-2.717	0.000	0.255	0.433
		Activity Meter Test	5300.00	0.088	0.150
			22400.00	0.054	0.091
			77100.00	0.032	0.055

Activity Meter Test

Suction (Mpa)	Wt of Can (g)	Wt of Can + Wet Soil (g)	Wt of Can + Dry Soil (g)	Gravimetric Water Content (%)	Volumetric Water Content (%)
77.1	8.4816	15.3371	15.1225	0.032	0.055
22.4	7.5888	14.8017	14.4353	0.054	0.091
5.3	7.7703	14.1253	13.6098	0.088	0.150

Pressure Plate Extractor Test

ASTM D 6836 - 02 (Method B)				
Sample I.D.	**GJ-R-FP-B1**		**Test Date**	
WT of Sample Ring =	70.19	g		
WT of Sample Ring + Soil =	284.64	g		
Water Content =	24.4	%		
Diameter of Sample Ring, D =	2.86	in		
Height of Sample Ring, L =	1.0	in		
Volume, V =	3.72E-03	ft^3	105.3	cm^3
Dry Unit Weight =	102.22	pcf	1.64	Mg/m^3
Water WT =	42.06	g		
Solid WT =	172.39	g		
Add Water for saturation =	6.26	g	Sr	118.13
Saturated Water Content =	28.03	%		
Tube Area, A =	0.19	cm^2		

Applied Pressure (psi)	Reading (cm)	Water out from soil sample (cc)	Suction (kPa)	Water Content	Volumetric Water Content
0	14	0.000	0.001	0.280	0.459
0.5	21.5	1.425	3.449	0.272	0.446
1	25.5	2.185	6.897	0.268	0.438
2	30.2	3.078	13.794	0.262	0.430
4	36.7	4.313	27.588	0.255	0.418
8	48.2	6.498	55.176	0.243	0.397
15	60.7	8.873	103.455	0.229	0.375
30	67.2	10.108	206.910	0.222	0.363
60	78	12.160	413.820	0.210	0.344
		-2.660	0.000	0.296	0.484
		Activity Meter Test	10800.00	0.076	0.125
			32000.00	0.051	0.084
			76100.00	0.034	0.055
Activity Meter Test					
Suction (Mpa)	**Wt of Can (g)**	**Wt of Can + Wet Soil (g)**	**Wt of Can + Dry Soil (g)**	**Gravimetric Water Content (%)**	**Volumetric Water Content (%)**
76.1	7.7345	14.8503	14.6194	0.034	0.055
32	8.2459	14.1766	13.8889	0.051	0.084
10.8	8.5669	14.7588	14.3191	0.076	0.125

Pressure Plate Extractor Test

ASTM D 6836 - 02 (Method B)				
Sample I.D.	**GJ-R-FP-B2**		**Test Date**	
WT of Sample Ring =	69.88	g		
WT of Sample Ring + Soil =	292.79	g		
Water Content =	20.4	%		
Diameter of Sample Ring, D =	2.86	in		
Height of Sample Ring, L =	1.0	in		
Volume, V =	3.72E-03	ft^3	105.3	cm^3
Dry Unit Weight =	109.79	pcf	1.76	Mg/m^3
Water WT =	37.77	g		
Solid WT =	185.14	g		
Add Water for saturation =	5.61	g	Sr	120.01
Saturated Water Content =	23.43	%		
Tube Area, A =	0.19	cm^2		

Applied Pressure (psi)	Reading (cm)	Water out from soil sample (cc)	Suction (kPa)	Water Content	Volumetric Water Content
0	9.8	0.000	0.001	0.234	0.412
0.5	15.5	1.083	3.449	0.228	0.402
1	17.7	1.501	6.897	0.226	0.398
2	21	2.128	13.794	0.223	0.392
4	21.9	2.299	27.588	0.222	0.390
8	33.2	4.446	55.176	0.210	0.370
15	45.7	6.821	103.455	0.197	0.347
30	49.6	7.562	206.910	0.193	0.340
60	59.4	9.424	413.820	0.183	0.323
		-1.862	0.000	0.244	0.430
		Activity Meter Test	4390.00	0.102	0.180
			10700.00	0.074	0.131
			46100.00	0.042	0.075
Activity Meter Test					
Suction (Mpa)	**Wt of Can (g)**	**Wt of Can + Wet Soil (g)**	**Wt of Can + Dry Soil (g)**	**Gravimetric Water Content (%)**	**Volumetric Water Content (%)**
46.1	8.4804	14.9079	14.6466	0.042	0.075
10.7	7.5849	13.0938	12.7134	0.074	0.131
4.39	7.7691	14.22	13.6227	0.102	0.180

Pressure Plate Extractor Test

ASTM D 6836 - 02 (Method B)				
Sample I.D.	GJ-R-RB-B1		Test Date	
WT of Sample Ring =	70.8	g		
WT of Sample Ring + Soil =	291.31	g		
Water Content =	19.0	%		
Diameter of Sample Ring, D =	2.86	in		
Height of Sample Ring, L =	1.0	in		
Volume, V =	3.72E-03	ft^3	105.3	cm^3
Dry Unit Weight =	109.88	pcf	1.76	Mg/m^3
Water WT =	35.21	g		
Solid WT =	185.30	g		
Add Water for saturation =	2.09	g	Sr	103.36
Saturated Water Content =	20.13	%		
Tube Area, A =	0.19	cm^2		

Applied Pressure (psi)	Reading (cm)	Water out from soil sample (cc)	Suction (kPa)	Water Content	Volumetric Water Content
0	19	0.000	0.001	0.201	0.354
0.5	25.5	1.235	3.449	0.195	0.343
1	27.2	1.558	6.897	0.193	0.340
2	30.7	2.223	13.794	0.189	0.333
4	33.5	2.755	27.588	0.186	0.328
8	40	3.990	55.176	0.180	0.317
15	45.6	5.054	103.455	0.174	0.306
30	51.8	6.232	206.910	0.168	0.295
60	63	8.360	413.820	0.156	0.275
		Activity Meter Test	5020.00	0.099	0.174
			19400.00	0.063	0.110
			52800.00	0.043	0.075

Activity Meter Test

Suction (Mpa)	Wt of Can (g)	Wt of Can + Wet Soil (g)	Wt of Can + Dry Soil (g)	Gravimetric Water Content (%)	Volumetric Water Content (%)
52.8	8.2427	14.7507	14.4833	0.043	0.075
19.4	7.7309	14.2339	13.8507	0.063	0.110
5.02	7.9805	14.7886	14.1779	0.099	0.174

Pressure Plate Extractor Test

ASTM D 6836 - 02 (Method B)

Sample I.D.	GJ-R-RB-B2		Test Date	
WT of Sample Ring =	69.87	g		
WT of Sample Ring + Soil =	294.29	g		
Water Content =	20.6	%		
Diameter of Sample Ring, D =	2.86	in		
Height of Sample Ring, L =	1.0	in		
Volume, V =	3.72E-03	ft^3	105.3	cm^3
Dry Unit Weight =	110.35	pcf	1.77	Mg/m^3
Water WT =	38.33	g		
Solid WT =	186.09	g		
Add Water for saturation =	0	g	Sr	107.10
Saturated Water Content =	20.60	%		
Tube Area, A =	0.19	cm^2		

Applied Pressure (psi)	Reading (cm)	Water out from soil sample (cc)	Suction (kPa)	Water Content	Volumetric Water Content
0	21.5	0.000	0.001	0.206	0.364
0.5	25.5	0.760	3.449	0.202	0.357
1	26.8	1.007	6.897	0.201	0.355
2	31	1.805	13.794	0.196	0.347
4	37.1	2.964	27.588	0.190	0.336
8	43.9	4.256	55.176	0.183	0.324
15	51	5.605	103.455	0.176	0.311
30	59.3	7.182	206.910	0.167	0.296
60	72	9.595	413.820	0.154	0.273
		Activity Meter Test	5250.00	0.090	0.159
			17100.00	0.060	0.106
			59900.00	0.036	0.063

Activity Meter Test

Suction (Mpa)	Wt of Can (g)	Wt of Can + Wet Soil (g)	Wt of Can + Dry Soil (g)	Gravimetric Water Content (%)	Volumetric Water Content (%)
59.9	8.5618	14.6353	14.4251	0.036	0.063
17.1	7.6517	13.7418	13.3988	0.060	0.106
5.25	7.3857	13.8145	13.2847	0.090	0.159

Large Scale Hanging Column Test On Sandy Soil

ASTM D 6836 - 02 (Method B)

Sample I.D.	GJ-R-L1-G1		Test Date	
WT of Sample =	23.08	lb		
Water Content =	0.0	%		
Diameter of Sample Ring, D =	11.65	in		
Height of Sample Ring, L =	3.0	in		
Volume, V =	1.85E-01	ft^3	5240.4	cm^3
Dry Unit Weight =	124.7	pcf	2.00	Mg/m^3
Water WT =	1300.00	g		
Solid WT =	10469.09	g		
Saturated Water Content =	12.42	%		
StandPipe Area, a =	20	cm^2		

Left Manometer Reading (cm)	Right Manometer Reading (cm)	Reading (cm)	Water Expelled from Soil Sample (mL)	Suction (kPa)	Grav. Water Content (%)	Volumetric Water Content (%)
180.7	180.7	17.5	0.0	0.000	12.418	24.818
179.3	182.3	22	90.0	0.294	11.558	23.100
176.4	185.2	26.4	178.0	0.863	10.717	21.420
172.7	188.5	30.4	258.0	1.550	9.953	19.893
164.7	196.5	40.7	464.0	3.119	7.985	15.960
155	206.5	47.9	608.0	5.051	6.610	13.211
146	215.1	50.6	662.0	6.778	6.094	12.180
130.5	231.4	53	710.0	9.897	5.636	11.264
		59.5	840.0	30.000	4.394	8.782
			-350.0	0.000	15.761	31.500
			-350.0	0.000	15.761	31.500
			-350.0	0.000	15.761	31.500
			-350.0	0.000	15.761	31.500
			-350.0	0.000	15.761	31.500

Large Scale Hanging Column Test On Sandy Soil

ASTM D 6836 - 02 (Method B)

Sample I.D.	GJ-C-DL-G1		Test Date	
WT of Sample =	23.08	lb		
Water Content =	0.0	%		
Diameter of Sample Ring, D =	11.65	in		
Height of Sample Ring, L =	3.0	in		
Volume, V =	1.85E-01	ft^3	5240.4	cm^3
Dry Unit Weight =	124.7	pcf	2.00	Mg/m^3
Water WT =	1300.00	g		
Solid WT =	10469.09	g		
Saturated Water Content =	12.42	%		
StandPipe Area, a =	20	cm^2		

Left Manometer Reading (cm)	Right Manometer Reading (cm)	Reading (cm)	Water Expelled from Soil Sample (mL)	Suction (kPa)	Grav. Water Content (%)	Volumetric Water Content (%)
184.4	184.4	10.5	0.0	0.000	12.418	24.818
182.5	186.3	14.4	78.0	0.373	11.672	23.329
179.6	189.1	19.8	186.0	0.932	10.641	21.267
175.6	193.1	25.2	294.0	1.717	9.609	19.205
171	197.9	31.8	426.0	2.639	8.348	16.685
164.1	204.4	39.6	582.0	3.953	6.858	13.707
153.7	214.8	43.8	666.0	5.993	6.056	12.104
145.2	223.5	45.5	700.0	7.680	5.731	11.454
130.5	238.2	47.5	740.0	10.564	5.349	10.691
115.7	253	48.6	762.0	13.467	5.139	10.271
		53.2	854.0	30.000	4.260	8.514
		55.5	900.0	70.000	3.821	7.636
			-210.0	0.000	14.423	28.827
			-210.0	0.000	14.423	28.827

Large Scale Hanging Column Test On Sandy Soil

ASTM D 6836 - 02 (Method B)				
Sample I.D.	**GJ-C-L1-G1**		**Test Date**	
WT of Sample =	23.08	lb		
Water Content =	0.0	%		
Diameter of Sample Ring, D =	11.65	in		
Height of Sample Ring, L =	3.0	in		
Volume, V =	1.85E-01	ft^3	5240.4	cm^3
Dry Unit Weight =	124.7	pcf	2.00	Mg/m^3
Water WT =	1300.00	g		
Solid WT =	10469.09	g		
Saturated Water Content =	12.42	%		
StandPipe Area, a =	20	cm^2		

Left Manometer Reading (cm)	Right Manometer Reading (cm)	Reading (cm)	Water Expelled from Soil Sample (mL)	Suction (kPa)	Grav. Water Content (%)	Volumetric Water Content (%)
178.8	178.8	10.5	0.0	0.000	12.418	24.818
177.2	180.2	15.6	102.0	0.294	11.443	22.871
174	183.5	21.3	216.0	0.932	10.354	20.694
167.5	190	27.5	340.0	2.207	9.170	18.327
161.9	195.7	34.9	488.0	3.315	7.756	15.502
156.2	201	40.5	600.0	4.394	6.686	13.364
137	220.5	44.2	674.0	8.190	5.980	11.951
		51.5	820.0	27.500	4.585	9.164

Large Scale Hanging Column Test On Sandy Soil

ASTM D 6836 - 02 (Method B)

Sample I.D.	**GJ-R-DL-G1**		**Test Date**	
WT of Sample =	23.08	lb		
Water Content =	0.0	%		
Diameter of Sample Ring, D =	11.65	in		
Height of Sample Ring, L =	3.0	in		
Volume, V =	1.85E-01	ft^3	5240.4	cm^3
Dry Unit Weight =	124.7	pcf	2.00	Mg/m^3
Water WT =	1300.00	g		
Solid WT =	10469.09	g		
Saturated Water Content =	12.42	%		
StandPipe Area, a =	20	cm^2		

Left Manometer Reading (cm)	Right Manometer Reading (cm)	Reading (cm)	Water Expelled from Soil Sample (mL)	Suction (kPa)	Grav. Water Content (%)	Volumetric Water Content (%)
170	170	7.7	0.0	0.000	12.418	24.818
168.5	171.7	14.7	140.0	0.314	11.080	22.145
167	173.1	19.6	238.0	0.598	10.144	20.274
160	180.5	26.5	376.0	2.011	8.826	17.640
153.7	186.6	33	506.0	3.227	7.584	15.158
149.4	191	37.8	602.0	4.080	6.667	13.325
138	203	43	706.0	6.376	5.674	11.340
		51.5	876.0	27.500	4.050	8.094

Appendix F

Calibration of Dosing Siphons, Tipping Buckets and Pressure Transducers

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Dosing Siphon Calibration Method

[1] Open inlet and drop pipe valves and allow water to flow through the calibrator until the basin flushes, then close the valves.

[2] Note maximum water level when the basin flushes.

[3] Mark on the basin wall and measure minimum water level after basin flushes. Record this initial water level on the field sheet.

[4] Close drop pipe valve and open inlet valve.

[5] Fill calibrator reservoir with water to 10 L level (at bottom of overflow T) and close inlet valve.

[6] Meter water into dosing basin in 10 L increments, checking off each 10 L on the field sheet.

[7] Repeat step 6 until total input approaches 100 L, then slow the flow of water into the basin.

[8] Watch for shimmer in the dosing basin stand pipe (indication that it is about to flush), and then shut off the drop pipe valve when flush occurs.

[9] Record total liters for flush; measure and record final water level on field sheet.

[10] Repeat steps 1–9 a minimum of 3 times for the drainage basins and 2 times for the runoff basins.

Results

Date	ID	Rep.	Initial Water Level (cm)	Final Water Level (cm)	Flush Total (L)
May 14, 2008	C Runoff	1	50	50	94.5
		2	50	50	95.0
		3	50	50	95.0
	C Drainage	1	50	50	94.5
		2	50	50	94.5
		3	50	50	94.0
May 15, 2008	R Runoff	1	53	53	84.0
		2	53	53	83.5
		3	53	53	83.0
	R Drainage	1	53	53	91.0
		2	53	53	92.5
		3	53	53	91.5

Tipping Bucket Gauge Calibration Method

[1] Take 3 squirt bottles of water to the site, 1 to zero the tippers and 2 weighed bottles for calibration.

[2] Disconnect the hose from the PVC inlet pipe.

[3] Slowly squeeze water into the hose to zero the tipper (listen for the tip).

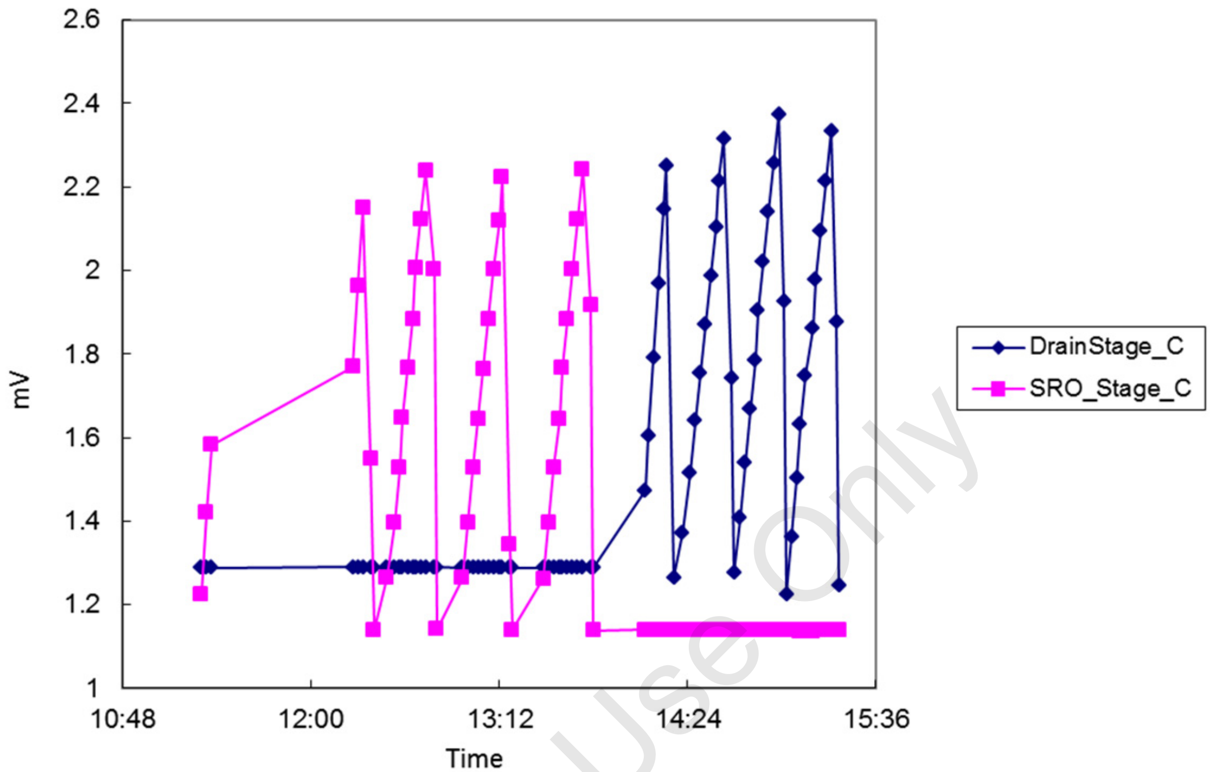
[4] Slowly squeeze water from a 1 weighed bottle until tips occur in one tipper. Use the other weighed bottle for the other tipper.

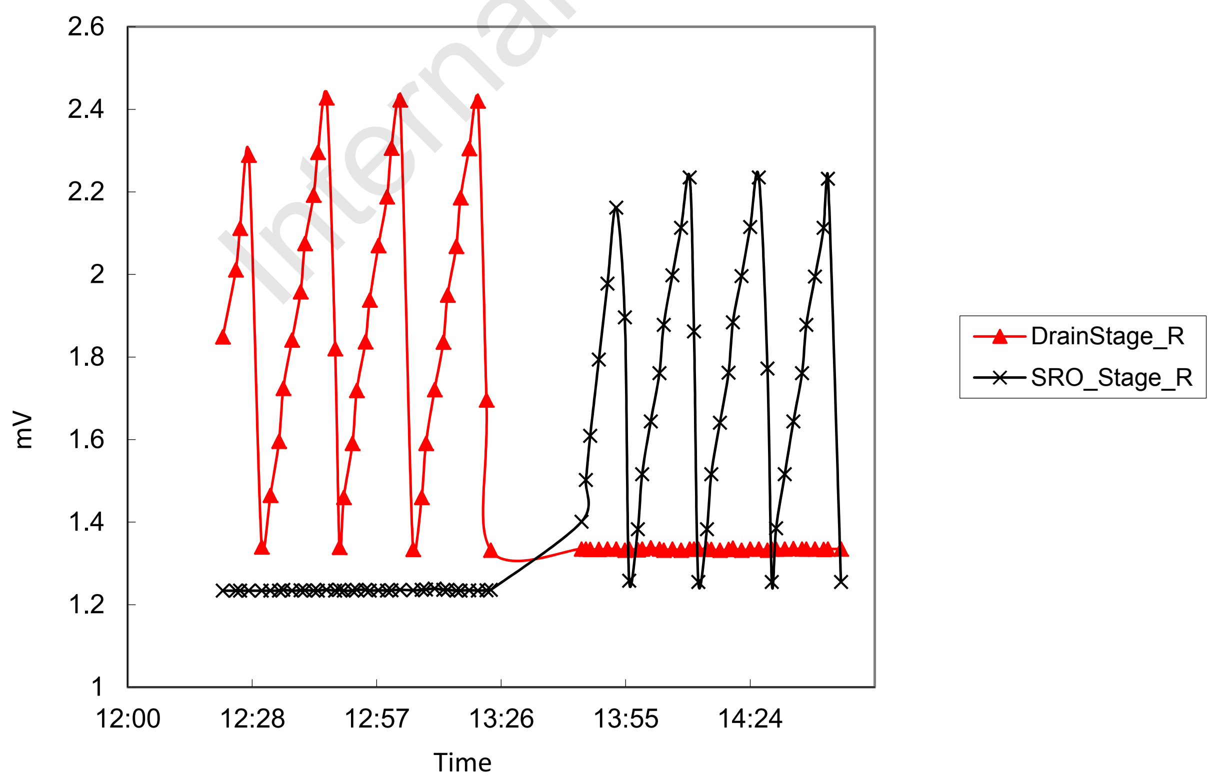
[5] Weigh the bottles to determine volume of water per tip

Date	Lysimeter	Zeroing Tips	Before Wt. (g)	After Wt (g)	No. of Tips	Volume (ml/tip)[a]	Time (MST)
1/29/2009	C	1	2254.5	891.5	10	136.3	3:00 PM
	R	1	2192.6	857.1	10	133.6	3:40 PM
12/2/2010	C	1	838.2	280.9	4	139.3	3:20 PM
	R	1	848.7	160.9	5	137.6	3:35 PM

[a]Assumes water density = 1.0 g/ml

Pressure Transducer Calibration, May 14, 2008. Data recorded during calibration of dosing siphons.





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Appendix G

Calibrations of Water Content Reflectometers

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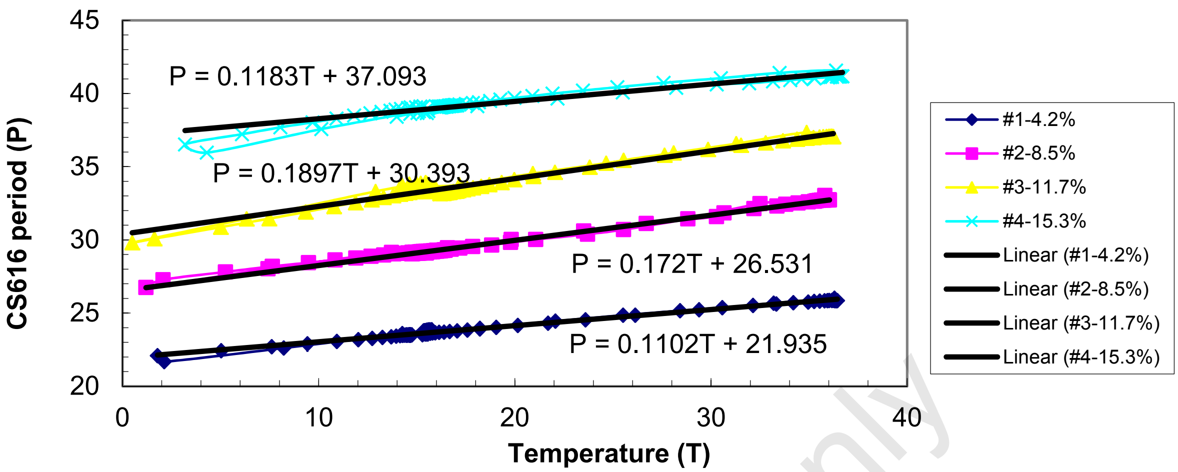
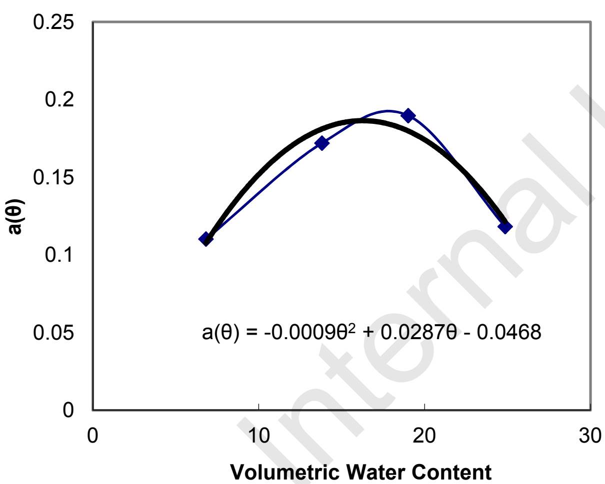
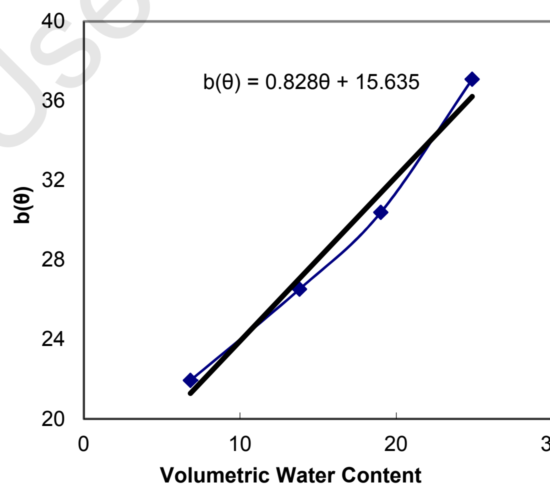
Calibration data for water content reflectometers in frost protection soil

Plot measured period vs temperature at different (gravimetric) water contents, determine coefficients for linear regression.



Convert gravimetric to volumetric water contents, determine a(θ) and b(θ) at the measured water contents and plot vs volumetric water content.





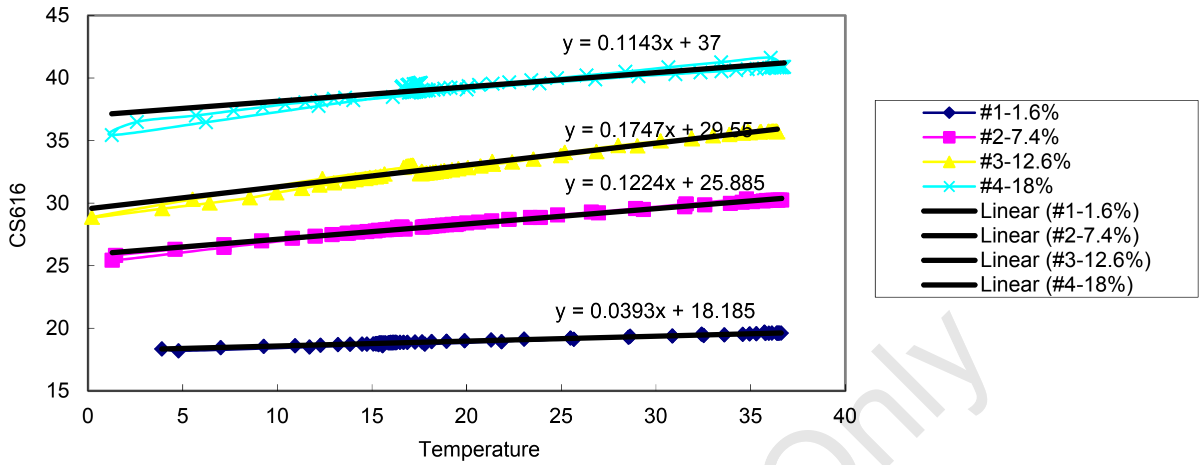
P = $(-0.0009\,\theta^2 + 0.0287\,\theta - 0.0468)\,T + (0.828\,\theta + 15.635)$
P = $-0.0009*T*\theta^2 + (0.287*T + 0.828)*\theta - 0.0468*T + 15.635$
$-0.0009*T*\theta^2 + (0.287*T + 0.828)*\theta - 0.0468*T + 15.635 - P = 0$
$a*\theta^2 + b*\theta + c = 0$

$$\theta = \frac{-b + \sqrt{b^2 - 4ac}}{2a}$$

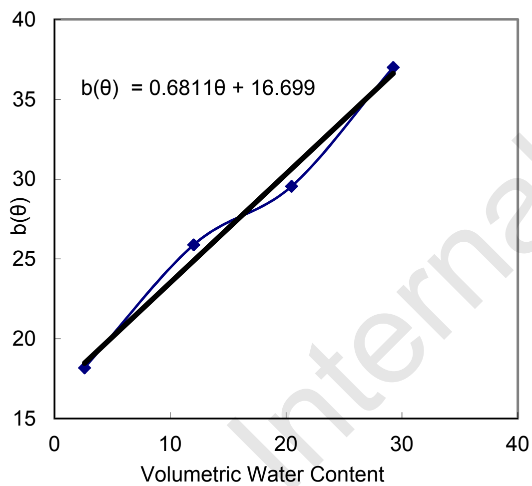
a = -0.0009*T
b = (0.287*T + 0.828)
c = (-0.0468*T + 15.635 - P)

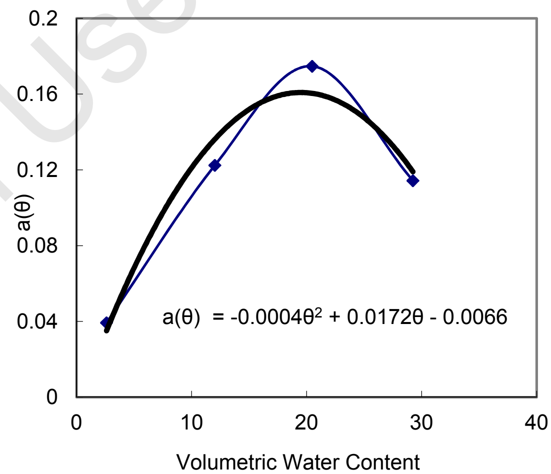
Calibration data for water content reflectometers in radon barrier soil

Plot measured period vs temperature at different (gravimetric) water contents, determine coefficients for linear regression. Convert gravimetric to volumetric water contents, determine a(θ) and b(θ) at the measured water contents and plot vs volumetric water content.



Convert gravimetric to volumetric water contents, determine a(θ) and b(θ) at the measured water contents and plot vs volumetric water content.





P = (- 0.0004 θ^2 + 0.0172 θ - 0.0066) T + (0.6811 θ + 16.699)

P = -0.0004*T*θ^2 + (0.0172*T + 0.6811)*θ - 0.0066*T + 16.699

-0.0004*T*θ^2 + (0.0172*T + 0.6811)*θ - 0.0066*T + 16.699 - P = 0

a*θ^2 + b*θ + c = 0

$$\theta = \frac{-b + \sqrt{b^2 - 4ac}}{2a}$$

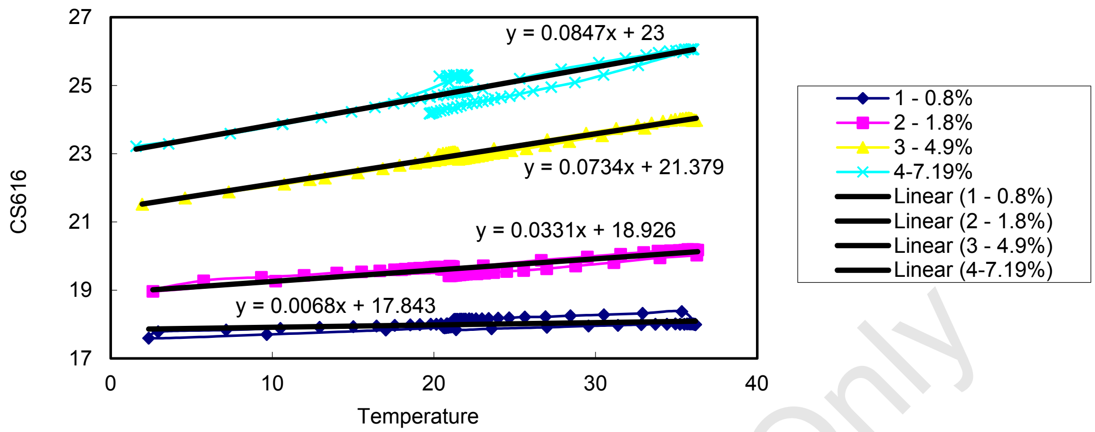
a = -0.0004*T

b = (0.0172*T + 0.6811)

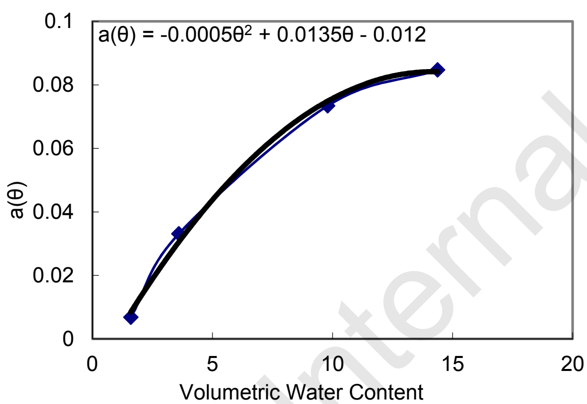
c = (-0.0066*T + 16.699 - P)

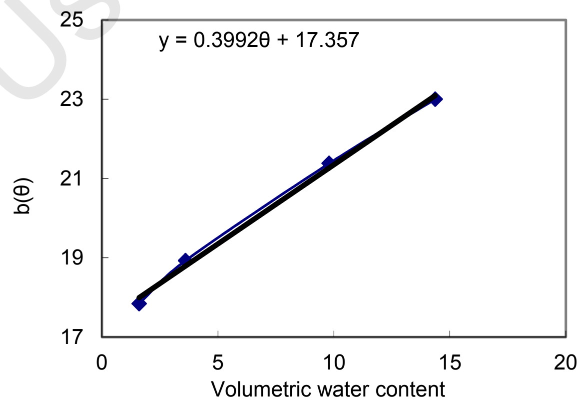
Calibration data for water content reflectometers in sand soil

Plot measured period vs temperature at different (gravimetric) water contents, determine coefficients for linear regression. Convert gravimetric to volumetric water contents, determine a(θ) and b(θ) at the measured water contents and plot vs volumetric water content.



Convert gravimetric to volumetric water contents, determine a(θ) and b(θ) at the measured water contents and plot vs volumetric water content.





P =
$(-0.0005\ \theta^2 + 0.0135\ \theta - 0.012)\ T + (0.3992\ \theta + 17.357)$

$P = -0.0005\ \theta^2\ T + 0.0135\ \theta\ T - 0.012\ T + 0.3992\ \theta + 17.357$

$-5e\text{-}4\ T\ \theta^2 + (0.0135\ T + 0.3992)\ \theta - 0.012\ T + 17.357 - P = 0$

$a\theta^2 + b\ \theta + c = 0$

$$\theta = \frac{-b + \sqrt{b^2 - 4ac}}{2a}$$

$a = -5e^{-4}\ T$

$b = 0.0135\ T + 0.3992$

$c = (-0.012\ T + 17.357 - P)$

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Appendix H

Calibrations of Thermal Dissipation Sensors

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HDU Calibration

Solid Weight (g) = 2,812
Water Weight (g) = 409.4
Initial Water Content (%) = 14.56

Suction (psi)	Dt								Water Expelled (cm^3)	Summary of Water Expelled (cm^3)	Water Content (%)
	11414	11415	11416	11417	11418	11419	11420	11421			
0.001	1.45	1.42	1.48	1.24	1.53	1.54	1.31	1.37	0	0	14.56
0.5	1.43	1.43	1.45	1.3	1.53	1.55	1.32	1.39	45	45	12.96
1	1.43	1.44	1.46	1.28	1.54	1.55	1.29	1.39	10	55	12.60
2	1.87	1.43	1.48	1.8	1.56	2.06	1.78	1.92	24	79	11.75
3	2.18	2.23	2.31	2.04	2.37	2.29	2.01	2.12	21	100	11.00
4	2.4	2.48	2.57	2.24	2.58	2.53	2.24	2.38	24	124	10.15
7	2.51	2.68	2.79	2.48	2.77	2.67	2.38	2.53	42	166	8.66
10	2.71	2.86	2.99	2.66	2.93	2.87	2.59	2.71	38	204	7.30
15	2.93	3.15	3.29	2.96	3.19	3.16	2.8	3.01	32	236	6.17
20	3.12	3.33	3.5	3.16	3.43	3.31	2.91	3.2	15	251	5.63
25	3.18	3.39	3.56	3.24	3.47	3.35	2.97	3.23	12	263	5.21
30	3.26	3.46	3.67	3.35	3.56	3.47	3.08	3.34	9	272	4.89
308.85	3.58	3.78	3.94	3.64	3.86	3.79	3.37	3.62			2.93
4113.17	3.83	4	4.16	3.86	4.14	3.96	3.58	3.92			1.60

HDU Calibration

Solid Weight (g) = 2,776.3
Water Weight (g) = 404.2
Initial Water Content (%) = 14.56

Suction (psi)	Dt								Water Expelled (cm^3)	Summary of Water Expelled (cm^3)	Water Content (%)
	11422	11423	11424	11425	11426	11427	11428	11429			
0.001	1.48	1.3	1.72	1.35	1.61	1.11	1.19	1.45	0	0	14.56
0.4	1.48	1.26	1.72	1.31	1.65	1.1	1.23	1.44	44	44	12.97
0.75	1.46	1.32	1.71	1.32	1.63	1.12	1.24	1.43	12	56	12.54
1	1.46	1.28	1.71	1.31	1.64	1.13	1.22	1.39	2	58	12.47
1.5	1.47	1.29	1.71	1.3	1.61	1.15	1.21	1.37	10	68	12.11
2	1.47	1.28	2.27	1.29	1.6	1.11	1.24	1.44	10	78	11.75
2.5	2.09	1.89	2.36	1.32	1.6	1.74	1.24	1.4	9	87	11.43
3	2.16	2.01	2.45	1.31	2.31	1.82	1.93	2.14	11	98	11.03
4	2.38	2.21	2.67	2.41	2.51	2.07	2.12	2.34	22	120	10.24
5	2.4	2.21	2.71	2.44	2.54	2.11	2.12	2.38	4	124	10.09
7	2.56	2.42	2.87	2.68	2.74	2.31	2.26	2.55	36	160	8.80
10	2.7	2.57	3.05	2.84	2.93	2.47	2.44	2.74	52	212	6.92
13	2.84	2.71	3.18	3.03	3.03	2.58	2.59	2.88	29	241	5.88
17	2.96	2.87	3.34	3.21	3.17	2.7	2.7	3.02	18	259	5.23
20	3.07	2.92	3.42	3.31	3.24	2.84	2.74	3.11	11	270	4.83
30.45	3.27	2.91	3.49	3.53	3.18	2.81	2.84	3.39			3.40
172.55	3.4	2.96	3.52	3.6	3.4	3	3.1	3.5			2.56
6742.5	3.68	3.69	4.13	4.02	3.95	3.54	3.49	3.77			0.80

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Appendix I

Instrument Location Details

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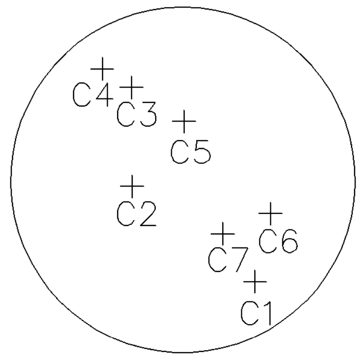
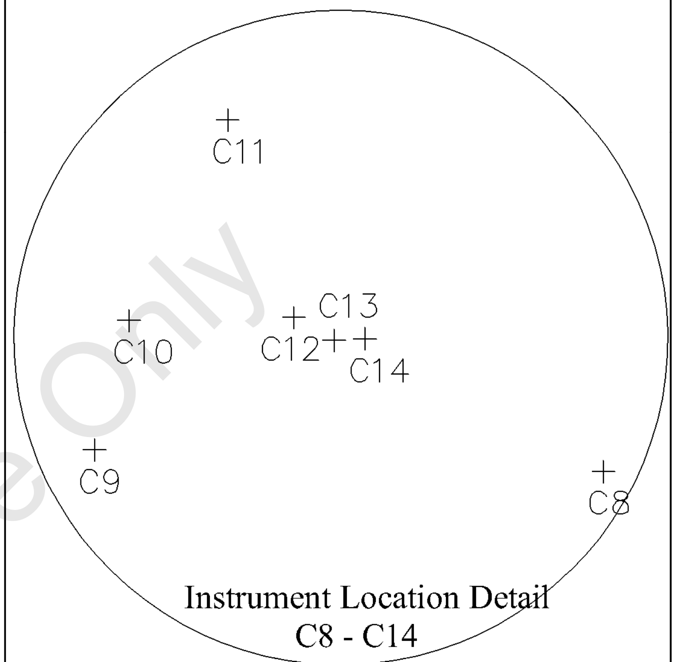


Instrument Location Detail
C1 - C7
Scale 1" = 1'

Instrument	N	E
C1	12,927.45	92,241.79
C2	12,928.07	92,240.99
C3	12,928.71	92,240.99
C4	12,928.83	92,240.80
C5	12,928.49	92,241.33
C6	12,927.89	92,241.89
C7	12,927.76	92,241.58



Instrument Location Detail
C8 - C14
Scale 1" = 1'

Instrument	N	E
C8	12,946.87	92,260.60
C9	12,947.01	92,259.30
C10	12,947.85	92,259.52
C11	12,949.15	92,260.16
C12	12,947.87	92,260.59
C13	12,947.72	92,260.85
C14	12,947.73	92,261.05

C Lysimeter Instrument Detail

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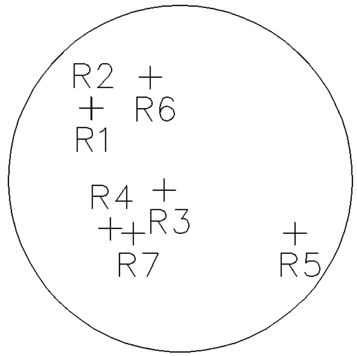
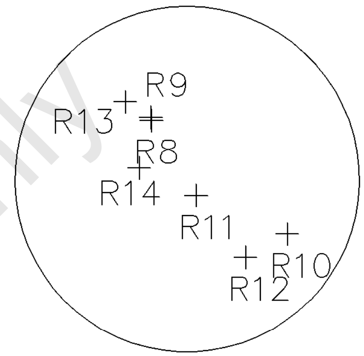


Instrument Location Detail
R1 - R7
Scale 1" = 1'

Instrument	N	E
R1	12,862.65	92,313.11
R2	12,862.65	92,313.10
R3	12,662.12	92,313.58
R4	12,861.87	92,313.23
R5	12,861.84	92,314.43
R6	12,862.85	92,313.49
R7	12,861.84	92,313.38



Instrument Location Detail
R8 - R14
Scale 1" = 1'

Instrument	N	E
R8	12,881.94	92,331.49
R9	12,881.96	92,331.49
R10	12,881.20	92,332.37
R11	12,881.45	92,331.78
R12	12,881.05	92,332.10
R13	12,882.06	92,331.32
R14	12,881.63	92,331.41

R Lysimeter Instrument Detail

M:\LTS\111\0029\19\001\S09772\S0977200.DWG 02/05/13 11:00am j50191