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Mixed Waste Landfill Design Report

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Abstract

An Evapotranspiration (ET) Cover is to be deployed over the Mixed Waste Landfill at Sandia National Laboratories in Albuquerque, New Mexico. This design report details the ET Cover design with all supporting information. The design is to be a soil cover 4 feet 3 inches thick (3 feet 6 inches of compacted native soil overlain by 9 inches of gravel admixture). The cover is to be seeded with a mixture of native grasses. The design assumes the soil will act similar to a "sponge" in that it will store all moisture from the worst case infiltration event until it can be removed via the combination of evaporation and transpiration known as ET.

The design is based on myriad of supporting data and calculations. A first order estimate of the required soil thickness was based on the soil's measured storage capacity. It was fine tuned using the combination of numerical modeling, relevant natural analog data, and available field data.

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Stephen F. Dwyer, John C. Stormont, and Clifford E. Anderson

Prepared by
Sandia National Laboratories
Albuquerque, New Mexico 87185 and Livermore, California 94550

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The gravel admixture surface layer was designed to assist any established vegetation minimize surface erosion. A very detailed set of calculations complimented by computer simulations was used to determine a 9 inch thick layer composed of one part gravel to two parts soil by weight would be adequate for the final cover design slopes to minimize surface erosion.

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1.0 SECTION 1

1.1 Introduction

1.1.1 Mixed Waste Landfill Background

The Mixed Waste Landfill (MWL) is a fenced 2.6 acre landfill located at Sandia National Laboratories, New Mexico (SNL/NM). It is located in Tech Area 3, (Figure 1). The MWL is a Radioactive Materials Management Area (RMMA) and a Resource Conservation and Recovery Act (RCRA) solid waste management unit (SWMU). The MWL was operated from March 1959 to December 1988 as the primary disposal site for SNL/NM technical and remote test areas involved in nuclear weapons research and development. The MWL was originally opened as the "Area 3 Low-Level Radioactive Dump" when the prior low-level radioactive dump in Tech Area 2 was closed in March 1959. Approximately 100,000 ft^3 of low-level radioactive waste and minor amounts of mixed waste containing approximately 6300 Ci of activity (at the time of disposal) were disposed of at the MWL.

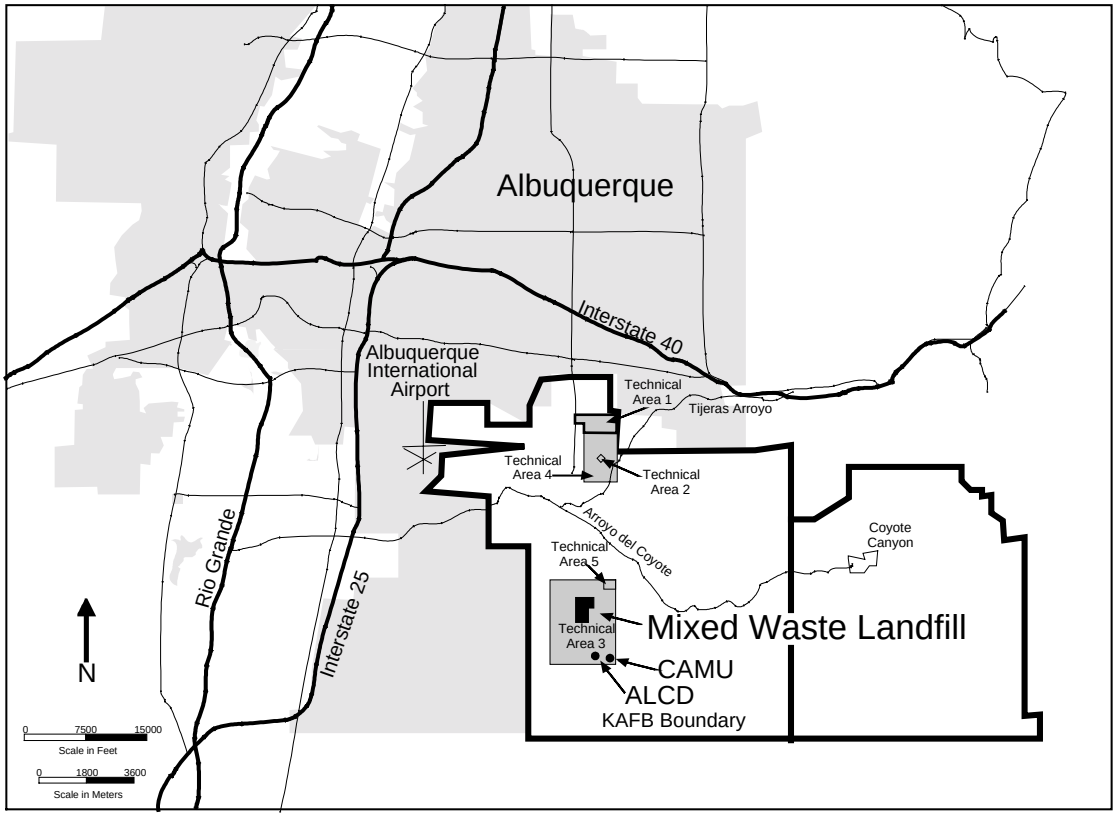

Figure 1. Location Map

The MWL consists of two distinct disposal areas: the classified area, occupying 0.6 acres, and the unclassified area occupying 2.0 acres (Figure 2). Wastes in the classified area

were disposed of in a series of vertical, cylindrical pits. Historical records indicate that early pits were 3 to 5 ft in diameter and 15 ft deep. Later pits were 10 ft in diameter and 25 ft deep. After the pits were filled with waste, they were backfilled with soil then capped with concrete. Waste in the unclassified area was disposed of in a series of parallel, north-south excavated trenches. The trenches were 15 to 25 ft wide, 150 to 180 ft long, and 15 to 20 ft deep. Waste filled trenches were backfilled with soil on a quarterly basis and covered with soils that were originally excavated from the site.

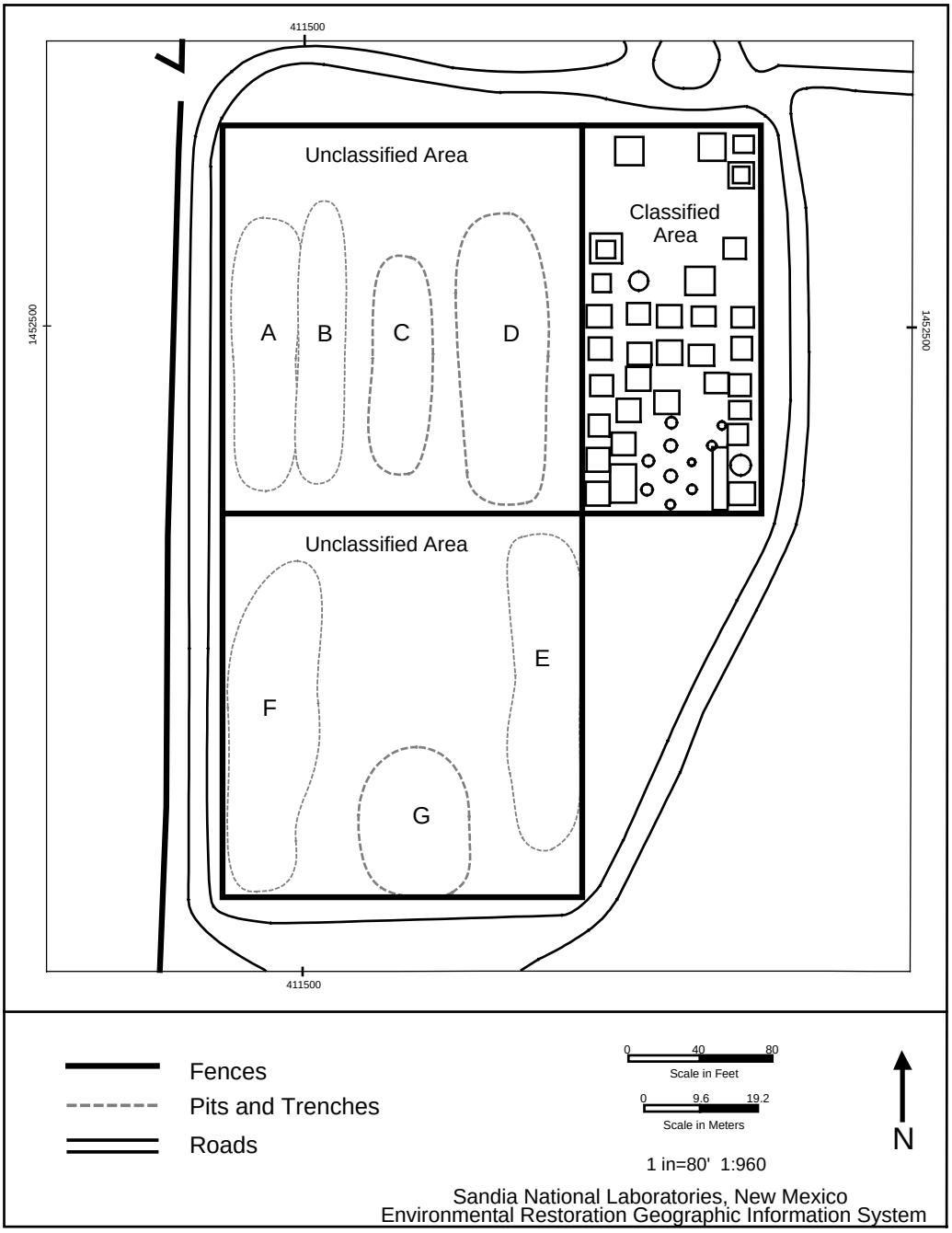

Figure 2. Existing MWL Plan View (Peace, 1999)

Wastes disposed in classified area pits included thorium, barium, enriched lithium, depleted, natural, and enriched uranium, liquid scintillation vials and beakers, neutron generator tubes and targets, plutonium-contaminated wastes, and plutonium-contaminated weapons-test debris from the Nevada Test Site. Between 1959 and 1962, small quantities of radioactively contaminated inorganic acids and organic solvents were disposed of in the southeast corner of the classified area. Wastes in unclassified area trenches were disposed of at random with no regard to waste source or type and included construction and demolition materials, contaminated equipment and soils, lead shielding, wood crates, steel drums, shipping casks, cardboard boxes, and dry solids.

1.1.2 General Site Environmental Conditions

SNL/NM is located within Kirtland Air Force Base (KAFB). The Base is bounded on the north by the City of Albuquerque, on the east by the Cibola National Forest, on the south by the Isleta Pueblo, and on the west by vacant land owned by the State of New Mexico and held in trust for the University of New Mexico. Tech Area 3 occupies about 1920 acres.

The topography in the general area has slopes ranging from 0 to 10% dipping westerly towards the Rio Grande River. Most slopes in the immediate area of the MWL are about 2%. The MWL is not in the 100-year floodplain (Sandia, 1993). The average elevation at SNL/NM is about 5400 ft above sea level (the mean elevation at the MWL is 5381 ft) (Sandia, 1996). The groundwater table maintains an irregular sloping surface generally at a depth of about 500 ft.

The climate in the Albuquerque area is generally mild and dry, with large diurnal and seasonal variations in temperature. Typical days are clear and sunny with light to moderate winds. The normal daily temperature ranges for winter months are from 23° F to 52° F and 57° F to 91° F during summer months. The average annual precipitation is about 8.5 inches, most of this occurring in brief, heavy thunderstorms from July through September. For a 100-year storm frequency, the 1-hour precipitation is 2.046 inches with the 6-hour precipitation being 2.494 inches per the National Oceanic and Atmospheric Administration (NOAA) found in Atlas 2, Precipitation-Frequency Atlas of the Western United States, Volume IV, New Mexico (Miller, 1973). The winter months are generally dry. The predominant wind direction is from the east particularly in the dry seasons. Strong easterly winds are experienced as they are channeled through the Tijeras Canyon.

KAFB is situated in the eastern portion of the Albuquerque-Belen basin, one of the largest of a series of north-trending basins in the Rio Grande trough. The Sandia and Manzano Mountains bound the basin to the east, the Lucero Uplift and Pueblo Plateau to the west, and the Nacimiento Uplift to the north, with the Socorro Channel defining the southern boundary. The upper strata of the basin is a complex sequence of gravel, sand, silt, clay, and caliche deposits (Santa Fe Formation) underlain by sedimentary rocks extending to about 10,000 ft below sea level.

KAFB/SNL/NM is located in Seismic Zone 2B alluding that there is a low to moderate risk for seismic activity. Although there have been no strong earthquakes in the past 300 years, the Tijeras and Hubbel Springs faults are considered active. These fault lines are located east of Tech Area 3, running north-south.

Two major plant groups comprise the existing natural vegetation at KAFB: Grassland Association, found through the mesa, and Pinon-Juniper Association, found at higher elevations in the Manzano Mountain area. The Grassland Association includes sage, cactus, and native grasses, with shrubs and small trees along arroyos. As the elevation increases to 5800 ft above sea level, juniper, scrub oak, pinon, and ponderosa pines appear.

Most wildlife on the SNL/NM site feed on grasses and other range plants. Fauna of the open mesa includes reptiles, rodents, rabbits, coyotes, and a variety of birds. Deer, bobcats, black bears, and an occasional cougar have been sighted in the wetter mountain areas.

1.1.3 Regulatory Requirements

Applicable state regulations for corrective action at the MWL are as follows:

The MWL is regulated as a SWMU under the Hazardous and Solid Waste Amendments (HSWA) to RCRA. The State of New Mexico is authorized by the EPA to implement the hazardous waste management provisions of RCRA for treatment, storage, and disposal facilities within the state. In addition, the state is authorized to implement corrective action provisions under HSWA and is the Administrative Authority for the HSWA Module of the RCRA operating permit. The purpose of the HSWA Module was to establish specific guidance for assessment, characterization, and remediation of SWMUs at SNL/NM. Under Module IV of the RCRA Part B Permit (HWSA Module), the MWL is identified as ADS 1289, E Site No. 76, and RFA Site No. 24, 25, 26, 27, 28, 29, 30, 11, 5, and 116. DOE Orders provide requirements for landfill closure and cover design in establishing performance requirements for the closed facility.

Hazardous waste management statutes for the State of New Mexico are codified in the New Mexico Hazardous Waste Act enacted in 1985, and regulations governing hazardous waste management are set forth in Title 20 NMAC 4.1, which incorporates Title 40 CFR Part 264.

Because HSWA regulations provide only general guidance for corrective actions, SNL/NM has elected to use landfill closure requirements as guidance. Title 40 Code of Federal Regulations (CFR) Part 264. – specifically 40CFR 264.310 Subpart G establishes the closure requirements for such permitted facilities, and 40CFR264 Subpart N includes requirements for hazardous waste landfills. Most relevant to this design are the regulatory requirements (40CFR264.310) for the design and performance of a final cover system, and the need for the cover to limit infiltration into the underlying wastes:

§264.310 Closure and post-closure care.

(a) At final closure of the landfill or upon closure of any cell, the owner or operator must cover the landfill or cell with a final cover designed and constructed to:
   (1) provide long-term minimization of migration of liquids through the closed landfill;
   (2) function with minimum maintenance;
   (3) promote drainage and minimize erosion or abrasion of the cover;
   (4) accommodate settling and subsidence so that the cover's integrity is maintained; and
   (5) have a permeability less than or equal to the permeability of any bottom liner system or natural subsoils present.

(b) After final closure, the owner or operator must comply with all post-closure requirements contained in §§264.117 through 264.120, including maintenance and monitoring throughout the post-closure care period (specified in the permit under § 264.117). The owner or operator must:
   (1) maintain the integrity and effectiveness of the final cover, including making repairs to the cap as necessary to correct the effects of settling, subsidence, erosion, or other events;
   (2) continue to operate the leachate collection and removal system (if such a system exists) until leachate is no longer detected;
   (3) maintain and monitor the leak detection system (if such a system exists) in accordance with §§264.301(c)(3)(iv) and (4) and §264.303(c), and comply with all other applicable leak detection system requirements of this part;
   (4) maintain and monitor the ground-water monitoring system and comply with all other applicable requirements of subpart F of this part;
   (5) prevent run-on and run-off from eroding or otherwise damaging the final cover; and
   (6) protect and maintain surveyed benchmarks used in complying with § 264.309.

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2.0 SECTION 2

2.1 Evapotranspiration (ET) Cover Design

Figure 3 shows a profile for the proposed cover design for deployment at the MWL.

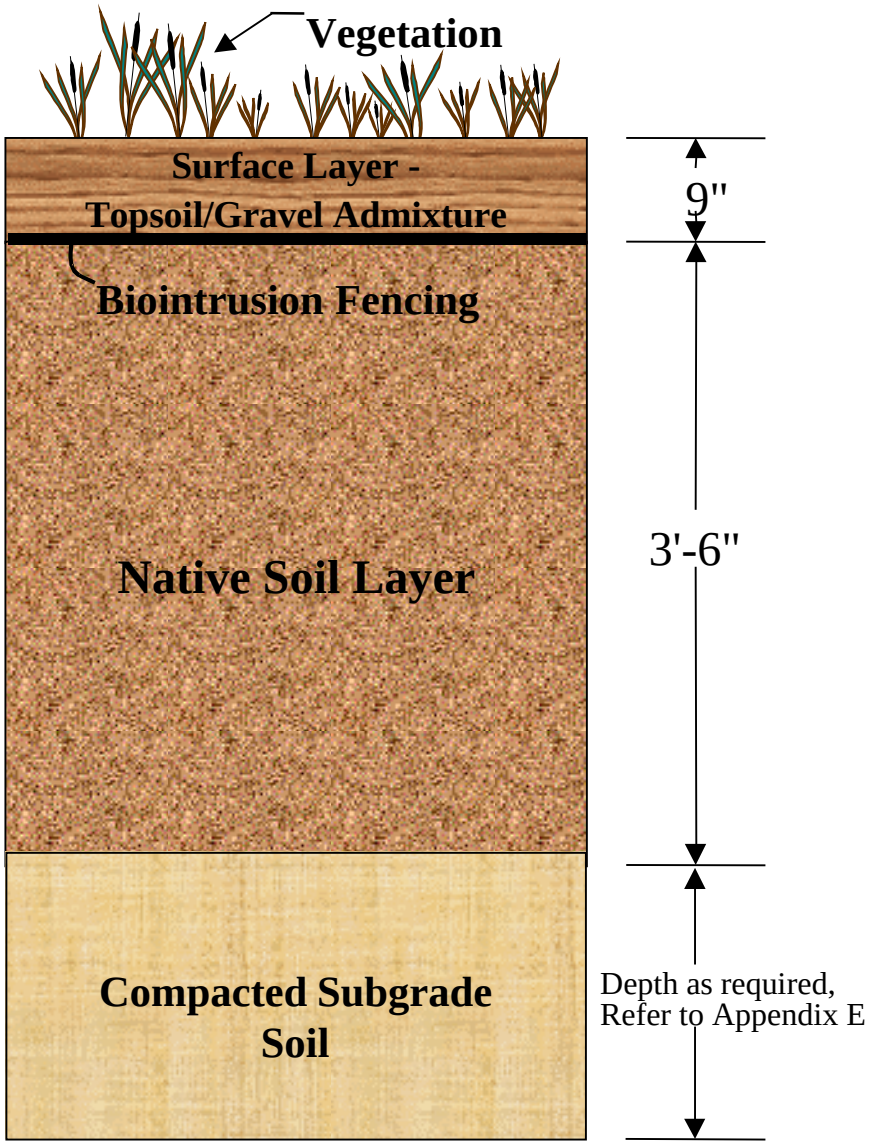

Figure 3. ET Cover Design for Deployment at MWL

2.1.1 Subgrade Layer

Prior to the placement of the subgrade soil, the existing MWL surface will be dynamically compacted with a (minimum 80,000-pound) vibratory kneading compactor. This will be done in an effort to reduce the threat of continued differential settlement. The subgrade material is to be made up of excavated soils from the Corrective Action

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Management Unit (CAMU) site located in the southeast section of Tech Area 3. This soil is piled northwest of the CAMU site. This soil has up to a 10% calcium carbonate content level (Appendix I) and is therefore not adequate for use as the native soil layer of the cover that will maintain plant root activity for moisture removal. This soil will be therefore placed and compacted to provide a stable foundation layer. The soil will be compacted as dry as reasonable but will not have the dry of optimum constraint as will the upper soil layer (the lower the initial moisture content, the higher the initial storage capacity of the soil). This soil is be placed to bring the site to grade before the actual cover soils are placed. Therefore the thickness of the subgrade soil will vary. Refer to the drawings in Appendix E for details. Also refer to the specifications in Appendix F for material specifications and details of the installation of this layer. The final grade of this layer will generally be between 3 and 5% as recommended by the EPA (EPA, 1991). These slopes will allow for adequate runoff but will not be too steep to induce significant surface erosion. The slopes will also allow for a small amount of differential settlement without much threat of ponding and thus increased infiltration potential.

2.1.2 Native Soil Layer

This soil layer's purpose is to act as a sponge and absorb the worst case precipitation/infiltration event until the water can be removed via evapotranspiration. Thus the thickness and soil texture is such to allow for the worst case scenario. In this case the thickness is to be 3.5 ft while sloped between 3 and 5% as recommended by the EPA (EPA 1991). The borrow site for the native soil layer is to be excavated from undisturbed topsoil directly adjacent to the MWL (west side). Only the upper 18 to 24 inches of borrow site soil is to used. This upper soil level will ensure that adequate nutrient levels for acceptable arid vegetation growth will be available. The in-situ soil beneath the borrow soil has a high level of calcium carbonate and consequently will not be used. The native soil layer is to be placed on the MWL in compacted lifts not to exceed 6 inches. The soil is to be placed dry of optimum and compacted to approximately represent the undisturbed borrow site in-situ density. The compaction will be enough to ensure uniform density while not too dense to inhibit root establishment. Refer to the drawings in Appendix E and specifications in Appendix F for complete details.

2.1.3 Biointrusion Layer

Biointrusion refers to the movement of plant roots and animals into the cover profile. A brief visit to the MWL site will reveal that small burrowing animals are present in the area. Refer to Figure 4. To protect against these small mammals burrowing through the cover and into the waste a biointrusion protection layer will be installed. The material of choice for this layer is a horizontally placed galvanized steel fence with ¼" squares to stop virtually all burrowing animal penetration past this point. This fencing will be placed between the topsoil gravel admixture layer and the compacted native soil layer at a depth of about 9 inches beneath the surface. The biointrusion layer will allow root penetration to accommodate evapotranspiration. Root penetration into the underlying waste is not a problem because the design cover depth exceeds the expected plant root

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depth. Adequate soil depth and water storage will be available to encourage growth of native grasses and shrubs. For the bulk of these species, the root depths are 6-12 inches deep, with a few species having a root depth reaching several feet. The design procedures outlined in this report have demonstrated that water infiltration should not exceed the 4'-3" depth of the cover and thus, roots should not extend beyond a 4'-3" depth.

Figure 4. MWL, Holes from Burrowing Animals

2.1.4 Surface Layer

The surface layer is to be a soil/gravel admixture. A gravel admixture can be effectively used in combination with vegetation. Erosion (Ligotke 1994) and water balance studies (Waugh *et al.*. 1994) suggest that moderate amounts of gravel mixed into the cover topsoil will control both water and wind erosion with little effect on vegetation or soil-water balance. As wind and water pass over the surface, removal of fines from the admixture is expected, leaving a vegetated erosion resistant pavement.

The ALCD described in *Appendix K* has installed covers with 1) no gravel mix, 2) a gravel to soil mix (gravel admixture), and 3) a gravel veneer on cover designs. Both the gravel admixture and gravel veneer have shown these designs to be effective at reducing surface erosion due to runoff when compared with the simple soil vegetation surface layer. The gravel admixture (Figure 5) and gravel veneer (Figure 6) have also provided for a superior plant coverage when compared to an untreated soil surface (Figure 7). The gravel admixture was chosen over the gravel veneer because it encouraged a better

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vegetation (native grasses) than the gravel veneer (deep rooted weeds and shrubs). The gravel admixture does not reduce evaporation while the gravel veneer does reduce evaporation.

Figure 5. ALCD, Vegetation Covering with No Surface Treatment

Figure 6. ALCD, Vegetation Covering with Gravel Admixture

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Figure 7. ALCD, Vegetation Covering with Gravel Veneer

2.1.5 Vegetation

The MWL cover will be drill-seeded with a mix of native species (Appendix F). The seed mix was selected to match the favorable vegetation found in the vicinity of the MWL (e.g., native grasses). The drill-seeding procedure will help reduce loss of seed due to wind and bird consumption. A tackified hydro-mulch will be applied over seeded areas to assist with moisture retention during seed germination. This seeding procedure may need to be repeated the following spring if the conditions were not adequate to allow adequate plant coverage from the first attempt.

2.2 Construction of the MWL

2.2.1 Construction Quality Assurance (CQA)

The Quality Assurance (QA) requirements for construction of the MWL cover closely adhere to that recommended by the EPA (EPA 1993). The QA process is intended to ensure that the cover is constructed as specified and that the design intent is achieved. QA procedures and results are to be thoroughly documented.

Materials quality assurance is of utmost importance. Materials and their installation must be tested to ensure compliance with the design, and recorded throughout the construction process. Soil testing includes plasticity index, sieve analysis, maximum size aggregate or

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debris, placement and compaction, moisture content, bond between lifts, lift thicknesses, etc. The QA Plan for the construction of the MWL is found in Appendix H.

2.2.2 Run-on Controls

The run-on control area for the MWL consists of about 6 acres east of the MWL. Using the Rational Formula, the flow rate is 15 cfs for undisturbed soil and 27 cfs for disturbed soil based on a 5-minute peak, 100-year flood event. Refer to Appendix G for a copy of the calculations. A proposed diversion trench located between the sled track (located east of the MWL) and MWL must be able to handle this flow as a minimum. Because many parties must be consulted to place this trench, it will be designed during the construction phase of this project.

2.3 Post-Construction Maintenance and Repairs of the MWL

2.3.1 Maintenance Issues

Periodic visual observations of the installed cover will be required after its installation to ensure that its integrity is continued. Observations will consist of a site walk-over by a registered professional engineer. Observations will occur at a minimum of once every six months for the first five years, then annually for the next 25 years. They will also be performed after each significant precipitation event. The observations should note any differential settlement, surface cracking, erosion, ponding, biointrusion, or other problems that could affect the integrity of the landfill cover.

2.3.2 Repair

Suggested repairs for the potential problems should be as follows:

- Settlement – add topsoil to depressed areas to bring the surface elevation back to its original grade.
- Surface cracking – cracks are to be filled with soil and reseeded. If the cracks extend into the compacted soil layer, the refilled soil will require compaction to match that of the existing landfill cover. This is to be performed with minimal disruption of vegetation.
- Erosion control – small gullies should be repaired by simply filling in the gullies with topsoil. Large gullies will require reengineering to avoid the problem from reoccurring.
- Ponding – fill in ponded area with additional soil.
- Biointrusion – requires occurrence specific repairs.

* *For all repairs, compaction requirements will be the same as originally specified for the MWL and after repair all affected areas are to be reseeded as specified for the MWL.*

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3.0 SECTION 3

3.1 Alternative Cover Technology Versus Traditional Cover Technology

3.1.1 Evapotranspiration Cover Concept

The ET Cover consists of a single, vegetated soil layer constructed to represent an optimum mix of soil texture, soil thickness, and vegetation cover (Dwyer, 1997). The ET Cover is a monolithic soil layer that has adequate soil water storage capacity to retain any infiltrated water until it can be removed via ET (Figure 8).

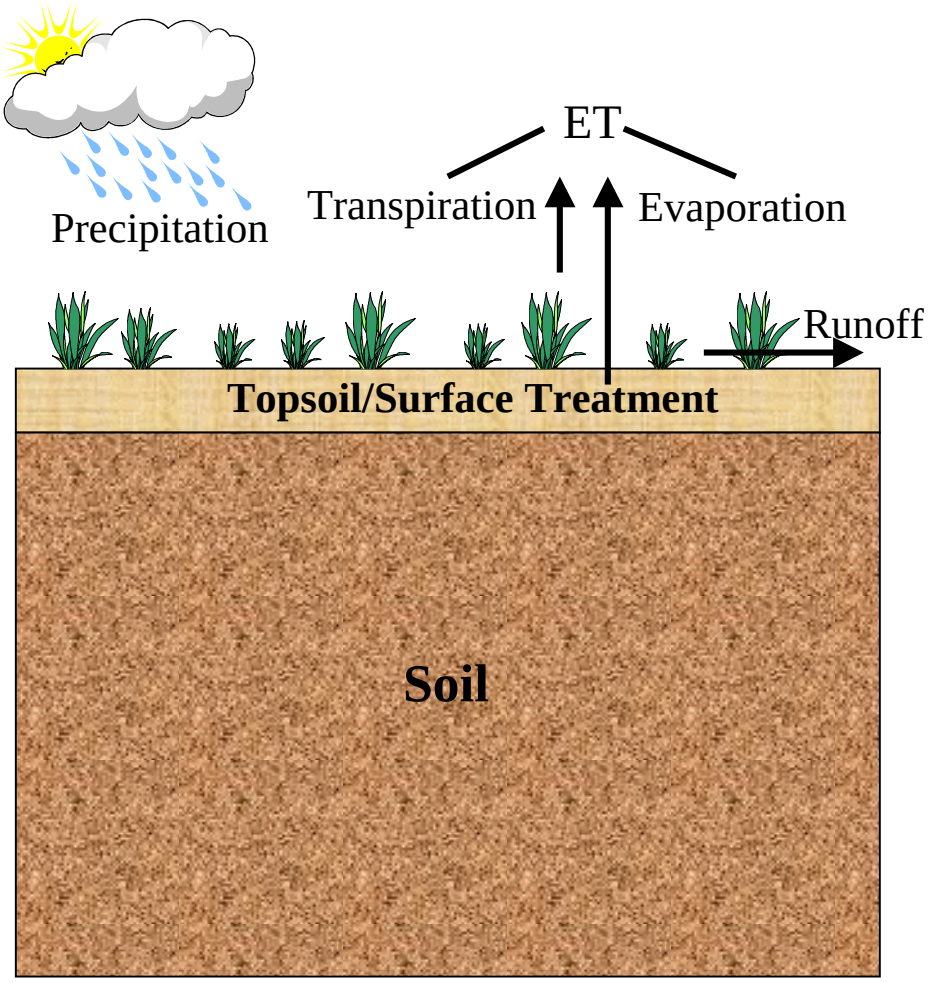

Figure 8. Typical ET Cover Profile

The concept relies on the soil acting like a sponge. The soil used will generally come from a nearby borrow site, for economic reasons. Any infiltrated water is held in this sponge until it can be evaporated and or transpired through vegetation. Studies have shown that a simple soil cover can be very effective at minimizing percolation and

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erosion, particularly in dry environments (Nyhan *et al.*. 1986, Nyhan *et al.*. 1990, Hauser *et al.*. 1994, and Dwyer 1998, Lass 1999).

3.1.1.1 Cover Soil Thickness

A first-order estimate of cover thickness can be determined from estimates of the storage capacity of the soil and the amount of infiltration that has to be stored. The design strategy for an ET Cover System is to ensure that the storage capacity is sufficient to store the worst case infiltration quantity due to the design precipitation event until it can be removed via ET. The maximum water content a soil can hold before it drains downward is referred to as its field capacity. This is essentially the soil water content after free or gravity drainage. Field capacity is often arbitrarily reported as the water content at about 330-cm of matric potential head (Jury *et al.*. 1991). Below field capacity, the hydraulic conductivity is often assumed to be so low that gravity drainage becomes negligible and the soil moisture is held in place by suction or matric potential. The storage capacity of a soil layer is thus calculated by multiplying its field capacity by the soil layer thickness. This assumes a consistent field capacity. However, not all of this stored water can be removed via transpiration (by plants). Vegetation can reduce the soil moisture content to the permanent wilting point, which is typically defined as the water content at 15,000 cm of matric potential head (Cassel and Nielsen 1986). Evaporation from the soil surface can further reduce the soil moisture below the wilting point to the residual saturation, which is the water content at an infinite matric potential. If water is only removed by plants, the net storage capacity, also referred to as the available water capacity, of a soil layer can be approximated by (Stormont and Morris, 1998):

$$NSC = (FC - PWP)b$$

where:

NSC = net storage capacity
FC = field capacity
PWP= permanent wilting point
b = soil layer thickness

From soil properties measured for the MWL borrow soil (Appendix I), the field capacity is estimated to be 16%. The permanent wilting point was assumed to be about 5%. Thus, the net storage capacity for this soil will be about 0.1 times its thickness.

It is important to note that the use of field capacity and permanent wilting point here is arbitrary and ignores other factors that affect the amount of moisture retained in a soil layer (e.g., Jury *et al.*. 1991, Cassel 1986). Nevertheless, these are simple and commonly used concepts. These terms should only be used to *approximate* the water storage capacity of a soil layer.

Commonly in dry environments, plants will reduce the water content of a near-surface soil to the permanent wilting point every growing season (Anderson *et al.*. 1993), making the entire net storage capacity available to store subsequent precipitation when ET is low and plants are dormant. Thus, an estimate of the required amount of infiltration that an

ET Cover has to store annually is the precipitation during dormant periods. For an average year in Albuquerque, there may be about 5 cm of precipitation from November through mid-March (estimated dormant period). Equating the dormant precipitation to the net storage capacity results in a required cover soil thickness of 50 cm (1.64 ft.) conservatively account for unusually wet years, the average dormant precipitation can be increased by some arbitrary amount. Doubling the dormant precipitation to 10 cm yields a required cover soil thickness of 100 cm (3.28 ft.). The water storage capacity depends on the soil's texture and density. It is recommended that the water storage capacity be determined at or near the in-situ density of the surrounding site soils since this is where it will eventually equilibrate.

3.1.1.2 Vegetation

The ultimate goal is to design a maintenance-free landfill cover. Some degree of maintenance or post-construction refinement may be necessary until the cover reaches a state of equilibrium with its inherent environment. A key element in the stability and performance of an ET Cover System is vegetation. A cover should be stabilized with vegetation comprising plant communities that closely emulate a selected local "climax" (Reith 1993). A "climax" community, in ecological terms, is the type of plant community one finds in an area that has long been undisturbed and is in equilibrium with all other environmental parameters (e.g., climate, soil, and landscape properties, fauna and other flora). Central to the concept of "climax" is the community's relative stability in the existing environment (Whittaker 1975). A diverse mixture of native plants on the cover will maximize water removal through ET (Link 1994). The cover will then be more resilient to natural and man-induced catastrophes and fluctuations in environments. Similarly, biological diversity in cover vegetation will be important to community stability and resilience given variable and unpredictable changes in the environment resulting from pest outbreaks, disturbances such as overgrazing, fires, etc., and climatic fluctuations. Local native species that have been selected through thousands of years of natural processes are best adapted to disturbances and climatic changes (Waugh 1994). In contrast, plantings of non-native species common on waste sites are genetically and structurally monotonous (Harper 1987) and are therefore more vulnerable to disturbances. Pedogenic processes will gradually change the physical and hydraulic properties of earthen material used to construct covers (Hillel 1980). Plant communities inhabiting the cover will also change in response to these changes in soil properties.

3.1.1.3 Surface Treatment

In very dry climates where the evaporation rate is higher than the precipitation rate, surface treatments may be warranted to help encourage native vegetation and reduce erosion. In these types of dry environments, a surface gravel veneer (Reith and Caldwell 1993) or gravel admixture (Waugh *et al.*, 1994) can be utilized. The addition of a surface gravel veneer can actually encourage vegetation. A gravel veneer is constructed by placing a one or two-inch thick layer of 1/2 inch to 2-inch diameter rounded gravel on the surface of the cover. It has several advantages in very dry climates. A gravel layer will reduce surface erosion due to runoff and wind erosion. It will serve to hold seed in place until it can germinate. In addition, moisture will be retained in the upper most layer of

soil allowing vegetation such as native grasses to be established. This increases the transpirational capacity available to remove moisture and prevent drainage after a desert deluge. The difference between this gravel veneer and a rock or riprap covering is that the moisture is retained in soil near the surface, apart from the waste, where water-seeking roots will not damage the cell.

Disadvantages of a gravel veneer include the reduced evaporation rate. Fine-grained soil has a higher evaporation rate than coarse-grained soil once the coarse-grained soil has become less conductive than the fine-grained soil. After the surface (gravel) dries, the lower portions will tend to remain moist because this coarse-grained gravel layer at this point is non-conductive. This reduced evaporation may be a large enough factor to disallow the use of a surface gravel veneer. There is no hard evidence revealing whether the added vegetation as a result of the gravel and consequently the additional transpiration will outweigh the reduced evaporation. This decision will need to be a site-specific decision.

An alternative to a surface gravel layer is a gravel admixture. A gravel admixture can be used in combination with vegetation. Erosion (Ligotke 1994) and water balance studies (Waugh *et al.*. 1994) suggest that moderate amounts of gravel mixed into the cover topsoil will control both water and wind erosion with little effect on vegetation or soil-water balance. As wind and water pass over the surface, some winnowing of fines from the admixture is expected, leaving a vegetated erosion resistant surface sometimes referred to as a “desert pavement”.

The design of a gravel admixture layer should be based on the need to protect the soil cover from water and wind erosion. A gravel admixture generally protects a cover from long-term wind erosion; the protection from water erosion will depend on the depth, velocity, and duration of water flowing across the landfill cover. These flow values can be established from the physical properties of the cover (slope, convex or concave grading, slope uniformity, and length of flow paths) and the intensity of the application of water (precipitation rates, infiltration - runoff relationship, snowmelt and off-site flows). For the Albuquerque area, runoff from severe storm events presents the critical stress on gravel admixture stability.

The need to use any gravel admixture for a soil cover can be established through a geomorphologic procedure or an empirical procedure (Anderson and Stormont, 1997). A geomorphologic evaluation involves the consideration of the geology, hydrology and specific landforms at a site; and comparing the results with similar conditions to predict what will happen over time. Equations of geomorphologic thresholds for water erosion and the formation of rills and gullies have been established for sites much larger than the MWL so that their application here is not warranted. The empirical Universal Soil Loss Equation (USLE) (Wischmeier and Smith, 1978) is particularly directed to the prediction of erosion from agricultural land and for areas disturbed by construction. The USLE equation is limited to the determination of average annual erosion rates and cannot establish erosion from specific events and peak erosional years. There is no direct

method within the USLE procedure to determine the depth or magnitude of gully or rill erosion on a landfill cover.

In humid climates, the establishment of a permanent vegetation cover will substantially minimize the potential for surface erosion. Vegetation serves to reduce the quantity of runoff, reduce soil mobilization due to raindrop impact, bind soil particles together through root systems, and reduce the surface velocity of flow. In arid and semi-arid climates the permanent vegetation cover may not have sufficient density to adequately provide erosion protection. Grasses and shrubs tend to be clumped leaving a substantial percentage of the soil exposed to direct wind and water flow. Such is the case at the MWL site.

Based on the above concerns, the gravel admixture for the MWL should be based on maintaining long term ecological stability and protection of the soil cover from runoff generated by a major storm event. The design condition for the major storm event will be to prevent rill or gully erosion from penetrating into the soil layer. The following steps were followed to design the gravel admixture at the MWL.

a. Establish physical parameters for the cover including area, maximum slope and slope length.
b. Determine rainfall quantities for the design storm from the NOAA Atlas 2 (Volume IV, New Mexico). Determine 5, 10, 15, 30 and 60-minute rainfall intensities using procedures in NOAA Atlas 2. A storm event with a 100-year frequency was used for the MWL.
c. Using appropriate surface infiltration conditions, establish a runoff hydrograph for the 100-year precipitation event. It is proposed that the hydrograph analysis use an initial abstraction / uniform infiltration loss method with a unit hydrograph procedure based on a three segment gamma function parameters calibrated to New Mexico rainfall-runoff conditions. This methodology is available in the AHYMO97 Program (Anderson, 1997).
d. Sheet flow erosion could be computed using the USLE (Williams, 1975) with a wash load factor based on Albuquerque area recommendations.
e. Rill or channelized erosion can be computed from the runoff hydrograph based on Meyer-Peter, Muller-Woo (MPM-Woo) Method (Mussetter, *et al*., 1994) and geomorphologic factors for channelized flow spacing and channel width and depth ratios.
f. From the hydraulic analysis of the cover surface, a critical particle size can be computed using the Shield's relation. This is the minimum size required to maintain an armored or stable channel configuration for the design flow event.
g. Based on the percentage of gravel in the gravel admixture layer, the scour depth necessary to establish an armor layer can be computed.

Additionally the total recommended depth for the gravel layer could be established based on scour depth, minimum thickness-diameter ratios and design safety factors.

Computations following this sequence are located in Appendix J. Based on these computations, the following criteria for the gravel admixture layer can be established.

3.1.2 Traditional RCRA Subtitle C Landfill Cover Concept

A design guidance document issued by the EPA in 1989 recommended that landfill closures for RCRA Subtitle 'C' and/or Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) facilities incorporate the following layers in a cover profile (EPA 1991):

1. Composite Barrier Layer. A layer consisting of a low hydraulic conductivity geomembrane/soil layer. A 60-cm (24-in.) layer of compacted natural or amended soil with a maximum saturated hydraulic conductivity of 1×10^{-7} cm/sec in intimate contact with an overlying 0.5-mm (20-mil) thick (minimum) geomembrane liner. The function of this composite barrier layer is to block moisture movement downward from the overlying drainage layer.
2. Drainage Layer. A minimum 30-cm (12-in) soil layer having a minimum hydraulic conductivity of 1×10^{-2} cm/sec, or a layer of geosynthetic material having the same characteristics. This layer's design intent is to minimize the time the infiltrated water is in contact with the bottom composite barrier layer and hence, to lessen the potential for the water to reach the waste.
3. Topsoil Vegetation Layer. A top layer with vegetation (or an armored top surface) and a minimum of 60 cm (24 in.) of soil graded at a slope between 3 and 5 percent. This layer should be capable of sustaining nonwoody plants, have an adequate water-holding capacity, and be sufficiently deep to allow for expected, long-term erosion losses.
4. Optional layers include:
   (a) Gas Vent Layer. This layer should be at least 30-cm (12-in.) thick and be above the waste and below the composite barrier layer. The layer is generally composed of coarse-grained soil, similar to that used for the drainage layer. Perforated, horizontal pipes within this layer should channel gases to a minimum number of vertical risers at a high point (in the cross section) to promote gas ventilation.
   (b) Biointrusion Layer. A 90-cm (3 ft) biotic barrier of cobbles directly beneath the top vegetation layer may stop the penetration of some deep-rooted plants and the invasion of burrowing animals.

Figure 9 depicts the traditional Subtitle "C" Soil Profile.

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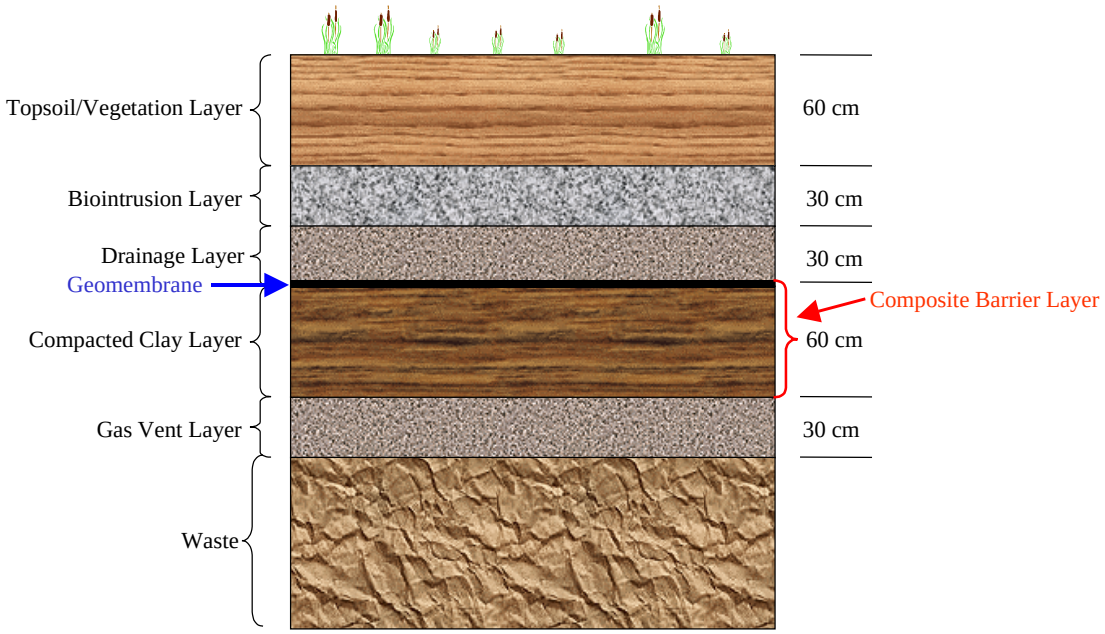

Figure 9. Traditional Subtitle 'C' Compacted Clay Cover

3.1.3 Performance History of Traditional RCRA Landfill Covers

Traditional covers presently in use for RCRA Subtitle 'C' and 'D' regulated facilities as recommended by the EPA are used throughout the country with little regard for regional conditions. RCRA Subtitle 'C' facilities are for hazardous waste while RCRA Subtitle 'D' facilities are for municipal solid waste. Experience in the western United States has shown these designs to be vulnerable to such things as desiccation cracking when installed in arid environments. An EPA design guidance document (EPA 1991) for final landfill covers states: "In arid regions, a barrier layer composed of clay (natural soil) and a geomembrane is not very effective. Since the soil is compacted 'wet of optimum', the layer will dry and crack". The clay barrier layer in the traditional Subtitle 'C' Cover must be constructed to yield a maximum hydraulic conductivity of 1 x 10^{-7} cm/sec. To achieve this, the soil often requires amendment (e.g. mixed with bentonite) and should be compacted 'wet of optimum'. Compacting this layer 'wet of optimum' in dry environments leads to drying and cracking of this layer. Desiccation, which can occur by several mechanisms, is an important failure mode for compacted soil hydraulic barriers, especially in arid environments (Suter *et al.*. 1993). The basic soil cover used with Subtitle 'D' covers has a barrier layer that is also subject to desiccation cracking, as well as deterioration due to freeze/thaw cycles, among other problems.

These traditional covers such as the Subtitle 'C' Cover are not only inherently problematic but are very expensive (Dwyer 1998c) and difficult to construct (Dwyer, 1998d). A study (EPA 1988) of existing landfills revealed that these traditional landfill cover technologies may not be working as well as intended. Randomly selected landfills

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revealed that the vast majority are leaking. Many have serious problems including groundwater contamination and serious ecological impacts such as flora and fauna mortality. Virtually all parts of the nation have experienced water contamination due to leachate leaking from landfills to some degree (EPA 1988). Not all of these problems are the result of inadequate covers. Many older landfills were crudely installed (e.g., poor siting, inadequate or lack of liner) thus destined for failure, but these problems can be mitigated by capping the entire landfill with a properly designed cover. A more recent study (Mulder 1995), titled the California Solid Waste Assessment Test Report found that 72 to 86 percent of existing landfills with compacted clay barrier layers are failing. It also concluded that these clay barriers leak regardless of climate or site-specific geology.

3.1.4 New EPA Landfill Closure Design Guidance *(currently in print)*

A common misconception by some design engineers and regulators is that the cover profile described in Section 3.1.2 is the closure required by regulation for RCRA/CERCLA facilities. The regulations for these facilities outlined in 40CFR264 and 265 are fairly vague and discuss minimizing infiltration and erosion and make no reference toward a specific design. The "EPA Recommended Design" shown in Figure 9 was actually born from the earlier Design Guidance Document (EPA 1991) issued. Due to information obtained from past and ongoing research efforts, as well as studies assessing existing waste disposal facilities, this document is currently being rewritten. The new guidance document "Technical Guidance for RCRA/CERCLA Final Covers" (EPA *in print*) scheduled for release in late 1999 will discuss a number of recommended designs taking into consideration site specific information such as climate and geology. This differs from the 1989 edition that recommended one design nationally with no regard for site specifics. Among the recommended designs considered are: the resistive barrier type as detailed in the 1989 edition and a number of alternative designs recommended for dry environments such as an Evapotranspiration (ET) Cover and a Capillary Barrier. A number of new products will be discussed as well as emerging materials to be considered.

3.1.5 Why ET Cover is a Good Choice for the MWL

An important advantage of ET Covers is they are much less expensive than their traditional counterparts. This issue is probably the single most important driving force for the deployment of these covers at present because they save large amounts of money during construction. At Warren Air Force Base in Cheyenne, Wyoming, the Air Force estimated they would save over $16 million by installing an ET Cover rather than a Compacted Clay Cover over a 42-acre hazardous waste landfill. A side-by-side study of constructed values showed that the cost savings for an ET Cover versus a Compacted Clay Cover is in excess of 50 percent (Dwyer 1998c).

Other advantages of an ET Cover system are that it is essentially maintenance free and it makes use of unsaturated conditions that govern water flow in dry environments. It allows for relatively easy repairs due to differential settlement problems. With an ET Cover, if differential settlement occurs within an ET cover, more soil can be applied to

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the surface to bring the cover back to its original grade. With a RCRA Subtitle 'C' Cover, any significant differential settlement can lead to the tearing of the geomembrane and cracking in the underlying clay barrier layer. The effectiveness of the drainage layer may be compromised. These potential flaws will typically occur at the landfills low point where ruptures or cracks will serve as a funnel for water to flow down to and through the underlying waste.

The MWL is still experiencing differential settlement (Figure 10). The ET Cover is much easier to build and requires less quality assurance during construction than its traditional counterpart (Dwyer *1998d*). The ET Covers are usually better able to prevent side slope instability than a RCRA Subtitle 'C' cover because they do not have a geomembrane which creates a slip plane. The ET Cover performance also increases with time as the plant community gets fully established, while the RCRA 'C' barrier layer continues to decline in its effectiveness due to barrier layer deterioration.

Figure 10. Differential Settlement at MWL

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3.1.5.1 Darcy's Law

A flawed assumption with the use of traditional RCRA Subtitle 'C' Covers is that flow occurs under saturated conditions. On the contrary, flow generally occurs under unsaturated conditions. This is particularly the case in dry environments. Darcy's Law can be used to represent the fundamental equation of flow for both scenarios:

For saturated systems: $Q = K_{sat}\, i\, A$

where: Q = flow rate
K_{sat} = saturated hydraulic conductivity
i = hydraulic gradient = *f*(gravity and positive pressure)
A = area

For unsaturated systems: $Q = K_{unsat}\, i\, A$

where: Q = flow rate
K_{unsat} = unsaturated hydraulic conductivity
i = hydraulic gradient = *f*(gravity and matric potential)
A = area

3.1.5.2 Moisture Driven by Total Potential Difference Toward Equilibrium

Water moves toward regions of higher water potential and is consequently governed by gravity *and* matric potential equilibrium for unsaturated flow. Under saturated conditions, the soil's matric potential is zero.

$$\psi_{Total} = \psi_{grav} + \psi_{matric} + \psi_s + \psi_a$$

where: ψ_{Total} = total soil water potential
ψ_{grav} = gravitational potential
ψ_{matric} = matric potential or soil suction
ψ_s = solute potential
ψ_a = air pressure potential

but ψ_s and ψ_a are generally considered to be zero for landfill cover applications, therefore the relationship can be simplified to:

$$\psi_{Total} = \psi_{grav} + \psi_{matric}$$

However, in the field water movement patterns are complicated by a number of things such as: climatic conditions, plants, structural voids, secondary pathways, non-homogenous soils, and hysteresis.

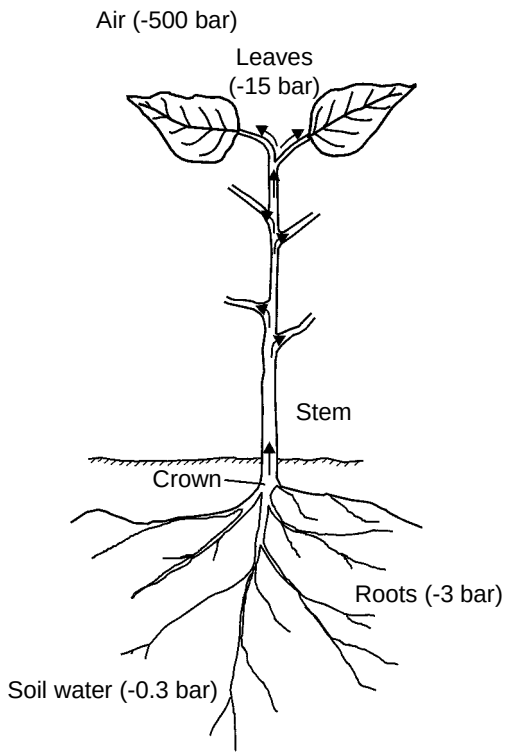

Figure 11. Typical Soil-Plant-Atmosphere Water Potential Variation (Hillel 1998)

ET provides the mechanism to remove stored water from the cover soil layer. Water can move upward in response to matric potential gradients induced from ET drying the upper portions of the cover soil layer. Evaporation from the surface will decrease the water content and increase the matric potential of the soil, resulting in an upward matric potential gradient and inducing upward flow.

Plant transpiration also relies upon matric potential gradients to remove water from the cover soil layer. Figure 11 shows the large matric potential difference between the soil and atmosphere. In dry environments, the total potential difference between soil moisture and atmospheric humidity can be up to 1000 bars (Hillel 1998). The largest portion of this overall potential difference occurs between the leaves and the atmosphere. The larger the soil-plant-atmospheric potential gradient, the more effective an ET Cover System can be. This is why well vegetated cover systems are well suited for dry environments such as the arid Southwest.

3.1.5.3 Potential Evapotranspiration versus Precipitation

Another way to explain why an ET Cover is effective in dry environments is due to the much larger potential evaporation compared to precipitation. Potential Evapo-transpiration (PET) is essentially the climatic 'demand' for water. The number can be calculated using Penman's equation (Jensen *et al.* 1990) found in Appendix C. The total calculated PET for Albuquerque (Albuquerque Airport per the National Weather Service) from 1991 through May 1999 was 690.2 inches while the actual precipitation during this

period was only 66.54 inches (Appendix A). This equates to greater than a 10:1 PET to precipitation ratio. There is generally a much greater demand for water by the atmosphere and plants than can be supplied to the soil in an area such as the Mixed Waste Landfill. A monthly break-out of PET versus precipitation for 1998 is graphically shown in Figure 11. The 1998 monthly data used in this figure is found in Appendix B.

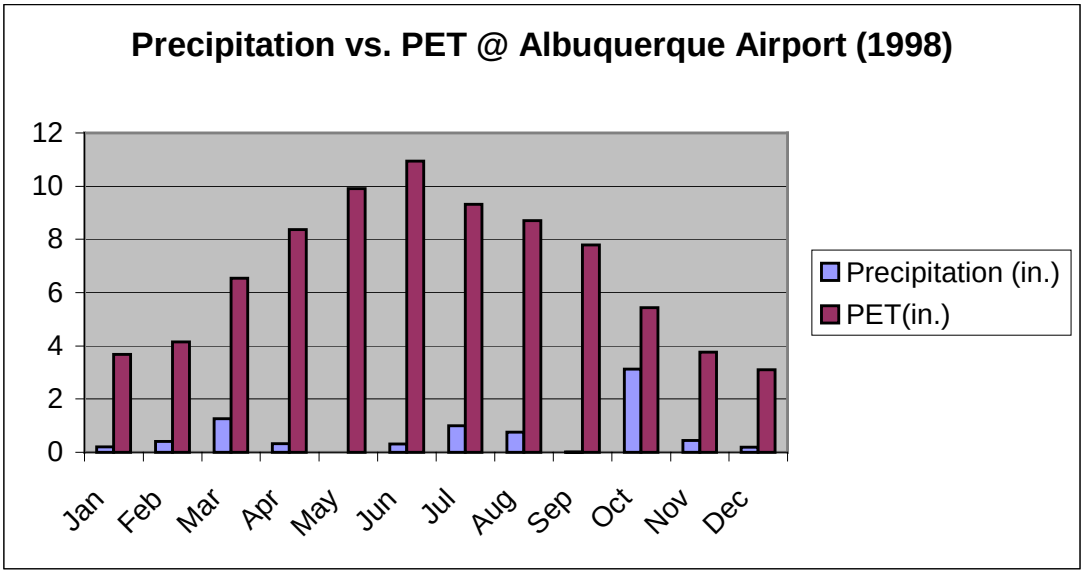

Figure 12. Actual Precipitation vs. PET in Albuquerque, NM for 1998

The principle features of the regulations (40CFR264) for the closure of a hazardous waste facilities allude to *minimization* of surface erosion and infiltration into the underlying waste. Much of this paper centers on the ability of the ET Cover to successfully reduce infiltration. An ET Cover has a lower erosion potential than a traditionally constructed RCRA Subtitle C Cover. An existing site in Oregon demonstrates this (Figure 13). A traditional cover consisting of an upper vegetation layer, middle drainage layer, and bottom barrier layer constructed in a semiarid region in Oregon reveals that the topsoil layer was not capable of maintaining an adequate vegetation stand. Eventually, sparsely located deep-rooted shrubs were established on the cover in contrast to the ideal more desirable grasses surrounding the landfill. Additionally, the high ground cover grasses are more efficient than the sparsely distributed shrubs at reducing surface erosion due to both runoff and wind.

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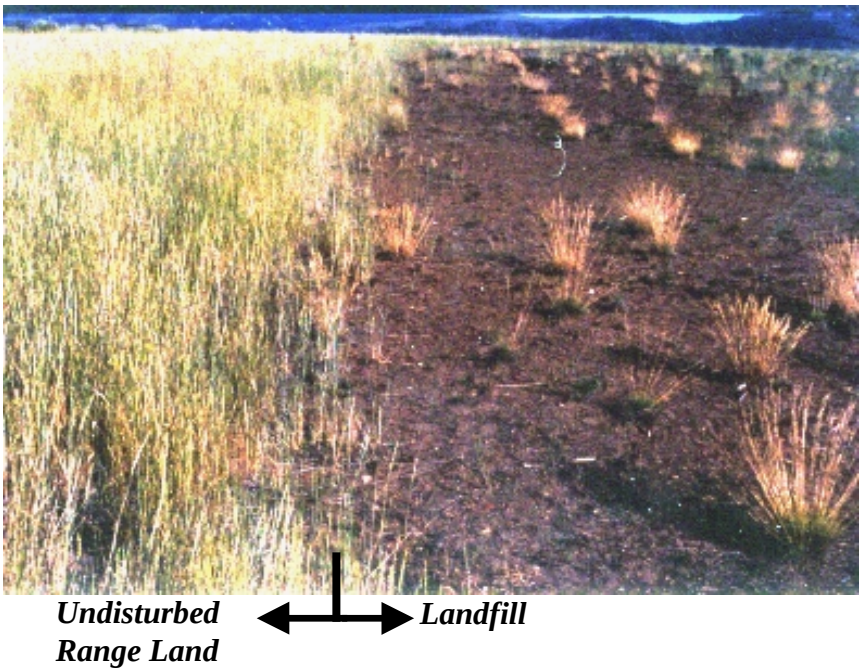

Figure 13. Oregon Landfill – Surface Vegetation of Undisturbed Rangeland versus Landfill

3.2 Equivalence Determination of an ET Cover System versus a Traditional RCRA Subtitle 'C' Compacted Clay Cover

3.2.1 Equivalence Determination Contained in New EPA Design Guidance Document

The equivalency determination of an alternative cover system versus a traditional RCRA Subtitle 'C' Compacted Clay Cover is discussed in the new EPA Design Guidance Document (Dwyer *et al.*, in print). A landfill cover system must be able to protect and isolate waste the length of time required for the contaminants to be deemed harmless to the surrounding community. The cover must limit percolation into the underlying waste; thereby, minimizing leachate generation, and remain intact for the duration of its design life. This includes erosion control with minimal or no maintenance requirements.

There is an increasing trend throughout the country to directly substitute alternative cover technologies for conventional landfill cover designs. As data on existing landfill system performance is documented, conventional cover designs utilizing impermeable clay barriers are being shown to be less effective. A recent study (Mulder *et al.*. 1995) found that 72 to 86 percent of landfills using clay barrier layers are failing regardless of the site's climate or geology.

Although alternative cover designs may be more effective than traditional covers, cost in most cases is the driving factor for the desired use of an alternative cover technology. A basic cost estimate comparison of the construction of alternative cover technology to that

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of conventional covers is usually sufficient to convince owners and/or operators to propose this cover system for acceptance by the regulatory community. In essence, if an alternative cover's performance can be proven as good or better than its conventional counterpart, the regulatory entity will likely grant its use. In general, the performance criterion includes the landfill's continued ability to isolate the waste from the surrounding environment by limiting percolation rate or the cover system's flux rate. The percolation rate has generally been believed to be dependent on the barrier layer's constructed saturated hydraulic conductivity. The saturated hydraulic conductivity is a measured value that has been traditionally considered to remain constant over the life of the landfill, generally changes over time. Therefore, this performance equivalence is a complex issue. Equivalence should include not only the cover's initial ability to prevent percolation, but also its ability to prevent biointrusion, resist erosion, require minimal maintenance, control gas emissions, etc. All of these factors contribute to the cover's ability to prevent percolation over its life span.

As more alternative cover systems are installed, and successfully perform, they establish confidence for their continued use at other sites. However, it may take years to obtain sufficient data from these deployments to establish alternative landfill cover performance. Many experiments and field-scale demonstrations throughout the country are currently producing *field data* to document the short-term performance of alternative cover technologies (Dwyer 1997, Benson 1997). *Natural analogs* can be used to show how a system may perform over longer periods (Waugh 1994). *Computer modeling* can also be used for direct comparisons among alternative cover systems (Khire 1995, Morris and Stormont 1997), and supplement information gained from field studies and natural analogs. The combination of these elements form the basis required by regulators for issuing alternative cover system permits.

3.2.2 Cover System's Flux Rate versus Barrier Layer's Saturated Hydraulic Conductivity

The regulations (40CFR264) governing the design and construction of hazardous waste landfill covers are vague. They simply state that infiltration and erosion should be minimized. The EPA issued a guidance document in 1989 (DOE 1991) that recommend a single design (Figure 9). This cover's ability to prevent percolation into the underlying waste centered on a barrier layer with a saturated hydraulic conductivity of 1×10^{-7} cm/sec. This also incorrectly assumed the system to have a flux rate of 1×10^{-7} cm/sec or lower. The problem with this design was that it was recommended for the entire nation with little regard for site geologies or climate. Many studies (Suter 1993, Mulder 1995, Dwyer 1997) have shown that the clay barrier layer is subject to desiccation and thus an increase in its saturated hydraulic conductivity over time.

A recent and very thorough investigation of an existing closure of a Uranium Mill Tailings Disposal Site (Waugh 1997) concluded that clay barrier layer's hydraulic conductivity will increase several orders of magnitude with time. The study noted that root intrusion, insect and earthworm intrusion, density changes, and desiccation effects will all contribute to increase the saturated hydraulic conductivity of the clay barrier

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layer. This exposes the earlier flawed thinking that hydraulic conductivity at construction will hold for the life of the cover system. In the past, the changed hydraulic conductivity properties would have been deemed a failure of the cover – but in reality considering all environmental factors, the cover may still have prevented moisture from reaching the underlying waste. It has been shown that even with higher hydraulic conductivity values, flux rates can still decrease because of an increase in transpiration due to the root intrusion. With the realization of the numerous studies throughout the country, the EPA has rewritten its EPA guidance document (EPA in print) to reflect these findings and move the designer more toward a flux rate basis for design. The flux rate is the entire cover system's ability to prevent percolation. The lower the flux rate, the better the cover system is at limiting percolation and thus minimizing the potential of leachate generation.

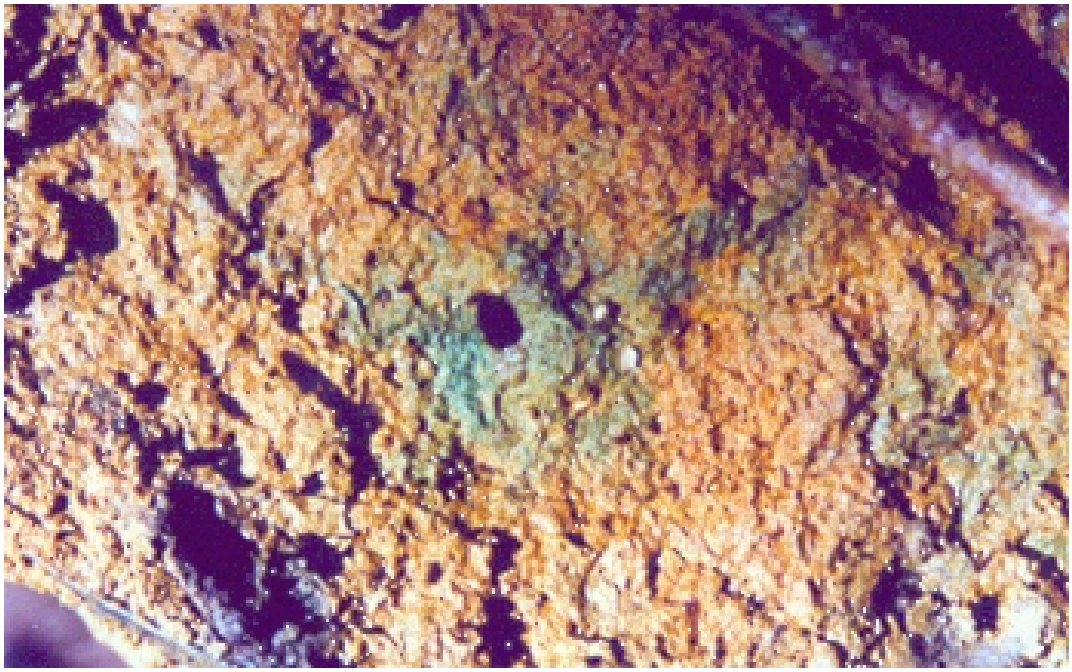

Figure 14. Root and Earthworm Intrusion into Clay Barrier Layer

3.2.3 Field Data to Predict Short Term Performance

Field data is perhaps the most valuable piece of information for determining whether a system is really going to work as planned. This is especially true for large-scale field data performed in representative sites with similar climates and geologies. Several sets of field data of this type are described below.

The first studies are those that are centered on the use of existing EPA recommended technologies, such as, the use of a compacted clay layer to act as an impermeable barrier. Suter *et al.* (1993) concluded that in general all compacted clay barrier layers will fail in the long-term. More specific studies performed on real sites are also examined. A study (EPA, 1988) of existing landfill performance revealed that many have serious problems from groundwater contamination to serious ecological impacts such as killing flora and fauna. Virtually all parts of the nation have experienced water contamination due to

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leachate leaking from landfills in some degree (EPA, 1988). Not all of these problems are the result of inadequate covers. Many older landfills were crudely installed (e.g., poor siting, inadequate or lack of liner) thus destined for failure, but these problems can be mitigated by capping the entire landfill with a good quality final cover. A more recent study (Mulder *et al.*. 1995) found 72 to 86% of landfills utilizing clay barrier layers are failing. This study was performed on 544 existing sites in the State of California. The failures reported in this study occurred regardless of climate or site-specific geology. The conclusion of all of these studies on existing landfill closures with compacted clay barrier layers is that they are likely to fail. This leads to those studies that address improving on currently used technologies.

3.2.3.1 Alternative Landfill Cover Demonstration

An important study dealing with alternative covers is conveniently located just a few hundred yards southeast of the MWL. This study is referred to as the Alternative Landfill Cover Demonstration (ALCD). There are six cover designs being tested in this demonstration project: two baseline cover profiles (traditional RCRA Subtitle 'D' and Subtitle 'C' Covers respectively) and four alternative cover designs. Alternative Test Cover 4 is an ET Cover System similar to that proposed for deployment at the MWL. Generally, a test plot such as this is all that is required by regulators to supply them with field data to make a decision on whether or not to permit an alternative cover system.

The first year's data is as follows (Dwyer 1998b):

Alternative Landfill Cover Demonstration

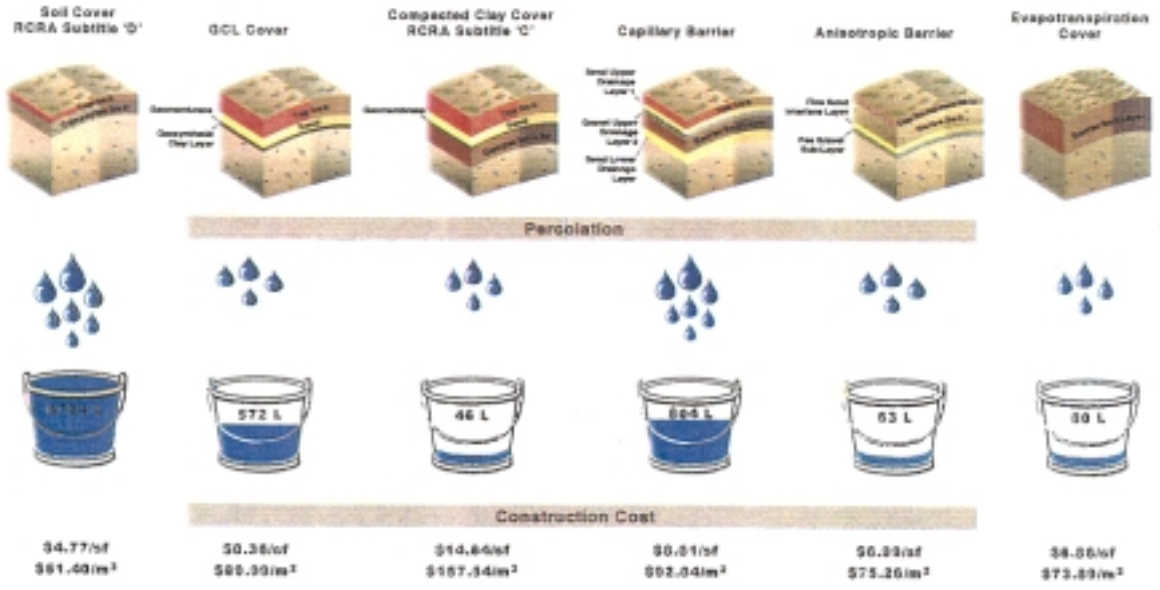

Figure 15. ALCD First Year Results

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These percolation volumes for year 1 put into terms of flux rates and cover efficiency are listed in Table 1:

Table 1. ALCD First Year Flux Rates

Title	Flux rate (cm/sec)	Flux Rate (cm/yr)	Efficiency*
Subtitle D Cover	2×10^{-8}	0.600	99.98%
GCL Cover	2×10^{-9}	0.050	99.998
Subtitle C Cover	1×10^{-10}	0.004	99.9999
Capillary Barrier	2×10^{-9}	0.070	99.998
Anisotropic Barrier	2×10^{-10}	0.006	99.9998
ET Cover	2×10^{-10}	0.007	99.9998

* Efficiency = (percolation volume ÷ volume of precipitation) x 100%

A de minimus flux rate has been suggested as 0.5 cm/yr (Benson 1998). Based on this factor, all of the covers, with the exception of Subtitle D Cover, are essentially impermeable.

The second year's data is currently being summarized. Copies of this data report will be available upon request.

3.2.3.2 ET Cover Results at California Sites

There are a number of alternative landfill cover systems installed in the United States today. Two installed in Southern California are described below. The Milliken Landfill in San Bernardino County, California had an ET Cover installed on it. This is a municipal solid waste landfill. The prescriptive landfill requirements for California are more stringent than that for most of the rest of the country as outlined in 40CFR Parts 257 and 258. The California Code of Regulations (CCR) Title 23, Chapter 15 provides the basis for Title 14 closure standards which state that the cover must have a minimum of a two-foot thick foundation layer, a one-foot thick barrier layer with a hydraulic conductivity maximum of 1×10^{-6} cm/sec, and a minimum one-foot thick vegetation top layer. The Cal EPA (Mulder 1995) study showed these barrier layers to be ineffective. Therefore the State of California is very receptive to allowing the use of alternative covers, such as an ET Cover. The Milliken site receives an annual precipitation average of about 12.7 inches a year (approximately 50% higher than Albuquerque). The design saturated hydraulic conductivity of the soil used was 5.2×10^{-5} cm/sec. Beginning in October 1996 to date, directly measured flux rates of this cover are: north slopes = 2.1×10^{-8} cm/sec, east slopes = 2.5×10^{-9} cm/sec, south slopes = 1.3×10^{-8} cm/sec, flat area = 2.1×10^{-9} cm/sec. Appendix D contains more details on flux rates (Lass, 1999).

Another alternative landfill with an ET cover known as the Phelan Landfill, is located northeast of Los Angeles near Palmdale, California. The design saturated hydraulic conductivity of the soil used for this site was 1.7×10^{-4} cm/sec. The average annualized rainfall is similar to the MWL – 7.3 inches per year. The directly measured flux rates (annualized) of the installed cover beginning in December 1997 to date are: upper layer =

3.7×10^{-8} cm/sec, north slopes = 3.1×10^{-8} cm/sec, and the east slopes = 2.4×10^{-9} cm/sec (Lass 1999). These flux rates show these covers appear to be working very well. As the vegetation becomes better established, the flux rates are expected to get lower. Refer to Appendix D for more details.

The role of plants on covers should not be underestimated. Ten sites in arid areas of California were evaluated for the effects of flux with no plant coverage versus limited plant coverage (up to 5%). The reduction in flux due to this minimal increase in vegetation is summarized in Table 2 (Lass 1999):

Table 2. Flux Reduction Due to up to a 5% Plant Coverage Increase

Site	Percent Reduction in Flux (up to 5% plant coverage)
Yermo	45%
Coachella	93%
Highgrove	91%
Lucerne Valley	97%
Miramar	99%
Mead Valley	86%
Picacho	99%
Baker	90%
Trona Argus	100%
29 Palms	98%

3.2.4 Natural Analogs for Predicting Long Term Performance

Conventional engineering approaches for designing landfill covers often fail to fully consider ecological processes. Natural ecosystems effective at capturing and or redistributing materials in the environment have evolved over millions of years. Consequently, when contaminants are introduced into the environment, ecosystem processes begin to influence the distribution and transport of these materials, just as they influence the distribution and transport of nutrients that occur naturally in ecosystems (Hakonson *et al.*, 1992). As the ecological status of the cover changes, so will performance factors such as water infiltration, water retention, ET, soil erosion, gas diffusion, and biointrusion. The objective in constructing an effective landfill is to design the cover so that subsequent ecological change will enhance and preserve the encapsulating system. Consideration of natural analogs can enhance a cover design by disclosing what properties are effective in a given environment or what processes may lead to possible modes of failure. These factors can in turn be avoided during the design and construction phases. Natural analog studies provide clues from past environments as to possible long-term changes in engineered covers. Analog studies involve the use of logical analogy to investigate natural and archaeological occurrences of materials, conditions, or processes that are similar to those known or predicted to occur in some part of the engineered cover system (Waugh 1994).

One use for analog studies (Suter 1993, Mulder 1995, Dwyer 1997, Waugh 1997) is to look at the effectiveness of traditional landfill covers. Another use is to look at the potential effectiveness of alternative covers. A number of studies cited earlier in this paper have identified that the traditional RCRA Subtitle C Compacted Clay Cover and its dependence on its clay barrier layer maintaining its impermeability does not perform as well as it original intent.

A study at Sandia National Laboratory concluded that there has been essentially no infiltration beyond a 20-foot depth in the past 35,000 years (Figure 16). Consequently, since the groundwater depth is about 500 ft, there is essentially no risk of recharge. Because this natural analog study reveals that there is no practical chance for the groundwater to be contaminated due to the landfill's leachate generation, one could draw the conclusion that no further action is required (no cover system is warranted). However, this is not the case since tritium contamination is found at the surface and there is still ongoing differential settlement. Because of this, a cover system is needed to ensure isolating the waste from the surrounding environment. Other reasons for a cover is the need to protect the site from damage due to erosion, redundancy, and potential climatic changes resulting in increased precipitation.

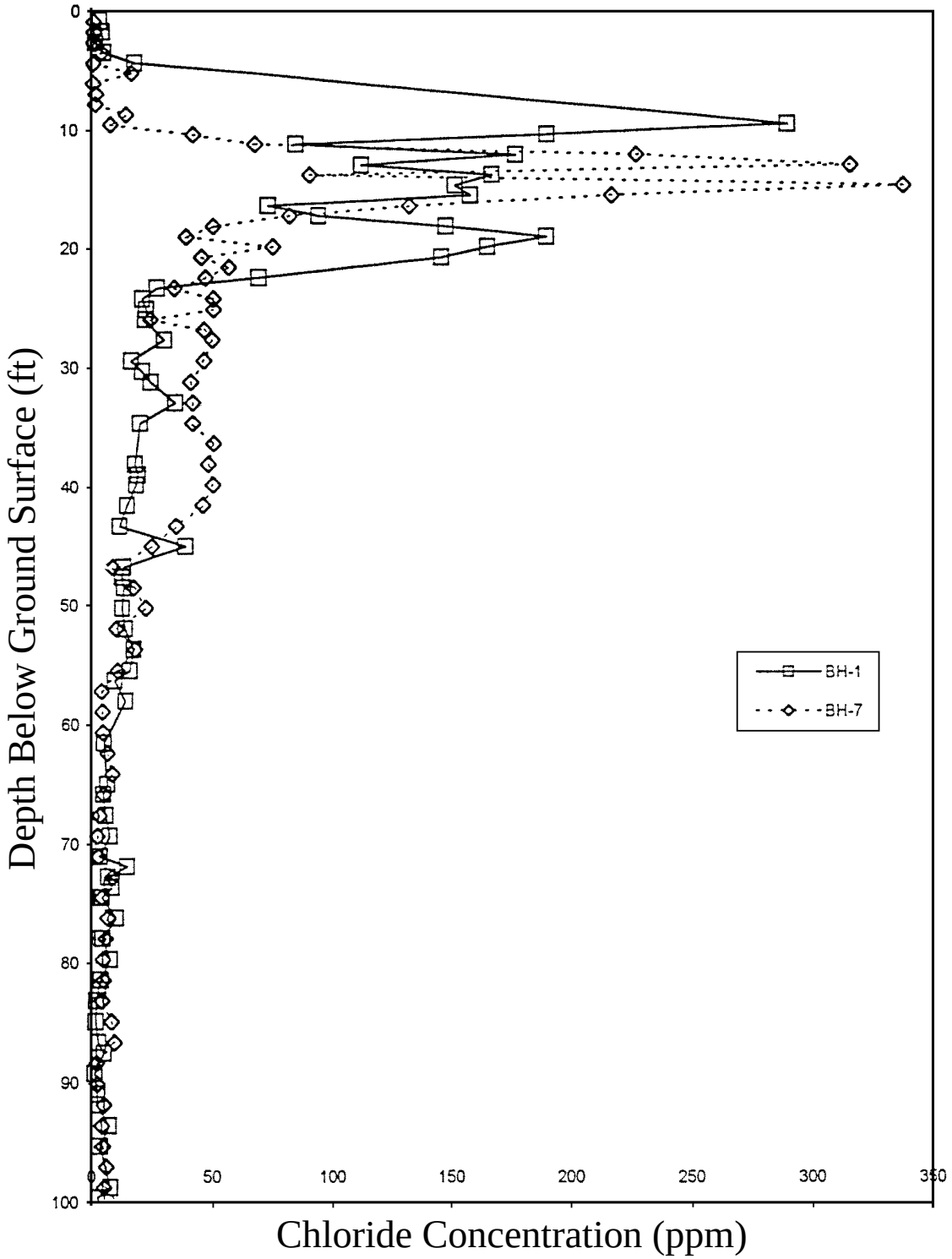

Figure 16. Chloride Concentration Profiles in Boreholes 1 and 7 at the MWL (Peace 1999)

The primary waste concern in the MWL is tritium. This waste form will be deemed harmless in the next couple hundred years. Consequently a natural analog to determine the cover systems performance over this length of time is warranted. The best analog for this is trenching adjacent to the site and determining the depth of calcium carbonate deposits or formation of a caliche layer. Soils in semiarid and arid regions commonly have carbonate-rich horizons at some depth below the surface, or if the climate is dry enough or the surface erosion intensive enough, these horizons may extend to the surface. The position of the $CaCO_3$ bearing horizon is therefore, related to depth of leaching, which, in turn, is related to climate (Birkeland 1984).

The origin of carbonate horizons involves carbonate-bicarbonate equilibria (Birkeland 1984), as shown by the following reactions:

$$\begin{array}{ccccccc} & & CO_2 & + & H_2O & & \\ & & g & & l & & \\ & & & \uparrow\downarrow & & & \\ CaCO_3 & + & H_2CO_3 & \Leftrightarrow & Ca^{2+} & + & 2HCO_3^- \\ c & & aq & & aq & & aq \end{array}$$

An increase in $C0_2$ content in the soil air or a decrease in pH will drive the reaction to dissolve carbonate and cause the reaction to move as Ca^{2+} and HCO^{3-} with the soil water. Dissolution is also favored by increasing the amount of water moving through the soil, as long as the water is not already saturated with respect to $CaCO_3$. Precipitation of carbonate occurs under conditions when the reaction to CO_2 lowers. As the pressure lowers, the pH and ion concentration increases until saturation takes place. At this point, precipitation and/or evapotranspiration will occur.

All the above conditions are found in soils in which $CaCO_3$ has accumulated. Carbon dioxide partial pressures in soil air are 10 to more than 100 times that in the atmosphere; this decreases the pH, which, in turn, increases $CaCO_3$ solubility. The partial pressure of $C0_2$ is high as a result of $C0_2$ produced by root and microorganism respiration and organic matter decomposition. Thus, one would expect the highest $C0_2$ partial pressure to be associated with the A horizon located near the surface, with values diminishing down to the base of the zone of roots. The amount of water leaching through the soil also is greater near the surface than at depth, so as the water moves vertically through the soil, the Ca^{+} and HCO^{3-} content might increase to the point of saturation after which further dissolution of $CaCO_3$ is not possible. Combining the effects of high $C0_2$ partial pressure and downward-percolating water, we might visualize the formation of a $CaCO_3$-rich horizon as follows. In the upper parts of the soil, Ca^{2+} may already be present or may be derived by weathering of calcium-bearing minerals. Due to plant growth and biological activity, $C0_2$ partial pressure is high and forms HCO^{3-} upon contact with water. Water leaching through the profile can carry the Ca^{2+} and HCO^{3-} downward in the profile. Precipitation as a $CaCO_3$-rich horizon would take place by a combination of decreasing $C0_2$ partial pressure below the zone of rooting and major biological activity and the progressive increase in concentration with depth in Ca^{2+} and HCO^{3-} in the soil solution as the water percolates downward, and water is lost by evapotranspiration. The position of

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the $CaCO_3^-$ bearing horizon is, therefore, related to depth of leaching, which, in turn, is related to the climate.

A total of 10 test pits were excavated from undisturbed areas just west of the MWL. A very well defined caliche/calcium carbonate layer was found to be at 18-inches to 24-inches deep in all test trenches. From this natural analog it is concluded that infiltration does not generally go deeper than this. Figures 17 and 18 are photographs of two MWL trenches showing the $CACO_3$/soil interface.

Figure 17. Trench A - $CaCO_3$/Soil Interface at Shallow Depth

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Figure 18. Trench B - $CaCO_3$/Soil Interface at Shallow Depth

3.2.5 Numerical Modeling of Landfill Cover Design to Predict Performance

Numerical simulations were conducted to provide insight into the expected performance of the proposed landfill cover and along with other information, can be used to evaluate the proposed cover.

Two computer programs were used for the simulations: UNSAT-H and HELP. UNSAT-H contains more sophisticated models of water flow, transpiration, and evaporation in unsaturated soils compared to HELP. On the other hand, more input data and parameters are required for UNSAT-H. Consequently, UNSAT-H has principally been used for research and detailed studies of water balance. In contrast, the HELP model is widely used by design engineers and regulatory agencies to evaluate and compare landfill cover and liner designs. Comparative evaluations of these models can be found in the literature (e.g., Khire *et al.*., 1997; Nichols, 1991; Thompson and Tyler, 1984; Schroeder *et al.*., 1994; Fleenor and King, 1995).

3.2.5.1 UNSAT-H Simulations

3.2.5.1.1 Overview of UNSAT-H

UNSAT-H is a finite difference computer program to solve for water and heat flow in soils. This program has been used to study near-surface water movement in soils and particularly landfill cover systems by a number of investigators (e.g., Fayer and Jones, 1990; Khire *et al.*., 1997; Fayer and Gee, 1997). Version 2.05 of UNSAT-H was used for these simulations, and is documented in the Version 2.0 manual (Fayer and Jones, 1990) and subsequent updates available from the code author.

3.2.5.1.2 Input Parameters

A set of input parameters were developed for the UNSAT-H simulations based on measurements, values from the literature, and expert opinion. These input parameters are referred to as the "baseline parameters," and the simulations using these parameters are referred to as the "baseline simulations."

3.2.5.1.2.1 Model Geometry and Nodal Spacing

The modeled geometry was a 183-cm thick soil profile, consisting of one layer from the ground surface to 122 cm and another layer from 122 to 183 cm depth. The top layer is identified as the cover soil, and is intended to serve as the principal soil water storage and rooting medium. The underlying 61-cm layer is a foundation layer to establish a suitable surface onto which to place the cover soil.

A total of 69 nodes were used to construct the model. Near the top boundary, bottom boundary and the interface between the two layers, nodal spacing was as small as 0.1 cm. The largest nodal spacing of 4 cm was used in the midsections of the two layers.

3.2.5.1.2.2 Soil Data

The input parameters for the soils used in these simulations came from tests on specimens obtained from probable borrow sources for the MWL cover. The "MWL west" borrow soil is a likely source for the topmost 122 cm of the cover system and is referred to as the cover soil. The "CAMU" borrow source soil will be used for the underlying foundation soil. The borrow locations and a complete description of the test program are given in Anderson and Stormont (1999).

3.2.5.1.2.2.1 Saturated Hydraulic Conductivity

Saturated hydraulic conductivities were measured on both the MWL west soil and the CAMU borrow soil. The geometric mean of the three tests on the MWL west soil resulted in a value of 1.94×10^{-4} cm/sec, and was used as the saturated hydraulic conductivity for the cover soil. The single measured hydraulic conductivity on the CAMU soil was 2.16×10^{-4} cm/sec, and this value was used for the saturated hydraulic conductivity of the foundation soil.

3.2.5.1.2.2.2 Moisture Characteristic Curve

The van Genuchten function was used to represent the moisture characteristic curves of the cover and foundation soil layers in the UNSAT-H simulations. Moisture characteristic curves were measured for the MWL west soil, and used in the RETC computer program (van Genuchten *et al.*., 1991) to compute the van Genuchten parameters. Average values for these parameters computed from the four moisture characteristic curves were assigned to the MWL west soil. The van Genuchten 'm' parameter was assumed to be equal to '1-1/n'. For the development of the baseline parameters, the residual water content was treated as a fitting parameter and the best fit of the experimental data was achieved with a residual water content of zero. Simulations with a more physically realistic value of θ_r are discussed in a subsequent section of this report. For the CAMU soil, the saturated volumetric water content was derived from a dry density measurement on the soil, and the residual water content was assumed to be the same value as that previously measured for a soil-gravel mixture. The remaining parameters were assumed to be the same as those assigned to the MWL west soil. The parameters are summarized in Table 3. See Appendix I for details of the soil properties.

Table 3. Van Genuchten parameters (with m=1-1/n)

Soil type	θ_s	θ_r^*	α (1/cm)	n
MWL west	0.405	0.00	0.012	1.622
CAMU	0.382	0.053	0.012	1.622

$^*\theta_r$ equaling zero is not physically realistic but serves as a fitting parameter computed by the RETC model.

3.2.5.1.2.2.3 Unsaturated Hydraulic Conductivity Function

The Mualem conductivity function was assumed to describe the unsaturated hydraulic conductivity of the soils. The parameters used to describe this model are the same as those that describe the moisture characteristic curves.

3.2.5.1.2.3 Vegetative Data

The parameters for the models that describe vegetation included in UNSAT-H were derived from expert opinion as well as the open literature. The type of vegetation is assumed to be both cool season and warm season grasses, similar to those used in vegetative studies associated with the ALCD project.

3.2.5.1.2.3.1 Onset and Termination of Growing Season

The dates for the onset and termination of growing season were based on conversations with personnel at the USDA Plant Material Center in Los Lunas, NM. Their opinion was that a growing season that began on day 75 and terminated on day 299 was reasonable for the MWL site.

3.2.5.1.2.3.2 Leaf Area Index (LAI)

A value of 1.0 was assigned as the maximum Leaf Area Index (LAI) as suggested by Steve Dwyer. This value was confirmed as reasonable by the USDA personnel, and corresponds to a "poor stand of grass" in HELP documentation. The LAI increased from 0 at day 75 to 1.0 at day 135, remained at this value until day 250, after which it decreased linearly to 0.0 at day 299.

3.2.5.1.2.3.3 Percent Bare Area (PBA)

Based on observations from the ALCD re-vegetation plots, a value of 70% was decided to be representative of the area used as the PBA.

3.2.5.1.2.3.4 Rooting Depth

The maximum rooting depth was assumed to be 80 cm. This value is conservative with respect to reported values for rooting depths of various grasses, such as blue grama and Indian ricegrass, which often exceed 100 cm (Foxx *et al.*., 1984; Weaver, 1920).

3.2.5.1.2.3.5 Root Length Distribution Function

In UNSAT-H, the root length distribution (RLD) is assumed to follow an exponential function:

$$RLD = a \exp(-bz) + c$$

where:
z = depth below the surface
a, b, and c are fitting parameters.

The parameters used for the RLD function are a=0.315, b=0.0073, and c=0.076. These values were measured for bunchgrass (Fayer and Jones, 1990). These resulting distribution of roots with these parameters are appropriate for a grass that has considerable roots at depth, consistent with observations of grasses such as blue grama and buffalo grass that are expected to be dominant at the MWL site (Weaver, 1920).

3.2.5.1.2.3.6 Root Growth Model

The roots were assumed to grow over a period of 60 days, based on the time it takes for blue grama grass to reach maturity (Foxx *et al.*., 1984). The rate of growth was assumed to follow a common sinusoidal growth model (e.g., Mathur and Rao, 1999).

3.2.5.1.2.3.7 Ratio of Actual to Potential Transpiration

Transpiration is a function of the water status of the soil. Below the wilting point, there is no transpiration. Wilting was assumed to occur at 2,400 cm of suction to correspond to a water content of 5%, which is in the range of water contents at which plants in sandy soils wilt (Hillel, 1998). Between 2,400 and 1,500 cm of suction, the ratio of actual transpiration to potential transpiration increases linearly from zero at 2,400 cm to one at 1,500 cm . Between 1,500 cm and 30 cm, actual transpiration is equivalent to the

potential transpiration. At 30 cm, the soil conditions are assumed to become anaerobic and transpiration at lower suctions is prohibited.

3.2.5.1.2.4 Climatic Data

3.2.5.1.2.4.1 Precipitation

A ten-year precipitation history (1981-1990) for Albuquerque was used as input to the simulations. The precipitation history included the five wettest consecutive years from Albuquerque's official precipitation record for the years 1932 through 1997 (Peace *et al.*, 1999). The approach of selecting the five wettest consecutive years is consistent with the recommendations by the State of New Mexico for the evaluation of alternative landfill covers (State of New Mexico, 1997). Three preceding years and two subsequent years of the five wettest consecutive years (1984-1988) were included to obtain a 10-year history. Consequently, the precipitation data used as input was obtained from 1981 through 1990. The annual precipitation record is included in Figure 19. Because the precipitation was applied over a 6 hour period, the infiltrability of the soil was never exceeded and consequently there was no run-off.

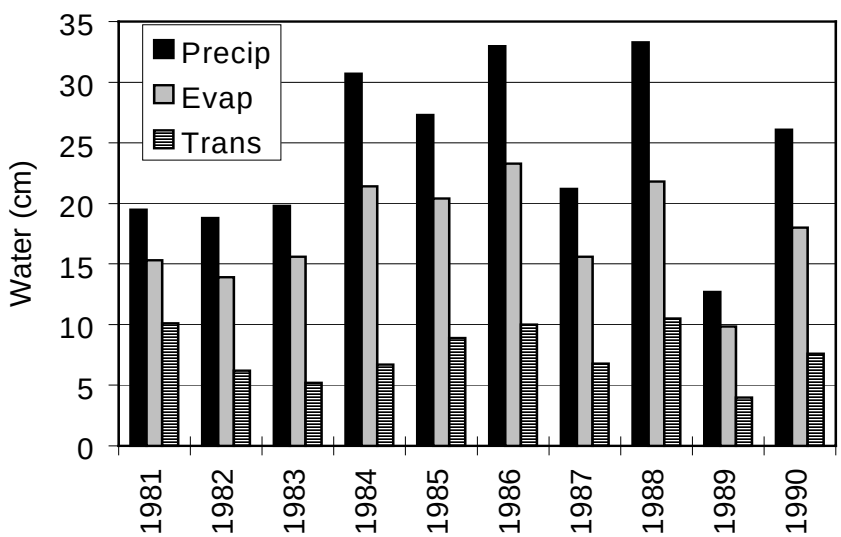

Figure 19. Annual Precipitation, Evaporation and Transpiration for Baseline Simulations

3.2.5.1.2.4.2 Potential Evapotranspiration

The potential evapotranspiration (PET) was obtained from HELP3 simulations, as reported by Peace *et al.* (1999). The daily PET values were obtained directly from previous UNSAT-H input files (Wolford, 1998).

3.2.5.1.2.4.3 PET Partitioning

In UNSAT-H, PET is partitioned into potential evaporation (PE) and potential transpiration (PT) using a function that is based on the value of the LAI for a particular

day. The parameters for this function are those recommended in the UNSAT-H documentation for Version 2.05.

3.2.5.1.2.5 Initial Condition

The initial condition for the simulations is a suction head for each node. From compaction tests and construction practices, the estimated volumetric water content of the as-placed soils are expected to be in the range of 10 to 16%, corresponding to suction heads between 350 cm and 750 cm. To be consistent with these values, the initial suction heads were assumed to linearly decrease from 660 cm at the ground surface to 477 cm at the 183-cm depth (bottom of the model).

3.2.5.1.3 Results

The annual flux at the 122-cm depth from the results of the baseline simulations (corresponding to the bottom of the cover layer) is given in Figure 20. The annual flux at the 61-cm depth is also given. These results indicate that there is an *upward* flux at the base of the cover soil during all 10 years of the simulation. At the 61-cm depth, there is a downward flux for years 1984 through 1990. This downward flux is relatively small, less than $2x10^{-8}$ cm/sec for all years.

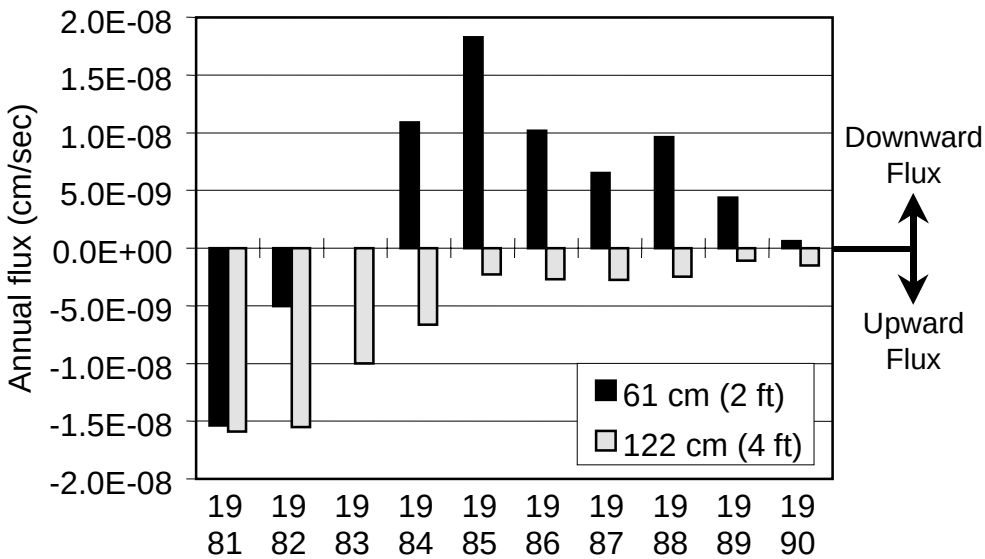

Figure 20. Annual Flux for Baseline Simulations

The calculated water balance components for the ten-year period are given in Figure 19, excluding the flux past the 122-cm depth because these values were so small. As there was no run-off in these simulations, the precipitation is equivalent to the infiltration into the top of the cover soil. The results shown in the figure indicate how significant evaporation is to the water balance, accounting for well over half of the precipitation every year. The transpiration achieves a maximum value of about 10 cm. As part of an ongoing evapotranspiration study, the annual transpiration from a blue grama dominated grass near Albuquerque is expected to be more than 12 cm per year (James Cleverly,

Department of Biology, University of New Mexico, personal communication). Thus, the calculated transpiration may be underpredicted.

The water contents at the 61-cm and 122-cm depth are given in Figure 21. At 122 cm, the soil loses moisture from the initial value associated with the cover construction and approaches a nearly constant value of about 6% by volume. This value is consistent with the values measured to a depth of 30 m near the MWL site that predominately fall in the 4 to 7% range (Peace *et al.*., 1999). The decrease in water at this depth is due to upward flow to the zone at which water is being removed by evapotranspiration. The soil at this depth is essentially isolated from precipitation events as the water content does not increase. The soil at the 61 cm depth also decreases from the initial construction value, but does not remain as constant. The volumetric water content varies between about 5 and 10% on an approximately annual behavior. The water contents increase during periods when the potential evapotranspiration is low, and decreases when the potential evapotranspiration is great. This result is consistent with observed behavior of monitored soil covers (e.g., Nyhan *et al.*., 1990).

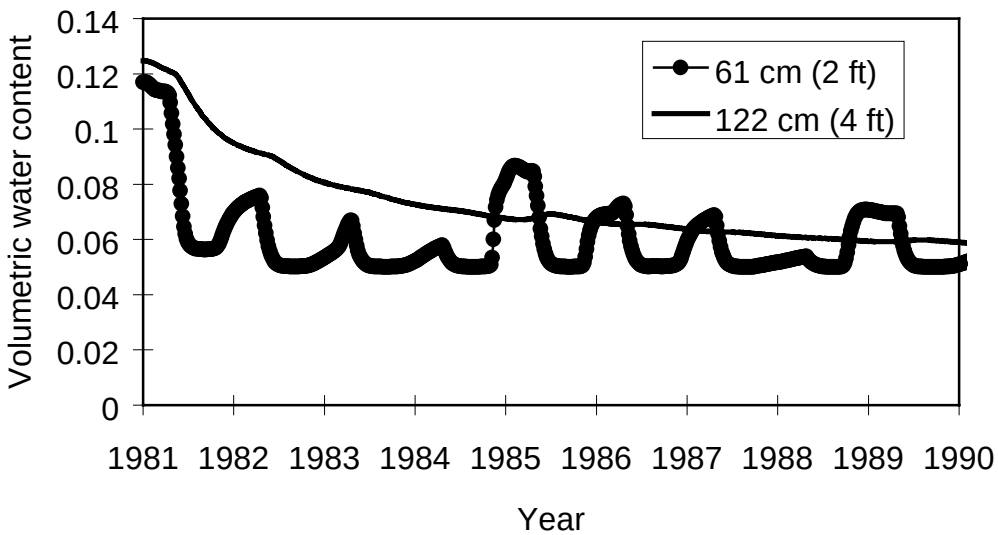

Figure 21. Water Contents from Baseline Simulations

3.2.5.1.4 Additional Simulations

A number of additional simulations were conducted to investigate some of the sensitivities of the model response to the input parameters.

3.2.5.1.4.1 Initial Condition

The baseline simulations indicated that there was considerable drying out of the cover during the ten-year simulation period, resulting in an upward annual flux at the 122-cm depth. A simulation was conducted that allowed the cover to first dry out for a period of ten years, and then be subjected to the ten-year climatic record of the years 1981 to 1990. This was accomplished by simulating the climatic record of year 1981 for ten consecutive years to establish a new initial condition (i.e., drier) before simulating the 1981 to 1990

climatic record. The annual flux for these simulations are given in Figure 22. The annual flux at the 122-cm depth is positive for three of the ten years, however, it reaches a maximum value of only about $1x10^{-9}$ cm/sec. The annual flux at the 61-cm depth is positive every year.

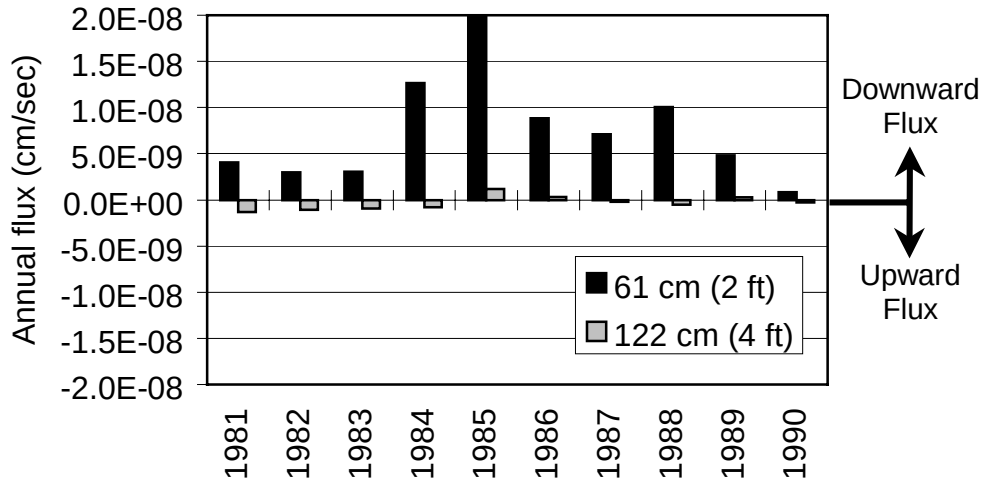

Figure 22. Annual Flux for Simulations with Drier Initial Conditions

3.2.5.1.4.2 Progressive Establishment of Vegetation

Two studies of vegetation were modeled. One consisted of a baseline simulation where the vegetation was modeled as being completely established beginning with the first year. The other study modeled the establishment of the vegetation over a 2-year period. For the first year, there was assumed to be no vegetation as reflected in a LAI of 0.0. In the second year, the vegetation was assumed to be partially established and a LAI of 0.5 was assigned. For the third year and beyond, the LAI was assumed to reach its maximum value of 1.0.

When the LAI was varied as described, the results were nearly identical to the baseline simulations. In order to have this condition have more impact on the results, the simulation was changed. The first year of the simulation was 1984 (the first year of the 5 wettest consecutive years), and the initial condition was the relatively wet suction profile used for the initial condition in the baseline simulations. The simulation then corresponded to construction of the cover at the beginning of 1984 with no vegetation in the first year, limited vegetation in the following year (1985), and full vegetation for the remaining 3 years of the simulation (1986, 1987 and 1988).

Results for these simulations are given in Figure 23. As expected, there is more downward flux during the first and second years as the vegetation is increasing. At the 122-cm depth during the first year, the annual flux rate is $2x10^{-8}$ cm/sec. The flux decreases the second year to less than 10^{-8} cm/sec, and becomes negative indicating upward flow by the third year. These simulations indicate that even with reduced

transpiration during first and second years, there is sufficient evaporative demand to result in low annual flux rates from a 122-cm thick soil cover.

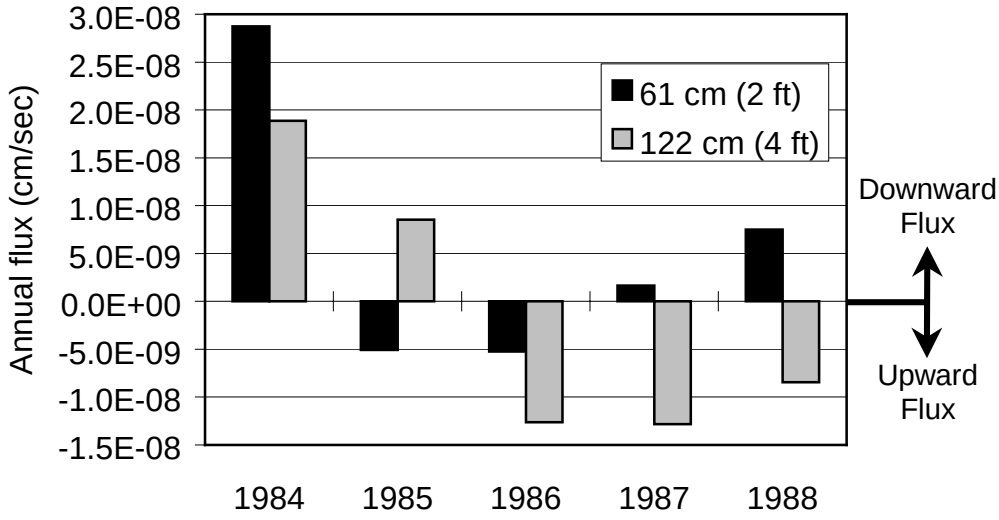

Figure 23. Annual Flux for Simulations with Progressive Development of Vegetation

3.2.5.1.4.3 Increased Hydraulic Conductivity of Cover Soil

To provide some insight into how the hydraulic properties of the cover soil affect water movement within the cover, simulations were conducted with a saturated hydraulic conductivity of the cover soil that was doubled to 3.88 x 10^{-4} cm/sec. The remaining properties of the soil are assumed to remain unchanged. Results from these simulations are given in Figure 24. The increased hydraulic conductivity resulted in more upward and downward water flow compared to the baseline simulations. At the 122-cm depth, there is downward flow in one of the ten years simulated. Obviously, these simulations do not consider the full range of possible soil properties and consequently simulation results.

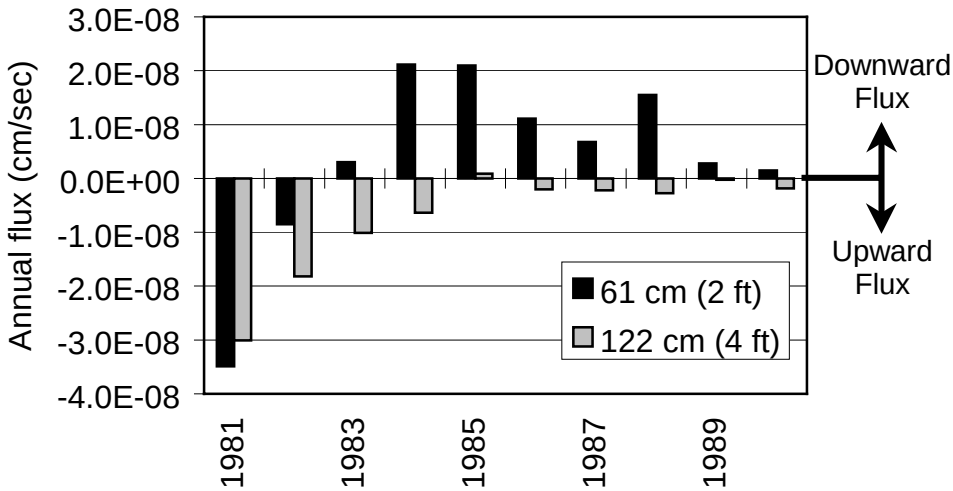

Figure 24. Annual Flux for Simulations with Increased Saturated Hydraulic Conductivity of Cover Soil

3.2.5.1.4.4 Simulations with Different Unsaturated Hydraulic Parameters

Simulations were conducted with an alternative set of parameters for the unsaturated hydraulic properties of the cover soil. These parameters were developed using the same experimental data and fitting program as described above for the baseline simulations with the exception that the residual water content was fixed at 3.5%. These alternative properties are given in Table 4 below. The properties for the foundation soil were not changed.

Table 4. Alternative van Genuchten Parameters (with m=1-1/n)

Soil type	θ_s	θ_r	α (1/cm)	n
MWL west	0.404	0.035	0.012	1.724

The calculated annual fluxes from these simulations were very similar to those from the baseline simulations. The annual flux (that is, upward or downward flow) at the 61 cm and 122 cm were the same for both sets simulations, and the magnitude of the annual fluxes were within about 10% of one another. The water content that the soil was equilibrating toward was 1 to 2% greater from these simulations compared to the baseline simulations.

3.2.5.1.4.5 Simulation Including Year with Doubled Precipitation

A simulation was conducted with doubled precipitation during the middle year (1986) of the baseline simulation precipitation history. The purpose of this simulation is to investigate the response of the cover to a year of extreme precipitation. The doubling was accomplished by doubling the quantity of each precipitation event for a total precipitation of 66 cm. This quantity of precipitation is well in excess of any recorded

precipitation for Albuquerque, and consequently represents a highly improbable occurrence.

Results for these simulations are given in Figure 25. Prior to 1986, the response of the cover is identical to the baseline simulations. During 1986, there is a relatively large annual flux past the 61 cm depth (greater than 10^{-7} cm/sec). Subsequent years have annual fluxes that are an order of magnitude or smaller at this depth. The maximum water content at 61-cm depth of 14% occurs during 1986. At 122-cm depth, the maximum flux occurs during 1987 as the preceding year's precipitation increased water content within the cover soil and moved downward. The annual flux at this depth was 2.4×10^{-8} cm/sec during 1987, which was the only year with a downward annual flux. The maximum water content of 9% (excluding the initial water content in 1981) is reached during 1987.

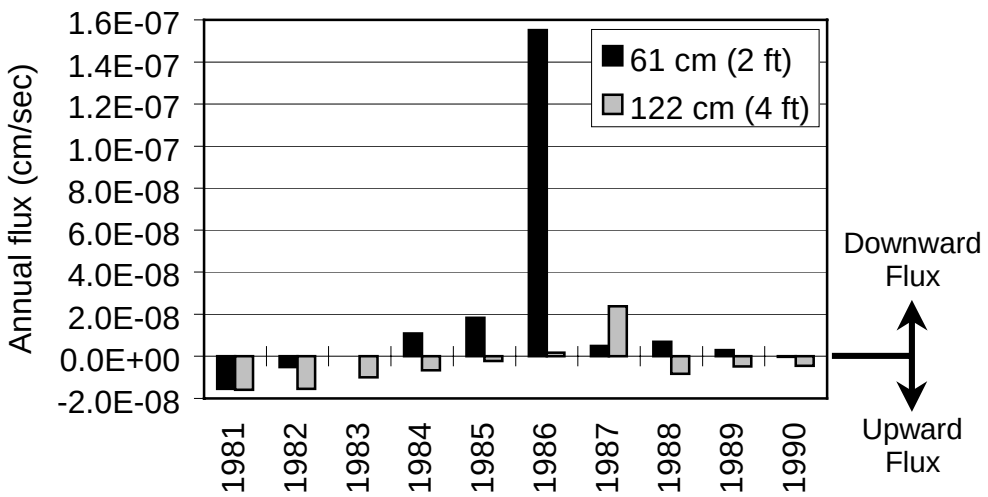

Figure 25. Annual Flux for Simulations with Doubled Precipitation During 1986

3.2.5.1.4.6 Alternative Climatic Conditions

Simulations were conducted with a different set of climatic input obtained from the New Mexico Climate Center web site (http://weather.nmsu.edu/). These climatic data (Appendix A) were from Albuquerque's Pino weather station for the period of time beginning in the middle of 1991 (Julian day 226) through 154th day of 1999. The Pino station, which is located near Interstate 25 and Montgomery Boulevard and is operated by the City of Albuquerque, was selected because it contained the longest climatic record for Albuquerque available from this web site. In addition to the daily precipitation data, the daily potential evapotranspiration calculated using the Penman method is tabulated at this web site and was used as input to the simulations.

The Pino precipitation record contained two years with well above average precipitation ranging from 45 cm in 1992 and 35 cm in 1997. Although the daily data does not reflect the intensity of the precipitation, it is likely that some of this precipitation came in the

form of high intensity, short duration storms in which appreciable run-off would be expected. Consequently, the precipitation data was "pre-processed" using the SCS curve number method to proportion precipitation into run-off and infiltration. An SCS curve number of 80 was assumed.

The annual flux past the 61 and 122-cm depths for these climatic conditions are given in Figure 26. These results indicate that the maximum annual flux at the 61 cm depth reaches 10^{-7} cm/sec during 1992, but reduces to lesser values in the remaining years of the simulation. At the 122-cm depth, downward fluxes occur only during two years: 1993 and 1998, with a maximum flux of about $4x10^{-8}$ cm/sec during 1993. The flux is upward at this location for all of the remaining years. Downward fluxes occur during years immediately following the years with the very large annual precipitation data.

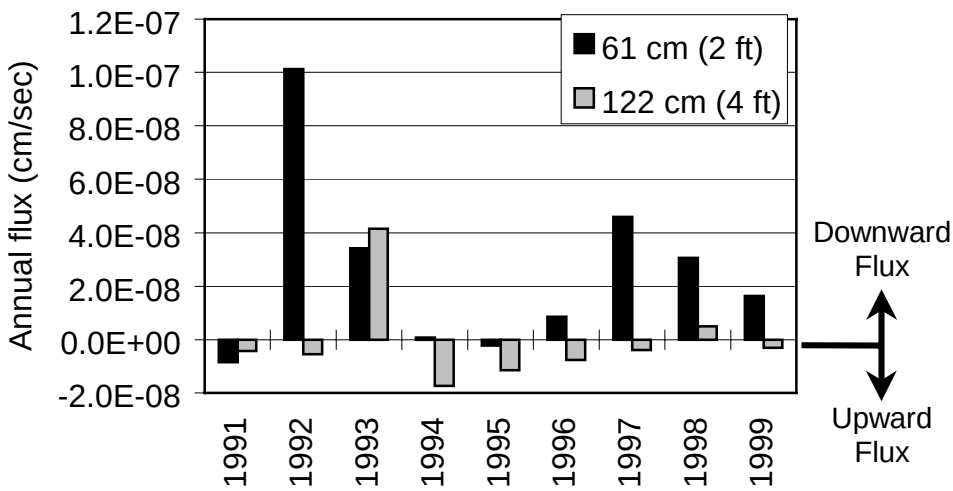

Figure 26. Annual Fluxes for Simulations Using Pino Station Climatic Data

The calculated major water balance components (precipitation, evaporation and transpiration) for these simulations are given in Figure 27. The run-off is not included in this figure as it is less than 0.5 cm every year except 1992, during which time a total of 4 cm run-off was predicted. In addition, the flux past the 122-cm depth is not included in this figure as it very small for every year except 1993 in which had a value of 1.31 cm.

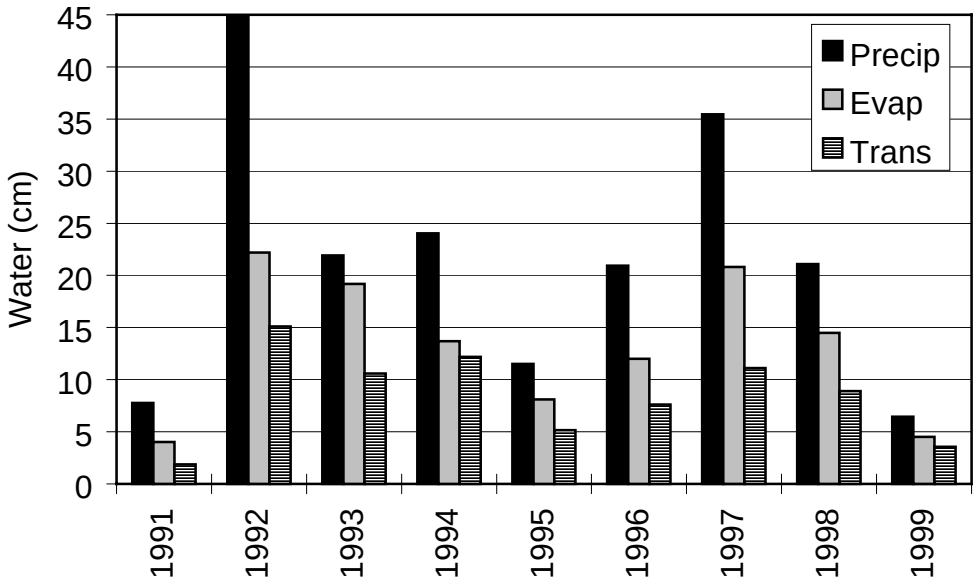

Figure 27. Precipitation, Evaporation and Transpiration for Simulations Using Pino Climatic Data

The volumetric water contents at the 61 and 122-cm depths are given in Figure 28. The 61-cm depth water contents increased significantly late in 1992 and into the early portions of 1993. The water contents subsequently decrease rapidly, coincident with an increase in the evapotranspirative demand beginning in the mid-spring. A similar pattern of increase during periods of low PET and decrease during periods of greater PET is observed during 1997 and 1998. The rapid decrease of water at the 61-cm depth occurs because it is modeled as being within the transpirative zone (i.e., within the 80 cm rooting depth), and thus water can be removed directly from the soil. The water content changes occurring at the 122 cm depth are more gradual and indicate an overall drying trend, although the water content does increase in response to the wetting of the overlying soil during late 1992 to early 1993. Drying of the soil at this level is much slower than at the 61-cm depth because water has to be drawn up to the rooting zone to be available for transpiration. After reaching peak values during 1993 (during which time the largest flux past this depth is calculated), the water contents gradually decrease to a value of about 7% by the end of the simulation history. During 1998, a slight increase in water content is predicted, coincident with a small annual flux at this depth.

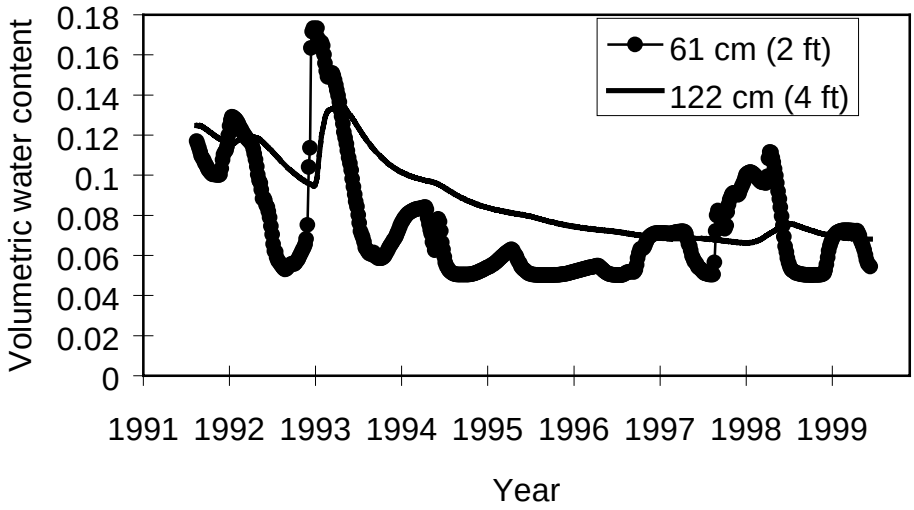

Figure 28. Calculated Water Contents from Simulations Using the Pino Climatic Data

3.2.5.2 HELP Simulations

3.2.5.2.1 HELP Overview

Conventional cover and liner designs are commonly evaluated using the Hydrologic Evaluation of Landfill Performance (HELP) computer program developed by the U.S. Environmental Protection Agency. This program is used by many designers to analyze landfill cover designs and is widely accepted by engineers and regulators. The HELP computer program utilizes a quasi-two-dimensional, deterministic, water routing numerical approach to determine water balances (Schroeder *et al.*, 1994). A notable difference between HELP and UNSAT-H is that HELP simulates unsaturated flow by assuming downward, gravity flow once the water content exceeds the field capacity. Flow due to suction gradients is not permitted. Shortcomings of this modeling approach are expected to be exacerbated in dry climates.

3.2.5.2.2 Input Parameters

The intent was to conduct HELP simulations that were comparable to the UNSAT-H baseline simulations. Because of the difference in these programs, there are some differences between the input parameters used for the two simulations.

3.2.5.2.2.1 Model Geometry

The HELP model consisted of a single, 122-cm thick soil layer. Another model that included an additional underlying 61-cm thick layer intended to represent the foundation soil was also constructed. These results were virtually identical to the single layer model, and for ease of obtaining flux rates from the bottom of the 122-cm cover soil layer the single layer model was used here.

The HELP model assumed a 2% slope with a slope length of 50 meters. The HELP program calculated a SCS run-off number of 86.2. UNSAT-H does not account for surface slope nor utilize a run-off number.

3.2.5.2.2.2 Soil Data

The HELP program uses unsaturated soil parameters based on the equation of Brooks and Corey. The RETC program can be used to compute Brooks and Corey parameters using the same moisture-matric potential data that is used to compute the van Genuchten parameters. The HELP model incorporates constraints on the relationship between residual moisture and the wilting point that must be applied with the RETC program in order to derive values for the HELP model. The RETC model can be used to fit moisture-matric potential data so that parameters derived for the Brooks and Corey equation (Brooks and Corey, 1964) in the HELP model are consistent with van Genuchten parameters used in the UNSAT-H model. Additionally, the HELP model uses the unsaturated hydraulic conductivity equation of Campbell (Campbell, 1974), which was fitted using the measured saturated hydraulic conductivity.

3.2.5.2.2.3 Vegetative and ET Data

The vegetation was assumed to be a fair stand of grass, this corresponds to LAI of 1.0. The evaporative zone depth was 80 cm and the growing season was from Julian Days 98 to 299 which are the HELP default values for Albuquerque.

3.2.5.2.2.4 Climatic Data

The same precipitation history used for the UNSAT-H simulations was used for the HELP simulations. The temperature and solar radiation data was synthetically generated by the HELP program for Albuquerque.

3.2.5.2.2.5 Initial Condition

The initial condition for the HELP simulations was a water content of 13% throughout the cover soil layer, corresponding to a suction head of about 500-cm.

3.2.5.2.3 Results

The HELP simulations provided percolation out of the bottom of the cover soil layer. Results from the baseline simulation is given in Figure 29. The percolation rate out of the bottom of the 122-cm thick cover soil layer is on the order of $2x10^{-9}$ cm/s every year except for 1981. The greater rate during this year is believed to be due to a reduction from the initial as-placed water content of about 13% to values in the range of 6 to 8% where the cover remains for most of the simulated period.

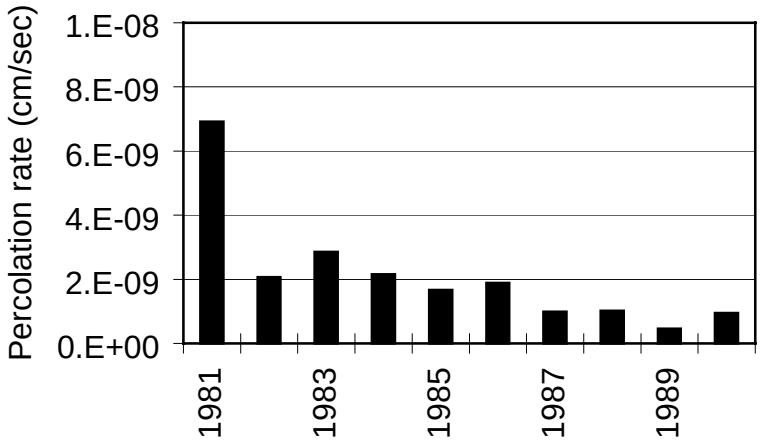

Figure 29. Percolation Rate out of Cover Soil from Baseline HELP Simulations

3.2.5.3 Discussion and Summary

The two computer programs, although there are substantial differences between them, produce results from the baseline simulations that are in reasonable agreement. Both programs indicate that there will be very little if any flux past the 122-cm depth. The UNSAT-H simulations indicate that there will be an upward flux at the 122 cm depth as the soil is slowly dried by evapotranspiration in the upper portions of the cover and water is drawn upward by suction gradients. The HELP program does not account for suction driven flow, and thus only downward flow is possible beneath the evaporative depth. Both programs calculated very small fluxes, and it is hard to differentiate between an upward flux of 10^{-9} cm/sec and a downward flux of 10^{-9} cm/sec. (A 10^{-9} cm/sec annual flux corresponds to less than 0.5 mm over the course of a year). Both simulations are consistent with the 122-cm thick soil cover serving to limit flux into underlying waste to very small quantities.

Without data with which to compare the numerical results, it is not possible to definitely state which program produces "better" results. However, the more complete model of unsaturated flow contained in UNSAT-H would seem to be a large advantage in its predictive capability. At the same time, UNSAT-H requires more input for which there may not be a substantial database (e.g., root length density function parameters). The ease of use of the HELP model, and particularly the ready availability of default values, may actually be a limitation since little understanding of the models embedded in HELP is needed to produce results.

The additional UNSAT-H simulations with varied input parameters indicate that the soil cover limits annual fluxes past the 122-cm depth to very small values and often-negative values due to upward flow. Even in the cases of extreme precipitation and no vegetation, the predicted annual fluxes remain small. These results indicate the importance of the ET component of the water balance for the conditions and properties used in these simulations. Additional simulations further investigating the sensitivity of the models to soil properties and vegetative model parameters may be insightful.

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Appendix A

Weather Data Calculated PET for Albuquerque (1991 – May 1999)

Albuquerque Airport
1/1/91 to 5/7/99

NMSU Weather Data Request #3459
Begining Date: 01/01/91
Ending Date: 05/07/99
Location: National Weather Service
Format: ENGLISH
Request Date: FRI -- 7-MAY 99 (127), 13:2:58 (MST)

Weather Summary From: C~T13459.CVT
Elevation: 1183 meters

Date	Air Temp (F)			Rel Humid (%)		Soil Temp (F)	Wind Speed (MPH)		Sol Rad (L)	Rain (In)	PET (In)	Heat Units (F) Corn 86 50 50	Cotn 86 55 55	Genr 086 050 050 <= Max <= Min <= Base
MM/DD/YY	MX	MN	AV	MX	MN	AV	MX	AV						
01/01/91	59	31	42	57	25	38	7	2.2	258	0.00	0.10	5	2	5
01/02/91	60	26	42	67	19	37	8	1.8	294	0.00	0.11	5	3	5
01/03/91	59	29	44	64	27	39	6	1.5	227	0.00	0.08	5	2	5
01/04/91	53	37	43	89	54	41	9	1.6	100	0.00	0.03	2	0	2
01/05/91	55	38	45	96	87	44	4	1.0	107	0.16	0.01	3	0	3
01/06/91	62	38	47	96	54	45	7	1.3	205	0.00	0.06	6	4	6
01/07/91	63	36	48	94	41	45	7	1.3	296	0.00	0.09	7	4	7
01/08/91	60	32	45	95	45	41	6	1.2	251	0.00	0.07	5	3	5
01/09/91	60	38	47	94	45	44	11	3.3	224	0.04	0.08	5	3	5
01/10/91	58	37	46	95	39	44	12	3.5	315	0.12	0.10	4	2	4
01/11/91	56	32	42	92	30	39	10	1.6	322	0.00	0.10	3	1	3
01/12/91	56	31	41	87	23	38	8	1.0	222	0.00	0.07	3	1	3
01/13/91	58	31	41	80	16	37	6	0.7	191	0.00	0.07	4	2	4
01/14/91	59	30	42	74	13	37	5	0.7	0	0.00	0.02	5	2	5
01/15/91	59	28	43	73	20	38	6	1.3	0	0.00	0.02	5	2	5
01/16/91	55	27	43	84	40	39	13	2.7	227	0.00	0.07	3	0	3
01/17/91	46	35	40	94	46	40	16	3.7	74	0.08	0.02	0	0	0
01/18/91	53	31	40	95	42	40	8	1.9	224	0.00	0.06	2	0	2
01/19/91	58	25	42	97	31	37	10	2.2	353	0.00	0.11	4	2	4
01/20/91	52	32	41	87	43	39	16	4.2	150	0.04	0.06	1	0	1
01/21/91	52	33	38	85	41	38	10	2.5	0	0.00	0.01	1	0	1
01/22/91	52	31	36	88	47	36	3	0.4	0	0.00	0.00	1	0	1
01/23/91	50	29	38	95	62	37	7	1.7	239	0.12	0.05	0	0	0
01/24/91	56	26	40	96	26	37	9	1.8	363	0.00	0.11	3	1	3
01/25/91	61	24	41	96	20	37	6	1.0	375	0.00	0.12	6	3	6
01/26/91	66	32	48	82	16	42	10	1.5	327	0.00	0.13	8	6	8
01/27/91	65	33	49	52	16	42	13	3.5	327	0.00	0.15	8	5	8
01/28/91	62	27	45	64	18	40	15	2.4	337	0.00	0.13	6	4	6
01/29/91	57	29	43	90	26	40	20	4.3	253	0.00	0.10	4	1	4
01/30/91	54	28	39	91	20	38	13	3.3	384	0.00	0.13	2	0	2
01/31/91	61	22	40	69	17	36	6	1.3	387	0.00	0.13	6	3	6
02/01/91	63	27	43	53	17	38	7	1.7	320	0.00	0.12	7	4	7
02/02/91	70	34	50	53	17	42	7	1.2	351	0.00	0.14	10	8	10
02/03/91	70	32	49	80	19	43	7	1.4	346	0.00	0.14	10	8	10
02/04/91	67	36	49	45	16	43	7	1.8	391	0.00	0.16	9	6	9
02/05/91	66	31	46	51	17	42	8	1.5	394	0.00	0.15	8	6	8
02/06/91	68	25	47	66	15	42	9	2.2	406	0.00	0.16	9	7	9
02/07/91	66	34	52	51	18	45	16	5.5	406	0.00	0.19	8	6	8
02/08/91	70	38	52	44	16	48	8	1.7	2	0.00	0.05	10	8	10
02/09/91	67	38	51	70	18	48	11	2.2	337	0.00	0.14	9	6	9
02/10/91	61	41	51	83	23	48	10	2.7	158	0.00	0.07	6	3	6
02/11/91	54	45	49	94	68	49	9	1.9	124	0.12	0.03	2	0	2
02/12/91	61	47	52	94	77	52	10	1.2	162	0.20	0.04	6	3	6
02/13/91	72	39	55	94	26	51	13	2.5	418	0.00	0.16	11	9	11
02/14/91	72	41	54	91	16	49	10	1.8	439	0.00	0.17	11	9	11
02/15/91	65	39	52	78	20	48	10	2.6	353	0.00	0.14	8	5	8
02/16/91	72	41	57	76	22	51	15	3.1	289	0.00	0.14	11	9	11
02/17/91	64	42	51	87	37	49	18	4.6	248	0.00	0.11	7	5	7

02/18/91	50	39	43	93	54	45	15	3.9	162	0.04	0.05	0	0	0
02/19/91	51	32	41	94	45	45	8	2.2	306	0.04	0.08	1	0	1
02/20/91	58	26	42	96	33	43	7	1.3	461	0.00	0.13	4	2	4
02/21/91	71	29	48	93	14	45	10	2.0	468	0.00	0.18	11	8	11
02/22/91	71	30	51	66	15	47	11	1.9	463	0.00	0.18	11	8	11
02/23/91	70	37	54	62	15	49	9	1.4	275	0.00	0.12	10	8	10
02/24/91	72	47	59	48	14	53	14	3.2	401	0.00	0.19	11	9	11
02/25/91	62	37	50	52	19	50	9	1.9	418	0.00	0.15	6	4	6
02/26/91	62	31	48	69	22	48	11	3.6	351	0.00	0.14	6	4	6
02/27/91	69	33	52	71	20	51	10	2.0	422	0.00	0.16	10	7	10
02/28/91	53	40	48	93	51	48	16	2.2	81	0.39	0.02	2	0	2
03/01/91	63	40	51	94	34	48	20	5.7	227	0.20	0.10	7	4	7
03/02/91	59	41	49	94	38	46	17	7.4	5	0.16	0.04	5	2	5
03/03/91	69	32	50	95	16	47	9	2.0	508	0.00	0.19	10	7	10
03/04/91	77	33	54	95	13	49	11	1.6	511	0.00	0.21	14	11	14
03/05/91	77	43	61	64	24	53	21	5.4	508	0.00	0.24	14	11	14
03/06/91	73	50	58	64	17	53	15	4.0	5	0.00	0.07	12	9	12
03/07/91	62	42	53	45	16	51	22	7.0	530	0.00	0.24	6	4	6
03/08/91	64	30	46	44	16	48	8	1.8	544	0.00	0.19	7	5	7
03/09/91	68	33	59	49	15	53	12	7.8	5	0.00	0.08	9	7	9
03/10/91	78	41	58	45	14	54	13	3.2	427	0.00	0.21	14	12	14
03/11/91	72	49	60	43	15	54	22	6.3	315	0.00	0.20	11	9	11
03/12/91	68	37	55	39	15	54	16	5.0	554	0.00	0.24	9	7	9
03/13/91	62	34	49	32	16	50	7	1.1	301	0.00	0.12	6	4	6
03/14/91	66	33	52	57	15	53	19	6.4	556	0.00	0.24	8	6	8
03/15/91	64	36	51	39	16	54	12	3.2	539	0.00	0.21	7	5	7
03/16/91	52	37	46	88	20	50	21	9.0	516	0.00	0.20	1	0	1
03/17/91	65	28	46	65	16	50	7	1.9	566	0.00	0.20	8	5	8
03/18/91	74	35	55	48	14	54	8	1.8	525	0.00	0.21	12	10	12
03/19/91	72	48	57	44	14	56	25	6.8	372	0.00	0.23	11	9	11
03/20/91	69	41	56	59	16	58	17	4.7	492	0.00	0.22	10	7	10
03/21/91	52	38	45	81	26	50	17	7.0	298	0.00	0.12	1	0	1
03/22/91	58	34	45	74	22	49	17	6.3	516	0.00	0.20	4	2	4
03/23/91	69	29	53	90	15	52	5	0.9	7	0.00	0.03	10	7	10
03/24/91	80	38	58	51	12	57	10	2.4	559	0.00	0.25	15	13	15
03/25/91	79	42	60	51	12	59	18	4.6	516	0.00	0.26	15	12	15
03/26/91	75	41	54	54	17	57	31	7.2	492	0.00	0.27	13	10	13
03/27/91	70	31	54	85	15	58	20	5.6	594	0.00	0.25	10	8	10
03/28/91	54	35	45	86	29	52	23	10.9	482	0.00	0.19	2	0	2
03/29/91	64	28	48	95	16	55	20	5.7	618	0.00	0.24	7	5	7
03/30/91	63	34	50	45	18	56	15	4.2	613	0.00	0.23	7	4	7
03/31/91	70	28	49	84	14	54	11	2.2	621	0.00	0.23	10	8	10
04/01/91	82	38	62	35	11	60	14	4.3	611	0.00	0.30	16	14	16
04/02/91	75	44	62	26	13	62	18	5.9	633	0.00	0.31	13	10	13
04/03/91	79	40	61	48	12	62	10	1.9	561	0.00	0.24	15	12	15
04/04/91	81	44	63	50	12	63	19	3.9	513	0.00	0.26	16	13	16
04/05/91	81	44	64	75	14	67	9	2.7	606	0.00	0.27	16	13	16
04/06/91	86	43	67	78	11	68	13	3.0	618	0.00	0.29	18	16	18
04/07/91	85	51	70	28	11	70	16	5.5	628	0.00	0.34	18	15	18
04/08/91	79	50	66	25	12	67	18	5.7	613	0.00	0.32	15	12	15
04/09/91	79	45	63	19	12	66	9	2.6	642	0.00	0.29	15	12	15
04/10/91	82	45	67	43	11	68	16	4.9	642	0.00	0.32	16	14	16
04/11/91	82	55	69	17	11	66	22	8.3	654	0.00	0.39	19	14	19
04/12/91	67	43	57	26	14	64	18	5.8	654	0.00	0.29	9	6	9
04/13/91	65	33	52	26	15	60	21	5.1	673	0.00	0.27	8	5	8
04/14/91	74	35	55	49	13	61	11	2.3	673	0.00	0.27	12	10	12
04/15/91	83	34	61	54	11	61	13	2.5	678	0.00	0.30	17	14	17
04/16/91	83	41	65	31	11	63	14	3.2	563	0.00	0.27	17	14	17
04/17/91	80	58	70	20	12	68	14	5.0	666	0.00	0.34	19	14	19
04/18/91	78	48	65	46	13	66	14	4.5	611	0.00	0.29	14	12	14
04/19/91	82	47	65	31	11	67	10	2.3	673	0.00	0.30	16	14	16
04/20/91	86	43	67	50	10	67	11	2.8	661	0.00	0.31	18	16	18
04/21/91	80	48	66	34	12	66	19	5.8	692	0.00	0.35	15	13	15
04/22/91	79	40	62	34	12	66	15	3.7	644	0.00	0.30	15	12	15
04/23/91	80	42	63	37	12	66	14	3.1	635	0.00	0.29	15	13	15
04/24/91	78	44	63	38	12	67	14	4.5	659	0.00	0.31	14	12	14

04/24/91	78	44	63	38	12	67	14	4.5	659	0.00	0.31	14	12	14
04/25/91	77	47	64	35	13	70	14	4.1	255	0.00	0.16	14	11	14
04/26/91	78	49	65	37	13	71	15	4.3	17	0.00	0.09	14	12	14
04/27/91	77	46	64	45	12	67	19	6.3	695	0.00	0.34	14	11	14
04/28/91	68	40	55	29	14	65	23	5.3	704	0.00	0.30	9	7	9
04/29/91	76	33	56	41	12	63	14	3.2	716	0.00	0.30	13	11	13
04/30/91	83	41	62	37	11	66	10	1.6	709	0.00	0.30	17	14	17
05/01/91	85	44	66	34	11	67	11	2.7	697	0.00	0.32	18	15	18
05/02/91	83	46	66	33	11	68	17	4.7	714	0.00	0.35	17	14	17
05/03/91	80	47	65	29	11	68	17	4.6	745	0.00	0.35	15	13	15
05/04/91	78	48	64	24	12	68	15	3.8	764	0.00	0.34	14	12	14
05/05/91	80	46	64	24	12	68	11	2.7	709	0.00	0.31	15	13	15
05/06/91	87	43	67	42	11	69	11	2.9	602	0.00	0.29	18	16	18
05/07/91	88	50	71	65	10	71	15	4.4	718	0.00	0.36	18	16	18
05/08/91	93	50	72	41	9	73	8	1.7	699	0.00	0.33	18	16	18
05/09/91	92	51	73	45	9	73	11	2.7	616	0.04	0.31	19	16	19
05/10/91	90	54	73	45	10	74	13	3.8	673	0.00	0.34	20	16	20
05/11/91	90	51	74	42	10	75	17	3.6	711	0.00	0.35	19	16	19
05/12/91	89	47	69	36	10	74	12	2.1	673	0.00	0.32	18	16	18
05/13/91	92	53	73	39	9	76	10	2.4	697	0.00	0.34	20	16	20
05/14/91	90	51	74	33	10	76	16	4.3	723	0.00	0.37	19	16	19
05/15/91	80	48	68	40	12	74	17	5.5	738	0.00	0.36	15	13	15
05/16/91	86	46	69	43	10	77	15	3.4	726	0.00	0.34	18	16	18
05/17/91	91	47	71	36	9	77	13	2.4	730	0.00	0.35	18	16	18
05/18/91	95	49	73	41	9	76	10	1.9	726	0.00	0.35	18	16	18
05/19/91	93	56	77	38	10	78	14	4.7	551	0.00	0.32	21	16	21
05/20/91	87	66	77	75	17	78	22	8.6	403	0.16	0.27	26	21	26
05/21/91	83	60	72	87	35	72	13	3.8	477	0.12	0.21	22	17	22
05/22/91	87	53	71	92	12	69	10	1.9	728	0.04	0.32	20	16	20
05/23/91	89	51	72	62	11	72	14	2.5	714	0.00	0.33	19	16	19
05/24/91	90	53	73	41	11	73	8	1.9	733	0.00	0.34	20	16	20
05/25/91	95	50	75	63	9	74	12	2.1	733	0.00	0.35	18	16	18
05/26/91	95	55	76	37	9	74	14	2.9	738	0.00	0.37	21	16	21
05/27/91	94	51	76	42	9	75	9	2.0	709	0.00	0.34	19	16	19
05/28/91	94	56	77	41	9	76	12	2.9	723	0.00	0.36	21	16	21
05/29/91	92	49	74	47	9	75	14	3.0	754	0.00	0.37	18	16	18
05/30/91	90	49	73	34	10	74	13	3.5	738	0.00	0.36	18	16	18
05/31/91	87	49	72	33	10	73	16	5.0	649	0.00	0.34	18	16	18
06/01/91	82	50	68	66	12	74	17	4.9	735	0.00	0.35	16	14	16
06/02/91	82	47	67	76	12	74	17	3.8	726	0.00	0.33	16	14	16
06/03/91	87	50	71	54	11	75	12	2.9	742	0.00	0.34	18	16	18
06/04/91	95	51	74	55	9	69	10	1.7	718	0.00	0.34	19	16	19
06/05/91	89	53	73	40	10	66	10	2.5	511	0.00	0.26	20	16	20
06/06/91	93	54	75	58	9	63	13	2.5	742	0.00	0.36	20	16	20
06/07/91	95	56	76	48	9	62	10	1.8	738	0.00	0.35	21	16	21
06/08/91	96	56	78	50	9	67	16	3.8	630	0.00	0.34	21	16	21
06/09/91	92	62	76	77	11	75	15	4.1	473	0.00	0.27	24	19	24
06/10/91	79	61	68	77	31	70	13	2.9	375	0.00	0.17	20	15	20
06/11/91	84	57	71	76	17	72	13	2.5	570	0.00	0.26	21	16	21
06/12/91	88	55	74	77	11	74	14	3.5	695	0.00	0.33	21	16	21
06/13/91	91	62	78	85	10	77	15	4.7	625	0.04	0.33	24	19	24
06/14/91	87	55	71	83	12	60	10	1.5	62	0.04	0.07	21	16	21
06/15/91	94	53	75	48	9	62	7	1.7	730	0.00	0.35	20	16	20
06/16/91	97	58	78	43	8	63	7	2.1	716	0.00	0.36	22	17	22
06/17/91	100	53	79	52	8	58	11	2.1	742	0.00	0.37	20	16	20
06/18/91	103	54	80	46	7	59	7	1.5	750	0.00	0.38	20	16	20
06/19/91	103	58	82	41	7	67	10	1.8	611	0.00	0.33	22	17	22
06/20/91	99	60	80	30	8	76	13	1.9	482	0.00	0.27	23	18	23
06/21/91	98	51	77	37	8	79	10	1.9	761	0.00	0.37	19	16	19
06/22/91	99	53	77	26	8	79	8	1.9	759	0.00	0.38	20	16	20
06/23/91	102	54	79	34	7	80	8	1.7	740	0.00	0.38	20	16	20
06/24/91	103	55	81	47	7	80	10	2.2	714	0.00	0.37	21	16	21
06/25/91	104	67	89	39	7	83	12	4.3	709	0.00	0.41	27	22	27
06/26/91	104	68	87	39	7	85	8	2.8	721	0.00	0.39	27	22	27
06/27/91	102	60	84	41	7	83	10	2.9	709	0.00	0.38	23	18	23
06/28/91	101	71	86	39	10	85	13	1.9	561	0.00	0.30	29	24	29

06/28/91	101	71	86	39	10	85	13	1.9	561	0.00	0.30	29	24	29
06/29/91	101	71	85	61	10	86	18	3.5	630	0.00	0.35	29	24	29
06/30/91	97	70	83	69	14	85	7	2.1	613	0.00	0.31	28	23	28
07/01/91	97	67	79	81	20	82	16	3.0	556	0.94	0.29	27	22	27
07/02/91	91	65	77	89	35	77	19	3.9	580	0.04	0.27	26	21	26
07/03/91	91	64	77	89	29	78	18	2.8	666	0.00	0.30	25	20	25
07/04/91	92	68	80	62	17	81	19	3.3	721	0.00	0.35	27	22	27
07/05/91	95	63	80	87	10	82	11	2.1	730	0.00	0.34	25	20	25
07/06/91	98	64	82	67	10	83	8	2.0	723	0.00	0.35	25	20	25
07/07/91	100	66	88	77	9	90	29	2.5	62	0.00	0.09	26	21	26
07/08/91	99	70	83	56	9	84	11	3.6	621	0.00	0.35	28	23	28
07/09/91	91	68	78	88	24	82	13	2.1	349	0.20	0.17	27	22	27
07/10/91	90	67	76	89	23	78	11	2.3	380	0.00	0.19	27	22	27
07/11/91	90	67	78	78	16	77	7	1.6	349	0.04	0.18	27	22	27
07/12/91	94	67	79	76	15	80	22	3.4	644	0.00	0.32	27	22	27
07/13/91	86	66	76	86	33	79	15	2.8	465	0.00	0.21	26	21	26
07/14/91	84	67	73	88	48	80	8	4.2	74	0.00	0.06	26	21	26
07/15/91	85	65	72	90	45	77	14	2.3	418	0.04	0.17	25	20	25
07/16/91	89	63	74	90	36	78	16	1.7	528	0.00	0.22	25	20	25
07/17/91	92	63	78	91	17	81	9	2.0	695	0.00	0.31	25	20	25
07/18/91	96	64	81	85	13	82	8	1.9	699	0.00	0.33	25	20	25
07/19/91	98	66	80	76	13	82	12	2.5	537	0.04	0.28	26	21	26
07/20/91	93	65	76	89	25	80	15	2.2	458	0.04	0.22	26	21	26
07/21/91	90	67	75	89	37	78	15	3.0	444	0.04	0.21	27	22	27
07/22/91	88	67	74	90	36	78	10	2.1	422	0.08	0.19	27	22	27
07/23/91	85	67	77	92	0	81	0	5.1	100	0.51	0.12	26	21	26
07/24/91	90	70	75	79	0	80	39	4.1	57	0.00	0.12	28	23	28
07/25/91	88	65	76	88	45	81	34	5.2	115	0.00	0.08	26	21	26
07/26/91	90	65	76	90	39	82	54	4.1	241	0.00	0.13	26	21	26
07/27/91	94	62	78	93	31	82	28	3.9	413	0.00	0.21	24	19	24
07/28/91	93	66	79	85	24	82	35	4.9	599	0.00	0.31	26	21	26
07/29/91	85	67	77	80	45	80	26	4.2	776	0.00	0.33	26	21	26
07/30/91	91	68	78	78	39	82	31	4.2	824	0.00	0.37	27	22	27
07/31/91	93	65	79	94	38	82	38	2.8	845	0.00	0.36	26	21	26
08/01/91	91	68	79	91	45	82	18	3.6	843	0.39	0.36	27	22	27
08/02/91	92	72	78	71	0	82	9	4.7	833	0.43	0.43	29	24	29
08/03/91	88	68	77	90	45	81	0	3.1	821	0.00	0.34	27	22	27
08/04/91	85	67	73	92	46	79	0	3.9	809	0.04	0.33	26	21	26
08/05/91	90	65	77	92	38	81	0	3.0	807	0.00	0.34	26	21	26
08/06/91	93	66	80	90	27	82	0	3.8	812	0.00	0.37	26	21	26
08/07/91	93	74	81	69	0	84	0	3.6	824	0.00	0.42	30	25	30
08/08/91	83	70	79	89	0	82	17	2.1	845	0.04	0.37	27	22	27
08/09/91	91	73	76	66	37	79	35	4.1	871	0.00	0.40	30	25	30
08/10/91	86	65	73	96	51	77	42	4.6	905	0.00	0.36	26	21	26
08/11/91	86	66	75	96	55	78	17	2.7	945	0.00	0.37	26	21	26
08/12/91	93	74	85	68	38	83	19	2.5	991	0.00	0.44	30	25	30
08/13/91	95	65	82	96	0	80	48	5.2	993	1.11	0.50	26	21	26
08/14/91	84	65	74	97	59	80	19	3.5	979	0.27	0.38	25	20	25
08/15/91	89	67	77	96	46	81	18	2.6	983	0.00	0.40	27	22	27
08/16/91	93	75	80	65	37	82	23	2.9	988	0.00	0.44	31	26	31
08/17/91	94	69	79	82	38	81	43	5.7	974	0.00	0.45	28	23	28
08/18/91	88	66	75	97	52	80	30	4.7	952	0.31	0.39	26	21	26
08/19/91	90	69	78	93	31	81	43	3.8	680	0.00	0.31	28	23	28
08/20/91	93	66	83	95	38	83	17	3.2	384	0.00	0.18	26	21	26
08/21/91	95	73	80	89	28	83	33	2.2	243	0.20	0.14	30	25	30
08/22/91	96	72	81	66	0	83	44	6.2	439	0.00	0.32	29	24	29
08/23/91	93	66	78	88	31	81	45	3.8	979	0.00	0.43	26	21	26
08/24/91	91	69	77	87	38	80	39	4.1	745	0.44	0.33	28	23	28
08/25/91	93	65	79	93	34	80	28	3.4	979	0.00	0.42	26	21	26
08/26/91	92	68	80	86	33	81	26	4.0	979	0.00	0.43	27	22	27
08/27/91	93	64	79	91	27	81	17	2.4	955	0.00	0.41	25	20	25
08/28/91	94	67	79	84	33	82	23	3.1	938	0.00	0.41	27	22	27
08/29/91	96	65	81	86	26	82	16	2.4	955	0.00	0.42	26	21	26
08/30/91	92	71	79	79	37	81	54	3.7	654	0.23	0.30	29	24	29
08/31/91	91	64	77	92	33	79	45	4.0	838	0.00	0.37	25	20	25
09/01/91	88	64	76	88	33	79	25	3.0	883	0.00	0.37	25	20	25

09/01/91	88	64	76	68	33	79	25	3.0	883	0.00	0.37	25	20	25
09/02/91	95	61	77	89	24	79	24	2.8	993	0.00	0.44	24	19	24
09/03/91	99	64	80	81	15	80	45	4.6	943	0.00	0.47	25	20	25
09/04/91	86	66	74	95	41	77	34	4.3	613	1.04	0.27	26	21	26
09/05/91	86	67	75	96	47	77	35	5.4	804	0.15	0.34	27	22	27
09/06/91	86	68	76	94	50	78	23	3.6	852	0.00	0.34	27	22	27
09/07/91	90	65	77	95	39	79	22	2.3	852	0.01	0.35	26	21	26
09/08/91	93	65	79	96	31	80	22	2.3	948	0.00	0.40	26	21	26
09/09/91	76	66	71	93	62	76	32	4.3	272	0.01	0.10	21	16	21
09/10/91	79	65	72	95	66	76	19	2.9	559	0.00	0.20	22	17	22
09/11/91	87	62	74	96	43	77	35	4.3	921	0.07	0.38	24	19	24
09/12/91	85	62	71	95	48	76	36	4.1	690	0.02	0.28	24	19	24
09/13/91	80	62	70	94	54	75	18	2.8	537	0.00	0.20	21	16	21
09/14/91	88	57	71	98	15	75	19	2.2	871	0.00	0.37	22	17	22
09/15/91	89	53	71	79	15	74	18	2.3	840	0.00	0.37	20	16	20
09/16/91	87	57	73	88	27	74	31	4.9	730	0.00	0.33	22	17	22
09/17/91	81	64	71	96	54	74	22	3.2	449	0.07	0.18	23	18	23
09/18/91	67	54	63	97	92	71	31	2.7	107	0.78	0.01	11	6	11
09/19/91	64	51	56	97	67	68	27	4.6	284	0.01	0.09	8	5	8
09/20/91	68	48	57	94	63	67	27	4.2	673	0.00	0.22	9	7	9
09/21/91	75	50	61	97	60	68	18	2.5	807	0.00	0.27	13	10	13
09/22/91	86	53	70	98	42	71	29	3.7	857	0.00	0.35	20	16	20
09/23/91	82	57	69	93	51	71	23	3.1	659	0.00	0.25	20	15	20
09/24/91	83	58	70	96	35	71	26	4.6	845	0.00	0.35	21	16	21
09/25/91	88	53	70	91	32	71	15	2.0	852	0.00	0.35	20	16	20
09/26/91	86	57	70	94	22	72	33	3.6	824	0.00	0.36	22	17	22
09/27/91	85	50	68	96	20	71	21	2.7	859	0.00	0.36	18	15	18
09/28/91	84	52	68	90	17	70	29	3.6	738	0.00	0.32	18	15	18
09/29/91	83	52	68	86	22	70	25	2.8	840	0.00	0.35	18	14	18
09/30/91	87	54	70	90	20	71	28	2.7	828	0.00	0.35	20	16	20
10/01/91	85	61	71	77	32	72	23	3.4	766	0.00	0.33	23	18	23
10/02/91	89	54	70	95	13	72	8	1.8	809	0.00	0.35	20	16	20
10/03/91	92	50	71	94	10	71	10	2.4	814	0.00	0.37	18	16	18
10/04/91	91	51	71	69	10	71	14	2.9	809	0.00	0.38	19	16	19
10/05/91	78	54	66	83	35	70	12	4.0	778	0.00	0.31	16	12	16
10/06/91	84	49	66	94	29	69	11	3.0	776	0.00	0.32	17	15	17
10/07/91	85	53	68	85	31	70	8	2.5	769	0.00	0.31	19	15	19
10/08/91	89	57	69	77	19	70	6	1.7	439	0.00	0.21	22	17	22
10/09/91	88	50	69	91	17	69	7	2.0	403	0.00	0.20	18	16	18
10/10/91	88	55	71	69	11	70	15	3.9	480	0.00	0.26	21	16	21
10/11/91	86	48	66	71	11	69	7	2.1	504	0.00	0.24	18	16	18
10/12/91	86	45	64	84	12	68	7	1.9	475	0.00	0.22	18	16	18
10/13/91	90	46	67	87	11	68	8	1.7	482	0.00	0.23	18	16	18
10/14/91	84	53	66	69	14	68	9	2.9	477	0.00	0.24	19	15	19
10/15/91	86	45	64	82	13	67	7	1.7	468	0.00	0.22	18	16	18
10/16/91	88	46	66	83	12	67	8	2.3	465	0.00	0.23	18	16	18
10/17/91	90	58	67	50	10	67	12	2.1	427	0.00	0.24	22	17	22
10/18/91	93	46	67	62	9	67	14	2.9	465	0.00	0.26	18	16	18
10/19/91	79	47	62	73	20	66	11	2.8	444	0.00	0.20	15	12	15
10/20/91	83	49	66	77	13	66	12	4.0	432	0.00	0.23	17	14	17
10/21/91	82	54	66	89	23	67	11	2.8	363	0.01	0.17	18	14	18
10/22/91	79	50	64	92	20	66	14	4.0	422	0.00	0.20	15	12	15
10/23/91	76	49	62	96	37	66	13	3.5	346	0.00	0.15	13	11	13
10/24/91	74	47	60	93	34	64	12	2.7	334	0.00	0.14	12	10	12
10/25/91	76	44	58	93	26	63	10	2.1	325	0.00	0.14	13	11	13
10/26/91	78	40	58	95	19	63	9	2.0	420	0.00	0.18	14	12	14
10/27/91	74	41	55	96	25	62	24	3.9	329	0.06	0.15	12	10	12
10/28/91	64	40	52	96	21	60	17	5.1	418	0.00	0.17	7	5	7
10/29/91	68	38	52	85	27	59	12	3.2	394	0.00	0.16	9	7	9
10/30/91	65	38	49	98	39	58	22	7.7	406	0.29	0.17	8	5	8
10/31/91	56	29	41	97	38	55	14	5.1	377	0.00	0.12	3	1	3
11/01/91	60	29	43	100	32	54	9	2.1	413	0.00	0.13	5	3	5
11/02/91	71	31	49	100	16	54	10	3.0	408	0.00	0.17	11	8	11
11/03/91	55	30	41	87	36	53	8	1.9	394	0.00	0.11	3	0	3
11/04/91	65	27	45	97	17	53	9	2.0	401	0.00	0.14	8	5	8
11/05/91	72	31	51	77	17	53	11	3.3	387	0.00	0.17	11	9	11

11/05/91	72	31	51	77	17	53	11	3.3	387	0.00	0.17	11	9	11
11/06/91	76	37	54	92	18	55	7	1.9	396	0.00	0.17	13	11	13
11/07/91	78	38	57	89	19	56	10	2.8	382	0.00	0.18	14	12	14
11/08/91	62	36	48	93	43	56	11	2.8	370	0.00	0.12	6	4	6
11/09/91	74	35	54	95	32	55	6	1.7	365	0.00	0.14	12	10	12
11/10/91	69	47	58	90	41	57	13	2.8	141	0.00	0.06	10	7	10
11/11/91	65	49	56	96	50	58	13	2.9	181	0.02	0.06	8	5	8
11/12/91	57	46	51	87	66	56	8	2.6	103	0.01	0.03	4	1	4
11/13/91	61	50	55	95	73	57	9	2.8	122	0.00	0.03	6	3	6
11/14/91	67	49	57	96	52	58	13	3.9	141	0.00	0.06	9	6	9
11/15/91	65	43	54	98	47	56	12	3.3	165	0.25	0.06	8	5	8
11/16/91	53	34	44	96	45	53	19	5.3	334	0.01	0.11	2	0	2
11/17/91	62	37	48	79	25	50	16	4.4	365	0.00	0.15	6	4	6
11/18/91	66	32	49	95	21	51	20	5.6	358	0.00	0.16	8	6	8
11/19/91	56	34	45	93	28	50	20	6.2	356	0.00	0.14	3	1	3
11/20/91	60	26	42	97	27	49	8	1.6	356	0.00	0.11	5	3	5
11/21/91	66	27	46	95	19	49	8	2.1	346	0.00	0.13	8	6	8
11/22/91	72	40	53	68	16	51	14	4.4	344	0.00	0.18	11	9	11
11/23/91	55	25	40	50	17	49	11	3.4	351	0.00	0.13	3	0	3
11/24/91	59	24	39	53	16	46	8	2.3	349	0.00	0.13	5	2	5
11/25/91	66	27	43	54	14	47	8	1.9	341	0.00	0.14	8	6	8
11/26/91	70	29	46	63	15	47	6	1.7	341	0.00	0.14	10	8	10
11/27/91	72	30	48	71	14	48	8	2.2	339	0.00	0.15	11	9	11
11/28/91	73	37	54	63	15	49	18	5.1	212	0.00	0.15	12	9	12
11/29/91	55	29	43	52	19	49	22	7.4	329	0.00	0.15	3	0	3
11/30/91	58	26	41	99	19	46	23	7.2	325	0.02	0.15	4	2	4
12/01/91	37	28	34	99	84	45	11	3.8	72	0.05	0.00	0	0	0
12/02/91	47	27	35	96	44	44	13	3.9	303	0.00	0.08	0	0	0
12/03/91	56	21	36	97	20	43	8	1.9	322	0.00	0.10	3	1	3
12/04/91	58	26	39	84	21	42	10	2.5	284	0.00	0.10	4	2	4
12/05/91	55	30	40	72	36	42	10	3.6	184	0.00	0.07	3	0	3
12/06/91	67	28	45	89	19	44	9	2.8	308	0.00	0.13	9	6	9
12/07/91	68	28	45	94	23	45	11	2.2	303	0.00	0.12	9	7	9
12/08/91	69	29	48	92	19	46	8	1.5	294	0.00	0.12	10	7	10
12/09/91	72	35	51	77	23	48	10	2.3	298	0.00	0.13	11	9	11
12/10/91	70	45	55	97	38	50	9	3.2	229	0.14	0.10	10	8	10
12/11/91	60	48	54	97	69	52	23	5.0	119	0.69	0.03	5	3	5
12/12/91	61	40	50	97	38	50	13	3.7	313	0.00	0.11	6	3	6
12/13/91	60	31	44	99	38	48	8	2.9	313	0.00	0.10	5	3	5
12/14/91	58	30	42	82	24	46	11	3.3	313	0.00	0.12	4	2	4
12/15/91	55	30	38	94	41	43	10	3.4	210	0.00	0.07	3	0	3
12/16/91	54	32	40	93	42	43	9	3.7	141	0.00	0.05	2	0	2
12/17/91	57	38	47	89	52	44	10	3.8	172	0.00	0.06	4	1	4
12/18/91	52	44	47	98	70	47	11	2.8	36	0.45	0.00	1	0	1
12/19/91	53	44	47	98	91	48	14	2.6	72	0.26	0.00	2	0	2
12/20/91	55	40	48	97	61	47	25	7.7	117	0.02	0.04	3	0	3
12/21/91	54	34	45	98	67	47	23	6.6	134	0.53	0.04	2	0	2
12/22/91	52	33	42	99	65	45	18	5.4	236	0.13	0.06	1	0	1
12/23/91	58	30	42	99	43	45	14	2.8	284	0.01	0.09	4	2	4
12/24/91	55	31	42	96	44	44	11	2.5	260	0.00	0.08	3	0	3
12/25/91	42	36	39	98	86	44	9	3.1	41	0.36	-0.00	0	0	0
12/26/91	50	32	39	98	75	44	8	2.1	167	0.15	0.03	0	0	0
12/27/91	51	30	39	99	57	43	8	2.3	251	0.00	0.06	1	0	1
12/28/91	54	27	39	99	56	42	8	1.7	298	0.00	0.07	2	0	2
12/29/91	58	29	41	99	53	43	9	1.9	301	0.00	0.08	4	2	4
12/30/91	62	32	44	99	41	44	10	2.2	303	0.00	0.10	6	4	6
12/31/91	58	31	42	98	23	44	9	2.0	315	0.00	0.10	4	2	4
01/01/92	55	29	39	96	25	42	7	4.0	308	0.00	0.11	3	0	3
01/02/92	53	27	37	81	33	41	8	4.3	294	0.00	0.10	2	0	2
01/03/92	44	33	39	63	48	41	7	5.1	105	0.00	0.04	0	0	0
01/04/92	51	37	43	98	59	43	5	1.7	110	0.01	0.02	1	0	1
01/05/92	59	43	49	98	63	46	6	1.8	181	0.04	0.05	5	2	5
01/06/92	59	43	49	98	63	46	6	1.8	181	0.04	0.05	5	2	5
01/07/92	52	32	40	96	41	44	10	4.2	291	0.00	0.09	1	0	1
01/08/92	50	32	40	88	36	43	6	2.6	189	0.00	0.06	0	0	0
01/09/92	58	29	41	83	21	43	10	5.3	320	0.00	0.13	4	2	4

01/09/92	58	29	41	83	21	43	10	5.3	320	0.00	0.13	4	2	4
01/10/92	52	30	40	99	19	41	9	4.9	150	0.03	0.07	1	0	1
01/11/92	46	33	37	99	76	40	4	2.1	76	0.53	0.01	0	0	0
01/12/92	44	33	37	99	62	39	15	7.1	146	0.59	0.04	0	0	0
01/13/92	48	27	36	98	44	40	5	2.0	329	0.00	0.08	0	0	0
01/14/92	50	25	35	99	36	39	5	2.4	332	0.00	0.09	0	0	0
01/15/92	44	23	32	87	41	38	8	4.8	282	0.00	0.08	0	0	0
01/16/92	45	17	30	97	30	38	3	1.7	337	0.00	0.08	0	0	0
01/17/92	39	22	32	97	49	37	5	2.1	141	0.00	0.03	0	0	0
01/18/92	42	28	35	92	53	38	8	4.2	143	0.00	0.04	0	0	0
01/19/92	47	24	34	93	44	38	6	2.6	320	0.00	0.08	0	0	0
01/20/92	49	26	37	97	43	39	6	3.3	246	0.09	0.07	0	0	0
01/21/92	52	36	42	98	60	42	14	6.2	255	0.08	0.07	1	0	1
01/22/92	56	27	41	99	19	41	8	3.5	365	0.00	0.13	3	1	3
01/23/92	57	27	40	68	18	40	8	4.0	370	0.00	0.14	4	1	4
01/24/92	62	25	40	85	17	40	6	2.2	365	0.00	0.13	6	4	6
01/25/92	59	29	45	82	24	41	7	3.4	222	0.00	0.09	5	2	5
01/26/92	54	35	45	99	41	44	6	2.0	191	0.03	0.06	2	0	2
01/27/92	57	29	40	99	52	43	5	2.3	296	0.00	0.08	4	1	4
01/28/92	61	30	43	98	41	43	5	2.1	365	0.00	0.11	6	3	6
01/29/92	61	28	43	99	41	44	6	2.2	360	0.00	0.11	6	3	6
01/30/92	64	31	44	95	28	44	5	2.1	372	0.00	0.13	7	5	7
01/31/92	64	30	45	90	20	44	4	2.1	341	0.00	0.13	7	5	7
02/01/92	52	33	44	90	48	43	6	2.6	112	0.00	0.03	1	0	1
02/02/92	60	44	50	94	51	46	5	2.3	191	0.00	0.06	5	3	5
02/03/92	56	42	49	97	48	47	9	4.1	153	0.01	0.05	3	1	3
02/04/92	58	40	48	67	40	47	9	4.6	267	0.00	0.11	4	2	4
02/05/92	62	30	45	98	31	47	4	2.0	389	0.00	0.13	6	4	6
02/06/92	60	30	46	98	29	46	6	2.3	277	0.00	0.10	5	3	5
02/07/92	59	37	49	74	23	46	8	3.4	198	0.00	0.09	5	2	5
02/08/92	58	37	47	99	56	47	6	2.2	186	0.03	0.05	4	2	4
02/09/92	63	30	45	100	31	47	9	2.8	351	0.00	0.12	7	4	7
02/10/92	63	31	46	96	41	47	8	2.6	227	0.01	0.08	7	4	7
02/11/92	62	39	49	98	45	48	8	2.9	263	0.00	0.09	6	4	6
02/12/92	67	35	49	98	30	48	6	2.4	329	0.00	0.12	9	6	9
02/13/92	62	39	50	95	56	48	7	2.7	174	0.04	0.06	6	4	6
02/14/92	64	39	52	92	22	50	11	4.7	430	0.00	0.17	7	5	7
02/15/92	64	31	46	95	27	48	4	1.9	341	0.00	0.12	7	5	7
02/16/92	59	37	48	79	21	48	16	7.8	399	0.00	0.18	5	2	5
02/17/92	60	32	45	76	17	47	8	4.1	370	0.00	0.15	5	3	5
02/18/92	58	26	43	87	18	46	5	2.2	317	0.00	0.11	4	2	4
02/19/92	68	32	47	66	15	47	8	3.2	449	0.00	0.18	9	7	9
02/20/92	73	29	50	71	13	48	7	2.3	451	0.00	0.19	12	9	12
02/21/92	73	36	54	69	14	50	8	3.6	387	0.00	0.18	12	9	12
02/22/92	70	40	54	45	14	50	6	2.9	788	0.00	0.30	10	8	10
02/23/92	69	36	51	64	18	50	17	5.8	382	0.00	0.19	10	7	10
02/24/92	61	36	48	73	21	51	14	8.3	399	0.00	0.19	6	3	6
02/25/92	60	27	45	96	19	49	7	2.7	463	0.00	0.16	5	3	5
02/26/92	63	38	49	54	17	51	8	3.0	470	0.00	0.18	7	4	7
02/27/92	69	30	49	54	15	51	6	2.6	489	0.00	0.19	10	7	10
02/28/92	73	33	51	66	14	52	4	1.9	489	0.00	0.20	12	9	12
02/29/92	73	32	53	66	14	52	6	2.3	458	0.00	0.19	12	9	12
03/01/92	70	40	54	50	15	52	9	2.9	332	0.00	0.16	10	8	10
03/02/92	72	36	54	97	16	52	7	2.7	387	0.16	0.16	11	9	11
03/03/92	61	43	50	97	42	53	12	4.5	315	0.08	0.11	6	3	6
03/04/92	60	39	49	97	41	51	15	7.4	363	0.00	0.14	5	3	5
03/05/92	66	44	54	86	30	52	14	8.1	516	0.00	0.22	8	6	8
03/06/92	74	34	54	97	13	53	6	2.2	525	0.00	0.21	12	10	12
03/07/92	76	39	57	62	12	54	8	3.9	532	0.00	0.25	13	11	13
03/08/92	61	39	50	67	19	53	13	6.0	384	0.00	0.17	6	3	6
03/09/92	61	31	46	91	24	51	12	5.2	458	0.00	0.17	6	3	6
03/10/92	63	31	47	94	20	52	5	2.6	528	0.00	0.18	7	4	7
03/11/92	68	34	48	89	15	53	14	4.0	494	0.00	0.20	9	7	9
03/12/92	68	33	50	91	15	53	4	2.3	528	0.00	0.19	9	7	9
03/13/92	74	32	53	83	13	54	5	2.0	554	0.00	0.22	12	10	12
03/14/92	79	34	56	68	12	55	5	2.2	561	0.00	0.24	15	12	15

03/14/92	79	34	56	68	12	55	5	2.2	561	0.00	0.24	15	12	15
03/15/92	81	36	58	54	11	56	7	2.4	561	0.00	0.25	16	13	16
03/16/92	77	39	58	56	12	57	9	3.1	559	0.00	0.25	14	11	14
03/17/92	67	46	55	86	26	57	13	5.1	382	0.07	0.17	9	6	9
03/18/92	65	41	53	86	17	55	14	7.1	511	0.00	0.22	8	5	8
03/19/92	73	36	54	73	13	55	6	2.9	573	0.00	0.23	12	9	12
03/20/92	74	35	55	66	13	55	8	3.2	473	0.00	0.21	12	10	12
03/21/92	73	42	58	46	13	56	13	5.3	561	0.00	0.27	12	9	12
03/22/92	69	44	56	62	21	57	9	4.0	496	0.00	0.21	10	7	10
03/23/92	73	39	57	89	14	58	9	3.8	537	0.00	0.23	12	9	12
03/24/92	73	37	56	64	13	58	6	2.8	597	0.00	0.24	12	9	12
03/25/92	78	38	58	51	12	58	6	3.0	599	0.00	0.26	14	12	14
03/26/92	80	41	61	49	11	59	6	3.0	590	0.00	0.27	15	13	15
03/27/92	66	43	53	95	19	57	9	2.9	184	0.07	0.09	8	6	8
03/28/92	65	44	54	98	38	58	10	4.4	391	0.00	0.15	8	5	8
03/29/92	70	45	58	96	29	59	6	3.7	575	0.00	0.22	10	8	10
03/30/92	75	43	60	94	17	60	11	6.2	575	0.00	0.26	13	10	13
03/31/92	73	45	60	92	14	60	11	3.8	575	0.00	0.24	12	9	12
04/01/92	0	0	48	0	0	56	6	4.1	131	0.00	0.03	0	0	0
04/02/92	65	47	56	96	0	60	6	3.5	220	0.24	0.11	8	5	8
04/03/92	70	37	54	98	19	59	4	2.0	616	0.00	0.22	10	8	10
04/04/92	75	38	58	95	13	60	7	2.8	640	0.00	0.26	13	10	13
04/05/92	75	41	59	91	14	61	14	5.1	580	0.00	0.26	13	10	13
04/06/92	78	43	61	91	13	63	8	3.3	637	0.00	0.27	14	12	14
04/07/92	82	42	62	66	11	63	6	2.2	637	0.00	0.28	16	14	16
04/08/92	85	46	66	59	11	64	7	3.0	637	0.00	0.30	18	15	18
04/09/92	83	45	65	52	11	64	7	3.1	625	0.00	0.29	17	14	17
04/10/92	85	48	67	50	11	65	9	3.4	644	0.00	0.31	18	15	18
04/11/92	87	46	67	55	10	65	5	2.1	654	0.00	0.30	18	16	18
04/12/92	88	45	77	62	10	66	14	4.5	656	0.00	0.33	18	16	18
04/13/92	87	60	70	79	17	67	16	6.0	501	0.03	0.28	23	18	23
04/14/92	83	59	68	60	12	69	13	2.6	506	0.00	0.25	21	16	21
04/15/92	82	49	66	58	12	66	13	3.5	604	0.00	0.29	16	14	16
04/16/92	80	47	64	60	12	65	12	3.4	535	0.00	0.25	15	13	15
04/17/92	82	48	65	68	12	66	10	3.5	654	0.00	0.30	16	14	16
04/18/92	81	46	67	94	13	66	28	9.5	656	0.08	0.35	16	13	16
04/19/92	69	46	56	97	15	65	17	4.7	668	0.05	0.26	10	7	10
04/20/92	75	41	59	86	13	64	15	3.9	692	0.00	0.29	13	10	13
04/21/92	80	42	62	71	12	65	9	2.5	697	0.00	0.29	15	13	15
04/22/92	84	45	65	72	11	66	15	4.2	687	0.00	0.33	17	15	17
04/23/92	89	45	66	58	10	66	12	2.4	692	0.00	0.32	18	16	18
04/24/92	92	48	71	43	9	68	16	4.8	680	0.00	0.37	18	16	18
04/25/92	81	61	71	62	21	70	17	7.5	623	0.00	0.33	21	16	21
04/26/92	85	55	70	57	18	70	15	3.4	621	0.00	0.29	20	15	20
04/27/92	91	54	74	84	10	71	9	2.8	683	0.00	0.32	20	16	20
04/28/92	93	52	74	62	9	71	14	3.7	695	0.00	0.36	19	16	19
04/29/92	94	51	74	52	9	72	11	2.5	690	0.00	0.34	19	16	19
04/30/92	94	53	74	51	9	72	15	3.3	680	0.00	0.35	20	16	20
05/01/92	94	54	75	57	9	72	14	3.5	668	0.00	0.35	20	16	20
05/02/92	84	60	69	93	17	70	16	3.8	298	0.07	0.17	22	17	22
05/03/92	75	58	68	95	46	69	7	3.3	272	0.11	0.11	17	12	17
05/04/92	80	58	69	93	32	69	11	3.4	437	0.00	0.19	19	14	19
05/05/92	84	58	70	92	15	71	18	5.6	633	0.09	0.31	21	16	21
05/06/92	81	54	68	96	30	70	19	6.4	556	0.78	0.26	18	13	18
05/07/92	81	53	68	96	34	70	10	3.1	690	0.00	0.28	17	13	17
05/08/92	83	56	70	92	16	72	13	4.0	656	0.00	0.30	20	15	20
05/09/92	81	55	67	93	13	72	16	4.5	625	0.00	0.29	18	13	18
05/10/92	77	55	66	80	18	70	15	5.0	535	0.00	0.25	16	11	16
05/11/92	85	54	71	68	14	70	16	4.5	690	0.00	0.33	20	15	20
05/12/92	90	53	73	90	10	72	12	3.0	714	0.00	0.33	20	16	20
05/13/92	90	58	70	69	12	72	20	5.0	547	0.04	0.31	22	17	22
05/14/92	88	56	70	92	14	72	17	2.9	542	0.00	0.26	21	16	21
05/15/92	93	54	72	92	9	73	20	3.7	697	0.00	0.35	20	16	20
05/16/92	92	61	75	59	11	75	13	4.6	685	0.00	0.36	24	19	24
05/17/92	92	55	73	81	11	75	22	4.3	661	0.06	0.34	21	16	21
05/18/92	86	61	73	83	22	75	16	5.6	652	0.00	0.32	24	19	24

05/18/92	86	61	73	83	22	75	16	5.6	652	0.00	0.32	24	19	24
05/19/92	86	60	72	88	16	75	14	4.2	573	0.05	0.28	23	18	23
05/20/92	85	59	69	92	25	75	18	5.6	640	0.03	0.30	22	17	22
05/21/92	84	56	70	90	12	75	13	5.0	702	0.00	0.33	20	15	20
05/22/92	85	52	69	96	11	74	26	6.2	592	0.34	0.31	19	15	19
05/23/92	75	55	64	93	41	72	19	7.0	599	0.00	0.25	15	10	15
05/24/92	70	53	60	96	49	68	15	5.3	360	0.14	0.14	12	8	12
05/25/92	80	50	63	97	19	69	13	3.9	633	0.00	0.27	15	13	15
05/26/92	77	53	65	94	30	69	12	3.5	465	0.00	0.20	15	11	15
05/27/92	84	54	67	93	19	70	27	5.9	604	0.03	0.30	19	15	19
05/28/92	86	52	69	95	13	72	17	3.0	668	0.14	0.30	19	16	19
05/29/92	82	60	68	93	26	73	21	5.6	618	0.00	0.29	21	16	21
05/30/92	84	55	68	95	23	73	22	3.4	559	0.02	0.25	20	15	20
05/31/92	86	51	70	96	14	73	10	2.3	692	0.01	0.30	19	16	19
06/01/92	88	58	71	74	18	73	19	3.3	458	0.01	0.24	22	17	22
06/02/92	89	54	72	88	11	75	10	2.6	742	0.00	0.34	20	16	20
06/03/92	94	56	75	81	10	76	25	4.5	687	0.00	0.36	21	16	21
06/04/92	94	57	76	92	10	78	11	2.6	733	0.00	0.35	22	17	22
06/05/92	96	66	78	25	0	79	16	2.8	432	0.00	0.28	26	21	26
06/06/92	92	61	77	38	10	75	13	3.2	666	0.00	0.34	24	19	24
06/07/92	89	61	73	83	11	75	18	5.9	580	0.08	0.32	24	19	24
06/08/92	85	56	71	92	12	73	15	4.1	685	0.00	0.32	21	16	21
06/09/92	88	56	73	80	11	73	11	3.7	721	0.00	0.34	21	16	21
06/10/92	93	59	76	62	9	75	12	2.8	733	0.00	0.36	23	18	23
06/11/92	97	55	78	67	8	76	11	2.7	750	0.00	0.37	21	16	21
06/12/92	96	59	80	53	8	77	11	2.4	766	0.00	0.38	23	18	23
06/13/92	95	54	76	48	8	76	13	3.1	781	0.00	0.39	20	16	20
06/14/92	95	58	78	38	9	76	13	3.6	778	0.00	0.40	22	17	22
06/15/92	95	61	80	34	8	76	17	4.6	709	0.00	0.39	24	19	24
06/16/92	96	55	77	31	8	75	19	4.7	785	0.00	0.43	21	16	21
06/17/92	97	56	78	33	8	76	9	3.4	781	0.00	0.41	21	16	21
06/18/92	104	73	82	18	7	81	9	1.2	236	0.00	0.19	30	25	30
06/19/92	104	64	89	38	7	79	10	3.1	726	0.00	0.40	25	20	25
06/20/92	99	64	83	36	8	79	14	5.1	640	0.00	0.39	25	20	25
06/21/92	97	68	81	54	10	80	26	6.6	668	0.00	0.41	27	22	27
06/22/92	96	62	80	77	11	80	13	3.7	714	0.00	0.36	24	19	24
06/23/92	98	70	83	46	9	81	16	5.0	654	0.03	0.39	28	23	28
06/24/92	98	62	80	87	8	79	17	4.2	697	0.00	0.37	24	19	24
06/25/92	101	66	84	40	8	79	13	4.3	668	0.00	0.39	26	21	26
06/26/92	98	66	82	41	8	80	13	3.9	702	0.00	0.39	26	21	26
06/27/92	98	64	83	51	8	80	15	4.7	757	0.00	0.42	25	20	25
06/28/92	101	59	83	39	7	79	12	3.4	692	0.00	0.38	23	18	23
06/29/92	102	63	83	35	7	79	14	3.5	745	0.00	0.41	25	20	25
06/30/92	101	60	83	46	7	79	18	4.8	747	0.00	0.43	23	18	23
07/01/92	97	65	82	25	8	79	19	5.0	745	0.00	0.43	26	21	26
07/02/92	96	61	80	27	8	80	14	3.9	766	0.00	0.41	24	19	24
07/03/92	102	60	83	39	7	81	18	6.1	723	0.00	0.45	23	18	23
07/04/92	101	77	88	38	8	84	16	6.7	680	0.00	0.44	32	27	32
07/05/92	105	69	88	38	7	85	10	3.0	733	0.00	0.41	28	23	28
07/06/92	107	69	90	45	6	86	14	3.4	750	0.00	0.42	28	23	28
07/07/92	106	73	91	36	6	87	9	3.4	740	0.00	0.42	30	25	30
07/08/92	103	71	88	36	7	88	13	3.5	728	0.00	0.41	29	24	29
07/09/92	101	72	84	47	9	87	19	5.2	656	0.24	0.40	29	24	29
07/10/92	100	72	82	49	9	85	17	4.9	637	0.00	0.39	29	24	29
07/11/92	94	68	81	90	13	85	14	4.4	676	0.00	0.34	27	22	27
07/12/92	92	68	80	71	10	85	16	5.8	699	0.00	0.38	27	22	27
07/13/92	97	60	80	60	8	85	14	4.5	745	0.00	0.40	23	18	23
07/14/92	100	63	83	36	8	86	13	4.7	750	0.00	0.43	25	20	25
07/15/92	101	64	84	27	7	86	12	3.8	618	0.00	0.37	25	20	25
07/16/92	102	66	86	33	7	87	18	3.8	714	0.00	0.40	26	21	26
07/17/92	99	69	83	72	10	88	26	5.9	656	0.00	0.39	28	23	28
07/18/92	94	63	86	90	10	81	17	3.8	647	0.00	0.32	25	20	25
07/19/92	92	68	79	42	15	80	24	4.3	673	0.00	0.36	27	22	27
07/20/92	91	64	78	74	21	78	12	3.7	518	0.01	0.26	25	20	25
07/21/92	95	68	82	70	13	80	19	5.3	687	0.00	0.37	27	22	27
07/22/92	98	68	84	67	10	82	10	3.6	711	0.00	0.37	27	22	27

07/23/92	99	70	84	91	11	82	15	4.6	599	0.14	0.33	28	23	28
07/24/92	95	67	79	92	15	82	17	4.8	678	0.04	0.35	27	22	27
07/25/92	92	66	79	93	24	83	10	3.3	671	0.06	0.31	26	21	26
07/26/92	95	70	80	84	22	83	10	2.6	585	0.00	0.28	28	23	28
07/27/92	91	69	78	88	36	82	18	3.6	508	0.00	0.24	28	23	28
07/28/92	95	67	80	91	30	83	16	3.7	716	0.00	0.33	27	22	27
07/29/92	95	67	81	89	33	84	12	2.9	647	0.00	0.30	27	22	27
07/30/92	99	68	80	80	25	83	22	3.4	599	0.00	0.31	27	22	27
07/31/92	92	65	77	94	32	83	19	5.6	582	0.11	0.29	26	21	26
08/01/92	82	64	72	97	57	79	13	4.2	329	1.00	0.13	23	18	23
08/02/92	90	64	77	98	41	80	16	2.4	630	0.12	0.26	25	20	25
08/03/92	93	65	79	97	34	82	9	2.3	702	0.00	0.30	26	21	26
08/04/92	97	67	81	84	22	83	7	2.9	702	0.00	0.34	27	22	27
08/05/92	97	66	82	83	26	83	13	2.9	697	0.00	0.33	26	21	26
08/06/92	96	70	83	75	29	84	20	3.6	668	0.00	0.33	28	23	28
08/07/92	96	68	82	92	30	84	8	2.4	683	0.01	0.31	27	22	27
08/08/92	97	66	81	80	26	83	14	3.2	599	0.00	0.30	26	21	26
08/09/92	96	68	82	80	24	84	7	2.6	640	0.00	0.31	27	22	27
08/10/92	102	68	86	65	14	84	15	3.5	704	0.01	0.37	27	22	27
08/11/92	98	67	87	89	27	84	27	5.5	504	0.66	0.28	27	22	27
08/12/92	88	65	75	97	49	81	14	4.5	523	0.24	0.23	26	21	26
08/13/92	88	67	77	90	44	82	11	3.5	597	0.00	0.26	27	22	27
08/14/92	94	65	80	95	30	83	16	3.0	673	0.00	0.31	26	21	26
08/15/92	93	69	81	70	36	83	10	4.0	633	0.00	0.30	28	23	28
08/16/92	94	66	80	88	33	83	10	3.8	649	0.00	0.30	26	21	26
08/17/92	98	70	84	72	25	83	18	3.5	618	0.00	0.31	28	23	28
08/18/92	96	70	82	68	32	84	14	4.9	621	0.00	0.32	28	23	28
08/19/92	95	67	81	80	36	83	28	5.2	563	0.55	0.29	27	22	27
08/20/92	94	65	78	93	24	82	8	2.8	659	0.01	0.31	26	21	26
08/21/92	94	64	80	87	30	82	11	4.6	652	0.00	0.32	25	20	25
08/22/92	91	64	76	94	37	80	18	3.5	461	0.24	0.22	25	20	25
08/23/92	90	68	76	95	38	81	15	2.8	494	0.03	0.22	27	22	27
08/24/92	86	66	74	96	42	80	15	5.0	511	0.00	0.23	26	21	26
08/25/92	89	60	75	94	30	79	13	3.1	625	0.00	0.28	23	18	23
08/26/92	93	64	79	91	24	80	12	3.1	633	0.00	0.30	25	20	25
08/27/92	91	67	77	77	32	81	10	3.3	609	0.00	0.28	27	22	27
08/28/92	95	64	76	88	28	80	14	2.5	513	0.00	0.25	25	20	25
08/29/92	91	67	77	90	28	79	16	4.9	432	0.00	0.23	27	22	27
08/30/92	92	65	77	79	31	79	7	2.4	563	0.00	0.26	26	21	26
08/31/92	94	62	77	74	16	80	11	2.3	599	0.00	0.29	24	19	24
09/01/92	94	59	77	72	14	79	16	3.9	637	0.00	0.33	23	18	23
09/02/92	95	62	77	61	14	79	10	3.1	590	0.00	0.31	24	19	24
09/03/92	99	55	76	79	12	79	9	2.2	611	0.00	0.31	21	16	21
09/04/92	97	59	78	82	11	79	14	3.5	563	0.00	0.31	23	18	23
09/05/92	96	58	77	74	11	78	14	3.6	599	0.00	0.32	22	17	22
09/06/92	97	54	76	79	11	79	10	2.7	630	0.00	0.32	20	16	20
09/07/92	98	57	78	63	13	79	9	2.6	585	0.00	0.31	22	17	22
09/08/92	101	60	81	70	11	80	10	2.6	590	0.00	0.32	23	18	23
09/09/92	100	58	79	85	8	80	12	2.5	618	0.00	0.32	22	17	22
09/10/92	98	57	79	51	10	80	19	5.5	616	0.00	0.37	22	17	22
09/11/92	91	61	78	72	28	81	11	4.7	590	0.00	0.30	24	19	24
09/12/92	91	60	75	92	21	81	9	2.8	590	0.00	0.28	23	18	23
09/13/92	96	61	78	74	15	81	9	2.8	590	0.00	0.30	24	19	24
09/14/92	88	67	79	96	39	82	15	4.8	430	0.18	0.20	27	22	27
09/15/92	87	65	75	98	49	81	16	4.4	556	0.46	0.24	26	21	26
09/16/92	89	64	76	98	45	81	7	2.6	547	0.01	0.23	25	20	25
09/17/92	94	64	78	98	38	80	8	2.0	516	0.00	0.23	25	20	25
09/18/92	95	65	80	96	30	80	15	4.4	508	0.00	0.26	26	21	26
09/19/92	88	68	75	90	42	79	19	4.2	337	0.02	0.17	27	22	27
09/20/92	88	65	74	94	34	78	19	4.9	449	0.08	0.22	26	21	26
09/21/92	91	57	74	96	22	77	13	3.2	563	0.00	0.27	22	17	22
09/22/92	89	58	73	74	16	77	15	4.3	563	0.00	0.29	22	17	22
09/23/92	84	54	70	73	33	77	10	3.2	556	0.00	0.25	19	15	19
09/24/92	89	55	71	83	22	77	8	2.4	561	0.00	0.26	21	16	21
09/25/92	93	52	73	89	15	77	14	3.8	556	0.00	0.29	19	16	19

09/26/92	91	59	75	64	11	77	11	4.1	559	0.00	0.30	23	18	23
09/27/92	89	53	72	73	20	77	8	2.5	549	0.00	0.26	20	16	20
09/28/92	89	53	71	85	14	76	18	5.8	544	0.00	0.30	20	16	20
09/29/92	84	56	71	53	13	76	13	4.8	551	0.00	0.29	20	15	20
09/30/92	85	50	67	68	13	75	11	3.1	544	0.00	0.26	18	15	18
10/01/92	86	46	65	73	13	74	8	2.6	530	0.00	0.25	18	16	18
10/02/92	88	45	65	76	12	74	7	1.8	535	0.00	0.25	18	16	18
10/03/92	89	43	65	89	10	73	8	2.1	537	0.00	0.26	18	16	18
10/04/92	90	42	66	71	10	73	9	2.3	530	0.00	0.26	18	16	18
10/05/92	93	47	68	68	10	73	8	2.0	492	0.00	0.25	18	16	18
10/06/92	91	47	67	81	11	73	10	2.3	496	0.00	0.25	18	16	18
10/07/92	82	46	63	63	11	71	17	4.8	530	0.00	0.28	16	14	16
10/08/92	77	38	57	69	13	69	7	1.9	508	0.00	0.21	14	11	14
10/09/92	87	38	61	71	11	69	12	2.3	501	0.00	0.25	18	16	18
10/10/92	86	40	71	62	11	69	10	2.4	496	0.00	0.24	18	16	18
10/11/92	88	42	63	66	12	69	7	1.9	492	0.00	0.24	18	16	18
10/12/92	93	53	67	67	10	72	7	1.3	420	0.00	0.22	20	16	20
10/13/92	91	45	66	72	12	70	20	3.2	411	0.00	0.24	18	16	18
10/14/92	86	51	67	71	15	71	13	3.7	463	0.00	0.24	19	16	19
10/15/92	82	49	65	75	14	70	15	3.9	473	0.00	0.24	16	14	16
10/16/92	83	42	62	78	13	69	11	2.9	468	0.00	0.23	17	14	17
10/17/92	88	44	64	79	11	69	6	1.7	465	0.00	0.22	18	16	18
10/18/92	87	43	66	81	12	69	11	2.8	437	0.00	0.22	18	16	18
10/19/92	88	52	68	88	15	70	8	2.0	346	0.00	0.18	19	16	19
10/20/92	83	57	67	71	30	71	12	2.7	315	0.00	0.16	20	15	20
10/21/92	84	51	69	93	28	71	14	3.5	425	0.00	0.20	18	15	18
10/22/92	78	56	68	96	41	71	12	4.7	296	0.06	0.14	17	12	17
10/23/92	80	59	68	98	50	71	16	4.7	308	0.40	0.13	20	15	20
10/24/92	77	60	69	94	47	71	11	5.2	401	0.00	0.17	19	14	19
10/25/92	83	55	67	98	42	70	7	2.2	415	0.00	0.17	19	14	19
10/26/92	83	49	64	100	20	68	8	1.9	439	0.00	0.19	17	14	17
10/27/92	84	46	63	95	17	67	7	2.1	406	0.00	0.19	17	15	17
10/28/92	67	52	59	97	66	66	9	3.3	191	0.14	0.06	10	6	10
10/29/92	74	49	59	100	46	65	11	2.2	279	0.01	0.10	12	10	12
10/30/92	74	45	58	96	36	63	14	3.4	415	0.00	0.17	12	10	12
10/31/92	73	48	59	94	36	62	17	4.4	251	0.00	0.12	12	9	12
11/01/92	66	39	53	75	16	60	14	5.2	418	0.00	0.19	8	6	8
11/02/92	73	36	57	75	16	58	17	5.2	396	0.00	0.20	12	9	12
11/03/92	59	40	47	71	34	57	15	5.5	79	0.00	0.06	5	2	5
11/04/92	54	36	43	83	22	55	11	4.1	403	0.00	0.14	2	0	2
11/05/92	58	36	45	73	31	55	6	2.2	308	0.00	0.11	4	2	4
11/06/92	63	29	44	91	21	54	7	2.2	391	0.00	0.14	7	4	7
11/07/92	69	29	47	92	17	54	7	2.0	382	0.00	0.15	10	7	10
11/08/92	75	30	50	95	15	54	13	2.5	389	0.00	0.17	13	10	13
11/09/92	73	34	53	86	25	55	11	2.4	377	0.00	0.15	12	9	12
11/10/92	74	38	56	93	30	56	13	3.3	358	0.00	0.15	12	10	12
11/11/92	66	40	51	94	15	56	18	4.7	360	0.00	0.16	8	6	8
11/12/92	65	31	45	63	16	54	11	3.0	384	0.00	0.16	8	5	8
11/13/92	70	33	48	54	14	53	8	3.1	377	0.00	0.17	10	8	10
11/14/92	75	32	50	57	14	53	9	2.5	370	0.00	0.17	13	10	13
11/15/92	74	33	51	66	15	52	10	2.7	365	0.00	0.17	12	10	12
11/16/92	76	33	52	77	20	52	7	1.7	341	0.00	0.15	13	11	13
11/17/92	75	34	54	93	13	54	9	1.8	351	0.00	0.15	13	10	13
11/18/92	72	47	57	63	14	55	9	3.0	303	0.00	0.15	11	9	11
11/19/92	68	39	51	90	22	51	6	1.7	265	0.00	0.11	9	7	9
11/20/92	63	38	48	84	26	52	22	6.1	150	0.03	0.10	7	4	7
11/21/92	55	29	41	72	30	50	19	4.8	339	0.00	0.12	3	0	3
11/22/92	59	26	41	92	23	48	11	2.0	243	0.00	0.09	5	2	5
11/23/92	58	35	44	94	18	49	20	4.9	215	0.05	0.10	4	2	4
11/24/92	52	23	38	95	19	47	18	4.5	346	0.00	0.12	1	0	1
11/25/92	52	22	35	60	20	45	8	2.7	346	0.00	0.11	1	0	1
11/26/92	54	24	36	56	20	44	14	3.9	337	0.00	0.12	2	0	2
11/27/92	57	21	36	58	18	43	9	2.8	349	0.00	0.12	4	1	4
11/28/92	58	18	36	58	18	43	7	2.0	341	0.00	0.12	4	2	4
11/29/92	61	23	40	57	17	43	9	2.5	306	0.00	0.12	6	3	6

11/30/92	56	32	41	41	21	43	11	4.2	191	0.00	0.10	3	1	3
12/01/92	64	24	42	46	15	42	10	3.7	339	0.00	0.15	7	5	7
12/02/92	63	24	43	43	16	43	10	2.5	322	0.00	0.13	7	4	7
12/03/92	53	44	48	100	35	45	10	1.7	55	0.04	0.02	2	0	2
12/04/92	57	34	42	101	80	46	16	4.6	98	0.71	0.02	4	1	4
12/05/92	37	27	32	100	78	42	15	3.9	153	0.11	0.02	0	0	0
12/06/92	37	32	34	99	91	42	10	2.6	74	0.24	0.00	0	0	0
12/07/92	43	28	34	101	75	42	7	4.2	155	0.10	0.03	0	0	0
12/08/92	44	29	36	99	78	41	17	4.2	141	0.04	0.02	0	0	0
12/09/92	57	28	41	101	48	42	9	2.0	322	0.00	0.09	4	1	4
12/10/92	62	29	43	101	42	43	10	3.5	315	0.00	0.11	6	4	6
12/11/92	66	34	46	95	35	44	9	3.0	310	0.00	0.12	8	6	8
12/12/92	60	29	43	101	26	44	23	4.2	301	0.00	0.12	5	3	5
12/13/92	47	32	38	98	48	44	12	3.9	174	0.00	0.05	0	0	0
12/14/92	41	23	32	98	47	43	8	2.7	177	0.00	0.04	0	0	0
12/15/92	48	21	35	99	42	40	17	3.8	263	0.00	0.07	0	0	0
12/16/92	48	26	38	90	34	41	16	4.3	294	0.00	0.09	0	0	0
12/17/92	53	22	36	91	31	40	7	2.2	317	0.00	0.09	2	0	2
12/18/92	65	25	43	97	34	41	13	2.3	294	0.00	0.11	8	5	8
12/19/92	58	34	43	76	41	42	14	3.6	198	0.00	0.08	4	2	4
12/20/92	51	31	38	82	37	41	9	4.2	186	0.00	0.07	1	0	1
12/21/92	60	28	41	89	37	41	12	3.9	251	0.00	0.10	5	3	5
12/22/92	63	33	44	94	40	42	10	4.6	265	0.00	0.11	7	4	7
12/23/92	60	31	42	55	17	42	13	6.1	308	0.00	0.16	5	3	5
12/24/92	58	34	42	59	27	42	8	2.7	191	0.00	0.08	4	2	4
12/25/92	55	36	44	55	32	43	10	3.8	165	0.00	0.08	3	0	3
12/26/92	60	34	45	78	34	44	8	2.4	301	0.00	0.10	5	3	5
12/27/92	63	32	46	95	35	44	10	2.6	227	0.00	0.09	7	4	7
12/28/92	64	46	54	91	55	46	12	2.5	69	0.00	0.03	7	5	7
12/29/92	72	48	59	99	38	48	15	3.7	208	0.05	0.09	11	9	11
12/30/92	65	50	55	94	57	50	10	2.2	184	0.00	0.06	8	5	8
12/31/92	65	50	55	94	57	50	10	2.2	184	0.00	0.06	8	5	8
01/01/93	50	43	46	99	92	50	7	2.4	55	0.19	-0.00	0	0	0
01/02/93	55	42	47	100	87	50	6	2.4	98	0.00	0.01	3	0	3
01/03/93	58	37	46	100	26	49	15	4.1	124	0.00	0.06	4	2	4
01/04/93	52	28	38	91	23	47	9	2.3	294	0.00	0.09	1	0	1
01/05/93	58	35	46	93	41	47	7	2.5	220	0.00	0.07	4	2	4
01/06/93	56	46	49	99	80	48	7	2.0	117	0.27	0.02	3	1	3
01/07/93	63	44	53	100	57	49	16	4.8	265	0.00	0.09	7	4	7
01/08/93	63	44	51	97	60	50	24	5.9	150	0.31	0.06	7	4	7
01/09/93	58	38	49	95	47	50	13	3.5	232	0.00	0.08	4	2	4
01/10/93	52	42	47	83	58	49	13	6.3	184	0.04	0.06	1	0	1
01/11/93	63	39	49	98	38	49	19	5.6	236	0.05	0.10	7	4	7
01/12/93	60	34	45	96	24	49	7	2.6	296	0.00	0.11	5	3	5
01/13/93	56	34	43	100	50	48	12	2.6	136	0.17	0.04	3	1	3
01/14/93	51	40	43	100	84	48	8	2.0	124	0.00	0.02	1	0	1
01/15/93	58	38	46	100	49	48	11	3.1	241	0.00	0.07	4	2	4
01/16/93	62	33	47	100	43	48	9	2.2	248	0.00	0.08	6	4	6
01/17/93	60	47	51	98	67	49	13	2.9	129	0.04	0.03	5	3	5
01/18/93	51	47	48	98	84	50	10	4.2	38	0.35	-0.00	1	0	1
01/19/93	54	37	45	100	47	49	16	4.8	246	0.03	0.08	2	0	2
01/20/93	58	30	43	99	39	48	9	2.5	325	0.00	0.10	4	2	4
01/21/93	64	31	45	100	26	47	8	2.8	334	0.00	0.12	7	5	7
01/22/93	67	33	47	97	24	47	7	2.9	329	0.00	0.13	9	6	9
01/23/93	68	33	48	99	14	47	14	3.8	341	0.00	0.15	9	7	9
01/24/93	54	24	38	88	23	46	10	3.1	341	0.00	0.11	2	0	2
01/25/93	60	30	42	76	17	45	10	2.9	346	0.00	0.13	5	3	5
01/26/93	61	28	43	87	18	44	7	2.8	308	0.00	0.12	6	3	6
01/27/93	59	36	47	65	18	45	7	2.4	203	0.00	0.09	5	2	5
01/28/93	64	40	49	88	20	46	8	2.8	286	0.00	0.12	7	5	7
01/29/93	53	33	44	84	44	46	14	5.5	344	0.00	0.11	2	0	2
01/30/93	50	30	40	99	56	46	12	3.6	203	0.00	0.05	0	0	0
01/31/93	61	32	47	99	43	46	10	3.0	332	0.00	0.11	6	3	6
02/01/93	67	32	48	100	17	47	13	3.2	358	0.00	0.15	9	6	9
02/02/93	63	27	44	66	16	46	7	2.8	365	0.00	0.14	7	4	7

02/03/93	64	27	45	68	17	45	11	3.0	372	0.00	0.15	7	5	7
02/04/93	55	33	43	74	35	45	9	3.1	229	0.00	0.08	3	0	3
02/05/93	57	26	40	88	27	45	8	2.6	372	0.00	0.12	4	1	4
02/06/93	60	26	41	73	18	44	8	2.8	358	0.00	0.13	5	3	5
02/07/93	67	27	45	62	15	44	7	2.5	372	0.00	0.15	9	6	9
02/08/93	67	34	50	91	24	45	12	2.3	201	0.04	0.09	9	6	9
02/09/93	59	43	50	99	40	47	16	5.1	260	0.03	0.10	5	2	5
02/10/93	56	38	46	92	33	47	21	8.0	310	0.00	0.13	3	1	3
02/11/93	60	32	46	95	25	47	14	5.7	403	0.00	0.16	5	3	5
02/12/93	64	27	46	99	16	46	11	3.0	403	0.00	0.15	7	5	7
02/13/93	65	36	50	62	17	47	8	2.4	272	0.00	0.12	8	5	8
02/14/93	64	46	54	97	19	48	18	5.2	265	0.07	0.13	7	5	7
02/15/93	56	40	48	95	33	49	20	7.1	377	0.00	0.14	3	1	3
02/16/93	62	34	48	96	20	48	12	3.1	375	0.00	0.14	6	4	6
02/17/93	67	34	51	95	15	49	16	3.7	406	0.00	0.17	9	6	9
02/18/93	72	35	54	64	15	48	17	3.7	382	0.00	0.18	11	9	11
02/19/93	75	40	57	95	21	50	21	4.5	401	0.01	0.19	13	10	13
02/20/93	66	47	54	97	35	52	23	6.9	289	0.04	0.13	8	6	8
02/21/93	61	39	49	73	19	50	20	6.2	389	0.00	0.17	6	3	6
02/22/93	62	33	48	77	15	49	16	4.1	415	0.00	0.17	6	4	6
02/23/93	67	37	52	50	15	49	11	3.0	337	0.00	0.15	9	6	9
02/24/93	61	41	52	74	23	50	15	6.4	162	0.00	0.10	6	3	6
02/25/93	61	36	47	93	18	49	16	4.7	465	0.00	0.18	6	3	6
02/26/93	69	28	49	87	14	48	11	2.7	446	0.00	0.18	10	7	10
02/27/93	61	41	52	52	34	49	12	4.6	220	0.00	0.11	6	3	6
02/28/93	62	40	50	75	41	50	14	5.1	239	0.20	0.10	6	4	6
03/01/93	51	37	43	83	40	48	22	9.7	310	0.03	0.12	1	0	1
03/02/93	64	30	48	98	16	47	15	3.9	475	0.00	0.18	7	5	7
03/03/93	67	29	50	84	14	48	11	3.6	494	0.00	0.20	9	6	9
03/04/93	62	34	49	85	22	48	13	4.3	482	0.00	0.18	6	4	6
03/05/93	66	31	48	74	15	48	11	3.3	494	0.00	0.19	8	6	8
03/06/93	71	33	51	57	13	48	10	2.6	489	0.00	0.20	11	8	11
03/07/93	74	32	53	56	13	49	10	3.1	506	0.00	0.22	12	10	12
03/08/93	78	35	56	54	12	49	10	2.9	513	0.00	0.23	14	12	14
03/09/93	79	36	58	55	12	50	16	4.1	523	0.00	0.25	15	12	15
03/10/93	77	36	56	46	12	51	11	3.4	511	0.00	0.24	14	11	14
03/11/93	74	36	54	79	13	51	29	4.4	506	0.15	0.23	12	10	12
03/12/93	65	34	48	85	17	51	17	5.5	532	0.00	0.22	8	5	8
03/13/93	56	28	41	54	23	50	11	4.4	528	0.00	0.18	3	1	3
03/14/93	65	34	49	75	24	50	15	2.9	243	0.00	0.11	8	5	8
03/15/93	75	48	61	78	14	51	16	6.8	537	0.00	0.27	13	10	13
03/16/93	79	42	61	70	12	53	12	3.0	535	0.00	0.24	15	12	15
03/17/93	80	41	62	49	12	53	13	3.5	542	0.00	0.26	15	13	15
03/18/93	76	53	65	39	15	55	20	6.6	427	0.00	0.25	15	11	15
03/19/93	76	44	59	59	13	55	13	4.0	549	0.00	0.25	13	11	13
03/20/93	79	41	61	53	13	55	13	4.7	520	0.00	0.26	15	12	15
03/21/93	79	50	64	35	12	56	14	4.3	358	0.00	0.21	15	12	15
03/22/93	75	50	62	43	16	56	14	4.1	542	0.00	0.26	13	10	13
03/23/93	79	44	62	82	13	57	15	2.8	549	0.02	0.24	15	12	15
03/24/93	80	45	63	64	12	57	14	3.4	556	0.00	0.26	15	13	15
03/25/93	82	41	62	63	12	57	11	2.5	563	0.00	0.26	16	14	16
03/26/93	80	48	65	46	12	57	14	4.5	487	0.00	0.25	15	13	15
03/27/93	66	43	54	52	15	57	21	7.3	597	0.01	0.27	8	6	8
03/28/93	72	33	56	74	15	56	14	3.7	592	0.00	0.24	11	9	11
03/29/93	61	40	51	63	21	55	23	8.0	451	0.10	0.21	6	3	6
03/30/93	72	35	56	89	15	55	14	4.3	559	0.00	0.24	11	9	11
03/31/93	75	40	59	75	13	56	12	2.5	597	0.00	0.24	13	10	13
04/01/93	75	41	61	58	13	56	11	3.6	542	0.00	0.24	13	10	13
04/02/93	78	48	64	43	12	57	16	4.8	501	0.00	0.26	14	12	14
04/03/93	74	43	60	43	13	57	15	4.2	618	0.00	0.28	12	10	12
04/04/93	78	37	58	51	12	57	11	2.5	618	0.00	0.26	14	12	14
04/05/93	82	40	63	51	11	57	17	4.1	561	0.00	0.28	16	14	16
04/06/93	72	46	60	42	14	58	24	8.5	594	0.07	0.31	11	9	11
04/07/93	69	38	55	61	14	57	14	4.5	602	0.00	0.25	10	7	10
04/08/93	69	39	54	40	14	57	16	4.3	640	0.00	0.27	10	7	10

04/09/93	78	33	56	73	12	56	11	3.1	644	0.00	0.27	14	12	14
04/10/93	83	39	64	32	11	56	18	5.8	642	0.00	0.34	17	14	17
04/11/93	85	43	66	42	10	58	15	4.2	640	0.00	0.32	18	15	18
04/12/93	83	42	64	36	11	58	16	4.4	573	0.00	0.29	17	14	17
04/13/93	75	43	59	66	13	58	18	3.5	327	0.00	0.17	13	10	13
04/14/93	69	47	57	75	14	58	20	5.2	485	0.00	0.22	10	7	10
04/15/93	75	34	56	57	13	57	11	2.1	654	0.00	0.26	13	10	13
04/16/93	77	42	58	46	12	57	17	3.9	437	0.00	0.22	14	11	14
04/17/93	82	39	64	62	11	58	13	2.6	642	0.00	0.28	16	14	16
04/18/93	85	42	67	53	10	59	18	4.9	628	0.00	0.32	18	15	18
04/19/93	83	48	66	37	11	60	13	2.9	656	0.00	0.31	17	14	17
04/20/93	79	42	61	29	12	59	10	1.9	664	0.00	0.28	15	12	15
04/21/93	81	41	63	43	11	59	13	2.2	668	0.00	0.29	16	13	16
04/22/93	92	46	70	47	9	60	17	3.0	625	0.00	0.32	18	16	18
04/23/93	85	53	69	39	11	61	21	4.7	539	0.00	0.30	19	15	19
04/24/93	81	48	65	31	11	61	20	5.6	678	0.00	0.35	16	13	16
04/25/93	85	46	68	38	11	61	9	3.1	676	0.00	0.32	18	15	18
04/26/93	88	55	74	29	10	62	12	4.2	621	0.00	0.33	21	16	21
04/27/93	89	59	74	47	10	63	12	2.3	587	0.00	0.29	23	18	23
04/28/93	88	54	71	38	10	64	14	3.5	656	0.00	0.33	20	16	20
04/29/93	83	49	66	53	13	63	18	5.1	504	0.00	0.27	17	14	17
04/30/93	87	49	69	95	10	63	15	4.1	633	0.00	0.31	18	16	18
05/01/93	80	50	67	29	12	63	19	5.2	532	0.00	0.29	15	13	15
05/02/93	80	42	62	69	12	62	10	3.2	690	0.00	0.30	15	13	15
05/03/93	87	43	67	65	10	62	15	4.0	695	0.00	0.34	18	16	18
05/04/93	88	47	70	43	10	63	17	5.2	685	0.00	0.36	18	16	18
05/05/93	84	48	69	46	11	63	17	5.6	668	0.00	0.34	17	15	17
05/06/93	83	49	67	28	11	63	13	4.0	702	0.00	0.34	17	14	17
05/07/93	84	47	67	43	11	63	19	5.4	699	0.00	0.35	17	15	17
05/08/93	85	48	70	40	10	63	23	8.4	702	0.02	0.40	18	15	18
05/09/93	81	53	66	25	11	64	12	4.4	718	0.00	0.35	17	13	17
05/10/93	82	44	65	67	12	64	11	3.5	707	0.00	0.32	16	14	16
05/11/93	89	47	70	48	10	64	16	4.1	707	0.00	0.35	18	16	18
05/12/93	87	58	73	26	11	65	16	7.0	668	0.00	0.39	22	17	22
05/13/93	84	56	71	45	13	66	15	4.2	613	0.00	0.31	20	15	20
05/14/93	89	56	73	86	11	66	11	3.1	666	0.00	0.32	21	16	21
05/15/93	93	57	76	58	9	67	14	3.8	628	0.00	0.33	22	17	22
05/16/93	90	63	76	47	9	68	12	3.7	683	0.00	0.35	25	20	25
05/17/93	90	55	74	42	10	67	11	3.9	704	0.00	0.36	21	16	21
05/18/93	89	55	73	39	12	68	11	3.7	671	0.00	0.34	21	16	21
05/19/93	86	58	71	59	17	68	17	3.5	482	0.00	0.25	22	17	22
05/20/93	93	52	73	89	10	67	17	3.5	637	0.00	0.32	19	16	19
05/21/93	93	57	77	66	10	68	11	3.9	661	0.00	0.34	22	17	22
05/22/93	90	60	75	37	10	69	24	3.6	506	0.00	0.28	23	18	23
05/23/93	93	53	74	51	9	68	16	4.3	673	0.00	0.36	20	16	20
05/24/93	92	61	73	49	10	69	20	3.4	547	0.00	0.30	24	19	24
05/25/93	90	56	75	56	12	69	12	4.2	523	0.00	0.29	21	16	21
05/26/93	89	65	77	41	11	69	11	5.2	680	0.00	0.37	26	21	26
05/27/93	91	67	80	29	9	70	19	5.2	707	0.00	0.39	27	22	27
05/28/93	90	58	75	89	11	70	15	3.5	528	0.10	0.27	22	17	22
05/29/93	91	53	73	95	10	69	17	2.8	707	0.00	0.33	20	16	20
05/30/93	98	57	77	55	8	69	9	2.6	718	0.00	0.37	22	17	22
05/31/93	100	52	79	72	8	69	11	3.5	709	0.00	0.38	19	16	19
06/01/93	96	56	78	45	8	70	15	4.2	747	0.00	0.40	21	16	21
06/02/93	94	52	77	49	9	69	18	5.8	738	0.00	0.41	19	16	19
06/03/93	90	54	74	33	9	69	19	4.9	752	0.01	0.40	20	16	20
06/04/93	93	52	74	30	9	69	10	2.6	742	0.00	0.37	19	16	19
06/05/93	94	51	76	44	8	69	12	3.6	745	0.00	0.38	19	16	19
06/06/93	93	57	76	23	9	69	20	5.8	554	0.00	0.35	22	17	22
06/07/93	85	53	70	46	11	70	15	4.6	745	0.00	0.37	19	15	19
06/08/93	87	46	69	45	10	69	15	4.0	757	0.00	0.37	18	16	18
06/09/93	90	48	71	45	9	69	11	2.7	735	0.00	0.35	18	16	18
06/10/93	92	53	74	44	9	70	8	2.9	709	0.00	0.35	20	16	20
06/11/93	97	61	80	66	8	71	10	3.9	714	0.00	0.38	24	19	24
06/12/93	102	59	81	47	7	72	10	3.3	721	0.00	0.40	23	18	23

06/13/93	106	63	85	42	6	73	8	3.1	721	0.00	0.41	25	20	25
06/14/93	102	66	85	39	7	75	12	5.1	711	0.00	0.42	26	21	26
06/15/93	95	70	82	43	10	76	13	6.5	721	0.00	0.43	28	23	28
06/16/93	94	65	77	83	10	76	20	4.5	609	0.16	0.33	26	21	26
06/17/93	97	65	79	93	10	75	9	3.1	642	0.00	0.33	26	21	26
06/18/93	99	65	83	87	8	75	14	3.6	721	0.00	0.37	26	21	26
06/19/93	101	65	84	42	7	75	13	3.9	726	0.00	0.41	26	21	26
06/20/93	99	69	82	62	11	76	16	7.0	654	0.00	0.41	28	23	28
06/21/93	96	67	78	80	11	76	20	5.1	652	0.17	0.36	27	22	27
06/22/93	101	62	80	94	7	75	10	2.6	690	0.00	0.35	24	19	24
06/23/93	102	59	81	90	7	74	11	2.5	742	0.00	0.38	23	18	23
06/24/93	106	54	82	60	6	74	8	2.7	735	0.00	0.40	20	16	20
06/25/93	107	65	86	46	6	75	15	4.0	714	0.00	0.42	26	21	26
06/26/93	101	75	87	42	8	77	11	5.5	690	0.00	0.42	31	26	31
06/27/93	101	65	83	75	8	78	9	3.2	714	0.00	0.38	26	21	26
06/28/93	104	64	84	57	7	78	9	2.9	714	0.00	0.39	25	20	25
06/29/93	102	70	86	46	8	78	12	4.4	671	0.00	0.39	28	23	28
06/30/93	94	70	81	68	20	79	10	4.1	525	0.00	0.28	28	23	28
07/01/93	99	67	81	90	13	79	12	3.6	637	0.00	0.33	27	22	27
07/02/93	95	73	83	68	18	80	11	4.6	680	0.00	0.36	30	25	30
07/03/93	95	68	82	70	14	80	13	5.5	621	0.00	0.35	27	22	27
07/04/93	96	73	84	59	11	80	15	6.1	630	0.00	0.37	30	25	30
07/05/93	97	70	84	42	9	80	13	5.0	704	0.00	0.40	28	23	28
07/06/93	102	64	83	50	8	80	12	3.3	690	0.00	0.38	25	20	25
07/07/93	106	64	87	51	6	81	10	3.3	709	0.00	0.40	25	20	25
07/08/93	107	69	88	49	6	82	11	3.7	676	0.00	0.40	28	23	28
07/09/93	104	73	85	46	8	82	19	4.9	630	0.00	0.40	30	25	30
07/10/93	98	68	80	94	12	82	13	3.6	635	0.22	0.33	27	22	27
07/11/93	95	68	79	95	20	81	14	3.1	618	0.00	0.30	27	22	27
07/12/93	92	68	76	93	29	79	14	3.4	401	0.12	0.20	27	22	27
07/13/93	90	66	74	94	34	78	12	2.8	370	0.10	0.18	26	21	26
07/14/93	96	64	79	95	15	77	13	2.8	659	0.00	0.32	25	20	25
07/15/93	85	67	74	93	44	77	14	3.5	363	0.20	0.16	26	21	26
07/16/93	92	67	75	94	31	77	12	2.9	532	0.57	0.25	27	22	27
07/17/93	89	65	75	94	19	77	12	3.0	504	0.00	0.24	26	21	26
07/18/93	99	66	82	91	8	77	11	3.2	676	0.00	0.35	26	21	26
07/19/93	98	69	80	89	11	77	16	4.2	654	0.12	0.35	28	23	28
07/20/93	94	66	78	94	20	77	17	4.1	602	0.00	0.30	26	21	26
07/21/93	96	65	79	92	10	77	10	3.7	654	0.00	0.34	26	21	26
07/22/93	99	64	82	90	9	78	9	2.6	640	0.19	0.33	25	20	25
07/23/93	99	67	82	92	10	78	9	2.8	628	0.00	0.32	27	22	27
07/24/93	96	74	84	52	12	78	12	3.8	668	0.00	0.36	30	25	30
07/25/93	101	69	84	42	8	78	10	2.8	654	0.00	0.36	28	23	28
07/26/93	99	69	83	47	8	79	13	3.3	594	0.00	0.34	28	23	28
07/27/93	104	64	85	75	7	78	7	2.6	690	0.00	0.37	25	20	25
07/28/93	102	65	83	59	7	78	17	4.9	644	0.00	0.39	26	21	26
07/29/93	98	71	84	57	11	79	10	3.6	692	0.00	0.37	29	24	29
07/30/93	102	66	84	85	7	79	8	2.5	680	0.00	0.35	26	21	26
07/31/93	103	67	85	92	8	80	15	3.2	666	0.28	0.36	27	22	27
08/01/93	102	71	85	89	9	80	13	3.3	664	0.00	0.35	29	24	29
08/02/93	86	66	75	95	33	79	9	2.9	401	0.21	0.18	26	21	26
08/03/93	96	66	80	94	15	78	25	5.0	652	0.13	0.34	26	21	26
08/04/93	92	67	80	89	23	78	16	4.4	602	0.00	0.30	27	22	27
08/05/93	98	70	79	77	16	78	10	2.8	384	0.01	0.23	28	23	28
08/06/93	90	72	79	65	32	78	13	3.4	382	0.00	0.20	29	24	29
08/07/93	88	67	75	94	36	78	9	2.7	458	0.13	0.20	27	22	27
08/08/93	94	66	79	93	16	78	8	2.4	640	0.00	0.30	26	21	26
08/09/93	100	65	82	93	11	78	9	2.3	654	0.00	0.33	26	21	26
08/10/93	104	70	86	54	8	79	8	2.9	652	0.00	0.36	28	23	28
08/11/93	105	69	84	54	7	80	15	3.4	611	0.00	0.36	28	23	28
08/12/93	102	64	82	91	8	80	20	3.8	618	0.00	0.35	25	20	25
08/13/93	98	64	82	88	9	79	11	3.7	637	0.00	0.34	25	20	25
08/14/93	90	66	76	95	19	79	11	3.6	523	0.22	0.26	26	21	26
08/15/93	94	65	78	94	21	78	8	2.5	637	0.00	0.30	26	21	26
08/16/93	97	69	81	86	12	79	16	3.7	542	0.00	0.30	28	23	28

08/17/93	95	68	79	88	16	79	13	4.4	587	0.12	0.31	27	22	27
08/18/93	93	67	74	94	25	78	22	4.1	494	0.88	0.26	27	22	27
08/19/93	85	66	74	94	43	77	9	2.2	461	0.03	0.19	26	21	26
08/20/93	94	66	80	94	18	78	11	2.8	630	0.06	0.30	26	21	26
08/21/93	94	67	80	89	12	78	10	3.2	630	0.00	0.31	27	22	27
08/22/93	96	68	80	86	11	79	11	3.0	585	0.00	0.30	27	22	27
08/23/93	100	63	80	92	8	79	9	2.7	621	0.00	0.32	25	20	25
08/24/93	100	60	80	87	8	79	10	2.4	621	0.00	0.32	23	18	23
08/25/93	95	68	80	71	16	80	13	4.1	611	0.00	0.32	27	22	27
08/26/93	94	65	77	89	25	80	16	3.6	532	0.00	0.27	26	21	26
08/27/93	91	68	78	89	21	79	11	4.6	585	0.00	0.29	27	22	27
08/28/93	93	68	77	88	19	79	12	4.2	523	0.01	0.28	27	22	27
08/29/93	88	67	74	90	31	79	12	3.5	403	0.00	0.20	27	22	27
08/30/93	94	65	75	94	19	79	10	3.2	520	0.04	0.26	26	21	26
08/31/93	75	63	67	94	62	78	8	3.0	198	0.20	0.07	19	14	19
09/01/93	85	61	72	93	35	76	8	2.4	594	0.00	0.25	23	18	23
09/02/93	95	62	77	94	11	77	10	2.5	599	0.00	0.30	24	19	24
09/03/93	89	63	75	88	16	77	8	3.5	597	0.00	0.29	25	20	25
09/04/93	94	60	75	93	10	77	8	2.4	592	0.00	0.29	23	18	23
09/05/93	97	62	79	86	8	77	12	3.1	575	0.00	0.31	24	19	24
09/06/93	95	62	76	63	12	78	13	3.8	592	0.00	0.32	24	19	24
09/07/93	93	65	77	84	13	78	9	2.7	549	0.00	0.28	26	21	26
09/08/93	91	62	76	89	11	78	21	4.0	580	0.00	0.30	24	19	24
09/09/93	90	61	76	90	14	78	9	2.9	573	0.00	0.28	24	19	24
09/10/93	90	60	74	77	11	77	16	4.0	480	0.00	0.26	23	18	23
09/11/93	89	63	76	73	20	77	8	2.8	523	0.00	0.25	25	20	25
09/12/93	89	64	73	88	16	77	22	3.8	461	0.02	0.24	25	20	25
09/13/93	87	59	68	94	17	76	15	3.3	387	0.17	0.20	23	18	23
09/14/93	83	60	69	93	19	75	10	3.6	547	0.00	0.25	22	17	22
09/15/93	83	51	67	95	18	74	10	3.0	566	0.00	0.25	17	14	17
09/16/93	90	56	72	94	12	74	9	2.4	537	0.00	0.26	21	16	21
09/17/93	88	56	71	87	10	74	9	2.6	568	0.00	0.27	21	16	21
09/18/93	87	48	68	90	10	73	13	2.9	573	0.00	0.27	18	16	18
09/19/93	88	48	67	66	10	72	8	2.6	566	0.00	0.28	18	16	18
09/20/93	93	45	70	79	9	72	8	2.4	549	0.00	0.28	18	16	18
09/21/93	93	63	78	66	11	74	10	3.7	530	0.00	0.29	25	20	25
09/22/93	93	63	78	88	17	75	11	3.6	523	0.00	0.27	25	20	25
09/23/93	93	64	77	92	14	76	12	2.6	313	0.01	0.18	25	20	25
09/24/93	84	63	72	94	37	76	11	3.2	241	0.05	0.12	24	19	24
09/25/93	89	56	71	94	10	75	8	2.2	523	0.00	0.25	21	16	21
09/26/93	92	56	72	78	9	73	13	4.7	544	0.00	0.31	21	16	21
09/27/93	84	50	67	69	12	73	9	3.0	528	0.00	0.25	17	15	17
09/28/93	88	48	66	82	10	73	7	2.3	525	0.00	0.25	18	16	18
09/29/93	86	46	66	80	11	72	9	2.8	520	0.00	0.25	18	16	18
09/30/93	86	50	67	82	11	72	8	2.0	411	0.00	0.20	18	16	18
10/01/93	93	50	69	89	9	72	10	2.6	504	0.00	0.26	18	16	18
10/02/93	95	45	70	85	8	72	10	2.6	494	0.00	0.27	18	16	18
10/03/93	90	56	71	90	11	73	8	2.8	477	0.00	0.24	21	16	21
10/04/93	93	49	69	93	9	72	6	1.9	475	0.00	0.24	18	16	18
10/05/93	92	49	69	84	9	72	8	2.5	470	0.00	0.25	18	16	18
10/06/93	81	53	67	77	13	72	11	3.1	241	0.00	0.14	17	13	17
10/07/93	81	53	67	77	13	72	11	3.1	241	0.00	0.14	17	13	17
10/08/93	81	49	63	96	21	69	10	2.3	470	0.00	0.20	16	13	16
10/09/93	83	50	67	95	24	69	12	2.4	380	0.00	0.17	17	14	17
10/10/93	85	52	67	90	16	69	9	2.4	420	0.00	0.20	19	15	19
10/11/93	88	51	67	88	11	69	9	2.1	387	0.00	0.20	19	16	19
10/12/93	86	50	68	90	11	69	10	2.5	458	0.00	0.22	18	16	18
10/13/93	83	49	65	67	12	69	7	2.1	454	0.00	0.22	17	14	17
10/14/93	86	44	64	93	11	68	11	2.6	411	0.00	0.21	18	16	18
10/15/93	80	51	65	78	14	69	13	3.2	349	0.00	0.18	16	13	16
10/16/93	82	48	65	83	13	68	12	3.8	399	0.00	0.21	16	14	16
10/17/93	76	53	63	95	25	68	16	3.8	306	0.03	0.15	15	11	15
10/18/93	77	47	61	96	15	68	14	2.7	384	0.00	0.17	14	11	14
10/19/93	68	46	53	96	25	66	14	2.8	229	0.22	0.10	9	7	9
10/20/93	74	42	56	96	16	64	10	3.6	425	0.00	0.19	12	10	12

10/21/93	70	40	54	95	16	63	9	2.5	427	0.00	0.17	10	8	10
10/22/93	72	35	53	95	13	62	8	2.3	415	0.00	0.17	11	9	11
10/23/93	75	43	56	91	13	62	8	2.7	387	0.00	0.17	13	10	13
10/24/93	79	36	55	93	12	61	7	2.0	418	0.00	0.19	15	12	15
10/25/93	81	38	58	93	11	61	7	1.9	375	0.00	0.18	16	13	16
10/26/93	72	50	58	71	14	62	16	6.3	334	0.00	0.19	11	9	11
10/27/93	58	37	48	94	34	62	8	3.0	174	0.00	0.07	4	2	4
10/28/93	72	33	52	96	18	60	10	2.6	384	0.00	0.16	11	9	11
10/29/93	61	35	50	92	29	61	15	5.5	341	0.02	0.14	6	3	6
10/30/93	50	29	37	97	32	59	7	2.9	267	0.02	0.08	0	0	0
10/31/93	64	26	43	97	15	56	6	1.7	391	0.00	0.14	7	5	7
11/01/93	71	35	51	90	14	57	10	2.6	303	0.00	0.14	11	8	11
11/02/93	65	37	51	77	17	58	11	3.5	356	0.00	0.15	8	5	8
11/03/93	65	37	51	77	17	58	11	3.5	356	0.00	0.15	8	5	8
11/04/93	74	39	58	83	13	58	21	5.5	372	0.00	0.20	12	10	12
11/05/93	73	38	57	42	13	58	17	5.3	368	0.00	0.20	12	9	12
11/06/93	60	30	45	52	16	58	8	2.5	368	0.00	0.14	5	3	5
11/07/93	70	29	48	63	14	56	8	2.5	344	0.00	0.15	10	8	10
11/08/93	74	34	52	86	13	57	13	2.8	358	0.00	0.17	12	10	12
11/09/93	74	32	51	61	13	57	6	2.1	353	0.00	0.16	12	10	12
11/10/93	75	32	53	46	13	57	10	2.5	339	0.00	0.17	13	10	13
11/11/93	74	42	59	89	18	58	19	5.4	232	0.00	0.14	12	10	12
11/12/93	68	43	56	86	21	59	12	3.6	303	0.00	0.14	9	7	9
11/13/93	57	35	47	95	39	58	15	3.9	103	0.15	0.05	4	1	4
11/14/93	59	31	43	97	33	55	7	1.9	246	0.00	0.08	5	2	5
11/15/93	50	39	44	96	42	53	21	5.8	210	1.01	0.07	0	0	0
11/16/93	55	35	42	96	46	53	7	1.8	263	0.00	0.07	3	0	3
11/17/93	53	32	44	96	55	52	9	1.9	150	0.00	0.04	2	0	2
11/18/93	67	40	51	92	25	52	7	1.7	232	0.00	0.09	9	6	9
11/19/93	70	36	52	91	14	53	10	2.8	320	0.00	0.14	10	8	10
11/20/93	64	33	45	89	16	53	6	1.9	322	0.00	0.12	7	5	7
11/21/93	67	29	45	80	14	52	7	1.9	320	0.00	0.13	9	6	9
11/22/93	69	32	49	86	15	52	6	1.8	227	0.00	0.11	10	7	10
11/23/93	73	39	57	77	18	53	12	3.0	224	0.00	0.12	12	9	12
11/24/93	69	39	54	95	15	54	18	4.2	315	0.00	0.15	10	7	10
11/25/93	57	30	43	59	21	53	12	4.1	310	0.00	0.13	4	1	4
11/26/93	53	22	35	36	17	50	11	2.8	325	0.00	0.12	2	0	2
11/27/93	59	21	37	32	16	48	10	2.1	317	0.00	0.12	5	2	5
11/28/93	61	29	41	34	15	48	7	2.1	232	0.00	0.11	6	3	6
11/29/93	66	24	42	40	14	48	6	2.0	301	0.00	0.13	8	6	8
11/30/93	66	24	42	40	14	48	6	2.0	301	0.00	0.13	8	6	8
12/01/93	67	33	47	28	16	50	8	3.1	282	0.00	0.14	9	6	9
12/02/93	67	33	47	28	16	50	8	3.1	282	0.00	0.14	9	6	9
12/03/93	57	26	42	32	16	49	16	3.7	303	0.00	0.13	4	1	4
12/04/93	62	21	39	39	15	48	8	2.6	303	0.00	0.13	6	4	6
12/05/93	67	27	42	28	14	47	7	2.3	296	0.00	0.14	9	6	9
12/06/93	66	24	44	35	14	47	10	3.0	289	0.00	0.14	8	6	8
12/07/93	70	28	47	53	13	48	8	1.9	272	0.00	0.13	10	8	10
12/08/93	63	32	47	48	17	49	6	2.1	172	0.00	0.09	7	4	7
12/09/93	74	37	53	52	13	50	13	2.6	251	0.00	0.14	12	10	12
12/10/93	73	31	49	51	13	50	7	2.5	275	0.00	0.14	12	9	12
12/11/93	63	39	48	43	16	50	8	2.5	131	0.00	0.08	7	4	7
12/12/93	63	36	45	89	20	50	29	8.8	229	0.11	0.15	7	4	7
12/13/93	58	26	40	94	16	48	9	3.1	298	0.00	0.11	4	2	4
12/14/93	61	27	41	50	15	47	7	2.1	286	0.00	0.12	6	3	6
12/15/93	65	24	42	63	15	47	16	4.3	284	0.00	0.14	8	5	8
12/16/93	55	29	42	51	17	47	16	4.8	284	0.00	0.13	3	0	3
12/17/93	56	23	38	48	17	46	7	2.2	277	0.00	0.10	3	1	3
12/18/93	62	29	42	48	16	46	9	2.3	272	0.00	0.12	6	4	6
12/19/93	59	27	44	51	20	47	10	3.4	189	0.00	0.09	5	2	5
12/20/93	57	35	45	54	19	48	9	2.7	260	0.00	0.11	4	1	4
12/21/93	41	38	39	96	24	48	7	2.5	41	0.00	0.02	0	0	0
12/22/93	45	27	36	97	38	47	9	2.9	275	0.08	0.07	0	0	0
12/23/93	48	22	34	97	32	44	13	3.1	294	0.00	0.08	0	0	0
12/24/93	46	21	32	77	21	43	9	2.4	286	0.00	0.08	0	0	0

12/25/93	52	21	34	92	18	42	6	1.9	294	0.00	0.09	1	0	1
12/26/93	56	20	37	90	17	42	7	2.4	275	0.00	0.10	3	1	3
12/27/93	62	35	47	61	28	44	10	2.6	141	0.00	0.07	6	4	6
12/28/93	60	45	52	68	34	47	7	2.2	138	0.00	0.06	5	3	5
12/29/93	60	45	52	68	34	47	7	2.2	138	0.00	0.06	5	3	5
12/30/93	55	35	44	97	44	46	6	1.8	275	0.00	0.08	3	0	3
12/31/93	55	35	44	97	44	46	6	1.8	275	0.00	0.08	3	0	3
01/01/94	63	30	44	97	20	43	0	2.2	310	0.00	0.12	7	4	7
01/02/94	66	33	47	93	14	43	0	4.9	344	0.00	0.16	8	6	8
01/03/94	69	30	46	52	14	43	0	2.8	339	0.00	0.16	10	7	10
01/04/94	65	32	47	60	16	43	0	3.3	337	0.00	0.15	8	5	8
01/05/94	73	29	50	89	13	43	0	3.2	315	0.00	0.16	12	9	12
01/06/94	65	38	50	47	16	44	25	8.9	308	0.00	0.20	8	5	8
01/07/94	54	24	37	35	17	42	10	3.7	351	0.00	0.13	2	0	2
01/08/94	60	22	37	43	15	40	7	2.0	339	0.00	0.13	5	3	5
01/09/94	61	24	39	47	15	40	9	2.4	294	0.00	0.12	6	3	6
01/10/94	62	24	41	46	15	40	17	2.7	334	0.00	0.14	6	4	6
01/11/94	58	25	40	42	16	40	9	2.7	282	0.00	0.11	4	2	4
01/12/94	59	26	41	44	16	39	15	5.1	349	0.00	0.16	5	2	5
01/13/94	67	26	41	38	14	39	11	3.9	360	0.00	0.17	9	6	9
01/14/94	66	27	42	40	14	40	10	2.5	346	0.00	0.15	8	6	8
01/15/94	65	32	44	35	15	41	8	2.6	220	0.00	0.12	8	5	8
01/16/94	68	31	49	49	14	42	19	5.9	358	0.00	0.19	9	7	9
01/17/94	64	26	42	28	15	41	7	2.1	368	0.00	0.15	7	5	7
01/18/94	71	27	44	29	13	41	7	2.1	370	0.00	0.17	11	8	11
01/19/94	72	26	45	37	13	41	9	2.1	372	0.00	0.17	11	9	11
01/20/94	72	30	47	35	13	41	9	2.5	346	0.00	0.17	11	9	11
01/21/94	62	29	43	84	20	42	10	3.0	356	0.00	0.13	6	4	6
01/22/94	66	27	43	95	17	42	6	1.7	353	0.00	0.13	8	6	8
01/23/94	64	27	46	74	26	43	7	1.8	310	0.00	0.11	7	5	7
01/24/94	72	37	52	88	14	45	10	2.3	339	0.00	0.15	11	9	11
01/25/94	69	34	51	64	14	46	21	5.1	377	0.00	0.19	10	7	10
01/26/94	55	32	44	47	17	45	19	5.6	337	0.00	0.15	3	0	3
01/27/94	58	26	40	64	16	43	10	2.1	391	0.00	0.13	4	2	4
01/28/94	49	34	41	96	20	43	20	8.4	236	0.00	0.11	0	0	0
01/29/94	47	28	37	97	44	43	0	2.4	201	0.04	0.05	0	0	0
01/30/94	54	26	38	97	22	42	0	3.9	351	0.00	0.12	2	0	2
01/31/94	40	22	30	97	50	42	0	3.4	169	0.02	0.04	0	0	0
02/01/94	45	17	30	97	20	39	0	4.4	415	0.00	0.12	0	0	0
02/02/94	51	19	35	63	18	39	0	2.8	344	0.00	0.11	1	0	1
02/03/94	63	38	42	29	15	43	8	0.5	17	0.00	0.04	7	4	7
02/04/94	63	32	45	95	15	41	16	3.0	167	0.00	0.09	7	4	7
02/05/94	64	28	46	97	16	42	12	3.5	346	0.00	0.14	7	5	7
02/06/94	68	27	46	75	14	43	8	2.3	370	0.00	0.15	9	7	9
02/07/94	74	34	53	48	13	44	16	4.0	317	0.00	0.18	12	10	12
02/08/94	58	40	49	96	17	45	6	3.8	79	0.16	0.05	4	2	4
02/09/94	59	34	47	96	21	45	11	4.4	346	0.01	0.13	5	2	5
02/10/94	64	28	45	95	18	45	9	2.4	370	0.00	0.14	7	5	7
02/11/94	68	31	50	95	14	46	21	5.1	353	0.00	0.17	9	7	9
02/12/94	56	33	46	49	16	46	16	6.2	396	0.00	0.17	3	1	3
02/13/94	57	24	41	38	16	44	12	3.9	389	0.00	0.15	4	1	4
02/14/94	66	37	48	42	15	45	9	2.7	275	0.00	0.13	8	6	8
02/15/94	74	36	51	49	13	46	10	3.2	394	0.00	0.19	12	10	12
02/16/94	74	34	53	48	13	47	11	3.3	391	0.00	0.19	12	10	12
02/17/94	76	41	57	38	12	48	10	3.0	286	0.00	0.16	13	11	13
02/18/94	72	47	61	39	13	50	26	7.8	372	0.00	0.23	11	9	11
02/19/94	60	38	49	57	16	49	16	4.9	406	0.00	0.17	5	3	5
02/20/94	61	29	45	49	17	47	11	2.3	322	0.00	0.13	6	3	6
02/21/94	61	38	47	43	18	47	16	2.4	150	0.00	0.08	6	3	6
02/22/94	57	33	45	47	16	46	21	6.8	382	0.00	0.18	4	1	4
02/23/94	58	28	41	40	16	46	13	3.8	437	0.00	0.17	4	2	4
02/24/94	70	24	46	35	13	46	11	2.5	439	0.00	0.18	10	8	10
02/25/94	75	29	54	28	12	47	13	3.7	401	0.00	0.20	13	10	13
02/26/94	72	41	56	23	13	50	11	3.7	415	0.00	0.21	11	9	11
02/27/94	75	37	56	46	13	51	12	2.7	408	0.00	0.19	13	10	13

02/28/94	66	38	53	46	15	51	21	6.0	425	0.00	0.21	8	6	8
03/01/94	69	39	52	63	14	52	15	3.4	444	0.00	0.19	10	7	10
03/02/94	69	37	52	46	14	51	11	2.6	370	0.00	0.16	10	7	10
03/03/94	73	41	54	31	13	51	7	2.8	275	0.00	0.15	12	9	12
03/04/94	81	41	58	43	12	53	21	3.1	372	0.00	0.20	16	13	16
03/05/94	78	40	59	87	12	55	16	3.2	442	0.00	0.21	14	12	14
03/06/94	79	37	58	45	12	55	10	2.5	463	0.00	0.22	15	12	15
03/07/94	79	43	60	32	12	56	19	4.6	437	0.00	0.24	15	12	15
03/08/94	64	37	50	93	17	56	25	5.8	358	0.02	0.16	7	5	7
03/09/94	60	29	44	95	27	54	10	3.4	470	0.00	0.16	5	3	5
03/10/94	67	32	51	82	14	55	13	3.8	473	0.00	0.19	9	6	9
03/11/94	75	39	57	27	12	54	13	3.6	406	0.00	0.21	13	10	13
03/12/94	69	40	55	47	14	55	21	6.3	439	0.00	0.22	10	7	10
03/13/94	65	43	53	56	20	55	17	7.5	310	0.00	0.18	8	5	8
03/14/94	61	46	53	96	27	55	13	4.3	181	0.15	0.08	6	3	6
03/15/94	79	42	59	95	14	56	12	3.3	456	0.00	0.21	15	12	15
03/16/94	79	44	62	95	14	59	9	3.0	485	0.00	0.22	15	12	15
03/17/94	84	45	64	84	11	59	18	4.0	485	0.00	0.25	17	15	17
03/18/94	82	46	66	53	12	60	13	3.8	444	0.00	0.23	16	14	16
03/19/94	77	57	67	41	14	61	17	5.0	415	0.00	0.23	17	12	17
03/20/94	69	49	61	88	18	61	17	5.9	291	0.00	0.15	10	7	10
03/21/94	75	40	58	87	13	60	9	2.7	516	0.00	0.22	13	10	13
03/22/94	81	44	61	46	11	60	18	4.5	477	0.00	0.26	16	13	16
03/23/94	74	48	63	31	13	60	17	4.9	422	0.00	0.23	12	10	12
03/24/94	76	46	63	45	13	61	13	3.5	442	0.00	0.22	13	11	13
03/25/94	79	47	64	43	12	60	20	5.5	425	0.00	0.24	15	12	15
03/26/94	61	44	52	38	16	59	22	8.2	420	0.00	0.22	6	3	6
03/27/94	58	33	45	68	16	56	24	7.2	346	0.00	0.16	4	2	4
03/28/94	62	26	44	85	15	56	9	2.6	544	0.00	0.18	6	4	6
03/29/94	72	30	53	52	13	58	16	4.0	499	0.00	0.22	11	9	11
03/30/94	66	42	55	27	15	58	17	6.0	473	0.00	0.23	8	6	8
03/31/94	77	37	57	46	12	59	9	2.6	544	0.00	0.24	14	11	14
04/01/94	81	42	62	45	11	63	17	3.8	549	0.00	0.27	16	13	16
04/02/94	82	46	65	23	11	62	17	5.3	556	0.00	0.30	16	14	16
04/03/94	77	43	62	24	12	61	14	4.4	528	0.00	0.26	14	11	14
04/04/94	79	54	65	19	12	61	19	6.1	413	0.00	0.27	17	12	17
04/05/94	69	46	59	21	14	60	24	7.4	573	0.00	0.29	10	7	10
04/06/94	74	35	55	24	13	59	12	3.7	556	0.00	0.25	12	10	12
04/07/94	78	40	60	20	12	60	15	4.5	496	0.00	0.26	14	12	14
04/08/94	81	42	63	28	11	61	18	5.2	516	0.00	0.28	16	13	16
04/09/94	77	48	64	18	12	61	23	6.0	575	0.00	0.31	14	11	14
04/10/94	76	43	60	30	12	62	20	7.0	573	0.00	0.31	13	11	13
04/11/94	73	42	57	30	13	63	12	4.5	578	0.00	0.27	12	9	12
04/12/94	77	45	61	22	12	63	13	3.8	568	0.00	0.27	14	11	14
04/13/94	83	41	64	26	11	63	15	3.6	520	0.00	0.27	17	14	17
04/14/94	83	55	70	17	11	65	20	5.8	578	0.00	0.33	19	14	19
04/15/94	82	47	68	22	11	65	13	4.8	580	0.00	0.30	16	14	16
04/16/94	82	52	68	20	11	66	17	5.8	587	0.00	0.33	17	14	17
04/17/94	85	47	67	20	10	66	14	3.9	606	0.00	0.31	18	15	18
04/18/94	86	48	68	19	10	66	8	2.4	492	0.00	0.25	18	16	18
04/19/94	93	51	72	19	9	67	12	2.9	532	0.00	0.30	19	16	19
04/20/94	90	58	74	35	10	69	21	5.4	578	0.07	0.34	22	17	22
04/21/94	88	55	72	55	10	69	18	4.0	578	0.00	0.30	21	16	21
04/22/94	84	58	69	92	13	69	22	6.2	465	0.24	0.26	21	16	21
04/23/94	78	55	64	93	31	67	16	3.2	270	0.02	0.13	17	12	17
04/24/94	81	55	68	93	11	67	19	8.1	602	0.00	0.32	18	13	18
04/25/94	73	47	61	46	13	66	21	9.5	618	0.00	0.33	12	9	12
04/26/94	78	46	64	26	12	66	17	6.0	611	0.00	0.32	14	12	14
04/27/94	72	44	61	37	14	65	22	6.5	482	0.00	0.25	11	9	11
04/28/94	75	35	58	58	12	65	13	4.1	618	0.00	0.27	13	10	13
04/29/94	73	44	62	46	13	66	17	5.3	625	0.00	0.29	12	9	12
04/30/94	77	44	62	36	12	67	15	4.4	613	0.00	0.29	14	11	14
05/01/94	83	57	69	23	11	68	16	7.5	582	0.00	0.36	20	15	20
05/02/94	82	50	66	21	11	68	14	4.4	611	0.00	0.31	16	14	16
05/03/94	86	45	68	34	10	68	16	4.2	621	0.00	0.32	18	16	18

05/04/94	91	50	73	32	9	70	15	3.5	623	0.00	0.33	18	16	18
05/05/94	93	60	78	39	9	72	14	5.6	563	0.00	0.34	23	18	23
05/06/94	91	59	76	81	9	72	13	4.3	575	0.00	0.31	23	18	23
05/07/94	84	55	71	27	11	70	16	4.2	286	0.00	0.20	20	15	20
05/08/94	81	60	71	47	13	69	13	5.7	246	0.00	0.19	21	16	21
05/09/94	83	49	68	90	11	70	15	3.4	609	0.00	0.28	17	14	17
05/10/94	84	47	67	42	11	69	13	4.2	559	0.00	0.29	17	15	17
05/11/94	84	54	69	57	11	71	11	4.1	609	0.00	0.30	19	15	19
05/12/94	81	58	67	46	12	71	20	5.8	480	0.02	0.28	20	15	20
05/13/94	85	51	68	58	11	71	20	4.8	525	0.00	0.28	18	15	18
05/14/94	90	58	74	48	10	73	13	4.6	613	0.00	0.33	22	17	22
05/15/94	92	59	78	44	9	75	21	6.8	590	0.00	0.36	23	18	23
05/16/94	91	60	79	16	9	75	13	6.4	508	0.00	0.33	23	18	23
05/17/94	93	49	74	29	9	73	12	2.7	551	0.00	0.29	18	16	18
05/18/94	91	59	76	33	9	75	19	3.6	604	0.00	0.33	23	18	23
05/19/94	90	62	77	56	9	77	17	5.0	621	0.00	0.34	24	19	24
05/20/94	91	55	74	88	9	78	15	3.2	642	0.00	0.31	21	16	21
05/21/94	89	68	76	45	11	77	22	7.2	468	0.13	0.32	27	22	27
05/22/94	81	59	69	89	15	73	18	4.5	349	0.17	0.19	20	15	20
05/23/94	88	55	71	93	12	73	19	4.0	427	0.00	0.23	21	16	21
05/24/94	90	60	74	92	12	75	19	5.3	561	0.03	0.30	23	18	23
05/25/94	86	61	73	93	10	76	18	4.7	637	0.15	0.31	24	19	24
05/26/94	80	55	67	72	15	72	13	4.1	351	0.00	0.19	18	13	18
05/27/94	88	57	72	81	11	75	11	3.8	637	0.00	0.31	22	17	22
05/28/94	96	57	77	65	8	77	10	2.4	594	0.00	0.31	22	17	22
05/29/94	99	60	80	45	8	79	12	3.0	628	0.00	0.34	23	18	23
05/30/94	102	59	82	45	7	80	10	2.3	611	0.00	0.33	23	18	23
05/31/94	100	65	82	36	8	80	17	6.1	482	0.03	0.35	26	21	26
06/01/94	99	65	82	65	8	80	21	6.4	568	0.07	0.37	26	21	26
06/02/94	96	64	81	66	8	80	19	5.1	630	0.01	0.36	25	20	25
06/03/94	94	65	78	65	10	77	27	6.8	618	0.00	0.37	26	21	26
06/04/94	97	64	81	64	8	79	10	3.3	616	0.00	0.33	25	20	25
06/05/94	99	61	82	42	8	80	15	3.5	625	0.00	0.35	24	19	24
06/06/94	99	64	84	21	7	79	14	4.1	616	0.00	0.36	25	20	25
06/07/94	97	67	83	20	8	79	19	5.3	628	0.00	0.39	27	22	27
06/08/94	99	60	80	22	8	79	13	3.5	654	0.00	0.37	23	18	23
06/09/94	101	59	82	24	7	80	9	2.6	649	0.00	0.36	23	18	23
06/10/94	104	66	86	41	7	81	18	4.2	613	0.00	0.37	26	21	26
06/11/94	103	77	87	15	7	82	28	5.6	568	0.00	0.40	32	27	32
06/12/94	102	71	86	16	7	82	15	4.5	547	0.00	0.36	29	24	29
06/13/94	101	70	86	29	7	83	24	3.9	578	0.00	0.35	28	23	28
06/14/94	100	68	86	25	7	83	15	4.3	611	0.00	0.37	27	22	27
06/15/94	98	69	84	15	8	82	15	5.2	635	0.00	0.40	28	23	28
06/16/94	100	61	83	18	7	82	12	3.1	628	0.00	0.36	24	19	24
06/17/94	102	72	86	33	7	82	18	4.6	542	0.00	0.35	29	24	29
06/18/94	97	73	84	26	8	82	24	5.3	602	0.00	0.38	30	25	30
06/19/94	94	77	86	17	9	79	16	6.3	580	0.00	0.38	32	27	32
06/20/94	97	70	84	23	9	77	17	5.3	494	0.00	0.33	28	23	28
06/21/94	91	74	82	41	12	79	14	3.8	463	0.02	0.27	30	25	30
06/22/94	96	74	83	38	10	80	14	4.1	468	0.00	0.30	30	25	30
06/23/94	102	71	86	37	7	80	18	6.3	644	0.00	0.42	29	24	29
06/24/94	105	67	87	27	6	81	9	2.8	640	0.00	0.37	27	22	27
06/25/94	109	68	89	31	6	83	11	2.9	635	0.00	0.38	27	22	27
06/26/94	110	70	91	17	5	83	9	3.3	633	0.00	0.39	28	23	28
06/27/94	111	69	91	35	5	84	20	4.6	633	0.00	0.41	28	23	28
06/28/94	111	81	95	13	5	85	21	4.8	501	0.00	0.38	34	29	34
06/29/94	107	74	91	16	6	85	13	4.0	587	0.00	0.38	30	25	30
06/30/94	108	74	92	21	6	85	16	3.2	542	0.00	0.35	30	25	30
07/01/94	109	74	93	22	6	85	16	4.2	566	0.00	0.38	30	25	30
07/02/94	105	78	91	19	6	86	15	4.7	556	0.00	0.38	32	27	32
07/03/94	101	75	89	17	7	85	13	4.1	477	0.00	0.32	31	26	31
07/04/94	99	76	88	15	8	83	12	4.1	444	0.00	0.30	31	26	31
07/05/94	100	75	87	30	7	83	16	6.0	625	0.00	0.41	31	26	31
07/06/94	99	67	85	16	8	83	11	4.9	656	0.00	0.40	27	22	27
07/07/94	102	62	84	17	7	83	0	2.9	654	0.00	0.37	24	19	24

07/08/94	98	65	83	40	8	82	0	5.9	556	0.15	0.36	26	21	26
07/09/94	97	66	82	78	8	83	0	4.3	580	0.01	0.33	26	21	26
07/10/94	99	68	84	41	8	83	0	3.9	611	0.00	0.35	27	22	27
07/11/94	102	68	85	40	7	83	19	4.5	556	0.00	0.35	27	22	27
07/12/94	103	71	88	27	7	84	16	3.8	559	0.00	0.35	29	24	29
07/13/94	103	67	87	34	7	84	12	4.0	618	0.00	0.37	27	22	27
07/14/94	101	75	86	26	7	85	19	7.8	611	0.00	0.45	31	26	31
07/15/94	99	78	87	21	8	85	28	6.7	580	0.05	0.41	32	27	32
07/16/94	97	74	83	42	9	84	15	7.0	537	0.00	0.37	30	25	30
07/17/94	92	72	79	68	14	84	22	4.8	432	0.01	0.26	29	24	29
07/18/94	94	67	79	90	13	84	13	3.9	473	0.04	0.26	27	22	27
07/19/94	97	66	82	82	9	84	13	3.7	590	0.00	0.32	26	21	26
07/20/94	100	67	84	46	8	85	12	3.3	556	0.06	0.32	27	22	27
07/21/94	100	71	83	60	8	85	21	5.5	523	0.01	0.34	29	24	29
07/22/94	98	70	84	64	9	85	14	3.2	537	0.00	0.30	28	23	28
07/23/94	100	71	86	57	8	87	11	3.8	580	0.00	0.33	29	24	29
07/24/94	102	67	86	53	7	87	10	3.1	566	0.00	0.32	27	22	27
07/25/94	104	73	89	34	7	88	13	4.6	559	0.00	0.36	30	25	30
07/26/94	101	76	84	50	8	88	22	6.3	444	0.00	0.34	31	26	31
07/27/94	92	71	82	73	14	83	19	3.5	434	0.06	0.24	29	24	29
07/28/94	91	63	81	93	13	84	18	5.7	711	1.18	0.36	25	20	25
07/29/94	93	62	77	97	12	79	18	4.4	661	1.60	0.34	24	19	24
07/30/94	95	66	79	96	18	80	15	3.3	685	0.00	0.33	26	21	26
07/31/94	99	68	82	87	10	80	8	3.4	671	0.00	0.35	27	22	27
08/01/94	96	72	82	85	14	79	19	5.1	561	0.00	0.32	29	24	29
08/02/94	97	70	82	89	11	87	28	2.0	203	0.27	0.14	28	23	28
08/03/94	98	69	83	90	9	84	13	4.0	587	0.00	0.32	28	23	28
08/04/94	96	72	84	68	10	84	19	4.9	532	0.00	0.31	29	24	29
08/05/94	95	75	85	37	10	83	16	6.4	609	0.00	0.38	31	26	31
08/06/94	99	70	84	55	9	84	10	2.8	559	0.00	0.31	28	23	28
08/07/94	103	69	86	79	7	84	17	3.1	559	0.00	0.32	28	23	28
08/08/94	99	76	87	42	8	85	24	5.1	561	0.04	0.35	31	26	31
08/09/94	98	68	86	67	8	84	12	3.8	578	0.00	0.32	27	22	27
08/10/94	97	73	86	42	11	84	13	5.4	580	0.00	0.35	30	25	30
08/11/94	93	71	83	40	12	84	13	6.3	525	0.00	0.34	29	24	29
08/12/94	95	69	83	44	11	84	10	3.8	580	0.00	0.32	28	23	28
08/13/94	99	66	85	66	8	85	10	3.3	585	0.00	0.32	26	21	26
08/14/94	93	74	84	27	11	81	18	6.9	408	0.00	0.31	30	25	30
08/15/94	90	69	77	87	19	81	15	4.3	341	0.03	0.20	28	23	28
08/16/94	97	72	82	82	10	83	10	2.9	559	0.00	0.29	29	24	29
08/17/94	100	67	84	81	8	84	9	2.5	556	0.00	0.30	27	22	27
08/18/94	103	68	86	59	7	84	9	2.5	542	0.00	0.31	27	22	27
08/19/94	100	73	86	43	8	83	15	6.2	551	0.00	0.37	30	25	30
08/20/94	99	70	84	44	8	83	15	3.7	554	0.00	0.33	28	23	28
08/21/94	97	68	80	68	10	84	18	4.4	528	0.03	0.31	27	22	27
08/22/94	99	66	82	85	9	83	11	2.9	535	0.00	0.29	26	21	26
08/23/94	100	68	84	64	8	83	13	3.1	499	0.00	0.29	27	22	27
08/24/94	95	71	82	51	11	83	20	4.4	418	0.04	0.27	29	24	29
08/25/94	96	69	83	54	10	82	13	4.1	525	0.00	0.31	28	23	28
08/26/94	100	68	84	62	8	83	13	4.1	520	0.00	0.31	27	22	27
08/27/94	98	71	86	31	9	83	9	4.3	568	0.00	0.34	29	24	29
08/28/94	99	71	86	35	8	83	18	4.2	542	0.00	0.33	29	24	29
08/29/94	98	70	84	84	8	84	15	4.1	499	0.01	0.29	28	23	28
08/30/94	94	69	80	88	11	83	15	4.3	418	0.10	0.25	28	23	28
08/31/94	90	67	78	89	17	82	10	3.5	475	0.02	0.24	27	22	27
09/01/94	93	72	81	56	15	82	15	5.9	539	0.00	0.33	29	24	29
09/02/94	91	69	81	69	20	82	16	7.2	489	0.02	0.30	28	23	28
09/03/94	89	69	77	92	24	81	14	5.4	356	0.18	0.20	28	23	28
09/04/94	84	67	71	92	52	80	18	4.2	277	0.23	0.13	26	21	26
09/05/94	92	62	77	92	13	80	16	3.5	518	0.00	0.27	24	19	24
09/06/94	85	68	76	85	34	80	13	4.7	437	0.00	0.21	27	22	27
09/07/94	89	65	75	90	18	80	20	3.2	442	0.06	0.22	26	21	26
09/08/94	96	64	79	87	10	80	12	3.7	528	0.00	0.29	25	20	25
09/09/94	96	66	80	80	9	80	9	2.8	449	0.00	0.25	26	21	26
09/10/94	97	63	79	69	9	80	14	3.8	458	0.00	0.28	25	20	25

09/11/94	94	68	80	54	11	80	14	4.3	432	0.00	0.27	27	22	27
09/12/94	92	68	80	64	13	81	14	4.6	449	0.00	0.27	27	22	27
09/13/94	92	66	78	85	14	81	15	5.3	422	0.19	0.25	26	21	26
09/14/94	91	64	76	92	13	80	11	3.2	432	0.00	0.23	25	20	25
09/15/94	89	57	73	90	10	77	11	4.2	511	0.00	0.27	22	17	22
09/16/94	87	59	73	34	13	76	17	6.3	430	0.00	0.28	23	18	23
09/17/94	87	62	74	43	10	76	14	5.0	494	0.00	0.29	24	19	24
09/18/94	87	56	72	42	10	76	11	3.2	499	0.00	0.27	21	16	21
09/19/94	89	55	72	42	10	75	10	2.7	463	0.00	0.25	21	16	21
09/20/94	92	58	74	49	9	76	9	2.6	446	0.00	0.25	22	17	22
09/21/94	80	64	71	60	16	74	8	2.6	153	0.00	0.11	22	17	22
09/22/94	79	59	68	84	18	74	14	5.9	465	0.00	0.24	19	14	19
09/23/94	95	52	71	66	9	75	8	2.4	470	0.00	0.26	19	16	19
09/24/94	92	55	73	47	9	75	10	3.6	470	0.00	0.27	21	16	21
09/25/94	89	58	74	37	10	75	11	3.9	449	0.00	0.26	22	17	22
09/26/94	92	57	73	42	10	75	20	2.6	399	0.00	0.23	22	17	22
09/27/94	96	55	73	70	8	75	11	2.5	465	0.00	0.26	21	16	21
09/28/94	96	51	73	52	8	74	9	2.1	465	0.00	0.26	19	16	19
09/29/94	96	51	73	69	8	74	7	1.9	463	0.00	0.25	19	16	19
09/30/94	95	59	75	46	9	75	7	1.9	396	0.00	0.23	23	18	23
10/01/94	88	61	73	46	10	75	18	4.9	372	0.00	0.25	24	19	24
10/02/94	86	57	71	71	10	75	14	3.5	427	0.00	0.23	22	17	22
10/03/94	86	61	71	42	12	74	8	2.4	317	0.00	0.19	24	19	24
10/04/94	88	56	71	63	11	74	9	2.1	346	0.00	0.19	21	16	21
10/05/94	91	57	75	70	9	74	16	4.9	422	0.00	0.26	22	17	22
10/06/94	81	58	71	39	12	73	14	4.4	372	0.00	0.22	20	15	20
10/07/94	75	53	64	92	17	72	14	5.6	320	0.05	0.17	14	10	14
10/08/94	74	48	61	86	14	70	17	5.4	396	0.00	0.20	12	10	12
10/09/94	73	46	59	50	13	69	12	3.9	432	0.00	0.21	12	9	12
10/10/94	75	40	57	53	13	68	10	2.6	434	0.00	0.20	13	10	13
10/11/94	79	38	58	54	12	67	9	2.4	420	0.00	0.20	15	12	15
10/12/94	84	43	62	53	11	67	9	2.1	420	0.00	0.21	17	15	17
10/13/94	83	47	67	52	11	67	28	9.9	399	0.00	0.30	17	14	17
10/14/94	67	50	61	91	14	67	30	14.8	329	0.17	0.23	9	6	9
10/15/94	73	41	60	95	14	64	21	5.9	358	0.00	0.19	12	9	12
10/16/94	74	57	65	78	24	66	11	3.8	210	0.00	0.12	16	11	16
10/17/94	70	46	58	91	16	65	11	3.0	296	0.00	0.13	10	8	10
10/18/94	74	47	58	93	19	65	12	3.0	380	0.00	0.17	12	10	12
10/19/94	81	48	63	92	14	66	8	2.2	389	0.00	0.18	16	13	16
10/20/94	83	49	64	90	12	66	9	2.4	389	0.00	0.19	17	14	17
10/21/94	82	46	61	82	11	66	10	1.8	389	0.00	0.19	16	14	16
10/22/94	81	39	60	91	11	65	9	1.5	377	0.00	0.17	16	13	16
10/23/94	87	46	64	86	10	66	9	1.3	384	0.00	0.19	18	16	18
10/24/94	84	51	64	44	11	66	12	2.1	301	0.00	0.17	18	15	18
10/25/94	73	48	59	70	24	65	15	3.8	303	0.00	0.15	12	9	12
10/26/94	71	48	57	91	37	65	12	2.7	344	0.00	0.13	11	8	11
10/27/94	80	44	60	93	12	64	11	2.4	351	0.00	0.17	15	13	15
10/28/94	87	44	64	65	10	64	9	1.7	368	0.00	0.19	18	16	18
10/29/94	88	43	64	80	10	64	10	1.8	346	0.00	0.19	18	16	18
10/30/94	79	49	64	64	12	64	12	3.0	243	0.00	0.15	15	12	15
10/31/94	78	43	58	39	12	63	9	2.7	368	0.00	0.19	14	12	14
11/01/94	81	35	57	62	11	62	11	1.9	341	0.00	0.17	16	13	16
11/02/94	75	54	63	59	15	63	15	4.2	165	0.00	0.12	15	10	15
11/03/94	70	55	61	59	26	62	16	6.2	150	0.00	0.12	13	8	13
11/04/94	56	38	50	91	21	60	19	6.3	253	0.03	0.11	3	1	3
11/05/94	72	31	48	92	13	58	8	1.9	339	0.00	0.15	11	9	11
11/06/94	78	35	54	78	12	58	9	1.7	339	0.00	0.16	14	12	14
11/07/94	83	42	61	42	11	60	11	1.9	289	0.00	0.16	17	14	17
11/08/94	71	45	59	92	25	61	14	3.2	193	0.06	0.10	11	8	11
11/09/94	72	36	52	94	14	58	8	2.0	334	0.00	0.14	11	9	11
11/10/94	73	38	54	74	14	57	13	3.1	301	0.00	0.15	12	9	12
11/11/94	55	45	52	93	47	57	14	3.7	60	0.16	0.02	3	0	3
11/12/94	62	46	55	92	84	58	8	2.3	93	0.17	0.01	6	4	6
11/13/94	63	39	50	92	28	56	11	2.3	320	0.00	0.12	7	4	7
11/14/94	62	37	48	89	21	55	8	2.2	320	0.00	0.12	6	4	6

11/15/94	61	38	50	69	28	54	13	3.6	306	0.00	0.12	6	3	6
11/16/94	69	42	58	62	26	56	19	4.5	296	0.00	0.14	10	7	10
11/17/94	63	35	51	52	16	55	20	5.1	315	0.00	0.15	7	4	7
11/18/94	70	31	50	88	15	53	10	1.6	308	0.00	0.13	10	8	10
11/19/94	68	35	48	84	14	53	17	4.7	296	0.00	0.15	9	7	9
11/20/94	58	31	41	39	16	51	17	3.1	310	0.00	0.13	4	2	4
11/21/94	68	25	44	77	14	50	4	1.1	308	0.00	0.12	9	7	9
11/22/94	60	34	49	82	17	50	4	2.6	169	0.00	0.08	5	3	5
11/23/94	58	39	49	91	35	52	14	2.9	143	0.00	0.06	4	2	4
11/24/94	68	34	48	94	25	52	8	1.5	289	0.00	0.11	9	7	9
11/25/94	71	40	55	92	22	53	8	1.5	177	0.00	0.08	11	8	11
11/26/94	73	39	57	91	13	54	20	5.5	284	0.00	0.16	12	9	12
11/27/94	51	28	45	38	18	53	16	4.5	294	0.00	0.12	1	0	1
11/28/94	61	21	41	45	15	49	6	1.4	294	0.00	0.11	6	3	6
11/29/94	57	28	41	28	16	48	8	1.5	294	0.00	0.11	4	1	4
11/30/94	64	30	41	29	15	47	9	1.7	294	0.00	0.13	7	5	7
12/01/94	69	31	47	32	14	47	7	1.3	277	0.00	0.12	10	7	10
12/02/94	69	32	50	48	14	48	11	2.0	279	0.00	0.13	10	7	10
12/03/94	70	29	47	69	14	48	8	1.3	265	0.00	0.12	10	8	10
12/04/94	72	32	50	62	13	49	9	1.4	241	0.00	0.12	11	9	11
12/05/94	58	48	52	92	24	51	12	1.7	36	0.33	0.02	4	2	4
12/06/94	64	43	54	92	44	52	15	4.2	167	0.11	0.07	7	5	7
12/07/94	66	37	49	93	39	51	0	1.5	253	0.00	0.09	8	6	8
12/08/94	66	35	49	93	27	50	0	2.2	263	0.00	0.10	8	6	8
12/09/94	58	33	43	78	36	49	0	2.5	265	0.00	0.09	4	2	4
12/10/94	54	29	40	62	17	47	0	2.9	263	0.00	0.10	2	0	2
12/11/94	61	34	47	40	16	47	0	3.0	275	0.00	0.12	6	3	6
12/12/94	50	39	43	92	25	47	0	2.4	76	0.06	0.03	0	0	0
12/13/94	55	36	41	93	69	47	0	2.0	124	0.00	0.03	3	0	3
12/14/94	60	34	44	94	26	47	0	2.0	227	0.00	0.08	5	3	5
12/15/94	64	30	45	93	20	46	0	2.4	265	0.00	0.11	7	5	7
12/16/94	59	34	44	75	17	46	0	3.7	272	0.00	0.12	5	2	5
12/17/94	68	35	47	45	14	45	0	3.7	272	0.00	0.15	9	7	9
12/18/94	68	36	48	76	15	46	0	2.7	260	0.00	0.12	9	7	9
12/19/94	71	30	48	89	14	46	8	2.0	267	0.00	0.12	11	8	11
12/20/94	69	31	47	71	14	45	9	2.1	270	0.00	0.12	10	7	10
12/21/94	68	35	47	49	14	45	8	2.8	265	0.00	0.14	9	7	9
12/22/94	63	37	51	38	15	45	11	3.9	165	0.00	0.11	7	4	7
12/23/94	56	45	51	87	17	47	23	6.1	72	0.02	0.06	3	1	3
12/24/94	59	39	47	93	44	48	11	2.0	210	0.00	0.07	5	2	5
12/25/94	59	43	49	91	54	49	11	2.1	131	0.00	0.04	5	2	5
12/26/94	64	43	52	92	39	49	15	3.4	167	0.35	0.07	7	5	7
12/27/94	59	39	47	92	54	49	11	1.9	169	0.01	0.05	5	2	5
12/28/94	61	38	47	92	47	49	7	1.3	258	0.00	0.08	6	3	6
12/29/94	60	32	45	92	41	48	9	1.9	260	0.00	0.08	5	3	5
12/30/94	58	32	43	92	30	47	20	4.4	210	0.00	0.09	4	2	4
12/31/94	57	29	41	90	21	45	7	1.8	277	0.00	0.09	4	1	4
01/01/95	58	28	41	93	24	44	11	2.5	243	0.00	0.09	4	2	4
01/02/95	49	31	40	91	32	45	11	2.0	220	0.00	0.06	0	0	0
01/03/95	56	27	41	94	44	44	8	2.3	224	0.00	0.07	3	1	3
01/04/95	47	33	40	91	68	44	14	5.0	110	0.04	0.03	0	0	0
01/05/95	51	38	42	92	67	45	19	7.2	100	0.40	0.03	1	0	1
01/06/95	52	35	43	84	36	44	21	5.5	275	0.00	0.10	1	0	1
01/07/95	63	27	42	94	25	43	5	1.4	279	0.00	0.10	7	4	7
01/08/95	69	33	47	92	20	45	8	1.3	263	0.00	0.11	10	7	10
01/09/95	67	30	46	93	22	45	8	2.2	270	0.00	0.11	9	6	9
01/10/95	64	30	45	93	28	45	7	1.6	232	0.00	0.09	7	5	7
01/11/95	65	30	48	93	16	45	7	1.6	208	0.00	0.09	8	5	8
01/12/95	61	40	52	85	32	47	18	6.0	251	0.00	0.11	6	3	6
01/13/95	60	32	46	93	24	46	14	3.3	284	0.00	0.11	5	3	5
01/14/95	66	32	48	89	22	46	7	2.0	286	0.00	0.11	8	6	8
01/15/95	66	34	52	93	17	47	14	2.8	234	0.00	0.11	8	6	8
01/16/95	57	38	49	60	18	48	22	8.1	282	0.00	0.15	4	1	4
01/17/95	52	29	38	92	27	45	19	3.1	191	0.00	0.07	1	0	1
01/18/95	51	26	37	86	18	44	13	2.9	301	0.00	0.10	1	0	1

01/19/95	53	24	38	66	18	42	8	2.1	241	0.00	0.09	2	0	2
01/20/95	64	36	46	44	15	44	8	2.2	263	0.00	0.12	7	5	7
01/21/95	63	30	47	80	15	46	10	2.3	286	0.00	0.12	7	4	7
01/22/95	58	33	45	46	17	46	12	3.5	303	0.00	0.13	4	2	4
01/23/95	59	30	42	49	18	45	9	3.2	246	0.00	0.11	5	2	5
01/24/95	63	35	44	55	19	45	9	2.5	215	0.00	0.10	7	4	7
01/25/95	61	37	48	85	21	46	11	3.1	169	0.01	0.08	6	3	6
01/26/95	57	38	47	93	28	47	23	4.7	265	0.18	0.10	4	1	4
01/27/95	56	36	46	76	22	46	20	7.2	317	0.00	0.14	3	1	3
01/28/95	58	27	41	93	16	45	12	2.8	310	0.00	0.11	4	2	4
01/29/95	57	30	41	69	17	44	14	4.0	317	0.00	0.13	4	1	4
01/30/95	57	25	39	88	17	44	9	1.8	334	0.00	0.11	4	1	4
01/31/95	65	26	42	83	15	43	8	1.8	289	0.00	0.12	8	5	8
02/01/95	72	34	50	49	14	45	12	2.7	322	0.00	0.16	11	9	11
02/02/95	76	34	54	78	13	47	9	2.6	332	0.00	0.16	13	11	13
02/03/95	67	42	55	28	14	48	15	5.0	344	0.00	0.18	9	6	9
02/04/95	70	32	50	49	14	48	8	2.1	346	0.00	0.15	10	8	10
02/05/95	73	34	51	47	13	48	8	2.1	351	0.00	0.16	12	9	12
02/06/95	76	31	51	51	12	48	7	1.8	353	0.00	0.17	13	11	13
02/07/95	74	31	51	47	13	48	17	4.9	356	0.00	0.20	12	10	12
02/08/95	65	35	49	54	17	49	12	3.0	349	0.00	0.15	8	5	8
02/09/95	70	35	54	76	18	49	17	3.5	286	0.00	0.14	10	8	10
02/10/95	59	46	51	76	19	49	19	4.2	84	0.01	0.06	5	2	5
02/11/95	60	39	49	77	21	49	18	5.5	329	0.00	0.14	5	3	5
02/12/95	67	37	53	75	14	49	18	5.3	325	0.00	0.16	9	6	9
02/13/95	67	49	57	90	35	51	15	3.9	186	0.00	0.09	9	6	9
02/14/95	69	50	59	72	24	53	22	7.5	241	0.00	0.15	10	7	10
02/15/95	59	48	52	92	71	53	15	1.5	103	0.38	0.02	5	2	5
02/16/95	69	47	55	91	15	54	15	4.2	349	0.00	0.16	10	7	10
02/17/95	63	33	49	70	17	52	7	2.1	349	0.00	0.13	7	4	7
02/18/95	71	38	52	67	14	52	13	2.0	351	0.00	0.15	11	8	11
02/19/95	70	35	52	56	14	52	10	2.1	391	0.00	0.16	10	8	10
02/20/95	77	35	54	74	12	52	8	2.3	389	0.00	0.18	14	11	14
02/21/95	68	46	56	84	15	53	11	2.6	184	0.00	0.09	9	7	9
02/22/95	75	43	57	92	16	54	10	1.8	380	0.00	0.16	13	10	13
02/23/95	70	45	57	63	18	55	14	3.0	313	0.00	0.15	10	8	10
02/24/95	68	46	58	64	25	54	17	6.7	243	0.00	0.15	9	7	9
02/25/95	73	46	59	88	15	56	13	3.7	329	0.00	0.16	12	9	12
02/26/95	67	41	54	88	20	55	14	3.9	317	0.00	0.14	9	6	9
02/27/95	72	40	56	84	15	56	11	3.3	396	0.00	0.18	11	9	11
02/28/95	72	39	56	85	15	56	13	3.1	351	0.02	0.16	11	9	11
03/01/95	65	44	54	88	37	57	12	6.8	351	0.00	0.15	8	5	8
03/02/95	65	42	53	63	21	57	12	6.4	411	0.00	0.19	8	5	8
03/03/95	74	39	57	84	13	57	16	3.5	399	0.00	0.19	12	10	12
03/04/95	70	48	60	53	14	58	19	6.1	418	0.00	0.22	10	8	10
03/05/95	70	42	57	51	21	58	19	5.0	389	0.00	0.19	10	8	10
03/06/95	66	48	56	88	36	57	26	5.1	165	0.06	0.09	8	6	8
03/07/95	61	33	47	72	16	55	10	3.7	427	0.00	0.16	6	3	6
03/08/95	61	31	48	45	15	54	12	4.0	415	0.00	0.17	6	3	6
03/09/95	70	40	53	41	14	56	11	2.5	446	0.00	0.19	10	8	10
03/10/95	77	35	57	70	13	57	11	2.7	451	0.00	0.20	14	11	14
03/11/95	79	42	61	54	12	58	16	6.2	444	0.00	0.26	15	12	15
03/12/95	65	49	56	82	17	59	20	6.4	380	0.01	0.18	8	5	8
03/13/95	71	38	55	57	13	58	15	3.5	473	0.00	0.21	11	8	11
03/14/95	79	41	59	43	12	58	10	3.4	437	0.00	0.22	15	12	15
03/15/95	73	40	58	38	13	59	12	3.9	477	0.00	0.22	12	9	12
03/16/95	75	41	59	74	14	60	8	3.2	463	0.00	0.21	13	10	13
03/17/95	76	42	61	69	13	60	14	4.1	434	0.00	0.21	13	11	13
03/18/95	77	51	63	78	14	62	14	4.5	449	0.00	0.22	14	11	14
03/19/95	80	47	65	53	12	62	21	7.9	458	0.00	0.28	15	13	15
03/20/95	80	47	65	43	12	62	17	5.2	461	0.00	0.25	15	13	15
03/21/95	83	46	67	56	11	63	19	5.3	489	0.00	0.27	17	14	17
03/22/95	74	51	64	31	13	63	18	6.3	451	0.00	0.25	13	10	13
03/23/95	77	40	61	33	13	62	16	4.1	384	0.00	0.21	14	11	14
03/24/95	77	46	63	48	13	63	17	5.1	485	0.00	0.25	14	11	14

03/25/95	62	39	51	55	16	61	20	6.1	473	0.00	0.21	6	4	6
03/26/95	66	34	48	24	14	60	12	3.9	525	0.00	0.22	8	6	8
03/27/95	71	33	54	36	13	58	12	4.3	415	0.00	0.20	11	8	11
03/28/95	71	42	57	51	13	60	19	5.7	511	0.00	0.25	11	8	11
03/29/95	70	36	53	53	14	60	13	4.4	482	0.00	0.22	10	8	10
03/30/95	71	39	56	34	13	61	15	4.1	504	0.00	0.23	11	8	11
03/31/95	70	42	55	51	14	62	10	3.6	508	0.00	0.22	10	8	10
04/01/95	72	39	58	66	14	61	16	4.6	461	0.00	0.21	11	9	11
04/02/95	75	52	63	35	12	61	14	6.6	528	0.00	0.29	14	10	14
04/03/95	71	45	57	48	13	62	20	6.8	463	0.00	0.25	11	8	11
04/04/95	70	41	56	70	15	60	12	3.7	372	0.00	0.17	10	8	10
04/05/95	80	40	61	83	12	62	12	3.3	530	0.00	0.24	15	13	15
04/06/95	82	43	63	34	11	63	14	3.1	542	0.00	0.26	16	14	16
04/07/95	83	43	64	40	11	63	15	4.1	539	0.00	0.28	17	14	17
04/08/95	81	46	65	19	11	62	20	6.2	549	0.00	0.31	16	13	16
04/09/95	80	46	63	35	11	62	26	8.8	535	0.00	0.33	15	13	15
04/10/95	62	39	50	26	15	59	20	6.2	456	0.00	0.22	6	4	6
04/11/95	71	33	54	47	13	58	14	4.1	566	0.00	0.24	11	8	11
04/12/95	81	37	59	31	11	60	8	2.2	566	0.00	0.26	16	13	16
04/13/95	89	44	67	30	10	62	13	3.9	556	0.00	0.30	18	16	18
04/14/95	82	48	66	20	11	63	18	4.8	563	0.00	0.30	16	14	16
04/15/95	80	45	64	32	11	63	21	5.2	437	0.00	0.25	15	13	15
04/16/95	77	47	64	19	12	62	14	4.9	399	0.00	0.23	14	11	14
04/17/95	60	46	53	26	16	61	24	9.8	511	0.00	0.27	5	3	5
04/18/95	72	37	57	27	13	61	16	5.6	580	0.00	0.28	11	9	11
04/19/95	58	39	50	83	16	61	21	8.5	468	0.00	0.20	4	2	4
04/20/95	68	36	52	66	14	60	16	5.1	580	0.00	0.25	9	7	9
04/21/95	76	37	58	49	12	62	13	4.4	556	0.00	0.26	13	11	13
04/22/95	72	42	58	36	13	63	14	4.3	566	0.00	0.26	11	9	11
04/23/95	73	38	56	46	13	63	10	2.7	563	0.00	0.24	12	9	12
04/24/95	79	41	62	26	12	64	13	3.8	568	0.00	0.27	15	12	15
04/25/95	84	47	66	19	11	65	15	4.8	568	0.00	0.31	17	15	17
04/26/95	85	44	66	19	10	66	13	3.4	559	0.00	0.29	18	15	18
04/27/95	80	53	67	20	11	66	12	5.1	473	0.00	0.27	17	13	17
04/28/95	84	46	66	50	11	64	16	4.1	325	0.00	0.20	17	15	17
04/29/95	87	49	70	22	10	66	16	4.5	585	0.00	0.32	18	16	18
04/30/95	88	56	73	21	10	67	21	7.4	465	0.00	0.33	21	16	21
05/01/95	83	59	72	25	11	68	15	5.5	451	0.00	0.28	21	16	21
05/02/95	85	58	71	32	11	69	25	6.1	463	0.00	0.29	22	17	22
05/03/95	82	48	67	27	11	68	17	5.4	594	0.00	0.32	16	14	16
05/04/95	87	45	70	26	10	69	17	5.4	578	0.00	0.32	18	16	18
05/05/95	85	57	72	31	10	70	23	7.5	468	0.00	0.31	21	16	21
05/06/95	81	46	66	21	11	69	15	4.9	585	0.00	0.30	16	13	16
05/07/95	62	45	55	21	15	67	23	7.8	437	0.00	0.23	6	4	6
05/08/95	74	39	59	39	13	66	20	8.5	597	0.00	0.32	12	10	12
05/09/95	82	46	66	33	11	68	16	4.4	597	0.00	0.30	16	14	16
05/10/95	85	47	69	36	10	70	13	4.3	590	0.00	0.31	18	15	18
05/11/95	87	50	71	33	10	71	17	4.1	549	0.01	0.30	18	16	18
05/12/95	86	57	74	18	10	71	23	8.2	561	0.00	0.36	22	17	22
05/13/95	85	61	73	19	10	72	18	7.0	599	0.00	0.37	23	18	23
05/14/95	90	54	73	31	9	73	12	3.3	575	0.00	0.31	20	16	20
05/15/95	94	57	79	23	8	74	15	4.0	559	0.00	0.32	22	17	22
05/16/95	89	61	74	19	10	74	21	7.7	468	0.00	0.34	24	19	24
05/17/95	73	50	63	21	13	72	22	9.8	520	0.00	0.32	12	9	12
05/18/95	85	49	68	36	10	73	10	2.9	602	0.00	0.29	18	15	18
05/19/95	88	50	71	31	10	73	9	2.5	477	0.00	0.25	18	16	18
05/20/95	91	55	76	43	9	74	15	4.7	587	0.00	0.33	21	16	21
05/21/95	94	55	76	23	9	76	13	3.1	597	0.00	0.32	21	16	21
05/22/95	95	59	79	16	8	76	19	6.4	606	0.00	0.39	23	18	23
05/23/95	86	58	74	17	10	76	22	6.2	551	0.00	0.33	22	17	22
05/24/95	87	50	70	20	10	75	16	4.4	618	0.00	0.33	18	16	18
05/25/95	91	48	72	35	9	75	18	5.1	597	0.00	0.34	18	16	18
05/26/95	84	54	69	59	11	74	22	5.9	480	0.11	0.28	19	15	19
05/27/95	85	53	71	37	10	73	14	4.6	623	0.00	0.32	19	15	19
05/28/95	89	57	73	23	10	75	12	3.2	547	0.00	0.30	22	17	22

05/29/95	89	58	74	37	10	76	18	6.2	602	0.00	0.36	22	17	22
05/30/95	89	57	73	32	10	77	15	5.2	623	0.00	0.35	22	17	22
05/31/95	92	59	77	18	9	78	14	5.2	635	0.00	0.37	23	18	23
06/01/95	96	61	79	16	8	80	11	3.7	635	0.00	0.36	24	19	24
06/02/95	96	59	80	21	8	80	20	5.8	623	0.00	0.39	23	18	23
06/03/95	88	56	74	17	10	80	14	4.6	640	0.00	0.35	21	16	21
06/04/95	90	58	76	17	9	80	13	4.1	590	0.00	0.33	22	17	22
06/05/95	95	57	79	27	8	81	13	4.2	635	0.00	0.36	22	17	22
06/06/95	93	62	79	15	9	82	19	6.3	644	0.02	0.40	24	19	24
06/07/95	91	58	76	23	9	81	18	5.3	625	0.00	0.36	22	17	22
06/08/95	89	59	75	19	9	74	17	6.5	642	0.00	0.39	23	18	23
06/09/95	91	56	74	18	9	74	11	4.1	652	0.00	0.36	21	16	21
06/10/95	97	59	79	18	8	77	18	4.2	649	0.00	0.38	23	18	23
06/11/95	89	61	76	30	10	77	13	5.7	628	0.00	0.36	24	19	24
06/12/95	97	62	81	43	8	79	10	4.7	625	0.00	0.36	24	19	24
06/13/95	99	71	86	20	8	80	13	5.7	611	0.00	0.39	29	24	29
06/14/95	100	63	84	19	7	80	11	3.5	611	0.00	0.36	25	20	25
06/15/95	97	65	82	18	8	79	12	3.7	520	0.00	0.32	26	21	26
06/16/95	95	62	80	72	8	78	25	6.7	573	0.10	0.35	24	19	24
06/17/95	94	72	81	49	9	79	21	9.1	606	0.00	0.42	29	24	29
06/18/95	93	67	81	69	9	80	15	6.1	606	0.00	0.35	27	22	27
06/19/95	97	71	83	45	8	82	22	6.9	582	0.00	0.39	29	24	29
06/20/95	96	65	82	71	8	82	19	5.8	613	0.00	0.36	26	21	26
06/21/95	98	66	83	58	8	83	17	4.4	602	0.00	0.35	26	21	26
06/22/95	98	66	82	42	8	83	13	3.8	628	0.00	0.36	26	21	26
06/23/95	99	60	81	29	8	82	14	3.4	637	0.00	0.36	23	18	23
06/24/95	97	60	81	22	8	81	20	5.1	625	0.00	0.38	23	18	23
06/25/95	95	68	80	48	9	82	26	8.6	561	0.01	0.40	27	22	27
06/26/95	95	64	78	81	10	81	22	6.2	547	0.01	0.33	25	20	25
06/27/95	95	65	80	49	9	82	13	4.1	594	0.00	0.34	26	21	26
06/28/95	99	63	82	33	8	82	18	5.0	594	0.00	0.37	25	20	25
06/29/95	100	65	84	25	7	83	19	5.1	609	0.00	0.38	26	21	26
06/30/95	91	64	77	91	12	84	20	6.7	559	0.51	0.32	25	20	25
07/01/95	89	65	75	86	11	82	18	5.1	551	0.02	0.30	26	21	26
07/02/95	92	65	78	83	10	81	16	3.9	537	0.00	0.29	26	21	26
07/03/95	93	64	81	40	9	80	23	7.2	628	0.00	0.39	25	20	25
07/04/95	95	59	80	21	8	80	18	4.7	618	0.00	0.36	23	18	23
07/05/95	98	63	81	19	8	81	10	3.5	628	0.00	0.36	25	20	25
07/06/95	99	64	84	36	8	82	14	5.5	570	0.00	0.36	25	20	25
07/07/95	97	69	85	35	8	84	17	6.0	613	0.00	0.38	28	23	28
07/08/95	97	70	84	40	8	85	14	5.5	623	0.00	0.38	28	23	28
07/09/95	97	67	84	47	8	85	16	4.9	613	0.00	0.36	27	22	27
07/10/95	98	65	85	36	8	85	19	6.4	630	0.00	0.39	26	21	26
07/11/95	98	67	86	23	8	86	15	6.8	642	0.00	0.41	27	22	27
07/12/95	97	66	85	22	8	86	16	5.6	623	0.00	0.38	26	21	26
07/13/95	97	67	84	27	8	87	14	5.8	587	0.00	0.37	27	22	27
07/14/95	99	73	83	41	8	87	19	6.8	439	0.05	0.34	30	25	30
07/15/95	97	71	81	67	10	87	18	6.0	537	0.00	0.34	29	24	29
07/16/95	91	69	78	83	18	86	16	4.9	408	0.00	0.24	28	23	28
07/17/95	93	67	74	89	15	85	25	6.7	492	0.19	0.31	27	22	27
07/18/95	94	68	80	86	11	85	14	5.4	561	0.00	0.32	27	22	27
07/19/95	94	68	82	80	13	86	14	5.1	566	0.02	0.31	27	22	27
07/20/95	93	66	79	91	13	79	21	4.5	492	0.70	0.27	26	21	26
07/21/95	97	68	78	89	14	80	20	3.6	568	0.12	0.30	27	22	27
07/22/95	99	66	82	89	8	83	11	2.9	606	0.00	0.32	26	21	26
07/23/95	100	62	83	54	7	83	12	4.2	637	0.00	0.37	24	19	24
07/24/95	104	60	83	39	7	82	12	3.9	635	0.00	0.38	23	18	23
07/25/95	104	61	84	40	7	82	9	3.3	630	0.00	0.37	24	19	24
07/26/95	107	61	85	47	6	83	13	2.6	623	0.00	0.36	24	19	24
07/27/95	107	64	86	36	6	83	9	3.1	616	0.00	0.37	25	20	25
07/28/95	104	65	88	39	7	84	16	5.7	611	0.00	0.39	26	21	26
07/29/95	102	66	85	22	7	84	9	3.4	613	0.00	0.36	26	21	26
07/30/95	99	73	84	22	8	84	24	5.3	520	0.42	0.36	30	25	30
07/31/95	96	69	83	14	8	83	19	5.3	544	0.00	0.36	28	23	28
08/01/95	92	68	81	14	9	84	11	4.6	590	0.00	0.35	27	22	27

08/02/95	99	69	83	14	8	84	11	3.7	592	0.00	0.36	28	23	28
08/03/95	102	67	85	14	7	84	17	4.5	580	0.00	0.37	27	22	27
08/04/95	100	70	86	14	7	85	14	5.6	587	0.00	0.39	28	23	28
08/05/95	99	73	86	13	8	86	7	6.8	575	0.09	0.41	30	25	30
08/06/95	97	69	84	14	8	86	7	4.2	580	0.00	0.35	28	23	28
08/07/95	98	71	86	13	8	85	4	4.8	578	0.00	0.37	29	24	29
08/08/95	99	70	86	14	8	85	8	5.6	537	0.00	0.36	28	23	28
08/09/95	100	72	87	13	7	86	6	4.3	568	0.00	0.36	29	24	29
08/10/95	99	74	88	13	8	86	6	6.5	561	0.00	0.39	30	25	30
08/11/95	99	74	87	13	8	87	8	5.1	561	0.00	0.37	30	25	30
08/12/95	100	72	86	13	7	87	8	5.9	575	0.00	0.39	29	24	29
08/13/95	98	72	85	13	8	88	7	6.0	563	0.02	0.38	29	24	29
08/14/95	90	73	79	13	9	85	10	4.3	272	0.03	0.23	30	25	30
08/15/95	91	69	77	14	9	84	11	3.5	382	0.01	0.26	28	23	28
08/16/95	93	71	77	14	9	84	8	4.4	372	0.14	0.28	29	24	29
08/17/95	91	69	76	14	9	84	14	3.4	394	0.09	0.26	28	23	28
08/18/95	89	67	77	15	10	84	13	3.5	499	0.00	0.29	27	22	27
08/19/95	93	78	81	20	21	85	20	6.1	456	0.00	0.32	32	27	32
08/20/95	90	75	81	27	20	83	15	5.0	346	0.00	0.24	31	26	31
08/21/95	95	76	87	60	25	87	22	2.2	210	0.00	0.13	31	26	31
08/22/95	96	69	82	78	23	86	21	5.0	496	0.00	0.28	28	23	28
08/23/95	95	70	81	68	22	86	16	5.2	468	0.00	0.28	28	23	28
08/24/95	95	69	82	75	22	87	9	4.1	518	0.00	0.28	28	23	28
08/25/95	97	70	83	65	18	87	13	4.1	496	0.00	0.28	28	23	28
08/26/95	97	69	82	69	24	88	19	4.8	470	0.00	0.27	28	23	28
08/27/95	96	72	82	76	22	87	15	4.4	377	0.00	0.23	29	24	29
08/28/95	95	69	83	78	21	87	12	4.0	461	0.00	0.25	28	23	28
08/29/95	96	70	83	67	24	87	10	3.3	477	0.00	0.25	28	23	25
08/30/95	100	68	83	74	19	88	20	4.3	482	0.00	0.28	27	22	27
08/31/95	97	69	83	70	24	89	10	3.6	461	0.00	0.25	28	23	28
09/01/95	95	70	83	65	21	88	18	6.0	485	0.00	0.29	28	23	28
09/02/95	93	66	80	66	19	88	14	4.5	506	0.00	0.28	26	21	26
09/03/95	94	67	82	60	17	88	12	4.5	504	0.00	0.29	27	22	27
09/04/95	97	68	83	55	20	88	9	3.9	496	0.00	0.28	27	22	27
09/05/95	98	66	82	54	14	88	9	2.9	506	0.00	0.28	26	21	26
09/06/95	101	64	82	74	12	88	10	2.5	496	0.00	0.27	25	20	25
09/07/95	98	71	85	49	16	89	12	5.1	494	0.00	0.31	29	24	29
09/08/95	93	74	82	61	25	90	15	5.2	465	0.00	0.27	30	25	30
09/09/95	92	67	76	83	26	90	23	5.4	430	0.00	0.25	27	22	27
09/10/95	85	65	75	89	33	90	15	4.9	475	0.00	0.23	25	20	25
09/11/95	85	62	73	103	39	86	20	4.7	465	0.68	0.21	24	19	24
09/12/95	91	65	77	95	20	85	14	2.4	465	0.00	0.22	26	21	26
09/13/95	88	62	75	91	20	82	13	3.8	363	0.00	0.19	24	19	24
09/14/95	80	62	70	88	38	79	15	6.1	227	0.02	0.13	21	16	21
09/15/95	66	60	63	107	82	75	12	5.5	98	0.98	0.01	13	8	13
09/16/95	80	61	69	101	49	76	7	2.2	341	0.00	0.13	21	16	21
09/17/95	86	60	73	103	41	78	8	1.7	487	0.00	0.20	23	18	23
09/18/95	89	63	75	100	29	80	15	3.4	477	0.12	0.22	25	20	25
09/19/95	85	62	73	101	34	80	11	3.2	446	0.00	0.20	24	19	24
09/20/95	87	64	74	88	35	79	11	3.6	449	0.00	0.21	25	20	25
09/21/95	85	56	70	88	35	78	21	7.2	468	0.00	0.24	21	16	21
09/22/95	61	46	54	89	58	73	15	4.7	222	0.01	0.08	6	3	6
09/23/95	81	47	64	97	39	72	9	2.9	465	0.00	0.19	16	13	16
09/24/95	87	57	72	97	24	75	11	2.6	420	0.00	0.20	22	17	22
09/25/95	86	56	70	87	24	75	8	2.4	454	0.00	0.21	21	16	21
09/26/95	89	59	73	92	23	76	11	2.6	420	0.00	0.20	23	18	23
09/27/95	91	58	75	86	22	77	8	2.4	456	0.00	0.22	22	17	22
09/28/95	76	60	66	105	49	75	17	3.4	201	0.55	0.08	18	13	18
09/29/95	84	58	70	106	28	73	13	3.7	432	0.00	0.20	21	16	21
09/30/95	79	53	66	90	22	72	12	3.2	465	0.00	0.21	16	12	16
10/01/95	84	52	67	87	29	73	10	2.9	451	0.00	0.20	18	15	18
10/02/95	82	54	68	90	11	70	14	4.9	456	0.00	0.24	18	14	18
10/03/95	84	50	66	77	22	70	7	2.5	449	0.00	0.21	17	15	17
10/04/95	87	49	69	83	12	69	20	6.8	454	0.00	0.28	18	16	18
10/05/95	75	45	61	73	14	67	11	3.7	451	0.00	0.21	13	10	13

10/06/95	76	46	60	72	18	66	11	3.4	444	0.00	0.20	13	11	13
10/07/95	85	59	65	75	21	70	9	0.8	446	0.00	0.19	22	17	22
10/08/95	86	49	66	86	11	68	12	2.2	439	0.00	0.21	18	16	18
10/09/95	84	49	66	81	13	67	10	2.5	341	0.00	0.18	17	15	17
10/10/95	87	51	68	76	14	68	10	2.6	422	0.00	0.22	19	16	19
10/11/95	86	47	67	71	14	67	11	2.9	425	0.00	0.22	18	16	18
10/12/95	85	55	67	63	16	70	10	1.4	437	0.00	0.20	20	15	20
10/13/95	88	62	68	46	14	70	16	2.8	432	0.00	0.24	24	19	24
10/14/95	79	50	63	83	27	68	8	2.5	485	0.00	0.20	15	12	15
10/15/95	84	48	65	92	21	67	7	2.1	485	0.00	0.21	17	15	17
10/16/95	82	47	64	90	21	67	10	3.0	449	0.00	0.21	16	14	16
10/17/95	86	47	65	85	12	67	7	2.0	485	0.00	0.23	18	16	18
10/18/95	87	45	65	80	14	66	9	2.3	475	0.00	0.23	18	16	18
10/19/95	87	44	66	83	13	66	18	4.1	473	0.00	0.25	18	16	18
10/20/95	75	48	60	75	19	66	12	3.0	465	0.00	0.20	13	10	13
10/21/95	85	42	61	89	12	65	12	2.7	449	0.00	0.22	18	15	18
10/22/95	83	47	66	70	12	65	22	6.7	454	0.00	0.27	17	14	17
10/23/95	71	46	57	67	13	64	12	3.0	444	0.00	0.19	11	8	11
10/24/95	79	44	59	70	20	64	10	3.0	444	0.00	0.21	15	12	15
10/25/95	80	42	60	83	13	64	10	2.7	430	0.00	0.20	15	13	15
10/26/95	82	40	61	74	11	63	15	4.2	439	0.00	0.23	16	14	16
10/27/95	85	42	62	66	12	63	9	2.3	444	0.00	0.22	18	15	18
10/28/95	82	42	60	74	15	63	10	2.3	413	0.00	0.20	16	14	16
10/29/95	81	42	60	70	15	63	9	2.3	391	0.00	0.19	16	13	16
10/30/95	77	48	61	79	20	63	15	3.0	327	0.00	0.16	14	11	14
10/31/95	74	53	61	78	29	64	12	3.8	360	0.00	0.16	14	10	14
11/01/95	72	48	59	80	32	63	15	4.8	368	0.00	0.17	11	9	11
11/02/95	71	46	58	84	29	62	13	4.1	389	0.00	0.17	11	8	11
11/03/95	66	42	53	86	36	61	13	5.1	389	0.00	0.16	8	6	8
11/04/95	63	41	51	76	40	61	13	4.3	391	0.00	0.15	7	4	7
11/05/95	65	41	54	97	43	60	7	2.6	212	0.01	0.08	8	5	8
11/06/95	63	48	56	106	56	61	15	4.9	124	0.14	0.04	7	4	7
11/07/95	71	41	55	101	31	59	10	2.0	396	0.00	0.15	11	8	11
11/08/95	74	41	56	99	29	59	6	1.5	396	0.00	0.15	12	10	12
11/09/95	78	40	59	99	24	59	14	3.3	382	0.00	0.17	14	12	14
11/10/95	74	51	63	79	24	59	24	7.0	380	0.00	0.20	13	10	13
11/11/95	69	41	53	74	17	58	8	2.9	394	0.00	0.17	10	7	10
11/12/95	75	35	53	74	22	57	8	2.8	353	0.00	0.16	13	10	13
11/13/95	81	39	57	79	15	57	10	3.1	372	0.00	0.19	16	13	16
11/14/95	76	40	56	73	22	57	7	2.1	375	0.00	0.16	13	11	13
11/15/95	75	42	59	82	23	57	15	5.7	370	0.00	0.19	13	10	13
11/16/95	71	44	56	83	29	58	7	2.7	360	0.00	0.15	11	8	11
11/17/95	73	43	56	95	21	57	12	3.7	358	0.00	0.16	12	9	12
11/18/95	73	38	53	74	22	56	8	2.2	368	0.00	0.16	12	9	12
11/19/95	75	35	52	83	18	56	7	1.8	365	0.00	0.16	13	10	13
11/20/95	75	36	53	73	18	55	7	2.3	360	0.00	0.16	13	10	13
11/21/95	70	37	53	73	28	57	10	2.5	346	0.00	0.14	10	8	10
11/22/95	77	34	55	89	15	57	9	2.6	356	0.00	0.17	14	11	14
11/23/95	74	36	53	65	16	56	6	2.1	346	0.00	0.16	12	10	12
11/24/95	72	35	51	62	17	55	6	2.0	356	0.00	0.15	11	9	11
11/25/95	73	35	52	60	17	54	7	2.2	344	0.00	0.16	12	9	12
11/26/95	76	36	55	68	14	53	19	3.8	227	0.00	0.14	13	11	13
11/27/95	66	39	52	64	20	53	13	4.2	337	0.00	0.15	8	6	8
11/28/95	58	33	44	57	19	51	13	3.5	341	0.00	0.13	4	2	4
11/29/95	67	31	48	60	22	50	11	3.5	334	0.00	0.15	9	6	9
11/30/95	73	35	50	64	19	50	9	2.6	341	0.00	0.16	12	9	12
12/01/95	76	32	52	68	15	50	7	2.1	339	0.00	0.16	13	11	13
12/02/95	76	35	55	60	14	50	16	4.1	310	0.00	0.18	13	11	13
12/03/95	73	36	53	61	17	51	8	2.2	332	0.00	0.15	12	9	12
12/04/95	76	35	55	69	13	51	14	3.6	322	0.00	0.17	13	11	13
12/05/95	73	39	55	52	18	51	5	2.2	313	0.00	0.15	12	9	12
12/06/95	70	44	56	60	26	51	12	3.0	172	0.00	0.10	10	8	10
12/07/95	73	48	57	96	24	52	19	4.7	181	0.09	0.11	12	9	12
12/08/95	62	39	50	106	27	52	12	3.7	332	0.00	0.12	6	4	6
12/09/95	59	32	44	89	36	50	8	2.2	320	0.00	0.10	5	2	5

12/10/95	64	30	45	90	30	49	6	1.6	317	0.00	0.11	7	5	7
12/11/95	70	31	48	88	23	49	6	1.9	325	0.00	0.13	10	8	10
12/12/95	74	30	51	86	11	49	13	2.7	317	0.00	0.16	12	10	12
12/13/95	74	39	53	63	12	49	16	3.2	255	0.00	0.15	12	10	12
12/14/95	71	33	51	71	17	49	15	3.7	315	0.00	0.16	11	8	11
12/15/95	60	36	48	73	33	49	11	3.4	301	0.00	0.11	5	3	5
12/16/95	59	34	47	74	31	47	12	3.9	227	0.00	0.10	5	2	5
12/17/95	52	38	44	90	36	47	13	3.7	227	0.02	0.08	1	0	1
12/18/95	48	32	40	102	51	47	10	3.1	232	0.02	0.06	0	0	0
12/19/95	51	25	37	99	43	45	10	2.4	313	0.00	0.08	1	0	1
12/20/95	53	31	42	80	44	45	8	2.9	298	0.00	0.09	2	0	2
12/21/95	41	30	36	105	75	44	7	2.3	55	0.14	0.00	0	0	0
12/22/95	44	31	37	106	69	43	10	2.4	98	0.00	0.01	0	0	0
12/23/95	48	26	36	102	55	43	9	2.3	255	0.00	0.06	0	0	0
12/24/95	43	32	38	100	68	44	10	3.7	124	0.00	0.02	0	0	0
12/25/95	51	27	37	102	46	43	9	3.3	275	0.00	0.08	1	0	1
12/26/95	56	31	41	89	36	43	9	3.4	298	0.00	0.10	3	1	3
12/27/95	58	31	42	84	30	43	10	3.3	313	0.00	0.11	4	2	4
12/28/95	57	27	41	89	41	43	9	2.3	272	0.00	0.08	4	1	4
12/29/95	56	31	43	91	26	43	14	3.5	315	0.00	0.11	3	1	3
12/30/95	61	24	41	81	22	42	14	3.7	289	0.00	0.12	6	3	6
12/31/95	58	25	46	83	21	42	15	2.3	220	0.00	0.08	4	2	4
01/01/96	50	34	42	102	27	45	17	6.5	265	0.14	0.10	0	0	0
01/02/96	39	29	34	103	55	43	16	4.5	167	0.01	0.04	0	0	0
01/03/96	51	24	36	96	40	42	10	2.5	329	0.00	0.09	1	0	1
01/04/96	63	32	47	80	21	42	15	3.8	248	0.00	0.11	7	4	7
01/05/96	64	33	51	72	20	43	13	4.0	327	0.00	0.14	7	5	7
01/06/96	58	34	46	80	33	45	12	4.0	322	0.00	0.12	4	2	4
01/07/96	53	27	39	93	38	44	8	1.9	327	0.00	0.09	2	0	2
01/08/96	62	25	41	94	27	43	8	1.9	334	0.00	0.11	6	4	6
01/09/96	67	29	45	82	21	43	7	2.6	332	0.00	0.14	9	6	9
01/10/96	68	29	47	85	19	43	10	3.1	260	0.00	0.12	9	7	9
01/11/96	63	32	47	69	24	44	10	2.9	339	0.00	0.13	7	4	7
01/12/96	66	30	46	71	17	44	11	3.0	341	0.00	0.14	8	6	8
01/13/96	70	30	47	67	19	44	7	2.7	344	0.00	0.15	10	8	10
01/14/96	72	29	48	75	14	44	9	2.7	349	0.00	0.16	11	9	11
01/15/96	71	32	51	61	15	45	8	3.2	341	0.00	0.16	11	8	11
01/16/96	73	38	56	56	18	46	18	3.9	344	0.00	0.17	12	9	12
01/17/96	67	47	55	47	15	47	31	12.9	198	0.00	0.22	9	6	9
01/18/96	53	32	42	42	12	44	18	4.8	353	0.00	0.15	2	0	2
01/19/96	64	25	45	56	12	43	19	4.0	356	0.00	0.16	7	5	7
01/20/96	56	31	45	66	16	44	15	3.8	356	0.00	0.14	3	1	3
01/21/96	61	23	41	54	20	43	9	2.6	363	0.00	0.13	6	3	6
01/22/96	66	29	47	60	12	43	20	4.9	363	0.00	0.18	8	6	8
01/23/96	53	30	40	75	9	43	21	5.9	370	0.00	0.15	2	0	2
01/24/96	55	20	37	58	15	41	9	2.2	365	0.00	0.12	3	0	3
01/25/96	62	22	43	57	11	41	18	4.5	368	0.00	0.16	6	4	6
01/26/96	63	36	49	53	16	43	20	5.6	372	0.00	0.18	7	4	7
01/27/96	61	28	42	50	19	44	11	4.5	380	0.00	0.16	6	3	6
01/28/96	68	27	47	62	12	44	21	4.2	365	0.00	0.17	9	7	9
01/29/96	69	29	49	55	12	44	14	3.8	389	0.00	0.18	10	7	10
01/30/96	72	35	53	43	12	46	14	4.0	363	0.00	0.19	11	9	11
01/31/96	69	40	56	54	27	47	16	3.0	291	0.00	0.13	10	7	10
02/01/96	61	43	51	94	36	48	19	6.4	227	0.02	0.10	6	3	6
02/02/96	58	41	48	88	48	47	19	4.4	186	0.00	0.07	4	2	4
02/03/96	62	37	49	89	19	47	11	2.6	387	0.00	0.14	6	4	6
02/04/96	62	32	46	58	22	47	9	3.7	399	0.00	0.16	6	4	6
02/05/96	72	32	50	72	20	48	6	1.9	399	0.00	0.16	11	9	11
02/06/96	71	35	51	75	25	48	7	1.5	308	0.00	0.12	11	8	11
02/07/96	77	40	56	65	20	49	10	3.6	418	0.00	0.20	14	11	14
02/08/96	74	41	56	63	19	50	12	3.6	415	0.00	0.19	12	10	12
02/09/96	76	40	57	64	15	51	11	3.2	420	0.00	0.20	13	11	13
02/10/96	78	37	58	63	12	51	22	4.6	427	0.00	0.22	14	12	14
02/11/96	61	41	52	56	18	52	19	5.8	384	0.00	0.18	6	3	6
02/12/96	62	37	50	42	18	51	16	4.6	327	0.00	0.15	6	4	6

02/13/96	69	45	54	56	18	52	9	1.9	377	0.00	0.16	10	7	10
02/14/96	72	38	55	64	22	52	14	3.9	413	0.00	0.19	11	9	11
02/15/96	75	39	56	72	17	53	10	2.2	439	0.00	0.19	13	10	13
02/16/96	67	41	53	64	25	53	10	3.5	430	0.00	0.18	9	6	9
02/17/96	77	38	56	64	14	53	10	2.3	418	0.00	0.19	14	11	14
02/18/96	80	40	61	55	12	54	26	7.3	456	0.00	0.28	15	13	15
02/19/96	70	44	58	53	14	53	17	5.2	303	0.00	0.17	10	8	10
02/20/96	77	51	63	58	24	55	20	6.3	422	0.00	0.23	14	11	14
02/21/96	75	42	58	77	17	55	9	2.2	306	0.00	0.14	13	10	13
02/22/96	77	37	58	68	12	55	17	4.9	477	0.00	0.24	14	11	14
02/23/96	60	45	54	70	19	54	15	4.8	363	0.00	0.15	5	3	5
02/24/96	71	46	58	44	18	54	12	3.2	301	0.00	0.15	11	8	11
02/25/96	64	52	59	58	30	55	19	6.9	212	0.00	0.13	8	5	8
02/26/96	58	42	51	87	30	56	26	8.8	444	0.01	0.18	4	2	4
02/27/96	58	37	47	66	24	53	17	5.0	499	0.00	0.19	4	2	4
02/28/96	61	29	46	73	20	51	17	5.9	437	0.00	0.18	6	3	6
02/29/96	61	35	48	44	16	51	18	6.2	492	0.00	0.21	6	3	6
03/01/96	59	34	47	47	12	51	14	5.2	518	0.00	0.21	5	2	5
03/02/96	66	34	49	45	12	51	10	3.1	525	0.00	0.21	8	6	8
03/03/96	70	30	52	55	9	51	9	2.7	468	0.00	0.20	10	8	10
03/04/96	71	38	55	47	13	52	20	4.9	468	0.00	0.22	11	8	11
03/05/96	71	46	59	45	17	53	21	5.8	444	0.00	0.23	11	8	11
03/06/96	64	38	54	54	15	53	26	9.6	439	0.00	0.23	7	5	7
03/07/96	54	28	42	62	24	51	13	3.9	513	0.00	0.17	2	0	2
03/08/96	56	31	44	57	14	51	17	6.0	518	0.00	0.20	3	1	3
03/09/96	64	27	46	49	14	51	10	3.0	547	0.00	0.20	7	5	7
03/10/96	73	32	53	51	11	52	9	2.8	520	0.00	0.22	12	9	12
03/11/96	79	37	58	52	9	53	16	4.3	551	0.00	0.27	15	12	15
03/12/96	77	38	59	43	11	54	17	4.6	554	0.00	0.27	14	11	14
03/13/96	77	39	59	43	8	54	24	7.8	506	0.00	0.30	14	11	14
03/14/96	64	38	52	60	22	55	15	4.4	496	0.00	0.20	7	5	7
03/15/96	64	37	51	75	21	55	14	4.0	532	0.00	0.20	7	5	7
03/16/96	69	34	53	71	15	55	16	4.2	559	0.00	0.23	10	7	10
03/17/96	74	41	59	68	18	56	26	8.4	513	0.00	0.27	12	10	12
03/18/96	67	39	53	62	17	57	12	4.5	578	0.00	0.24	9	6	9
03/19/96	65	37	51	47	17	57	12	3.9	585	0.00	0.23	8	5	8
03/20/96	72	35	55	56	14	56	11	4.2	590	0.00	0.25	11	9	11
03/21/96	80	40	61	57	10	57	11	3.2	508	0.00	0.24	15	13	15
03/22/96	78	54	65	45	15	60	19	5.5	513	0.00	0.27	16	12	16
03/23/96	77	54	66	45	12	59	23	9.0	578	0.00	0.34	16	11	16
03/24/96	65	46	56	42	10	58	23	10.6	606	0.00	0.32	8	5	8
03/25/96	71	42	56	33	14	56	16	5.6	530	0.00	0.26	11	8	11
03/26/96	61	39	50	41	18	57	16	6.1	585	0.00	0.24	6	3	6
03/27/96	69	35	53	60	15	59	12	3.3	602	0.00	0.24	10	7	10
03/28/96	76	39	59	74	14	63	15	4.2	551	0.00	0.25	13	11	13
03/29/96	72	46	60	51	15	60	23	9.7	547	0.00	0.30	11	9	11
03/30/96	72	37	55	50	11	59	17	4.1	625	0.00	0.27	11	9	11
03/31/96	76	42	60	46	13	60	14	5.1	609	0.00	0.29	13	11	13
04/01/96	78	48	66	48	14	61	14	6.6	618	0.00	0.32	14	12	14
04/02/96	83	56	67	75	16	62	20	7.5	547	0.00	0.31	20	15	20
04/03/96	74	50	63	82	14	62	18	5.7	625	0.00	0.28	12	10	12
04/04/96	69	46	57	64	25	61	16	5.5	458	0.00	0.21	10	7	10
04/05/96	54	37	43	98	40	58	14	3.7	143	0.34	0.05	2	0	2
04/06/96	59	32	46	101	35	57	9	2.8	599	0.00	0.18	5	2	5
04/07/96	71	36	55	100	20	59	7	2.4	621	0.00	0.23	11	8	11
04/08/96	82	43	63	71	13	62	10	3.1	642	0.00	0.29	16	14	16
04/09/96	88	49	69	69	12	64	9	3.1	644	0.00	0.31	18	16	18
04/10/96	86	54	70	63	12	64	15	5.0	463	0.00	0.26	20	16	20
04/11/96	77	46	64	56	10	63	18	6.6	664	0.00	0.33	14	11	14
04/12/96	76	46	62	64	13	63	15	3.9	654	0.00	0.29	13	11	13
04/13/96	74	53	64	40	11	62	24	9.2	616	0.00	0.34	14	10	14
04/14/96	68	45	56	36	10	62	17	6.4	685	0.00	0.31	9	7	9
04/15/96	73	40	59	46	13	61	13	5.0	671	0.00	0.30	12	9	12
04/16/96	80	47	64	38	10	62	14	4.4	516	0.00	0.27	15	13	15
04/17/96	82	50	68	44	10	62	19	6.8	654	0.00	0.35	16	14	16

04/18/96	83	49	67	55	11	63	20	5.8	673	0.00	0.34	17	14	17
04/19/96	77	52	65	56	9	64	19	6.6	680	0.00	0.34	15	11	15
04/20/96	81	42	64	47	7	64	16	4.4	692	0.00	0.33	16	13	16
04/21/96	79	44	64	42	10	64	16	4.9	695	0.00	0.33	15	12	15
04/22/96	78	48	62	51	10	65	12	2.6	687	0.00	0.30	14	12	14
04/23/96	84	46	66	65	10	65	11	3.0	687	0.00	0.31	17	15	17
04/24/96	93	48	72	62	7	67	15	3.8	695	0.00	0.36	18	16	18
04/25/96	90	55	75	37	8	67	20	6.7	568	0.00	0.35	21	16	21
04/26/96	92	59	75	36	10	69	12	3.8	685	0.00	0.36	23	18	23
04/27/96	93	55	76	42	11	69	21	5.7	618	0.00	0.36	21	16	21
04/28/96	92	57	76	35	8	70	20	7.5	678	0.00	0.42	22	17	22
04/29/96	71	42	57	43	12	69	18	3.7	709	0.00	0.29	11	8	11
04/30/96	87	41	66	66	7	69	14	3.6	711	0.00	0.34	18	16	18
05/01/96	90	48	71	41	7	70	17	4.3	714	0.00	0.37	18	16	18
05/02/96	91	53	73	30	8	71	15	3.4	709	0.00	0.36	20	16	20
05/03/96	91	53	73	33	8	72	17	4.4	718	0.00	0.38	20	16	20
05/04/96	92	52	73	48	6	72	16	3.8	728	0.00	0.37	19	16	19
05/05/96	94	48	72	44	5	73	14	3.0	730	0.00	0.37	18	16	18
05/06/96	95	47	72	52	5	73	17	3.4	735	0.00	0.38	18	16	18
05/07/96	97	52	74	43	7	74	14	2.5	714	0.00	0.36	19	16	19
05/08/96	95	52	76	57	9	75	12	3.3	709	0.00	0.36	19	16	19
05/09/96	93	55	76	40	12	76	13	3.7	685	0.00	0.36	21	16	21
05/10/96	92	56	75	40	7	76	11	3.0	726	0.00	0.36	21	16	21
05/11/96	96	54	77	56	9	77	10	3.2	726	0.00	0.37	20	16	20
05/12/96	101	63	82	62	8	79	10	3.3	714	0.00	0.38	25	20	25
05/13/96	101	59	82	46	7	80	20	4.1	668	0.00	0.38	23	18	23
05/14/96	95	67	83	28	7	81	18	6.3	721	0.00	0.43	27	22	27
05/15/96	95	58	79	32	9	80	15	4.9	735	0.00	0.41	22	17	22
05/16/96	96	61	80	50	11	81	15	4.2	714	0.00	0.38	24	19	24
05/17/96	95	60	80	60	11	78	16	5.2	721	0.00	0.39	23	18	23
05/18/96	99	65	84	44	10	77	18	5.4	730	0.00	0.42	26	21	26
05/19/96	97	67	83	37	11	77	20	6.0	606	0.00	0.38	27	22	27
05/20/96	97	65	82	40	10	77	16	5.3	738	0.00	0.42	26	21	26
05/21/96	98	61	81	37	9	78	12	3.5	738	0.00	0.39	24	19	24
05/22/96	95	62	80	41	11	78	19	4.8	733	0.00	0.40	24	19	24
05/23/96	90	59	77	39	14	77	17	5.3	714	0.00	0.38	23	18	23
05/24/96	92	60	77	59	12	78	16	4.6	673	0.00	0.36	23	18	23
05/25/96	84	62	72	53	11	77	18	5.9	611	0.00	0.33	23	18	23
05/26/96	77	52	66	41	15	75	21	8.2	726	0.00	0.37	15	11	15
05/27/96	87	49	70	64	13	75	16	5.0	747	0.00	0.37	18	16	18
05/28/96	87	57	73	49	9	75	14	4.1	633	0.00	0.33	22	17	22
05/29/96	94	54	76	42	7	76	13	3.1	747	0.00	0.38	20	16	20
05/30/96	93	56	77	44	8	77	11	3.5	752	0.00	0.38	21	16	21
05/31/96	92	55	76	39	10	77	15	4.3	738	0.00	0.38	21	16	21
06/01/96	95	53	76	58	7	78	8	2.6	742	0.00	0.37	20	16	20
06/02/96	97	56	79	47	7	78	11	3.3	707	0.00	0.37	21	16	21
06/03/96	96	68	83	56	14	80	17	6.6	683	0.00	0.40	27	22	27
06/04/96	100	66	83	54	10	81	13	3.3	716	0.00	0.38	26	21	26
06/05/96	103	63	85	42	8	81	10	3.1	709	0.00	0.39	25	20	25
06/06/96	103	67	88	36	8	82	18	4.9	721	0.00	0.42	27	22	27
06/07/96	94	74	83	54	19	83	17	7.1	661	0.00	0.39	30	25	30
06/08/96	97	69	83	61	14	83	19	4.9	633	0.00	0.36	28	23	28
06/09/96	100	69	84	52	13	83	18	5.0	599	0.00	0.36	28	23	28
06/10/96	102	66	84	51	10	83	19	3.4	668	0.00	0.37	26	21	26
06/11/96	100	68	85	55	12	84	19	5.0	656	0.00	0.38	27	22	27
06/12/96	97	70	85	55	14	84	13	5.0	590	0.00	0.34	28	23	28
06/13/96	86	70	77	82	31	83	13	5.3	351	0.05	0.19	28	23	28
06/14/96	90	67	76	88	28	84	17	5.6	580	0.00	0.29	27	22	27
06/15/96	93	62	78	88	21	84	13	4.0	630	0.00	0.31	24	19	24
06/16/96	97	66	83	67	14	85	12	3.5	649	0.00	0.34	26	21	26
06/17/96	98	70	83	69	14	85	26	4.4	542	0.00	0.31	28	23	28
06/18/96	100	67	84	62	13	85	8	2.8	580	0.00	0.31	27	22	27
06/19/96	103	69	87	44	10	86	16	4.8	656	0.00	0.39	28	23	28
06/20/96	106	72	89	39	9	86	12	3.7	654	0.00	0.39	29	24	29
06/21/96	104	69	87	45	11	87	22	5.2	604	0.00	0.38	28	23	28

06/22/96	101	76	88	49	15	88	13	5.1	590	0.00	0.36	31	26	31
06/23/96	100	69	84	62	10	89	16	3.8	599	0.00	0.34	28	23	28
06/24/96	99	64	81	62	12	88	19	4.5	592	0.00	0.34	25	20	25
06/25/96	97	67	83	61	15	89	13	4.0	661	0.00	0.35	27	22	27
06/26/96	95	66	82	105	23	90	22	9.3	563	0.50	0.33	26	21	26
06/27/96	84	67	74	105	50	87	14	5.5	430	0.04	0.18	26	21	26
06/28/96	90	68	78	96	40	86	13	5.2	618	0.02	0.28	27	22	27
06/29/96	90	67	77	100	38	85	22	5.8	425	0.26	0.21	27	22	27
06/30/96	91	67	80	90	27	85	15	5.3	690	0.00	0.33	27	22	27
07/01/96	95	70	83	77	24	86	11	4.2	730	0.00	0.36	28	23	28
07/02/96	94	73	83	68	27	87	14	5.1	654	0.00	0.34	30	25	30
07/03/96	91	74	81	70	29	88	12	4.7	570	0.00	0.29	30	25	30
07/04/96	95	71	83	79	24	90	11	3.7	699	0.00	0.34	29	24	29
07/05/96	99	71	86	79	19	83	9	3.9	721	0.00	0.37	29	24	29
07/06/96	99	70	87	70	19	77	12	5.1	685	0.00	0.37	28	23	28
07/07/96	100	72	87	68	17	76	11	4.5	723	0.00	0.39	29	24	29
07/08/96	101	74	86	65	15	79	18	5.5	702	0.00	0.40	30	25	30
07/09/96	97	70	83	102	23	83	16	6.3	633	0.25	0.34	28	23	28
07/10/96	94	68	79	103	32	84	19	4.0	559	0.24	0.27	27	22	27
07/11/96	-99	69	80	-1	-1	86	9	3.1	649	0.00	0.27	0	0	0
07/12/96	242	-4	72	125	0	87	14	4.3	644	0.00	4.98	18	16	18
07/13/96	93	72	71	78	29	89	18	3.0	136	0.00	0.12	29	24	29
07/14/96	80	69	74	85	54	84	9	2.7	93	0.04	0.04	25	20	25
07/15/96	86	66	75	96	44	83	15	5.3	201	0.19	0.11	26	21	26
07/16/96	89	66	76	95	41	84	21	3.8	282	0.10	0.14	26	21	26
07/17/96	93	68	80	96	30	86	13	3.5	320	0.02	0.17	27	22	27
07/18/96	96	69	81	86	27	87	17	4.3	284	0.00	0.18	28	23	28
07/19/96	93	69	81	89	31	87	9	3.6	291	0.00	0.16	28	23	28
07/20/96	97	70	82	82	25	87	25	4.7	282	0.00	0.19	28	23	28
07/21/96	93	68	82	86	30	87	9	4.0	294	0.00	0.17	27	22	27
07/22/96	97	70	85	77	22	88	9	4.5	315	0.00	0.20	28	23	28
07/23/96	97	73	84	72	26	88	20	5.4	289	0.00	0.20	30	25	30
07/24/96	96	68	84	76	23	87	12	4.9	298	0.00	0.20	27	22	27
07/25/96	94	67	81	82	23	87	27	5.4	289	0.02	0.19	27	22	27
07/26/96	94	69	82	71	25	87	10	3.9	301	0.00	0.18	28	23	28
07/27/96	95	70	83	73	26	87	15	5.8	284	0.00	0.20	28	23	28
07/28/96	95	70	83	73	25	89	18	4.8	317	0.01	0.20	28	23	28
07/29/96	97	75	86	63	21	85	12	3.9	306	0.00	0.20	31	26	31
07/30/96	99	73	85	68	22	88	16	4.7	284	0.00	0.20	30	25	30
07/31/96	94	73	82	76	25	88	18	4.8	277	0.00	0.18	30	25	30
08/01/96	95	68	81	91	29	90	6	2.4	117	0.11	0.08	27	22	27
08/02/96	87	70	77	82	38	85	0	3.6	270	0.00	0.14	28	23	28
08/03/96	87	69	78	84	44	85	0	3.0	380	0.00	0.17	28	23	28
08/04/96	92	71	82	75	27	84	0	5.2	523	0.00	0.28	29	24	29
08/05/96	95	67	82	76	19	85	0	3.2	635	0.00	0.32	27	22	27
08/06/96	96	78	83	43	16	88	10	2.0	375	0.00	0.22	32	27	32
08/07/96	92	70	79	79	29	84	19	6.6	513	0.00	0.29	28	23	28
08/08/96	89	68	77	87	33	84	14	4.3	370	0.00	0.19	27	22	27
08/09/96	87	71	78	74	36	84	11	5.2	587	0.00	0.28	29	24	29
08/10/96	90	68	77	81	35	85	16	4.0	520	0.00	0.25	27	22	27
08/11/96	94	66	80	87	19	85	13	3.8	630	0.00	0.31	26	21	26
08/12/96	96	65	81	64	17	85	10	3.3	637	0.00	0.33	26	21	26
08/13/96	97	62	81	76	18	85	10	2.8	630	0.00	0.31	24	19	24
08/14/96	98	64	81	76	13	85	12	3.2	625	0.00	0.33	25	20	25
08/15/96	98	64	82	73	15	85	10	3.0	623	0.00	0.32	25	20	25
08/16/96	98	67	83	61	18	85	23	4.2	575	0.00	0.32	27	22	27
08/17/96	93	69	79	76	25	86	27	5.2	613	0.00	0.32	28	23	28
08/18/96	91	66	78	78	26	85	10	3.2	566	0.00	0.27	26	21	26
08/19/96	93	66	79	86	27	85	15	4.3	530	0.03	0.27	26	21	26
08/20/96	90	67	77	95	32	85	15	5.1	547	0.00	0.27	27	22	27
08/21/96	90	66	78	89	30	85	15	5.4	458	0.06	0.24	26	21	26
08/22/96	91	69	81	75	22	84	12	6.0	454	0.00	0.26	28	23	28
08/23/96	87	70	79	68	32	83	15	6.5	418	0.00	0.24	28	23	28
08/24/96	87	65	76	81	37	82	13	5.7	480	0.00	0.24	26	21	26
08/25/96	82	67	74	90	54	82	13	4.7	363	0.07	0.16	25	20	25

08/26/96	86	67	73	96	44	81	13	4.2	391	0.40	0.18	27	22	27
08/27/96	87	65	74	97	41	82	10	3.0	492	0.12	0.21	26	21	26
08/28/96	83	68	73	95	51	83	11	3.7	327	0.00	0.14	26	21	26
08/29/96	88	64	76	98	38	82	10	3.9	551	0.00	0.24	25	20	25
08/30/96	89	68	77	86	36	84	8	3.8	580	0.00	0.27	27	22	27
08/31/96	93	65	79	91	25	84	15	4.4	582	0.00	0.29	26	21	26
09/01/96	95	66	80	86	20	84	19	5.0	504	0.00	0.28	26	21	26
09/02/96	90	66	77	74	29	84	17	4.4	480	0.00	0.25	26	21	26
09/03/96	91	64	76	85	28	84	11	3.8	525	0.00	0.26	25	20	25
09/04/96	89	63	74	86	32	83	14	3.2	482	0.00	0.23	25	20	25
09/05/96	87	64	75	89	35	83	13	3.6	463	0.00	0.21	25	20	25
09/06/96	92	63	77	95	24	84	8	2.7	563	0.00	0.26	25	20	25
09/07/96	94	63	78	85	20	85	13	4.4	561	0.00	0.29	25	20	25
09/08/96	91	66	77	78	28	85	15	5.0	547	0.00	0.28	26	21	26
09/09/96	90	66	75	74	27	84	16	5.9	511	0.00	0.28	26	21	26
09/10/96	89	65	75	82	23	84	15	4.9	480	0.00	0.25	26	21	26
09/11/96	84	60	73	107	44	84	15	6.5	494	0.70	0.22	22	17	22
09/12/96	76	60	65	102	59	79	19	4.0	279	0.34	0.10	18	13	18
09/13/96	83	60	70	99	42	80	19	3.1	504	0.00	0.21	22	17	22
09/14/96	77	62	67	101	52	80	20	4.7	346	0.12	0.14	20	15	20
09/15/96	80	56	68	100	28	78	14	5.4	559	0.00	0.25	18	13	18
09/16/96	83	55	68	92	33	77	11	3.2	528	0.00	0.23	19	14	19
09/17/96	83	59	70	87	23	77	10	3.2	518	0.00	0.23	21	16	21
09/18/96	83	57	70	90	25	77	13	3.8	542	0.00	0.25	20	15	20
09/19/96	82	57	68	77	29	77	11	4.3	535	0.00	0.25	20	15	20
09/20/96	85	58	71	80	21	77	11	3.2	525	0.00	0.25	22	17	22
09/21/96	88	55	71	70	17	76	10	2.6	528	0.00	0.25	21	16	21
09/22/96	91	55	72	83	18	77	11	3.0	513	0.00	0.26	21	16	21
09/23/96	90	56	72	79	17	77	10	3.0	513	0.00	0.26	21	16	21
09/24/96	86	56	71	83	30	77	13	4.8	439	0.00	0.22	21	16	21
09/25/96	86	60	72	90	28	78	18	5.9	485	0.00	0.25	23	18	23
09/26/96	82	56	70	84	25	77	18	5.2	439	0.06	0.22	19	14	19
09/27/96	80	55	68	71	16	75	16	5.1	511	0.00	0.26	18	13	18
09/28/96	79	47	63	76	19	74	7	2.7	504	0.00	0.22	15	12	15
09/29/96	83	50	67	78	17	74	11	3.5	504	0.00	0.24	17	14	17
09/30/96	85	54	69	64	25	74	10	3.3	480	0.00	0.23	20	15	20
10/01/96	88	56	71	81	23	75	9	2.6	477	0.00	0.23	21	16	21
10/02/96	89	55	74	83	17	76	16	6.0	482	0.00	0.27	21	16	21
10/03/96	77	61	68	68	40	77	18	9.5	482	0.00	0.25	19	14	19
10/04/96	81	59	70	77	38	77	15	8.0	446	0.00	0.23	20	15	20
10/05/96	80	61	69	90	38	78	13	4.1	434	0.00	0.19	21	16	21
10/06/96	84	55	69	88	33	77	8	2.6	449	0.00	0.20	20	15	20
10/07/96	86	55	70	84	22	77	11	2.7	437	0.00	0.21	21	16	21
10/08/96	86	55	69	83	28	76	8	3.0	434	0.00	0.21	21	16	21
10/09/96	92	53	71	88	17	76	7	2.2	434	0.00	0.22	20	16	20
10/10/96	91	55	72	81	18	76	9	3.4	430	0.00	0.23	21	16	21
10/11/96	90	53	72	72	16	76	8	2.8	427	0.00	0.22	20	16	20
10/12/96	90	55	71	62	17	76	7	2.1	420	0.00	0.22	21	16	21
10/13/96	89	55	71	71	17	76	9	2.7	418	0.00	0.22	21	16	21
10/14/96	85	52	70	77	20	75	17	3.3	396	0.02	0.20	19	15	19
10/15/96	82	56	68	93	26	75	18	3.5	403	0.00	0.19	19	14	19
10/16/96	82	50	66	85	24	74	18	4.5	427	0.00	0.21	16	14	16
10/17/96	83	50	66	68	21	73	11	2.9	422	0.00	0.21	17	14	17
10/18/96	75	51	62	61	24	72	12	4.1	422	0.00	0.20	13	10	13
10/19/96	81	50	66	72	27	71	15	4.8	284	0.00	0.16	16	13	16
10/20/96	75	58	66	71	28	71	19	5.9	329	0.00	0.18	17	12	17
10/21/96	64	36	53	76	11	69	26	9.4	377	0.00	0.21	7	5	7
10/22/96	58	29	42	88	18	65	11	3.2	430	0.00	0.15	4	2	4
10/23/96	67	28	48	72	21	63	9	2.7	408	0.00	0.16	9	6	9
10/24/96	71	37	55	76	15	64	11	3.1	394	0.00	0.17	11	8	11
10/25/96	74	36	57	61	16	63	23	7.1	358	0.00	0.21	12	10	12
10/26/96	64	43	48	99	33	62	20	6.8	124	0.03	0.09	7	5	7
10/27/96	62	44	51	103	65	61	14	7.0	253	0.09	0.08	6	4	6
10/28/96	65	44	52	90	52	60	22	7.1	263	0.00	0.11	8	5	8
10/29/96	62	38	48	85	26	58	11	3.6	403	0.00	0.15	6	4	6

10/30/96	73	33	51	95	18	57	7	2.1	370	0.00	0.15	12	9	12
10/31/96	76	42	57	88	12	58	15	3.5	391	0.00	0.19	13	11	13
11/01/96	69	36	53	80	17	58	10	3.9	382	0.00	0.17	10	7	10
11/02/96	65	46	54	62	20	58	10	3.6	191	0.00	0.11	8	5	8
11/03/96	75	50	60	56	21	58	14	6.5	251	0.00	0.18	13	10	13
11/04/96	69	40	53	70	23	58	9	2.9	370	0.00	0.16	10	7	10
11/05/96	73	36	52	81	20	57	9	2.5	243	0.00	0.12	12	9	12
11/06/96	70	34	52	81	15	57	16	4.7	372	0.00	0.18	10	8	10
11/07/96	64	35	49	65	10	55	14	4.3	377	0.00	0.17	7	5	7
11/08/96	67	36	49	48	10	54	9	3.3	365	0.00	0.17	9	6	9
11/09/96	74	34	51	61	17	54	9	2.9	358	0.00	0.17	12	10	12
11/10/96	75	36	52	62	13	55	7	2.5	356	0.00	0.17	13	10	13
11/11/96	77	35	53	65	15	54	7	2.1	332	0.00	0.16	14	11	14
11/12/96	77	35	54	69	16	55	8	2.2	339	0.00	0.16	14	11	14
11/13/96	74	38	54	63	20	55	8	2.3	325	0.00	0.15	12	10	12
11/14/96	75	40	56	69	20	55	9	2.9	255	0.00	0.13	13	10	13
11/15/96	67	48	58	55	28	55	14	5.3	122	0.00	0.09	9	6	9
11/16/96	63	40	56	54	29	55	20	8.7	239	0.00	0.14	7	4	7
11/17/96	68	33	49	70	29	54	9	2.5	322	0.00	0.13	9	7	9
11/18/96	75	36	53	80	20	54	10	2.5	325	0.00	0.15	13	10	13
11/19/96	79	37	56	72	22	55	7	2.3	322	0.00	0.16	15	12	15
11/20/96	79	37	58	73	12	55	12	3.3	279	0.00	0.16	15	12	15
11/21/96	79	37	55	60	13	55	9	2.1	317	0.00	0.16	15	12	15
11/22/96	77	38	56	65	21	55	13	2.9	291	0.00	0.15	14	11	14
11/23/96	63	43	52	68	25	55	17	5.1	243	0.00	0.12	7	4	7
11/24/96	60	36	48	76	26	54	13	4.2	313	0.00	0.13	5	3	5
11/25/96	62	29	43	75	24	52	7	2.0	308	0.00	0.11	6	4	6
11/26/96	63	28	47	69	18	51	13	4.5	291	0.00	0.14	7	4	7
11/27/96	57	37	45	62	29	51	13	3.7	258	0.00	0.11	4	1	4
11/28/96	42	36	39	101	61	50	10	3.0	53	0.02	0.01	0	0	0
11/29/96	55	36	42	97	49	51	23	5.3	177	0.04	0.06	3	0	3
11/30/96	51	34	41	85	40	49	17	7.2	279	0.00	0.10	1	0	1
12/01/96	55	25	39	81	28	48	9	3.0	306	0.00	0.10	3	0	3
12/02/96	58	25	40	86	21	47	13	3.7	275	0.00	0.11	4	2	4
12/03/96	59	30	41	68	20	47	9	3.7	298	0.00	0.12	5	2	5
12/04/96	63	25	43	73	10	46	13	3.3	298	0.00	0.13	7	4	7
12/05/96	66	23	45	72	13	46	17	4.1	325	0.00	0.15	8	6	8
12/06/96	66	34	52	52	18	47	18	6.1	284	0.00	0.16	8	6	8
12/07/96	65	37	51	79	32	49	9	2.8	282	0.00	0.11	8	5	8
12/08/96	69	39	51	74	29	50	9	3.3	286	0.00	0.13	10	7	10
12/09/96	73	37	54	76	26	50	8	3.3	277	0.00	0.13	12	9	12
12/10/96	70	42	57	69	30	51	18	4.4	227	0.00	0.12	10	8	10
12/11/96	69	44	56	82	32	52	13	4.5	282	0.00	0.13	10	7	10
12/12/96	69	37	51	86	31	51	7	2.2	279	0.00	0.11	10	7	10
12/13/96	70	35	50	81	31	51	10	3.0	282	0.00	0.12	10	8	10
12/14/96	71	34	50	84	18	50	10	3.5	282	0.00	0.14	11	8	11
12/15/96	45	25	38	65	29	49	14	4.7	160	0.00	0.06	0	0	0
12/16/96	54	19	37	75	20	46	9	3.2	289	0.00	0.10	2	0	2
12/17/96	44	20	33	59	30	45	13	4.8	289	0.00	0.09	0	0	0
12/18/96	36	12	24	73	11	42	10	2.8	296	0.00	0.07	0	0	0
12/19/96	46	13	28	57	13	41	7	2.3	286	0.00	0.09	0	0	0
12/20/96	52	17	33	48	15	40	9	2.9	289	0.00	0.10	1	0	1
12/21/96	60	22	38	54	19	41	7	2.4	193	0.00	0.09	5	3	5
12/22/96	66	26	47	64	16	42	15	3.7	243	0.00	0.12	8	6	8
12/23/96	61	39	49	55	24	44	15	5.5	279	0.00	0.14	6	3	6
12/24/96	56	31	41	55	18	44	13	4.4	279	0.00	0.12	3	1	3
12/25/96	56	31	41	55	18	44	13	4.4	279	0.00	0.12	3	1	3
12/26/96	67	22	41	67	13	43	9	2.5	286	0.00	0.13	9	6	9
12/27/96	65	29	47	55	20	44	12	2.8	241	0.00	0.11	8	5	8
12/28/96	65	29	47	55	20	44	12	2.8	241	0.00	0.11	8	5	8
12/29/96	61	28	44	81	26	46	10	3.0	272	0.00	0.11	6	3	6
12/30/96	66	30	46	67	23	46	9	3.1	258	0.00	0.12	8	6	8
12/31/96	63	28	45	68	22	45	9	3.0	301	0.00	0.12	7	4	7
01/01/97	69	43	54	70	31	49	9	2.6	232	0.00	0.10	10	7	10
01/02/97	72	37	54	84	33	49	14	3.8	279	0.00	0.13	11	9	11

01/03/97	71	41	58	99	43	51	19	6.8	224	0.10	0.11	11	8	11
01/04/97	61	48	53	99	36	52	19	6.3	289	0.08	0.12	6	3	6
01/05/97	52	40	47	94	59	51	14	3.0	57	0.00	0.01	1	0	1
01/06/97	46	23	36	101	56	48	18	5.7	79	0.02	0.03	0	0	0
01/07/97	30	18	24	99	61	46	10	4.3	148	0.00	0.03	0	0	0
01/08/97	34	10	22	98	59	44	10	3.2	291	0.00	0.05	0	0	0
01/09/97	44	17	30	97	43	42	10	3.1	327	0.06	0.08	0	0	0
01/10/97	53	23	37	96	41	42	9	3.1	322	0.00	0.09	2	0	2
01/11/97	56	31	44	91	38	43	16	4.9	286	0.00	0.10	3	1	3
01/12/97	45	29	39	77	41	44	17	6.6	270	0.00	0.09	0	0	0
01/13/97	33	24	28	69	49	42	15	6.6	127	0.00	0.04	0	0	0
01/14/97	52	26	38	73	42	42	16	5.8	251	0.00	0.09	1	0	1
01/15/97	52	26	38	85	24	43	11	3.5	325	0.00	0.11	1	0	1
01/16/97	52	26	30	85	24	43	10	3.5	325	0.00	0.10	1	0	1
01/17/97	55	28	40	82	29	42	11	4.1	317	0.00	0.11	3	0	3
01/18/97	58	28	41	71	25	43	12	4.8	284	0.00	0.12	4	2	4
01/19/97	60	33	45	68	25	44	10	4.7	272	0.00	0.12	5	3	5
01/20/97	65	43	51	86	35	47	12	2.8	215	0.00	0.09	8	5	8
01/21/97	60	40	49	99	25	47	21	5.8	234	0.02	0.11	5	3	5
01/22/97	58	29	45	79	32	46	12	2.6	251	0.00	0.09	4	2	4
01/23/97	64	39	50	71	27	46	20	6.5	258	0.00	0.14	7	5	7
01/24/97	63	34	49	81	26	47	14	4.0	339	0.00	0.14	7	4	7
01/25/97	67	29	48	86	23	47	9	2.8	332	0.00	0.13	9	6	9
01/26/97	66	40	51	69	25	48	17	5.1	232	0.00	0.13	8	6	8
01/27/97	63	39	52	92	28	49	13	4.3	341	0.00	0.14	7	4	7
01/28/97	52	30	41	77	28	47	14	4.5	339	0.00	0.12	1	0	1
01/29/97	58	31	45	73	27	47	14	3.6	232	0.00	0.10	4	2	4
01/30/97	61	33	45	75	29	47	9	3.7	351	0.00	0.13	6	3	6
01/31/97	70	32	48	71	19	47	9	3.7	360	0.00	0.17	10	8	10
02/01/97	71	33	52	66	15	48	9	3.3	360	0.00	0.17	11	8	11
02/02/97	70	32	50	69	15	48	14	3.2	365	0.00	0.16	10	8	10
02/03/97	64	33	48	71	16	49	12	3.7	377	0.00	0.16	7	5	7
02/04/97	61	34	49	56	21	48	17	7.3	327	0.00	0.17	6	3	6
02/05/97	61	41	52	57	28	49	14	6.4	246	0.00	0.13	6	3	6
02/06/97	63	34	49	79	11	49	20	7.6	377	0.00	0.19	7	4	7
02/07/97	55	25	40	59	20	48	12	3.5	394	0.00	0.14	3	0	3
02/08/97	56	32	43	54	29	47	14	4.9	296	0.00	0.12	3	1	3
02/09/97	61	28	44	77	21	48	10	2.6	384	0.00	0.14	6	3	6
02/10/97	64	26	44	56	12	47	12	2.9	399	0.00	0.16	7	5	7
02/11/97	68	31	49	55	19	48	17	4.7	320	0.00	0.16	9	7	9
02/12/97	62	38	49	81	26	50	11	3.4	387	0.00	0.14	6	4	6
02/13/97	51	35	44	97	41	50	13	4.9	177	0.06	0.06	1	0	1
02/14/97	56	27	41	100	35	48	8	2.4	415	0.00	0.12	3	1	3
02/15/97	64	27	45	92	24	48	7	2.4	403	0.00	0.14	7	5	7
02/16/97	69	34	50	66	18	49	10	3.5	394	0.00	0.17	10	7	10
02/17/97	71	36	54	58	17	50	11	3.9	329	0.00	0.16	11	8	11
02/18/97	67	45	53	102	29	52	21	4.8	174	0.16	0.09	9	6	9
02/19/97	61	42	50	104	46	52	12	4.7	303	0.00	0.10	6	3	6
02/20/97	68	38	52	95	23	53	17	6.2	420	0.00	0.19	9	7	9
02/21/97	55	38	47	76	13	52	15	5.8	451	0.00	0.18	3	0	3
02/22/97	56	29	45	82	29	49	16	6.2	446	0.00	0.16	3	1	3
02/23/97	64	36	51	79	23	50	13	6.2	315	0.00	0.15	7	5	7
02/24/97	62	38	49	85	33	51	28	9.4	422	0.00	0.19	6	4	6
02/25/97	41	35	37	87	60	48	17	6.6	76	0.00	0.03	0	0	0
02/26/97	56	33	45	93	29	48	17	6.3	399	0.00	0.15	3	1	3
02/27/97	60	35	49	65	21	50	18	6.9	339	0.00	0.16	5	3	5
02/28/97	55	39	47	94	40	51	20	7.1	306	0.04	0.11	3	0	3
03/01/97	53	37	43	95	26	51	14	4.9	322	0.00	0.11	2	0	2
03/02/97	62	28	46	77	16	50	12	3.8	482	0.00	0.18	6	4	6
03/03/97	72	35	53	70	10	51	14	4.4	487	0.00	0.22	11	9	11
03/04/97	71	34	55	69	10	52	20	5.7	494	0.00	0.24	11	8	11
03/05/97	64	36	49	48	13	52	14	5.2	501	0.00	0.22	7	5	7
03/06/97	69	32	50	50	19	52	13	3.9	485	0.00	0.20	10	7	10
03/07/97	78	40	58	64	16	54	9	2.8	470	0.00	0.21	14	12	14
03/08/97	79	44	61	61	10	56	15	3.2	451	0.00	0.22	15	12	15

03/09/97	77	50	63	31	8	57	17	7.7	473	0.00	0.30	14	11	14
03/10/97	77	39	57	50	11	57	9	3.1	504	0.00	0.23	14	11	14
03/11/97	78	42	59	43	9	57	10	3.3	511	0.00	0.25	14	12	14
03/12/97	80	43	59	67	17	58	21	3.2	434	0.00	0.21	15	13	15
03/13/97	82	41	62	70	9	59	18	4.6	518	0.00	0.27	16	14	16
03/14/97	68	41	56	54	23	59	16	6.1	518	0.00	0.23	9	7	9
03/15/97	78	38	58	63	11	59	11	3.0	520	0.00	0.24	14	12	14
03/16/97	81	46	63	53	14	60	14	3.5	506	0.00	0.25	16	13	16
03/17/97	79	48	64	46	13	61	17	5.1	468	0.00	0.25	15	12	15
03/18/97	76	47	63	44	12	62	14	6.0	547	0.00	0.28	13	11	13
03/19/97	75	41	59	56	15	62	8	2.8	537	0.00	0.23	13	10	13
03/20/97	82	41	61	61	10	62	8	2.1	539	0.00	0.24	16	14	16
03/21/97	87	43	65	57	10	63	11	2.7	539	0.00	0.27	18	16	18
03/22/97	78	47	63	52	16	65	8	3.0	539	0.00	0.24	14	12	14
03/23/97	82	48	64	71	10	66	16	4.0	501	0.00	0.25	16	14	16
03/24/97	73	50	62	66	13	65	22	6.6	542	0.00	0.27	12	9	12
03/25/97	60	42	47	96	28	60	16	7.2	251	0.04	0.12	5	3	5
03/26/97	64	37	48	99	34	59	18	6.6	456	0.12	0.18	7	5	7
03/27/97	69	40	56	107	22	60	20	5.8	573	0.00	0.23	10	7	10
03/28/97	76	44	60	60	14	61	15	4.7	582	0.00	0.27	13	11	13
03/29/97	76	41	68	66	15	62	15	4.0	570	0.00	0.25	13	11	13
03/30/97	64	45	55	60	14	60	15	6.7	320	0.00	0.17	7	5	7
03/31/97	68	49	57	72	23	60	10	4.6	365	0.00	0.17	9	7	9
04/01/97	75	43	60	87	13	61	15	5.7	573	0.00	0.27	13	10	13
04/02/97	77	41	63	58	10	62	15	4.8	599	0.00	0.28	14	11	14
04/03/97	75	43	59	83	18	63	24	4.9	568	0.08	0.25	13	10	13
04/04/97	55	40	47	77	28	61	22	8.7	508	0.00	0.20	3	0	3
04/05/97	64	44	53	66	24	59	19	8.1	468	0.00	0.22	7	5	7
04/06/97	69	44	57	65	18	61	14	3.7	568	0.00	0.23	10	7	10
04/07/97	75	41	59	67	16	62	15	4.1	609	0.00	0.26	13	10	13
04/08/97	76	44	61	55	13	63	14	5.1	616	0.00	0.29	13	11	13
04/09/97	82	53	66	54	10	64	18	7.8	618	0.00	0.35	18	14	18
04/10/97	77	48	63	40	10	64	23	7.1	597	0.00	0.32	14	11	14
04/11/97	62	41	50	73	19	62	19	6.2	432	0.00	0.19	6	4	6
04/12/97	63	40	51	77	24	62	17	6.8	602	0.00	0.24	7	4	7
04/13/97	64	38	52	67	22	63	12	3.9	621	0.00	0.23	7	5	7
04/14/97	73	39	57	69	16	63	12	3.6	625	0.00	0.26	12	9	12
04/15/97	79	42	61	62	11	64	10	3.2	630	0.00	0.28	15	12	15
04/16/97	81	45	65	54	11	65	20	5.0	602	0.00	0.30	16	13	16
04/17/97	75	56	63	70	25	66	19	5.0	358	0.01	0.18	16	11	16
04/18/97	78	51	63	85	24	67	13	3.8	549	0.00	0.24	15	12	15
04/19/97	84	47	66	71	13	67	17	3.8	580	0.00	0.28	17	15	17
04/20/97	84	50	69	56	11	68	15	4.6	580	0.00	0.30	17	15	17
04/21/97	87	54	73	50	14	69	20	6.0	516	0.00	0.30	20	16	20
04/22/97	86	58	73	67	16	70	17	6.3	539	0.00	0.30	22	17	22
04/23/97	73	54	65	63	22	68	15	6.0	349	0.00	0.19	14	9	14
04/24/97	74	45	59	89	22	66	22	7.8	325	0.01	0.19	12	10	12
04/25/97	54	41	46	93	44	63	16	6.2	198	0.02	0.08	2	0	2
04/26/97	60	39	49	92	41	63	11	5.0	415	0.00	0.14	5	3	5
04/27/97	71	40	57	98	27	65	11	3.4	637	0.00	0.24	11	8	11
04/28/97	84	45	67	83	13	67	17	5.6	664	0.00	0.33	17	15	17
04/29/97	86	52	70	53	11	68	20	6.4	609	0.00	0.34	19	16	19
04/30/97	84	54	70	33	11	69	13	4.9	609	0.00	0.32	19	15	19
05/01/97	86	51	71	48	12	70	20	6.9	671	0.00	0.37	19	16	19
05/02/97	83	49	67	66	10	72	14	4.0	666	0.00	0.32	17	14	17
05/03/97	87	47	70	46	9	72	12	4.2	668	0.00	0.34	18	16	18
05/04/97	89	60	76	39	15	74	11	4.2	554	0.00	0.30	23	18	23
05/05/97	94	53	77	50	10	75	17	3.6	630	0.00	0.33	20	16	20
05/06/97	96	62	79	44	11	76	14	4.0	549	0.00	0.32	24	19	24
05/07/97	92	54	74	57	11	75	13	3.4	508	0.00	0.28	20	16	20
05/08/97	92	56	75	57	10	75	9	2.8	535	0.00	0.28	21	16	21
05/09/97	78	59	68	66	30	76	17	7.1	644	0.00	0.31	19	14	19
05/10/97	81	57	67	82	27	77	18	7.3	640	0.00	0.31	19	14	19
05/11/97	79	57	67	89	30	77	12	4.1	477	0.00	0.21	18	13	18
05/12/97	80	56	68	86	29	78	10	4.0	625	0.00	0.27	18	13	18

05/13/97	89	56	73	81	12	79	12	3.4	676	0.00	0.32	21	16	21
05/14/97	94	57	75	53	11	80	17	4.0	678	0.00	0.36	22	17	22
05/15/97	91	58	75	74	18	80	21	5.4	604	0.00	0.32	22	17	22
05/16/97	88	62	76	66	21	82	18	4.9	635	0.00	0.32	24	19	24
05/17/97	90	62	77	66	19	83	14	4.0	578	0.00	0.29	24	19	24
05/18/97	91	64	77	62	21	83	20	5.2	587	0.00	0.32	25	20	25
05/19/97	88	62	73	95	22	83	16	5.1	573	0.02	0.28	24	19	24
05/20/97	79	58	67	95	37	81	17	4.4	477	0.01	0.20	19	14	19
05/21/97	83	59	69	93	22	81	10	4.4	582	0.00	0.27	21	16	21
05/22/97	81	57	68	73	25	80	18	4.0	449	0.00	0.22	19	14	19
05/23/97	87	54	71	88	19	80	16	3.0	616	0.00	0.28	20	16	20
05/24/97	89	61	75	59	19	80	15	5.7	537	0.00	0.30	24	19	24
05/25/97	86	62	75	44	18	82	16	6.3	697	0.00	0.37	24	19	24
05/26/97	87	63	75	47	11	83	14	5.2	685	0.00	0.36	25	20	25
05/27/97	88	58	73	44	11	83	10	4.1	692	0.00	0.35	22	17	22
05/28/97	92	57	76	48	16	84	9	3.1	676	0.00	0.33	22	17	22
05/29/97	97	63	81	64	10	86	13	4.5	647	0.00	0.36	25	20	25
05/30/97	100	60	82	46	11	87	15	3.5	685	0.00	0.37	23	18	23
05/31/97	93	70	81	73	30	89	14	5.4	578	0.00	0.30	28	23	28
06/01/97	101	64	83	84	7	90	12	3.7	692	0.00	0.37	25	20	25
06/02/97	100	59	82	46	7	89	14	4.6	716	0.00	0.41	23	18	23
06/03/97	101	58	82	45	6	89	11	3.3	697	0.00	0.38	22	17	22
06/04/97	100	67	84	61	11	91	14	4.7	621	0.00	0.36	27	22	27
06/05/97	94	65	81	68	14	90	17	5.4	599	0.00	0.34	26	21	26
06/06/97	91	63	75	99	19	80	19	7.0	365	0.51	0.24	25	20	25
06/07/97	81	61	70	91	38	78	19	7.5	477	0.20	0.23	21	16	21
06/08/97	85	58	71	90	19	78	12	4.5	602	0.00	0.29	22	17	22
06/09/97	88	57	74	82	16	79	10	3.5	702	0.00	0.33	22	17	22
06/10/97	95	59	78	74	11	81	11	3.9	702	0.00	0.36	23	18	23
06/11/97	96	64	81	79	11	83	14	4.7	680	0.00	0.36	25	20	25
06/12/97	91	63	77	52	14	80	20	4.8	561	0.00	0.31	25	20	25
06/13/97	92	62	78	57	11	79	16	5.0	711	0.00	0.38	24	19	24
06/14/97	79	61	68	83	29	76	20	5.8	248	0.00	0.15	20	15	20
06/15/97	77	59	68	107	52	76	11	4.9	511	0.55	0.20	18	13	18
06/16/97	86	56	72	95	16	77	15	4.2	690	0.00	0.32	21	16	21
06/17/97	93	55	76	85	14	79	9	3.0	704	0.00	0.34	21	16	21
06/18/97	96	60	80	80	13	80	10	3.8	707	0.00	0.36	23	18	23
06/19/97	100	65	84	63	10	82	20	4.1	685	0.00	0.38	26	21	26
06/20/97	100	63	83	66	9	82	15	4.3	707	0.00	0.39	25	20	25
06/21/97	98	63	82	50	9	82	11	3.4	714	0.00	0.38	25	20	25
06/22/97	98	59	82	36	10	82	15	4.0	709	0.00	0.39	23	18	23
06/23/97	97	64	82	36	10	82	17	4.9	718	0.00	0.41	25	20	25
06/24/97	96	61	80	38	10	82	14	3.6	716	0.00	0.38	24	19	24
06/25/97	98	58	79	53	8	82	18	4.9	678	0.00	0.39	22	17	22
06/26/97	95	68	79	83	20	83	23	6.6	621	0.10	0.35	27	22	27
06/27/97	94	65	80	70	21	84	19	4.0	673	0.00	0.34	26	21	26
06/28/97	96	66	82	64	17	85	9	2.9	613	0.00	0.31	26	21	26
06/29/97	101	63	83	64	11	84	10	3.0	673	0.00	0.36	25	20	25
06/30/97	102	64	85	69	12	85	10	3.1	687	0.00	0.36	25	20	25
07/01/97	105	68	87	55	11	86	8	3.1	697	0.00	0.38	27	22	27
07/02/97	104	65	88	47	11	86	14	4.9	704	0.00	0.41	26	21	26
07/03/97	103	72	88	50	13	88	13	4.8	671	0.00	0.39	29	24	29
07/04/97	94	68	81	82	28	88	28	9.1	633	0.01	0.36	27	22	27
07/05/97	95	64	80	83	25	87	10	3.9	676	0.00	0.33	25	20	25
07/06/97	97	67	84	66	16	87	22	6.6	671	0.00	0.39	27	22	27
07/07/97	98	72	83	57	14	88	21	6.1	637	0.08	0.38	29	24	29
07/08/97	96	67	81	69	17	87	17	4.7	582	0.00	0.32	27	22	27
07/09/97	96	68	81	60	14	86	17	5.0	602	0.00	0.34	27	22	27
07/10/97	84	69	76	69	34	85	10	4.6	332	0.00	0.18	27	22	27
07/11/97	92	60	76	76	15	84	12	4.2	635	0.00	0.33	23	18	23
07/12/97	96	65	82	64	18	85	11	3.6	678	0.00	0.35	26	21	26
07/13/97	100	68	85	65	11	88	16	3.9	678	0.00	0.37	27	22	27
07/14/97	100	68	85	65	17	88	20	4.6	570	0.00	0.33	27	22	27
07/15/97	99	68	86	72	14	89	14	5.2	671	0.00	0.37	27	22	27
07/16/97	96	71	85	60	19	88	10	4.1	480	0.00	0.27	29	24	29

07/17/97	99	68	85	67	12	88	10	3.6	604	0.00	0.33	27	22	27
07/18/97	99	72	86	55	16	90	20	4.3	582	0.00	0.33	29	24	29
07/19/97	100	72	85	63	14	90	21	5.6	592	0.00	0.36	29	24	29
07/20/97	97	71	85	83	17	91	16	5.1	661	0.07	0.35	29	24	29
07/21/97	94	65	78	102	27	90	19	5.1	680	0.12	0.33	26	21	26
07/22/97	93	69	79	91	29	89	14	4.9	618	0.00	0.30	28	23	28
07/23/97	96	70	83	82	21	90	10	4.2	654	0.00	0.33	28	23	28
07/24/97	95	70	81	79	28	91	18	4.9	551	0.00	0.29	28	23	28
07/25/97	93	65	78	99	29	90	20	4.5	635	0.25	0.30	26	21	26
07/26/97	93	67	79	96	34	90	13	4.3	640	0.00	0.30	27	22	27
07/27/97	92	68	79	100	28	89	16	4.4	501	0.13	0.25	27	22	27
07/28/97	84	67	74	105	44	86	11	4.4	313	0.09	0.14	26	21	26
07/29/97	88	67	76	97	32	86	14	5.0	532	0.00	0.25	27	22	27
07/30/97	87	64	73	103	48	87	12	4.4	542	0.22	0.23	25	20	25
07/31/97	89	67	77	102	42	87	11	3.7	494	0.06	0.22	27	22	27
08/01/97	93	66	78	93	36	86	39	4.6	547	1.16	0.26	26	21	26
08/02/97	92	69	81	94	28	85	12	4.4	566	0.00	0.28	28	23	28
08/03/97	94	68	82	94	26	86	11	3.3	582	0.00	0.28	27	22	27
08/04/97	95	68	83	77	25	87	17	6.1	602	0.00	0.33	27	22	27
08/05/97	86	72	79	84	42	86	11	3.9	334	0.01	0.16	29	24	29
08/06/97	93	66	79	93	28	87	14	4.4	618	0.00	0.30	26	21	26
08/07/97	83	66	74	86	43	87	11	5.4	468	0.00	0.22	25	20	25
08/08/97	89	64	77	88	40	87	11	4.5	594	0.00	0.27	25	20	25
08/09/97	93	65	80	88	26	88	13	4.8	687	0.00	0.32	26	21	26
08/10/97	94	67	81	81	27	89	12	3.5	618	0.00	0.30	27	22	27
08/11/97	96	69	83	76	23	90	13	4.3	590	0.00	0.31	28	23	28
08/12/97	94	71	80	67	29	89	20	4.5	439	0.00	0.25	29	24	29
08/13/97	91	68	78	100	33	90	13	4.9	520	0.27	0.25	27	22	27
08/14/97	90	65	74	106	35	88	19	4.0	530	0.18	0.24	26	21	26
08/15/97	93	64	78	98	24	87	9	2.6	594	0.00	0.27	25	20	25
08/16/97	94	66	81	86	19	87	10	2.8	585	0.00	0.28	26	21	26
08/17/97	94	69	79	91	26	87	13	3.5	501	0.06	0.25	28	23	28
08/18/97	89	68	77	96	44	88	7	3.0	504	0.00	0.22	27	22	27
08/19/97	95	69	81	94	29	90	13	2.9	594	0.00	0.28	28	23	28
08/20/97	98	69	83	88	23	91	12	3.9	597	0.00	0.31	28	23	28
08/21/97	96	68	83	92	24	92	17	4.2	587	0.02	0.30	27	22	27
08/22/97	97	72	82	86	27	91	12	4.0	456	0.00	0.25	29	24	29
08/23/97	92	69	79	89	33	91	18	4.8	561	0.60	0.28	28	23	28
08/24/97	91	69	80	96	31	90	11	4.2	592	0.00	0.28	28	23	28
08/25/97	92	66	80	80	26	88	9	3.5	602	0.00	0.29	26	21	26
08/26/97	93	65	79	81	20	88	8	2.8	594	0.00	0.29	26	21	26
08/27/97	96	63	79	80	16	88	8	2.3	590	0.00	0.29	25	20	25
08/28/97	99	62	81	82	13	89	8	2.5	582	0.00	0.30	24	19	24
08/29/97	96	67	81	68	21	89	8	2.4	461	0.00	0.24	27	22	27
08/30/97	98	70	82	61	20	90	21	3.6	559	0.00	0.31	28	23	28
08/31/97	95	66	82	77	15	91	15	5.4	568	0.00	0.32	26	21	26
09/01/97	95	72	84	53	16	92	14	6.7	573	0.00	0.35	29	24	29
09/02/97	95	69	83	57	20	92	16	6.1	566	0.00	0.33	28	23	28
09/03/97	93	72	83	62	24	92	17	6.3	547	0.00	0.31	29	24	29
09/04/97	90	69	80	74	32	92	11	4.5	487	0.00	0.25	28	23	28
09/05/97	93	68	81	76	30	92	9	3.6	551	0.00	0.27	27	22	27
09/06/97	93	69	82	74	25	93	11	3.7	539	0.00	0.27	28	23	28
09/07/97	95	68	83	64	26	93	9	3.6	523	0.00	0.27	27	22	27
09/08/97	97	68	83	57	16	93	10	4.3	547	0.00	0.31	27	22	27
09/09/97	97	67	83	70	22	93	19	4.6	542	0.08	0.30	27	22	27
09/10/97	92	70	80	75	29	91	16	5.2	508	0.00	0.27	28	23	28
09/11/97	90	66	78	98	30	90	17	5.0	525	0.32	0.26	26	21	26
09/12/97	91	67	77	90	33	88	17	3.4	489	0.00	0.23	27	22	27
09/13/97	94	67	80	92	26	89	16	3.3	528	0.00	0.26	27	22	27
09/14/97	93	68	79	84	29	90	19	4.8	482	0.00	0.25	27	22	27
09/15/97	95	67	80	88	29	91	15	3.4	477	0.00	0.24	27	22	27
09/16/97	95	68	81	87	27	91	9	2.8	454	0.00	0.23	27	22	27
09/17/97	97	70	82	69	24	91	10	3.5	504	0.00	0.27	28	23	28
09/18/97	92	69	80	77	30	90	18	5.0	370	0.00	0.21	28	23	28
09/19/97	96	67	82	87	24	90	10	3.3	463	0.00	0.24	27	22	27

09/20/97	90	70	79	66	30	90	22	8.8	454	0.00	0.29	28	23	28
09/21/97	75	59	68	104	55	84	26	6.9	143	0.28	0.07	17	12	17
09/22/97	80	58	68	106	52	81	11	3.2	487	0.00	0.18	19	14	19
09/23/97	84	60	72	105	33	82	15	4.2	492	0.00	0.22	22	17	22
09/24/97	77	65	70	79	45	80	12	4.0	284	0.00	0.13	21	16	21
09/25/97	84	63	73	84	28	81	12	3.9	427	0.00	0.21	24	19	24
09/26/97	92	60	74	93	1	82	8	2.0	480	0.00	0.25	23	18	23
09/27/97	90	61	74	82	18	83	12	3.2	475	0.00	0.24	24	19	24
09/28/97	90	58	75	76	20	82	11	3.7	489	0.00	0.25	22	17	22
09/29/97	89	58	74	73	28	83	10	3.2	482	0.00	0.23	22	17	22
09/30/97	93	62	76	83	18	84	11	2.7	451	0.00	0.23	24	19	24
10/01/97	93	63	77	65	18	84	12	4.8	468	0.00	0.27	25	20	25
10/02/97	88	64	75	85	24	85	11	3.8	444	0.02	0.22	25	20	25
10/03/97	90	63	77	82	22	84	15	4.2	465	0.00	0.24	25	20	25
10/04/97	88	61	74	77	20	84	10	4.0	470	0.00	0.24	24	19	24
10/05/97	90	55	72	71	17	82	8	2.6	465	0.00	0.24	21	16	21
10/06/97	89	58	74	73	20	82	15	4.1	427	0.00	0.23	22	17	22
10/07/97	82	58	69	84	30	81	21	5.0	272	0.05	0.15	20	15	20
10/08/97	78	54	66	90	32	78	13	3.5	420	0.00	0.18	16	12	16
10/09/97	87	55	71	79	19	79	14	5.6	449	0.00	0.25	21	16	21
10/10/97	88	70	78	66	26	82	17	9.4	446	0.04	0.29	28	23	28
10/11/97	90	58	75	74	15	82	21	10.1	403	0.05	0.30	22	17	22
10/12/97	65	47	57	42	12	75	18	8.2	465	0.00	0.25	8	5	8
10/13/97	70	39	52	74	10	72	11	3.8	473	0.00	0.21	10	8	10
10/14/97	74	39	57	77	11	70	12	4.3	458	0.00	0.22	12	10	12
10/15/97	76	40	63	71	14	71	7	2.3	451	0.00	0.20	13	11	13
10/16/97	76	40	58	73	14	70	11	3.0	456	0.00	0.21	13	11	13
10/17/97	77	43	58	72	15	70	6	2.1	444	0.00	0.19	14	11	14
10/18/97	81	39	59	82	11	70	7	1.8	439	0.00	0.20	16	13	16
10/19/97	83	41	60	72	10	70	7	1.7	427	0.00	0.20	17	14	17
10/20/97	78	45	61	68	20	70	13	2.7	380	0.00	0.18	14	12	14
10/21/97	77	44	61	77	21	70	12	4.1	403	0.00	0.19	14	11	14
10/22/97	73	49	60	91	36	71	17	6.1	337	0.19	0.16	12	9	12
10/23/97	71	46	58	90	29	68	16	5.6	413	0.00	0.18	11	8	11
10/24/97	72	38	57	88	20	66	19	7.3	413	0.09	0.21	11	9	11
10/25/97	57	37	48	94	24	64	18	5.8	387	0.02	0.15	4	1	4
10/26/97	60	35	45	75	24	60	12	3.6	408	0.00	0.15	5	3	5
10/27/97	62	32	48	88	23	59	7	2.4	296	0.00	0.11	6	4	6
10/28/97	72	39	54	87	18	61	8	2.3	391	0.00	0.16	11	9	11
10/29/97	75	38	56	85	21	61	12	2.9	370	0.00	0.17	13	10	13
10/30/97	76	38	56	83	14	61	10	2.4	387	0.00	0.17	13	11	13
10/31/97	82	41	62	73	13	62	12	3.5	387	0.00	0.20	16	14	16
11/01/97	80	42	61	71	14	63	13	3.7	382	0.00	0.20	15	13	15
11/02/97	74	42	57	58	10	63	8	3.3	382	0.00	0.19	12	10	12
11/03/97	74	35	54	69	12	61	7	2.4	375	0.00	0.17	12	10	12
11/04/97	79	40	57	71	10	62	9	2.6	358	0.00	0.18	15	12	15
11/05/97	73	38	55	66	17	61	9	2.9	353	0.00	0.16	12	9	12
11/06/97	73	40	56	63	20	61	11	3.1	325	0.00	0.16	12	9	12
11/07/97	76	41	57	73	16	62	11	2.1	344	0.00	0.16	13	11	13
11/08/97	74	39	56	71	16	61	17	3.7	353	0.00	0.17	12	10	12
11/09/97	71	44	55	60	23	61	13	3.3	205	0.00	0.12	11	8	11
11/10/97	56	38	47	68	37	60	12	5.1	301	0.00	0.12	3	1	3
11/11/97	49	42	45	99	52	57	12	2.4	41	0.10	0.01	0	0	0
11/12/97	53	44	48	101	83	56	10	3.6	91	0.18	0.01	2	0	2
11/13/97	58	45	51	99	42	57	20	7.4	322	0.07	0.12	4	2	4
11/14/97	62	39	50	88	38	55	21	5.4	298	0.00	0.12	6	4	6
11/15/97	54	31	46	90	45	53	9	3.3	332	0.00	0.10	2	0	2
11/16/97	58	32	43	89	38	52	8	3.0	322	0.00	0.11	4	2	4
11/17/97	59	33	45	93	44	52	7	2.4	313	0.00	0.10	5	2	5
11/18/97	63	34	46	95	20	52	10	3.0	322	0.00	0.13	7	4	7
11/19/97	67	31	47	89	24	52	7	2.3	313	0.00	0.12	9	6	9
11/20/97	71	39	55	74	16	53	14	4.1	251	0.00	0.14	11	8	11
11/21/97	63	40	49	74	24	53	8	2.8	289	0.00	0.12	7	4	7
11/22/97	65	37	48	81	14	52	11	2.7	313	0.00	0.13	8	5	8
11/23/97	68	34	48	69	18	52	9	3.2	310	0.00	0.14	9	7	9

11/24/97	73	34	50	78	18	52	7	1.9	308	0.00	0.14	12	9	12
11/25/97	71	35	51	80	24	52	7	2.0	270	0.00	0.12	11	8	11
11/26/97	72	36	54	87	15	52	13	2.9	205	0.00	0.11	11	9	11
11/27/97	68	44	53	73	33	54	17	5.1	193	0.01	0.11	9	7	9
11/28/97	59	33	46	81	28	52	13	4.1	303	0.00	0.12	5	2	5
11/29/97	61	29	44	83	25	51	9	2.4	298	0.00	0.11	6	3	6
11/30/97	59	29	46	80	26	50	12	3.3	234	0.00	0.09	5	2	5
12/01/97	62	43	50	96	30	52	10	2.9	184	0.05	0.08	6	4	6
12/02/97	50	39	44	98	57	51	15	4.5	160	0.04	0.05	0	0	0
12/03/97	56	31	43	96	32	49	15	4.6	267	0.00	0.10	3	1	3
12/04/97	55	29	39	80	22	48	8	3.3	301	0.00	0.11	3	0	3
12/05/97	58	28	40	83	24	46	8	3.1	296	0.00	0.11	4	2	4
12/06/97	61	30	45	77	30	47	9	3.8	253	0.00	0.10	6	3	6
12/07/97	57	42	49	99	57	50	15	5.4	138	0.13	0.05	4	1	4
12/08/97	62	44	52	94	34	51	21	6.8	265	0.02	0.12	6	4	6
12/09/97	49	35	43	81	27	50	22	9.5	291	0.00	0.13	0	0	0
12/10/97	47	26	35	86	22	45	11	3.5	239	0.00	0.08	0	0	0
12/11/97	40	28	33	77	24	43	16	5.4	196	0.00	0.07	0	0	0
12/12/97	45	21	32	67	11	41	14	3.7	291	0.00	0.10	0	0	0
12/13/97	53	19	33	77	18	40	6	2.0	284	0.00	0.09	2	0	2
12/14/97	59	22	37	74	21	40	7	2.2	279	0.00	0.10	5	2	5
12/15/97	60	24	39	78	16	41	6	2.0	284	0.00	0.11	5	3	5
12/16/97	62	26	42	72	16	41	8	3.3	282	0.00	0.12	6	4	6
12/17/97	61	26	41	63	18	42	7	3.3	282	0.00	0.12	6	3	6
12/18/97	61	25	41	74	20	42	8	2.1	279	0.00	0.11	6	3	6
12/19/97	67	26	45	74	18	42	13	2.5	267	0.00	0.12	9	6	9
12/20/97	54	34	38	95	26	44	13	6.2	48	0.08	0.06	2	0	2
12/21/97	54	34	41	93	55	44	10	2.4	119	0.03	0.03	2	0	2
12/22/97	53	33	40	95	48	42	27	6.8	57	0.04	0.04	2	0	2
12/23/97	46	34	38	93	55	43	11	4.9	143	0.03	0.04	0	0	0
12/24/97	49	32	40	90	42	42	14	5.2	232	0.01	0.08	0	0	0
12/25/97	40	28	33	97	73	42	10	3.6	50	0.08	0.00	0	0	0
12/26/97	40	20	29	81	40	40	14	7.1	229	0.03	0.07	0	0	0
12/27/97	42	19	30	80	34	39	9	4.2	289	0.00	0.08	0	0	0
12/28/97	44	25	33	85	20	38	17	5.0	275	0.00	0.09	0	0	0
12/29/97	51	25	36	74	31	38	10	4.7	284	0.00	0.10	1	0	1
12/30/97	56	29	41	79	34	39	12	4.6	246	0.00	0.10	3	1	3
12/31/97	65	33	33	63	25	46	4	2.7	198	0.00	0.11	8	5	8
01/01/98	61	29	42	91	33	42	7	2.1	275	0.00	0.09	6	3	6
01/02/98	64	28	44	92	34	43	6	1.8	277	0.00	0.10	7	5	7
01/03/98	65	35	49	90	33	45	12	2.9	263	0.00	0.10	8	5	8
01/04/98	58	36	44	99	57	45	13	2.3	138	0.20	0.04	4	2	4
01/05/98	55	34	44	101	37	45	15	3.4	205	0.00	0.07	3	0	3
01/06/98	50	28	39	91	21	43	14	5.0	303	0.00	0.11	0	0	0
01/07/98	52	29	39	75	25	42	11	4.0	294	0.00	0.10	1	0	1
01/08/98	55	25	38	80	21	41	10	3.6	289	0.00	0.11	3	0	3
01/09/98	60	25	43	81	21	42	14	3.3	296	0.00	0.12	5	3	5
01/10/98	61	33	47	77	26	44	15	3.5	296	0.00	0.12	6	3	6
01/11/98	59	38	48	85	31	45	16	5.1	301	0.00	0.12	5	2	5
01/12/98	63	27	44	91	22	45	12	2.9	303	0.00	0.12	7	4	7
01/13/98	60	31	45	78	38	45	13	4.0	255	0.00	0.10	5	3	5
01/14/98	57	30	43	87	22	45	15	5.0	296	0.00	0.12	4	1	4
01/15/98	58	25	40	68	20	43	10	3.4	303	0.00	0.12	4	2	4
01/16/98	66	33	47	65	26	44	10	2.9	301	0.00	0.13	8	6	8
01/17/98	69	31	49	83	25	46	14	4.0	306	0.00	0.14	10	7	10
01/18/98	68	32	48	85	23	47	8	2.2	294	0.00	0.12	9	7	9
01/19/98	71	31	49	83	15	47	14	2.9	298	0.00	0.14	11	8	11
01/20/98	62	38	50	60	22	47	16	4.4	275	0.00	0.13	6	4	6
01/21/98	59	38	46	79	31	48	17	5.0	227	0.00	0.10	5	2	5
01/22/98	58	31	43	88	26	47	8	3.2	313	0.00	0.11	4	2	4
01/23/98	62	27	44	83	22	47	9	2.4	320	0.00	0.12	6	4	6
01/24/98	63	29	44	65	21	47	8	2.8	303	0.00	0.12	7	4	7
01/25/98	65	35	48	63	14	47	14	4.6	337	0.00	0.16	8	5	8
01/26/98	65	33	48	50	14	47	10	3.3	334	0.00	0.15	8	5	8
01/27/98	67	27	45	64	13	47	6	1.9	320	0.00	0.13	9	6	9

01/28/98	70	29	48	62	10	47	14	3.5	337	0.00	0.17	10	8	10
01/29/98	67	29	47	53	15	47	8	2.6	296	0.00	0.13	9	6	9
01/30/98	64	30	47	65	22	48	16	5.1	341	0.00	0.16	7	5	7
01/31/98	61	30	44	79	21	48	12	3.3	339	0.00	0.13	6	3	6
02/01/98	62	32	45	61	20	48	10	3.3	341	0.00	0.14	6	4	6
02/02/98	66	26	45	68	19	48	12	2.9	351	0.00	0.14	8	6	8
02/03/98	69	33	52	64	15	49	27	7.5	353	0.00	0.20	10	7	10
02/04/98	57	39	49	74	27	51	21	8.6	232	0.00	0.13	4	1	4
02/05/98	56	35	44	85	32	50	17	6.8	365	0.00	0.14	3	1	3
02/06/98	62	26	44	82	22	49	9	2.7	363	0.00	0.13	6	4	6
02/07/98	63	33	49	70	28	50	19	6.3	368	0.00	0.16	7	4	7
02/08/98	66	39	52	69	23	51	19	5.9	358	0.00	0.17	8	6	8
02/09/98	55	40	47	97	46	52	18	6.2	210	0.17	0.08	3	0	3
02/10/98	58	31	44	88	26	50	13	4.0	377	0.00	0.13	4	2	4
02/11/98	58	32	45	67	23	49	12	4.5	346	0.00	0.14	4	2	4
02/12/98	57	36	46	70	19	49	18	4.9	401	0.00	0.16	4	1	4
02/13/98	60	28	46	72	24	48	8	2.8	315	0.00	0.12	5	3	5
02/14/98	62	41	51	91	31	51	10	3.1	251	0.00	0.10	6	4	6
02/15/98	51	39	46	86	43	50	17	5.8	127	0.03	0.05	1	0	1
02/16/98	51	33	42	80	27	48	24	10.3	413	0.00	0.17	1	0	1
02/17/98	56	29	44	91	20	48	17	4.0	372	0.03	0.13	3	1	3
02/18/98	53	36	43	91	42	49	21	8.7	322	0.00	0.12	2	0	2
02/19/98	57	28	43	91	24	49	9	2.7	422	0.00	0.14	4	1	4
02/20/98	59	34	48	73	24	50	12	3.8	267	0.00	0.11	5	2	5
02/21/98	60	38	47	84	34	51	15	5.9	401	0.00	0.15	5	3	5
02/22/98	64	39	52	67	28	52	23	8.3	432	0.00	0.20	7	5	7
02/23/98	70	37	53	75	16	53	15	3.7	437	0.00	0.19	10	8	10
02/24/98	76	36	54	67	11	54	25	7.5	406	0.00	0.25	13	11	13
02/25/98	54	37	45	66	23	54	22	9.6	370	0.00	0.17	2	0	2
02/26/98	54	34	44	68	19	48	22	8.8	411	0.17	0.18	2	0	2
02/27/98	53	32	42	56	17	51	20	7.6	353	0.00	0.16	2	0	2
02/28/98	53	27	39	42	12	50	16	5.3	477	0.00	0.18	2	0	2
03/01/98	57	25	41	42	10	50	13	3.9	477	0.00	0.18	4	1	4
03/02/98	62	30	46	43	15	51	9	3.2	465	0.00	0.18	6	4	6
03/03/98	72	31	51	57	10	53	14	3.6	477	0.00	0.21	11	9	11
03/04/98	72	35	54	55	11	54	17	4.8	477	0.99	0.23	11	9	11
03/05/98	70	37	56	56	10	55	14	3.8	427	0.00	0.20	10	8	10
03/06/98	68	47	56	72	23	56	18	5.5	291	0.00	0.15	9	7	9
03/07/98	53	35	44	86	25	54	26	10.3	439	0.00	0.18	2	0	2
03/08/98	57	27	42	69	16	53	12	3.2	473	0.00	0.16	4	1	4
03/09/98	63	28	47	61	14	54	9	3.5	499	0.00	0.19	7	4	7
03/10/98	64	32	48	56	17	55	11	3.9	506	0.00	0.20	7	5	7
03/11/98	66	33	49	51	13	55	18	7.2	506	0.00	0.24	8	6	8
03/12/98	63	33	49	58	25	56	12	4.1	496	0.00	0.19	7	4	7
03/13/98	72	36	54	67	18	57	12	3.2	454	0.00	0.19	11	9	11
03/14/98	74	45	59	84	18	60	17	4.4	406	0.00	0.19	12	10	12
03/15/98	60	42	50	97	32	60	14	5.6	446	0.26	0.16	5	3	5
03/16/98	64	37	51	93	28	57	14	4.9	451	0.00	0.17	7	5	7
03/17/98	64	46	54	76	31	58	22	7.3	439	0.00	0.19	7	5	7
03/18/98	67	43	52	84	27	57	24	6.9	337	0.01	0.17	9	6	9
03/19/98	64	35	49	56	14	56	8	3.8	549	0.00	0.21	7	5	7
03/20/98	70	36	54	67	19	58	12	3.6	511	0.00	0.21	10	8	10
03/21/98	73	44	58	61	18	61	9	3.4	504	0.00	0.22	12	9	12
03/22/98	81	42	62	62	10	62	11	3.4	547	0.00	0.26	16	13	16
03/23/98	82	44	63	57	9	63	11	3.2	487	0.00	0.24	16	14	16
03/24/98	84	44	65	62	11	65	13	3.8	556	0.00	0.28	17	15	17
03/25/98	83	45	67	57	11	66	16	4.2	544	0.00	0.27	17	14	17
03/26/98	74	45	60	65	22	67	24	8.5	432	0.00	0.24	12	10	12
03/27/98	63	42	52	75	30	65	21	8.3	563	0.00	0.23	7	4	7
03/28/98	77	38	58	77	12	65	25	6.4	563	0.00	0.28	14	11	14
03/29/98	68	45	56	63	24	65	24	9.3	535	0.00	0.26	9	7	9
03/30/98	50	38	43	84	29	63	25	10.4	530	0.00	0.19	0	0	0
03/31/98	63	34	47	66	16	62	15	5.3	590	0.00	0.23	7	4	7
04/01/98	72	32	54	69	9	62	15	4.8	597	0.00	0.26	11	9	11
04/02/98	58	38	48	60	21	63	24	9.6	594	0.03	0.25	4	2	4

04/03/98	70	33	52	67	9	63	9	3.0	597	0.00	0.24	10	8	10
04/04/98	78	37	59	59	10	64	17	4.3	599	0.00	0.28	14	12	14
04/05/98	75	42	60	57	11	66	14	3.5	602	0.00	0.26	13	10	13
04/06/98	64	45	54	53	19	65	21	7.6	480	0.00	0.23	7	5	7
04/07/98	63	37	51	67	18	64	23	7.7	585	0.00	0.25	7	4	7
04/08/98	67	36	53	60	11	65	14	4.8	616	0.00	0.25	9	6	9
04/09/98	74	35	56	56	10	66	11	2.8	613	0.00	0.25	12	10	12
04/10/98	80	40	61	53	9	67	11	3.2	618	0.00	0.28	15	13	15
04/11/98	85	45	67	44	7	69	17	6.3	618	0.00	0.35	18	15	18
04/12/98	74	50	62	33	12	70	22	8.9	621	0.00	0.34	12	10	12
04/13/98	75	42	60	55	11	70	14	5.2	625	0.00	0.29	13	10	13
04/14/98	77	41	61	55	8	70	23	6.3	633	0.14	0.32	14	11	14
04/15/98	66	39	54	55	19	69	22	7.8	611	0.00	0.27	8	6	8
04/16/98	61	43	51	53	17	68	21	7.7	611	0.00	0.26	6	3	6
04/17/98	64	36	51	62	11	68	15	4.3	659	0.00	0.25	7	5	7
04/18/98	71	37	55	51	10	67	13	3.5	578	0.00	0.24	11	8	11
04/19/98	75	41	58	50	11	69	9	3.5	625	0.00	0.27	13	10	13
04/20/98	80	44	64	50	10	71	17	5.4	642	0.00	0.32	15	13	15
04/21/98	75	47	63	57	16	73	13	5.3	630	0.00	0.29	13	10	13
04/22/98	81	47	65	49	11	74	16	4.3	637	0.00	0.31	16	13	16
04/23/98	88	51	71	50	12	75	12	3.7	578	0.00	0.30	19	16	19
04/24/98	85	56	72	37	10	76	21	7.1	649	0.00	0.37	21	16	21
04/25/98	82	54	68	49	11	77	20	6.9	599	0.00	0.33	18	14	18
04/26/98	68	46	56	71	24	74	21	8.5	518	0.00	0.25	9	7	9
04/27/98	68	41	54	77	24	73	10	3.8	535	0.00	0.21	9	7	9
04/28/98	74	42	59	64	17	73	13	4.2	654	0.15	0.28	12	10	12
04/29/98	75	50	62	62	19	75	18	5.0	556	0.00	0.26	13	10	13
04/30/98	81	47	65	74	15	77	12	3.4	637	0.00	0.28	16	13	16
05/01/98	85	49	69	57	9	78	16	4.5	642	0.00	0.32	18	15	18
05/02/98	87	49	70	55	8	79	11	3.3	616	0.00	0.31	18	16	18
05/03/98	87	48	71	52	6	79	15	4.2	666	0.00	0.34	18	16	18
05/04/98	87	52	71	45	8	80	17	5.2	666	0.00	0.35	19	16	19
05/05/98	85	50	69	47	8	80	17	4.9	664	0.00	0.34	18	15	18
05/06/98	82	50	67	54	10	80	17	4.9	671	0.00	0.33	16	14	16
05/07/98	84	48	68	62	9	80	14	4.0	659	0.00	0.32	17	15	17
05/08/98	75	51	65	50	10	79	23	7.6	633	0.00	0.33	13	10	13
05/09/98	82	45	65	63	10	79	10	3.3	676	0.00	0.31	16	14	16
05/10/98	88	48	71	59	8	75	16	4.8	683	0.00	0.35	18	16	18
05/11/98	84	51	70	48	10	72	17	5.2	683	0.00	0.35	18	15	18
05/12/98	85	50	70	46	7	73	15	4.1	680	0.00	0.34	18	15	18
05/13/98	86	50	70	49	10	73	16	5.2	676	0.00	0.35	18	16	18
05/14/98	79	54	65	50	15	72	18	5.2	470	0.00	0.25	17	12	17
05/15/98	80	45	63	53	10	72	12	3.7	692	0.00	0.31	15	13	15
05/16/98	92	47	71	45	6	73	13	3.6	644	0.00	0.34	18	16	18
05/17/98	92	63	78	37	10	75	12	3.2	415	0.00	0.25	25	20	25
05/18/98	95	59	78	58	10	77	15	4.6	499	0.00	0.30	23	18	23
05/19/98	93	61	78	65	11	78	14	3.3	482	0.00	0.26	24	19	24
05/20/98	94	56	76	65	11	78	11	2.8	456	0.00	0.25	21	16	21
05/21/98	89	65	76	52	13	77	17	4.4	320	0.00	0.21	26	21	26
05/22/98	86	59	73	57	8	77	16	4.2	535	0.00	0.29	23	18	23
05/23/98	88	56	73	52	7	78	13	4.1	697	0.00	0.35	21	16	21
05/24/98	89	54	73	37	8	78	14	3.9	661	0.00	0.34	20	16	20
05/25/98	89	61	75	36	8	80	13	3.1	637	0.00	0.33	24	19	24
05/26/98	90	53	73	51	9	79	14	3.5	683	0.00	0.34	20	16	20
05/27/98	92	55	75	37	8	80	11	3.2	695	0.00	0.35	21	16	21
05/28/98	95	55	76	56	9	80	10	2.7	680	0.00	0.34	21	16	21
05/29/98	95	54	76	47	7	81	11	3.1	685	0.00	0.36	20	16	20
05/30/98	94	56	77	51	9	81	14	3.8	625	0.00	0.34	21	16	21
05/31/98	95	57	78	37	7	81	10	2.9	671	0.00	0.35	22	17	22
06/01/98	100	57	81	60	6	82	15	4.1	683	0.00	0.38	22	17	22
06/02/98	101	60	82	39	9	83	14	3.6	676	0.00	0.38	23	18	23
06/03/98	97	63	82	35	9	83	19	6.0	664	0.00	0.40	25	20	25
06/04/98	85	62	74	37	10	83	18	6.3	709	0.00	0.39	24	19	24
06/05/98	88	53	72	44	9	81	14	4.4	707	0.00	0.36	20	16	20
06/06/98	88	51	74	56	14	81	17	6.1	695	0.00	0.36	19	16	19

06/07/98	93	69	80	48	7	83	18	7.8	604	0.00	0.40	28	23	28
06/08/98	88	56	74	46	9	82	16	4.4	702	0.00	0.36	21	16	21
06/09/98	87	57	73	47	14	81	15	4.4	446	0.00	0.26	22	17	22
06/10/98	75	55	62	96	28	77	15	4.1	117	0.29	0.08	15	10	15
06/11/98	82	50	67	104	27	75	12	3.3	642	0.00	0.27	16	14	16
06/12/98	91	57	76	79	19	78	12	3.8	621	0.00	0.30	22	17	22
06/13/98	94	67	81	70	10	81	19	6.2	695	0.00	0.39	27	22	27
06/14/98	90	58	77	42	8	80	22	7.0	723	0.00	0.41	22	17	22
06/15/98	93	58	77	45	10	81	12	3.6	697	0.00	0.36	22	17	22
06/16/98	95	60	79	52	7	82	16	4.8	709	0.00	0.39	23	18	23
06/17/98	93	62	79	29	7	82	19	6.2	723	0.00	0.42	24	19	24
06/18/98	96	57	78	51	10	83	11	3.7	702	0.00	0.37	22	17	22
06/19/98	101	58	81	52	8	84	12	3.7	702	0.00	0.39	22	17	22
06/20/98	100	59	83	60	8	85	15	4.1	702	0.00	0.38	23	18	23
06/21/98	99	62	82	47	8	86	15	4.1	704	0.00	0.39	24	19	24
06/22/98	99	60	81	48	7	86	14	4.1	678	0.00	0.38	23	18	23
06/23/98	100	62	82	46	9	86	16	3.3	685	0.00	0.37	24	19	24
06/24/98	103	62	84	59	10	81	17	3.4	625	0.00	0.35	24	19	24
06/25/98	103	64	85	60	11	82	15	3.7	664	0.00	0.37	25	20	25
06/26/98	103	66	86	49	9	82	17	5.1	695	0.00	0.41	26	21	26
06/27/98	105	61	86	56	6	83	13	3.3	709	0.00	0.39	24	19	24
06/28/98	106	63	86	35	5	83	14	3.2	709	0.00	0.41	25	20	25
06/29/98	106	68	90	57	7	85	14	3.5	690	0.00	0.39	27	22	27
06/30/98	105	72	89	52	10	86	22	5.8	697	0.02	0.43	29	24	29
07/01/98	104	73	85	0	22	84	21	7.3	613	0.01	0.44	30	25	30
07/02/98	106	67	78	112	39	82	17	5.7	422	0.01	0.25	27	22	27
07/03/98	94	69	81	75	30	81	14	4.3	623	0.00	0.31	28	23	28
07/04/98	96	72	81	80	28	81	10	3.3	528	0.01	0.27	29	24	29
07/05/98	94	69	81	89	30	82	13	4.3	647	0.00	0.31	28	23	28
07/06/98	93	70	79	81	30	83	14	3.9	623	0.00	0.30	28	23	28
07/07/98	92	67	78	90	31	83	12	3.1	539	0.00	0.25	27	22	27
07/08/98	95	66	77	93	30	83	21	4.4	566	0.12	0.28	26	21	26
07/09/98	92	67	78	95	27	82	8	2.9	554	0.00	0.26	27	22	27
07/10/98	99	70	84	73	22	82	8	2.8	671	0.00	0.33	28	23	28
07/11/98	103	75	88	64	18	83	16	3.1	656	0.00	0.35	31	26	31
07/12/98	107	76	90	56	12	84	16	3.7	628	0.00	0.37	31	26	31
07/13/98	105	75	89	53	11	83	17	4.8	690	0.00	0.41	31	26	31
07/14/98	106	73	89	61	12	84	15	4.4	661	0.00	0.39	30	25	30
07/15/98	101	70	87	61	15	84	19	5.3	613	0.00	0.36	28	23	28
07/16/98	93	73	84	63	26	83	16	5.5	580	0.00	0.31	30	25	30
07/17/98	94	68	78	79	24	81	12	2.9	325	0.00	0.18	27	22	27
07/18/98	96	68	81	71	16	80	10	2.2	594	0.00	0.29	27	22	27
07/19/98	98	70	84	62	18	81	11	3.4	666	0.00	0.35	28	23	28
07/20/98	97	70	82	74	21	89	0	5.4	602	0.60	0.33	28	23	28
07/21/98	93	65	79	92	22	87	0	4.2	666	0.00	0.32	26	21	26
07/22/98	92	70	77	89	25	87	0	4.8	594	0.02	0.30	28	23	28
07/23/98	87	69	73	94	40	85	9	3.7	396	0.08	0.18	28	23	28
07/24/98	88	68	74	92	37	85	0	4.5	480	0.00	0.23	27	22	27
07/25/98	90	66	77	96	33	86	0	3.8	635	0.00	0.29	26	21	26
07/26/98	93	69	80	85	28	87	21	4.9	537	0.05	0.28	28	23	28
07/27/98	90	71	78	75	33	85	13	4.2	289	0.00	0.17	29	24	29
07/28/98	96	73	83	67	19	86	15	4.4	644	0.00	0.34	30	25	30
07/29/98	98	69	88	77	21	88	14	3.5	609	0.00	0.31	28	23	28
07/30/98	95	71	81	83	25	88	12	4.2	528	0.10	0.28	29	24	29
07/31/98	92	69	78	82	30	87	18	4.7	528	0.00	0.27	28	23	28
08/01/98	90	69	79	88	34	87	16	5.5	590	0.00	0.29	28	23	28
08/02/98	92	71	79	76	30	87	14	4.2	408	0.00	0.22	29	24	29
08/03/98	96	70	83	85	22	88	24	4.4	580	0.06	0.30	28	23	28
08/04/98	93	65	76	91	28	87	30	6.2	559	0.21	0.30	26	21	26
08/05/98	86	60	73	98	33	85	13	4.2	618	0.00	0.27	23	18	23
08/06/98	88	64	76	86	30	86	9	3.2	633	0.00	0.28	25	20	25
08/07/98	93	64	79	80	22	87	10	3.6	628	0.00	0.31	25	20	25
08/08/98	97	65	81	81	16	87	10	3.1	633	0.00	0.32	26	21	26
08/09/98	95	67	82	65	20	81	9	3.0	506	0.00	0.26	27	22	27
08/10/98	97	67	89	68	20	81	9	3.4	594	0.00	0.30	27	22	27

08/11/98	98	67	83	66	12	84	26	4.5	602	0.00	0.34	27	22	27
08/12/98	95	68	81	88	23	85	16	5.4	587	0.03	0.31	27	22	27
08/13/98	87	65	76	98	29	85	17	4.0	530	0.33	0.24	26	21	26
08/14/98	92	66	79	79	18	84	10	3.1	542	0.00	0.27	26	21	26
08/15/98	93	64	80	75	21	84	10	2.8	594	0.00	0.29	25	20	25
08/16/98	94	66	81	75	20	85	11	3.3	623	0.00	0.31	26	21	26
08/17/98	95	66	81	66	18	85	11	3.7	582	0.00	0.31	26	21	26
08/18/98	92	69	82	73	26	84	14	5.6	499	0.00	0.27	28	23	28
08/19/98	96	69	80	77	26	85	19	3.9	566	0.00	0.29	28	23	28
08/20/98	89	70	80	82	31	85	19	6.4	477	0.00	0.26	28	23	28
08/21/98	90	69	80	73	27	85	15	5.6	551	0.00	0.29	28	23	28
08/22/98	92	67	80	75	26	85	10	3.1	554	0.00	0.27	27	22	27
08/23/98	93	68	81	69	25	85	9	3.0	559	0.00	0.28	27	22	27
08/24/98	97	68	84	66	18	86	8	3.0	587	0.00	0.30	27	22	27
08/25/98	98	68	83	86	19	87	12	3.6	578	0.11	0.30	27	22	27
08/26/98	95	69	81	88	28	87	11	3.6	528	0.00	0.26	28	23	28
08/27/98	94	71	83	79	32	87	17	3.5	501	0.02	0.25	29	24	29
08/28/98	92	72	81	82	31	86	21	5.2	329	0.00	0.19	29	24	29
08/29/98	91	69	81	75	22	84	14	4.8	442	0.00	0.24	28	23	28
08/30/98	91	64	78	72	14	84	10	3.3	585	0.00	0.29	25	20	25
08/31/98	92	62	78	80	22	84	11	3.3	578	0.00	0.28	24	19	24
09/01/98	92	65	80	58	20	84	15	5.0	530	0.00	0.29	26	21	26
09/02/98	91	68	80	64	19	84	18	6.4	487	0.00	0.29	27	22	27
09/03/98	83	68	75	95	39	83	11	4.0	224	0.00	0.11	26	21	26
09/04/98	86	68	76	96	40	83	7	3.8	275	0.01	0.13	27	22	27
09/05/98	93	68	81	78	18	83	15	5.4	504	0.00	0.28	27	22	27
09/06/98	93	64	81	67	12	84	11	5.0	561	0.00	0.31	25	20	25
09/07/98	93	64	79	54	12	84	12	4.4	559	0.00	0.31	25	20	25
09/08/98	93	62	78	58	16	84	15	3.8	544	0.00	0.29	24	19	24
09/09/98	92	65	80	59	18	84	17	5.4	542	0.00	0.31	26	21	26
09/10/98	91	67	80	67	26	85	19	5.1	530	0.00	0.28	27	22	27
09/11/98	92	68	80	67	19	86	12	5.0	528	0.00	0.29	27	22	27
09/12/98	90	62	73	63	27	85	6	2.7	535	0.00	0.26	24	19	24
09/13/98	97	61	79	76	16	84	11	2.6	501	0.00	0.26	24	19	24
09/14/98	100	71	85	53	11	86	37	6.1	525	0.00	0.35	29	24	29
09/15/98	94	71	80	59	23	86	22	6.9	508	0.00	0.32	29	24	29
09/16/98	88	68	77	66	26	87	14	4.6	487	0.00	0.26	27	22	27
09/17/98	89	66	77	70	27	86	13	3.9	489	0.00	0.25	26	21	26
09/18/98	92	63	77	75	21	86	8	2.7	506	0.00	0.25	25	20	25
09/19/98	95	62	79	75	16	86	10	2.7	477	0.00	0.25	24	19	24
09/20/98	90	65	76	76	22	85	15	3.4	375	0.00	0.20	26	21	26
09/21/98	92	64	76	85	21	84	14	3.6	415	0.00	0.22	25	20	25
09/22/98	92	59	77	79	24	84	12	3.8	489	0.00	0.25	23	18	23
09/23/98	93	73	81	64	28	86	15	6.4	468	0.00	0.28	30	25	30
09/24/98	95	64	80	78	23	86	11	3.7	475	0.00	0.25	25	20	25
09/25/98	93	68	80	68	1	86	10	3.4	418	0.01	0.25	27	22	27
09/26/98	92	60	76	77	14	85	11	2.8	494	0.00	0.25	23	18	23
09/27/98	94	55	76	73	14	84	8	2.4	482	0.00	0.25	21	16	21
09/28/98	95	62	80	61	24	85	12	4.7	480	0.00	0.27	24	19	24
09/29/98	94	69	82	65	26	87	11	4.3	396	0.00	0.23	28	23	28
09/30/98	91	65	78	81	27	87	18	3.5	413	0.00	0.21	26	21	26
10/01/98	86	62	73	83	28	85	11	3.7	313	0.00	0.17	24	19	24
10/02/98	85	54	69	54	13	81	13	3.8	485	0.00	0.26	20	15	20
10/03/98	86	51	71	67	19	81	8	4.1	475	0.00	0.25	19	16	19
10/04/98	85	67	76	59	24	76	17	6.1	434	0.00	0.25	26	21	26
10/05/98	73	50	66	50	10	73	19	7.8	442	0.00	0.25	12	9	12
10/06/98	75	40	58	58	11	69	9	3.1	475	0.00	0.22	13	10	13
10/07/98	79	44	62	62	13	69	11	3.3	470	0.00	0.23	15	12	15
10/08/98	83	46	64	66	14	70	9	2.7	449	0.00	0.22	17	14	17
10/09/98	88	49	68	64	16	71	8	2.8	446	0.00	0.23	18	16	18
10/10/98	88	51	69	78	14	72	14	2.9	442	0.00	0.23	19	16	19
10/11/98	89	50	68	64	8	71	9	2.5	451	0.00	0.24	18	16	18
10/12/98	90	54	71	61	16	71	10	4.0	427	0.00	0.25	20	16	20
10/13/98	88	56	71	68	17	72	9	3.1	415	0.00	0.22	21	16	21
10/14/98	89	54	71	66	14	72	14	2.6	422	0.00	0.22	20	16	20

10/15/98	86	55	72	69	15	71	22	6.5	363	0.00	0.24	21	16	21
10/16/98	80	50	65	52	11	70	18	4.4	430	0.00	0.23	15	13	15
10/17/98	71	46	57	49	10	68	17	5.9	434	0.00	0.23	11	8	11
10/18/98	76	45	65	49	20	67	19	7.2	418	0.01	0.24	13	11	13
10/19/98	74	59	61	87	31	68	15	7.5	205	0.28	0.14	17	12	17
10/20/98	62	51	57	97	70	67	11	3.5	98	0.90	0.02	7	4	7
10/21/98	59	51	55	97	65	66	12	4.8	119	0.14	0.04	5	2	5
10/22/98	58	52	55	93	68	65	10	3.7	86	0.02	0.02	5	2	5
10/23/98	63	52	57	93	69	66	8	3.4	193	0.00	0.06	8	4	8
10/24/98	71	56	62	94	53	67	6	2.0	232	0.00	0.08	14	9	14
10/25/98	81	53	65	97	29	68	10	3.4	372	0.00	0.17	17	13	17
10/26/98	81	61	68	84	32	69	13	5.1	306	0.02	0.16	21	16	21
10/27/98	64	50	55	99	66	67	12	4.9	141	1.66	0.05	7	5	7
10/28/98	72	43	56	104	38	64	10	2.4	349	0.01	0.13	11	9	11
10/29/98	74	44	59	97	44	65	8	2.5	377	0.00	0.14	12	10	12
10/30/98	78	49	63	98	31	65	14	3.1	272	0.02	0.13	14	12	14
10/31/98	66	47	57	95	31	66	12	4.0	327	0.07	0.13	8	6	8
11/01/98	68	41	53	95	35	64	7	2.1	370	0.00	0.13	9	7	9
11/02/98	70	42	55	97	26	63	13	3.2	365	0.00	0.15	10	8	10
11/03/98	71	39	54	92	22	62	7	2.0	365	0.00	0.15	11	8	11
11/04/98	67	39	53	94	35	61	10	2.8	356	0.00	0.13	9	6	9
11/05/98	64	41	53	95	45	61	12	4.3	353	0.00	0.13	7	5	7
11/06/98	69	41	55	96	21	61	12	3.1	351	0.00	0.15	10	7	10
11/07/98	68	45	57	76	19	60	14	4.1	353	0.00	0.16	9	7	9
11/08/98	72	38	56	87	27	60	11	2.9	341	0.00	0.14	11	9	11
11/09/98	68	46	55	70	29	60	29	9.6	289	0.00	0.18	9	7	9
11/10/98	58	35	45	74	20	58	11	3.8	351	0.00	0.14	4	2	4
11/11/98	67	32	50	78	27	57	8	3.0	334	0.00	0.13	9	6	9
11/12/98	69	45	55	91	32	58	15	4.8	232	0.03	0.11	10	7	10
11/13/98	67	43	53	93	39	59	10	3.7	325	0.03	0.12	9	6	9
11/14/98	73	40	54	89	21	58	11	3.1	329	0.00	0.15	12	9	12
11/15/98	73	39	54	89	23	58	8	1.9	325	0.00	0.14	12	9	12
11/16/98	76	37	54	92	21	58	6	1.5	322	0.00	0.14	13	11	13
11/17/98	75	37	55	93	21	58	8	2.3	320	0.00	0.14	13	10	13
11/18/98	75	42	57	83	22	58	11	2.7	320	0.00	0.15	13	10	13
11/19/98	72	40	57	84	21	58	11	3.1	306	0.00	0.14	11	9	11
11/20/98	58	40	51	72	25	57	9	2.9	143	0.00	0.07	4	2	4
11/21/98	66	36	48	72	20	56	8	3.0	315	0.00	0.14	8	6	8
11/22/98	71	30	49	83	27	55	6	1.8	313	0.00	0.13	11	8	11
11/23/98	75	34	51	88	19	55	7	1.7	308	0.00	0.14	13	10	13
11/24/98	74	39	41	67	21	56	6	2.4	277	0.00	0.14	12	10	12
01/00/98	0	0	39	0	0	0	1	0.0	0	0.00	-0.01	0	0	0
11/26/98	75	38	53	71	17	55	9	2.7	291	0.00	0.15	13	10	13
11/27/98	75	38	54	72	25	55	6	2.1	267	0.00	0.13	13	10	13
01/00/98	0	0	0	0	0	0	0	0.0	0	0.00	0.00	0	0	0
11/29/98	57	42	50	97	42	56	21	6.8	272	0.39	0.10	4	1	4
11/30/98	63	35	47	93	33	54	11	3.2	291	0.00	0.11	7	4	7
12/01/98	66	37	52	91	28	54	9	3.0	246	0.00	0.10	8	6	8
12/02/98	57	45	50	100	60	54	15	3.9	76	0.15	0.02	4	1	4
12/03/98	59	39	49	97	53	54	12	3.9	282	0.00	0.09	5	2	5
12/04/98	66	38	52	90	33	54	8	2.7	265	0.00	0.10	8	6	8
12/05/98	67	36	51	97	19	53	17	4.9	275	0.00	0.14	9	6	9
12/06/98	50	35	42	78	30	52	15	6.6	289	0.00	0.11	0	0	0
12/07/98	47	29	37	70	24	50	15	4.7	291	0.00	0.10	0	0	0
12/08/98	49	26	35	69	21	48	7	3.2	291	0.00	0.10	0	0	0
12/09/98	56	24	39	72	27	47	11	4.0	279	0.00	0.11	3	1	3
12/10/98	47	34	40	75	36	47	14	6.1	93	0.00	0.05	0	0	0
12/11/98	51	27	37	76	30	47	10	3.2	277	0.00	0.09	1	0	1
12/12/98	54	23	36	85	26	45	7	2.0	291	0.00	0.09	2	0	2
12/13/98	60	25	39	79	23	45	7	1.9	277	0.00	0.10	5	3	5
12/14/98	60	27	41	78	23	45	9	2.5	265	0.00	0.10	5	3	5
12/15/98	65	34	48	61	22	46	13	5.1	272	0.00	0.14	8	5	8
12/16/98	67	37	49	65	24	49	10	3.4	270	0.00	0.13	9	6	9
12/17/98	64	35	49	68	29	54	11	4.3	251	0.00	0.12	7	5	7
12/18/98	62	43	51	90	41	52	19	7.1	253	0.04	0.11	6	4	6

12/19/98	59	36	47	91	34	51	10	3.7	212	0.00	0.08	5	2	5
12/20/98	69	34	53	74	11	49	16	4.3	277	0.00	0.15	10	7	10
12/21/98	63	35	50	57	15	49	15	5.1	275	0.00	0.14	7	4	7
12/22/98	45	28	32	60	34	47	4	5.0	277	0.00	0.09	0	0	0
12/23/98	52	24	37	74	32	45	8	2.8	220	0.00	0.07	1	0	1
12/24/98	52	29	39	71	30	45	6	2.2	260	0.00	0.08	1	0	1
12/25/98	58	26	39	72	16	44	9	3.2	282	0.00	0.11	4	2	4
12/26/98	60	26	42	64	19	44	7	2.7	272	0.00	0.11	5	3	5
12/27/98	67	30	46	69	21	45	8	2.6	255	0.00	0.12	9	6	9
12/28/98	68	29	45	73	16	45	8	2.4	236	0.00	0.12	9	7	9
12/29/98	70	36	51	60	18	46	11	2.9	270	0.00	0.13	10	8	10
12/30/98	64	36	47	66	22	46	9	2.2	162	0.00	0.08	7	5	7
01/01/99	60	31	47	77	23	46	21	6.4	275	0.00	0.13	5	3	5
01/02/99	59	28	43	74	23	45	9	2.9	279	0.00	0.11	5	2	5
01/03/99	50	26	36	72	28	44	8	2.8	282	0.00	0.09	0	0	0
01/04/99	55	24	37	68	19	43	7	2.5	284	0.00	0.10	3	0	3
01/05/99	63	23	40	65	16	42	8	2.5	284	0.00	0.12	7	4	7
01/06/99	67	27	44	58	13	43	8	2.4	284	0.00	0.13	9	6	9
01/07/99	69	26	47	65	13	43	10	2.8	284	0.00	0.14	10	7	10
01/08/99	66	31	49	58	12	44	13	3.8	205	0.00	0.12	8	6	8
01/09/99	56	28	42	70	27	44	8	2.4	286	0.00	0.10	3	1	3
01/10/99	64	28	43	73	20	46	7	2.4	282	0.00	0.12	7	5	7
01/11/99	65	33	47	63	19	53	9	3.0	291	0.00	0.13	8	5	8
01/12/99	65	37	50	67	13	54	19	5.2	232	0.00	0.14	8	5	8
01/13/99	63	33	46	73	23	49	8	2.6	291	0.00	0.12	7	4	7
01/14/99	61	34	45	61	20	48	9	2.8	298	0.00	0.12	6	3	6
01/15/99	66	27	44	59	14	46	9	3.1	303	0.00	0.14	8	6	8
01/16/99	68	30	48	64	11	46	19	4.4	270	0.00	0.15	9	7	9
01/17/99	66	42	54	48	21	46	17	5.7	303	0.00	0.16	8	6	8
01/18/99	72	32	52	72	20	48	9	3.0	303	0.00	0.14	11	9	11
01/19/99	72	38	53	60	17	48	13	3.4	303	0.00	0.15	11	9	11
01/20/99	68	35	52	65	20	48	19	4.9	289	0.00	0.15	9	7	9
01/21/99	61	37	50	65	24	48	33	10.9	258	0.11	0.17	6	3	6
01/22/99	55	30	43	63	22	46	14	4.8	322	0.00	0.13	3	0	3
01/23/99	63	27	45	59	17	45	8	3.1	322	0.00	0.14	7	4	7
01/24/99	74	33	52	57	11	47	10	2.5	308	0.00	0.16	12	10	12
01/25/99	74	35	53	50	10	47	10	2.7	286	0.00	0.15	12	10	12
01/26/99	60	41	51	55	22	48	15	5.2	325	0.00	0.15	5	3	5
01/27/99	64	32	46	62	19	47	10	2.6	248	0.00	0.11	7	5	7
01/28/99	58	36	45	57	18	47	12	5.2	344	0.00	0.15	4	2	4
01/29/99	46	32	39	99	55	46	19	7.0	155	0.15	0.05	0	0	0
01/30/99	54	28	40	97	39	45	6	2.0	286	0.00	0.08	2	0	2
01/31/99	58	29	43	92	32	45	8	2.7	306	0.00	0.10	4	2	4
02/01/99	66	33	47	90	10	46	15	3.8	310	0.00	0.15	8	6	8
02/02/99	63	33	46	58	14	46	9	3.6	356	0.00	0.15	7	4	7
02/03/99	68	27	45	70	11	46	7	2.0	353	0.00	0.15	9	7	9
02/04/99	69	30	50	66	15	46	12	3.2	277	0.00	0.14	10	7	10
02/05/99	68	47	57	54	20	48	16	3.7	193	0.00	0.11	9	7	9
02/06/99	63	40	52	65	24	49	15	6.3	372	0.00	0.17	7	4	7
02/07/99	71	31	51	68	16	49	10	3.0	368	0.00	0.16	11	8	11
02/08/99	73	39	57	59	16	50	17	6.2	363	0.00	0.20	12	9	12
02/09/99	75	36	54	66	10	51	8	2.6	377	0.00	0.18	13	10	13
02/10/99	75	36	53	66	11	51	24	7.7	382	0.00	0.24	13	10	13
02/11/99	48	29	39	37	11	48	22	9.7	408	0.00	0.19	0	0	0
02/12/99	57	25	38	38	10	46	8	3.2	403	0.00	0.15	4	1	4
02/13/99	64	26	44	45	10	46	4	4.0	396	0.00	0.17	7	5	7
02/14/99	72	31	51	43	11	48	9	2.6	391	0.00	0.18	11	9	11
02/15/99	71	33	52	61	9	49	18	5.0	396	0.00	0.20	11	8	11
02/16/99	62	33	48	46	17	49	9	2.9	320	0.00	0.14	6	4	6
02/17/99	69	31	49	57	10	49	14	3.2	349	0.00	0.16	10	7	10
02/18/99	75	35	55	46	10	50	14	3.8	406	0.00	0.21	13	10	13
02/19/99	74	38	58	49	11	51	8	5.7	389	0.00	0.22	12	10	12
02/20/99	72	44	59	50	16	53	14	4.9	396	0.00	0.20	11	9	11
02/21/99	67	39	55	54	23	53	17	5.5	415	0.00	0.19	9	6	9
02/22/99	68	41	53	62	8	53	16	4.5	329	0.00	0.17	9	7	9

02/23/99	67	34	50	32	9	52	10	3.7	427	0.00	0.20	9	6	9
02/24/99	74	34	53	39	8	52	12	2.9	439	0.00	0.21	12	10	12
02/25/99	72	40	55	43	10	53	12	3.1	317	0.00	0.17	11	9	11
02/26/99	72	38	56	42	8	54	20	4.2	415	0.00	0.21	11	9	11
02/27/99	71	32	53	51	10	54	8	2.5	413	0.00	0.18	11	8	11
02/28/99	76	36	56	47	11	55	11	2.7	449	0.00	0.21	13	11	13
03/01/99	80	42	62	39	8	55	20	5.7	446	0.00	0.26	15	13	15
03/02/99	75	41	60	44	10	56	14	3.4	458	0.00	0.22	13	10	13
03/03/99	75	42	56	42	9	56	14	3.7	470	0.00	0.23	13	10	13
03/04/99	74	39	57	51	10	55	15	4.2	341	0.00	0.19	12	10	12
03/05/99	73	44	59	46	10	56	14	4.3	470	0.00	0.23	12	9	12
03/06/99	73	39	56	52	13	56	21	5.8	415	0.00	0.22	12	9	12
03/07/99	70	48	58	56	17	57	30	12.0	251	0.00	0.22	10	8	10
03/08/99	63	41	51	74	20	57	18	6.4	489	0.00	0.21	7	4	7
03/09/99	73	33	53	62	13	57	13	2.9	475	0.00	0.21	12	9	12
03/10/99	73	38	56	55	9	57	16	3.4	461	0.00	0.21	12	9	12
03/11/99	76	36	58	55	9	57	16	5.7	482	0.00	0.25	13	11	13
03/12/99	60	40	49	56	17	57	20	6.1	437	0.00	0.19	5	3	5
03/13/99	62	35	48	72	22	57	15	5.4	513	0.00	0.20	6	4	6
03/14/99	72	33	53	65	12	57	9	2.7	506	0.00	0.21	11	9	11
03/15/99	77	37	57	49	10	57	10	3.1	456	0.00	0.22	14	11	14
03/16/99	78	38	59	58	8	58	15	4.9	494	0.00	0.26	14	12	14
03/17/99	52	40	46	82	43	57	13	4.3	203	0.04	0.07	1	0	1
03/18/99	49	35	41	95	52	53	14	4.6	179	0.05	0.05	0	0	0
03/19/99	64	30	46	86	27	54	7	2.8	518	0.00	0.18	7	5	7
03/20/99	74	35	55	86	16	57	10	2.9	530	0.00	0.22	12	10	12
03/21/99	81	42	61	64	13	59	13	3.3	530	0.00	0.25	16	13	16
03/22/99	80	43	63	49	8	60	17	4.8	551	0.00	0.28	15	13	15
03/23/99	79	47	64	43	10	61	15	4.1	535	0.00	0.27	15	12	15
03/24/99	77	43	62	52	10	61	10	2.9	535	0.00	0.24	14	11	14
03/25/99	72	47	61	60	25	61	15	5.9	461	0.00	0.22	11	9	11
03/26/99	74	50	61	80	31	60	19	8.0	306	0.06	0.18	12	10	12
03/27/99	73	47	60	91	19	62	17	5.9	528	0.00	0.24	12	9	12
03/28/99	78	43	61	65	13	62	13	3.2	542	0.00	0.24	14	12	14
03/29/99	79	46	63	57	13	64	17	5.8	537	0.00	0.28	15	12	15
03/30/99	82	49	66	62	10	64	15	5.1	542	0.00	0.28	16	14	16
03/31/99	79	45	65	50	10	63	21	7.1	556	0.00	0.31	15	12	15
04/01/99	73	50	62	52	10	61	24	9.2	422	0.00	0.27	12	9	12
04/02/99	67	39	51	72	17	59	28	8.6	422	0.00	0.22	9	6	9
04/03/99	59	38	48	53	12	58	19	6.7	556	0.00	0.23	5	2	5
04/04/99	68	34	48	57	13	57	25	7.7	523	0.00	0.26	9	7	9
04/05/99	66	34	48	60	9	58	15	4.2	585	0.00	0.24	8	6	8
04/06/99	78	37	59	56	10	60	16	3.2	566	0.00	0.26	14	12	14
04/07/99	77	50	63	50	10	60	24	6.3	136	0.00	0.15	14	11	14
04/08/99	71	43	56	50	7	59	15	5.0	518	0.00	0.25	11	8	11
04/09/99	78	35	58	51	6	59	28	7.1	563	0.00	0.31	14	12	14
04/10/99	71	38	54	39	7	60	11	4.3	582	0.00	0.26	11	8	11
04/11/99	79	38	60	41	7	60	14	5.5	434	0.00	0.25	15	12	15
04/12/99	75	46	62	46	18	60	8	2.7	239	0.00	0.13	13	10	13
04/13/99	64	53	58	63	11	61	22	8.8	573	0.00	0.28	9	5	9
04/14/99	79	42	62	72	10	62	19	5.8	580	0.00	0.29	15	12	15
04/15/99	67	47	57	53	16	63	18	6.5	582	0.00	0.27	9	6	9
04/16/99	67	40	54	51	13	63	12	4.3	597	0.00	0.25	9	6	9
04/17/99	74	35	56	57	9	63	13	3.7	611	0.00	0.26	12	10	12
04/18/99	81	41	61	46	7	64	9	2.7	587	0.00	0.27	16	13	16
04/19/99	88	42	65	43	6	65	7	2.2	566	0.00	0.28	18	16	18
04/20/99	86	44	68	50	7	66	16	4.6	604	0.00	0.32	18	16	18
04/21/99	85	50	71	37	10	66	20	7.0	580	0.00	0.34	18	15	18
04/22/99	88	55	74	37	10	67	23	7.8	616	0.00	0.38	21	16	21
04/23/99	87	56	73	40	10	68	19	5.8	575	0.00	0.33	21	16	21
04/24/99	79	55	68	71	24	69	19	8.2	389	0.05	0.23	17	12	17
04/25/99	71	41	59	69	15	67	19	6.5	654	0.00	0.29	11	8	11
04/26/99	83	43	65	68	12	67	16	5.4	649	0.00	0.32	17	14	17
04/27/99	86	48	76	60	11	70	10	2.6	635	0.00	0.29	18	16	18
04/28/99	79	49	66	59	11	68	16	3.4	339	0.00	0.18	15	12	15

04/29/99	83	56	69	44	8	68	15	5.0	654	0.00	0.34	20	15	20	
04/30/99	76	51	64	42	10	68	15	4.6	666	0.00	0.31	14	11	14	
05/01/99	68	44	58	55	15	66	22	7.6	652	0.01	0.30	9	7	9	
05/02/99	78	41	61	61	10	67	15	4.6	676	0.00	0.31	14	12	14	
05/03/99	79	45	64	59	12	67	25	8.4	475	0.00	0.29	15	12	15	
05/04/99	75	55	65	43	11	64	25	11.0	551	0.00	0.35	15	10	15	
05/05/99	80	51	66	32	9	65	20	7.5	671	0.00	0.37	16	13	16	
05/06/99	83	44	65	44	9	67	15	4.4	676	0.00	0.33	17	14	17	
05/06/99	78	48	63	69	20	65	13	4.0	460	%66.54	%690.20	%46669	%36365	%46669	<-AV

Appendix B

Calculated PET for Albuquerque by Month (1998)

Alb-Airport 1998

NMSU Weather Data Request #3875
Begining Date: 01/01/98
Ending Date: 01/31/98
Location: Airport, Alb
Format: ENGLISH
Request Date: FRI -- 4 JUN 99 (155), 14:41:44 (MST)

Weather Summary From: C-T13875.CVT
Elevation: 1618 meters

Date	Air Temp (F)			Rel Humid (%)		Soil Temp (F)	Wind Speed (MPH)		Sol Rad (L)	Rain (In)	PET (In)	Heat Units (F) Corn	Cotn	Genr	
												86	86	086	<= Max
												50	55	050	<= Min
												50	55	050	<= Base
MM/DD/YY	MX	MN	AV	MX	MN	AV	MX	AV							
01/01/98	49	24	0	96	47	0	6	1.3	263	0.00	0.05	0	0	0	
01/02/98	49	26	0	95	57	0	6	1.2	162	0.00	0.03	0	0	0	
01/03/98	54	33	0	95	51	0	4	1.2	215	0.00	0.05	2	0	2	
01/04/98	52	30	0	98	53	0	5	1.4	236	0.00	0.05	1	0	1	
01/05/98	48	29	0	103	34	0	9	2.4	196	0.00	0.06	0	0	0	
01/06/98	42	24	0	79	45	0	8	2.0	270	0.00	0.05	0	0	0	
01/07/98	45	23	0	87	33	0	7	2.1	279	0.00	0.06	0	0	0	
01/08/98	47	24	0	68	33	0	9	1.8	277	0.00	0.07	0	0	0	
01/09/98	50	23	0	75	32	0	5	1.7	286	0.00	0.07	0	0	0	
01/10/98	49	31	0	100	53	0	9	2.4	115	0.04	0.04	0	0	0	
01/11/98	48	32	0	101	49	0	9	2.4	229	0.07	0.05	0	0	0	
01/12/98	50	26	0	91	44	0	7	1.5	291	0.00	0.06	0	0	0	
01/13/98	48	27	0	94	53	0	8	1.4	234	0.00	0.04	0	0	0	
01/14/98	46	28	0	88	32	0	11	2.6	296	0.00	0.07	0	0	0	
01/15/98	47	23	0	83	30	0	4	1.2	286	0.00	0.06	0	0	0	
01/16/98	54	29	0	72	41	0	9	2.1	275	0.00	0.08	2	0	2	
01/17/98	53	29	0	88	51	0	6	1.5	229	0.00	0.05	2	0	2	
01/18/98	57	31	0	88	32	0	7	1.4	270	0.00	0.08	4	1	4	
01/19/98	55	29	0	84	39	0	10	2.5	251	0.00	0.08	3	0	3	
01/20/98	46	34	0	65	15	0	11	4.1	267	0.00	0.10	0	0	0	
01/21/98	44	28	0	94	39	0	5	1.8	201	0.00	0.05	0	0	0	
01/22/98	46	25	0	97	27	0	5	1.4	303	0.00	0.06	0	0	0	
01/23/98	50	30	0	58	27	0	7	2.5	322	0.00	0.09	0	0	0	
01/24/98	55	25	0	77	29	0	7	1.1	317	0.00	0.08	3	0	3	
01/25/98	55	29	0	70	17	0	12	3.0	332	0.00	0.11	3	0	3	
01/26/98	57	29	0	63	23	0	7	1.3	327	0.00	0.10	4	1	4	
01/27/98	54	27	0	72	25	0	3	1.1	253	0.00	0.08	2	0	2	
01/28/98	60	25	0	66	13	0	4	1.3	339	0.00	0.11	5	3	5	
01/29/98	58	28	0	51	16	0	6	1.5	317	0.00	0.11	4	2	4	
01/30/98	55	29	0	68	25	0	9	1.8	320	0.00	0.09	3	0	3	
01/31/98	51	26	0	84	35	0	10	2.5	337	0.00	0.08	1	0	1	
01/31/98	51	28	0	82	35	0	7	1.9	268	0.11	2.15	35	6	35	<-AVR

NMSU Weather Data Request #3876
Begining Date: 02/01/98
Ending Date: 02/28/98
Location: Airport, Alb
Format: ENGLISH
Request Date: FRI -- 4 JUN 99 (155), 14:42:31 (MST)

Weather Summary From: C-T13876.CVT
Elevation: 1618 meters

Date	Air Temp (F)			Rel Humid (%)		Soil Temp (F)	Wind Speed (MPH)		Sol Rad (L)	Rain (In)	PET (In)	Heat Units (F) Corn	Cotn	Genr	
												86	86	086	<= Max
												50	55	050	<= Min
MM/DD/YY	MX	MN	AV	MX	MN	AV	MX	AV	-			50	55	050	<= Base
02/01/98	52	26	0	76	21	0	5	1.7	356	0.00	0.09	1	0	1	
02/02/98	54	23	0	73	28	0	8	1.7	303	0.00	0.08	2	0	2	
02/03/98	58	28	0	81	32	0	16	3.7	317	0.00	0.11	4	2	4	
02/04/98	43	33	0	103	58	0	18	5.9	115	0.03	0.04	0	0	0	
02/05/98	47	33	0	104	51	0	11	3.2	232	0.01	0.05	0	0	0	
02/06/98	52	29	0	90	41	0	6	1.7	320	0.00	0.07	1	0	1	
02/07/98	55	34	0	78	27	0	15	3.6	341	0.00	0.11	3	0	3	
02/08/98	53	29	0	102	44	0	9	1.9	279	0.11	0.06	2	0	2	
02/09/98	47	32	0	99	44	0	8	1.7	301	0.00	0.05	0	0	0	
02/10/98	46	28	0	79	39	0	11	2.9	246	0.00	0.06	0	0	0	
02/11/98	47	25	0	96	36	0	13	2.1	337	0.00	0.07	0	0	0	
02/12/98	50	28	0	80	26	0	10	2.3	403	0.00	0.09	0	0	0	
02/13/98	53	26	0	79	26	0	6	1.4	382	0.00	0.09	2	0	2	
02/14/98	56	34	0	63	32	0	6	2.0	396	0.00	0.10	3	1	3	
02/15/98	44	32	0	104	57	0	8	2.5	129	0.35	0.03	0	0	0	
02/16/98	43	26	0	88	47	0	11	2.6	298	0.00	0.05	0	0	0	
02/17/98	46	26	0	85	40	0	6	1.6	334	0.00	0.06	0	0	0	
02/18/98	50	33	0	104	31	0	13	3.4	363	0.01	0.08	0	0	0	
02/19/98	52	32	0	70	29	0	6	1.8	408	0.00	0.09	1	0	1	
02/20/98	47	29	0	100	47	0	11	2.1	203	0.02	0.04	0	0	0	
02/21/98	54	34	0	101	37	0	8	2.1	329	0.00	0.07	2	0	2	
02/22/98	54	30	0	82	38	0	9	2.0	353	0.00	0.08	2	0	2	
02/23/98	60	35	0	77	32	0	6	2.3	422	0.00	0.11	5	3	5	
02/24/98	67	32	0	81	15	0	22	3.7	408	0.00	0.18	9	6	9	
02/25/98	44	30	0	76	29	0	14	4.4	258	0.00	0.08	0	0	0	
02/26/98	42	25	0	72	19	0	12	4.2	444	0.00	0.10	0	0	0	
02/27/98	40	22	0	65	20	0	14	4.1	406	0.00	0.09	0	0	0	
02/28/98	41	21	0	53	16	0	12	3.9	473	0.00	0.10	0	0	0	
02/28/98	50	29	0	84	34	0	10	2.7	327	0.53	2.26	35	11	35	<-AVR

NMSU Weather Data Request #3877
Begining Date: 03/01/98
Ending Date: 03/31/98
Location: Airport, Alb
Format: ENGLISH
Request Date: FRI -- 4 JUN 99 (155), 14:43:7 (MST)

Weather Summary From: C-T13877.CVT
Elevation: 1618 meters

Date	Air Temp (F)			Rel Humid (%)		Soil Temp (F)	Wind Speed (MPH)		Sol Rad (L)	Rain (In)	PET (In)	Heat Units (F) Corn	Cotn	Genr	
												86	86	086	<= Max
												50	55	050	<= Min
MM/DD/YY	MX	MN	AV	MX	MN	AV	MX	AV				50	55	050	<= Base
03/01/98	48	22	0	48	17	0	12	4.2	482	0.00	0.13	0	0	0	
03/02/98	54	26	0	55	22	0	5	1.4	465	0.00	0.11	2	0	2	
03/03/98	64	29	0	62	14	0	10	1.5	482	0.00	0.14	7	5	7	
03/04/98	65	36	0	44	19	0	10	2.4	482	0.00	0.17	8	5	8	
03/05/98	61	44	0	66	31	0	8	1.8	263	0.00	0.11	6	3	6	
03/06/98	61	36	0	89	21	0	14	2.6	337	0.00	0.12	6	3	6	
03/07/98	46	31	0	98	49	0	12	3.4	227	0.04	0.05	0	0	0	
03/08/98	48	27	0	62	21	0	10	2.2	506	0.00	0.10	0	0	0	
03/09/98	53	28	0	52	14	0	10	3.0	523	0.00	0.14	2	0	2	
03/10/98	56	26	0	75	15	0	6	1.9	525	0.00	0.12	3	1	3	
03/11/98	57	33	0	49	26	0	14	4.6	523	0.00	0.16	4	1	4	
03/12/98	62	26	0	70	21	0	5	1.8	508	0.00	0.13	6	4	6	
03/13/98	65	37	0	58	20	0	8	1.7	480	0.00	0.15	8	5	8	
03/14/98	61	39	0	91	38	0	13	2.7	341	0.10	0.10	6	3	6	
03/15/98	49	35	0	105	81	0	13	3.0	55	1.26	0.01	0	0	0	
03/16/98	59	35	0	104	53	0	10	2.6	413	0.37	0.08	5	2	5	
03/17/98	57	41	0	101	52	0	10	2.2	365	0.01	0.07	4	1	4	
03/18/98	46	35	0	94	32	0	17	4.9	289	0.06	0.08	0	0	0	
03/19/98	55	29	0	76	28	0	6	1.8	556	0.00	0.11	3	0	3	
03/20/98	60	35	0	69	23	0	9	2.3	547	0.00	0.14	5	3	5	
03/21/98	66	36	0	83	13	0	9	2.3	547	0.00	0.16	8	6	8	
03/22/98	74	42	0	50	15	0	8	1.7	551	0.00	0.20	12	10	12	
03/23/98	76	44	0	56	15	0	7	1.7	559	0.00	0.21	13	11	13	
03/24/98	78	46	0	60	17	0	9	2.3	573	0.00	0.23	14	12	14	
03/25/98	77	50	0	45	12	0	12	2.8	578	0.00	0.27	14	11	14	
03/26/98	66	41	0	94	31	0	20	4.7	327	0.08	0.15	8	6	8	
03/27/98	60	41	0	67	35	0	12	3.6	356	0.00	0.13	5	3	5	
03/28/98	67	40	0	75	14	0	14	3.6	508	0.00	0.19	9	6	9	
03/29/98	53	31	0	102	38	0	13	3.3	208	0.02	0.07	2	0	2	
03/30/98	43	30	0	101	33	0	13	2.9	289	0.01	0.06	0	0	0	
03/31/98	58	31	0	80	26	0	9	2.6	480	0.00	0.12	4	2	4	
03/31/98	60	35	0	74	27	0	11	2.7	430	1.95	4.01	158	98	158	<-AVR

NMSU Weather Data Request #3878
Begining Date: 04/01/98
Ending Date: 04/30/98
Location: Airport, Alb
Format: ENGLISH
Request Date: FRI -- 4 JUN 99 (155), 14:43:33 (MST)

Weather Summary From: C~T13878.CVT
Elevation: 1618 meters

Date	Air Temp (F)			Rel Humid (%)		Soil Temp (F)	Wind Speed (MPH)		Sol Rad (L)	Rain (In)	PET (In)	Heat Units (F) Corn	Cotn	Genr	
												86	86	086	<= Max
												50	55	050	<= Min
MM/DD/YY	MX	MN	AV	MX	MN	AV	MX	AV				50	55	050	<= Base
04/01/98	65	34	0	69	10	0	15	3.8	616	0.00	0.20	8	5	8	
04/02/98	53	33	0	55	25	0	14	4.6	413	0.00	0.14	2	0	2	
04/03/98	64	32	0	76	15	0	7	2.1	616	0.00	0.16	7	5	7	
04/04/98	71	38	0	53	9	0	14	2.6	618	0.00	0.22	11	8	11	
04/05/98	65	42	0	41	18	0	8	1.9	623	0.00	0.18	8	5	8	
04/06/98	56	40	0	59	27	0	14	3.5	351	0.00	0.13	3	1	3	
04/07/98	55	37	0	66	25	0	12	3.9	494	0.00	0.14	3	0	3	
04/08/98	58	36	0	73	23	0	10	2.4	442	0.00	0.12	4	2	4	
04/09/98	65	35	0	61	15	0	9	1.8	635	0.00	0.17	8	5	8	
04/10/98	74	38	0	43	9	0	8	2.4	647	0.00	0.24	12	10	12	
04/11/98	78	42	0	40	7	0	19	3.8	644	0.00	0.31	14	12	14	
04/12/98	66	47	0	45	18	0	17	4.1	578	0.00	0.23	8	6	8	
04/13/98	67	40	0	68	14	0	9	2.3	656	0.00	0.19	9	6	9	
04/14/98	66	41	0	34	13	0	14	3.3	656	0.00	0.22	8	6	8	
04/15/98	52	38	0	77	29	0	12	3.1	368	0.00	0.10	1	0	1	
04/16/98	53	30	0	70	24	0	9	2.2	635	0.00	0.12	2	0	2	
04/17/98	55	33	0	85	28	0	10	2.4	544	0.00	0.11	3	0	3	
04/18/98	59	36	0	54	15	0	12	3.0	542	0.00	0.16	5	2	5	
04/19/98	66	31	0	71	13	0	7	1.4	671	0.00	0.16	8	6	8	
04/20/98	71	45	0	49	13	0	15	3.8	664	0.00	0.26	11	8	11	
04/21/98	69	40	0	68	16	0	12	2.5	666	0.00	0.20	10	7	10	
04/22/98	74	50	0	44	16	0	13	2.8	668	0.00	0.25	12	10	12	
04/23/98	79	48	0	50	17	0	9	2.1	633	0.00	0.25	15	12	15	
04/24/98	81	55	0	35	9	0	12	3.3	668	0.00	0.35	18	13	18	
04/25/98	67	51	0	46	21	0	10	2.7	518	0.00	0.20	9	6	9	
04/26/98	56	32	0	104	43	0	17	3.1	243	0.55	0.07	3	1	3	
04/27/98	63	38	0	100	27	0	9	2.1	680	0.00	0.14	7	4	7	
04/28/98	66	43	0	71	26	0	11	2.2	642	0.04	0.16	8	6	8	
04/29/98	69	42	0	93	23	0	11	2.1	666	0.00	0.17	10	7	10	
04/30/98	76	45	0	75	16	0	7	1.7	659	0.00	0.21	13	11	13	
04/30/98	65	40	0	63	19	0	11	2.8	582	0.59	5.56	233	158	233	<-AVR

NMSU Weather Data Request #3879
Begining Date: 05/01/98
Ending Date: 05/31/98
Location: Airport, Alb
Format: ENGLISH
Request Date: FRI -- 4 JUN 99 (155), 14:43:56 (MST)

Weather Summary From: C-T13879.CVT
Elevation: 1618 meters

Date	Air Temp (F)			Rel Humid (%)		Soil Temp (F)	Wind Speed (MPH)		Sol Rad (L)	Rain (In)	PET (In)	Heat Units (F) Corn 86 / 50 / 50	Cotn 86 / 55 / 55	Genr 086 / 050 / 050	
MM/DD/YY	MX	MN	AV	MX	MN	AV	MX	AV							<= Max / <= Min / <= Base
05/01/98	76	51	0	47	19	0	12	2.1	604	0.00	0.23	14	11	14	
05/02/98	80	51	0	50	13	0	7	1.7	676	0.00	0.26	16	13	16	
05/03/98	81	52	0	58	7	0	11	2.3	687	0.00	0.29	17	13	17	
05/04/98	79	50	0	30	9	0	12	2.8	692	0.00	0.31	15	12	15	
05/05/98	77	50	0	51	15	0	9	2.4	661	0.00	0.25	14	11	14	
05/06/98	73	55	0	46	12	0	12	3.4	683	0.00	0.28	14	9	14	
05/07/98	74	48	0	43	11	0	8	1.8	676	0.00	0.23	12	10	12	
05/08/98	69	48	0	57	20	0	14	2.8	415	0.00	0.19	10	7	10	
05/09/98	74	43	0	68	19	0	10	2.3	697	0.00	0.22	12	10	12	
05/10/98	82	50	0	50	9	0	12	2.6	707	0.00	0.31	16	14	16	
05/11/98	77	54	0	35	9	0	12	2.5	707	0.00	0.29	16	11	16	
05/12/98	79	49	0	35	10	0	13	2.8	711	0.00	0.30	15	12	15	
05/13/98	79	53	0	33	11	0	15	4.1	721	0.00	0.36	16	12	16	
05/14/98	70	47	0	54	21	0	14	3.6	532	0.00	0.22	10	8	10	
05/15/98	71	39	0	66	17	0	10	2.2	726	0.00	0.20	11	8	11	
05/16/98	83	47	0	45	8	0	12	2.7	640	0.00	0.32	17	14	17	
05/17/98	83	59	0	32	15	0	15	2.6	537	0.00	0.32	21	16	21	
05/18/98	88	55	0	48	10	0	13	2.1	652	0.00	0.34	21	16	21	
05/19/98	87	62	0	42	13	0	11	2.0	644	0.00	0.34	24	19	24	
05/20/98	83	58	0	48	16	0	15	2.4	420	0.00	0.28	21	16	21	
05/21/98	85	56	0	65	10	0	21	2.3	418	0.00	0.29	21	16	21	
05/22/98	83	50	0	30	9	0	10	2.4	735	0.00	0.33	17	14	17	
05/23/98	80	51	0	24	9	0	10	2.1	730	0.00	0.30	16	13	16	
05/24/98	82	52	0	33	11	0	10	2.2	730	0.00	0.31	17	14	17	
05/25/98	80	58	0	48	20	0	14	4.5	613	0.00	0.34	19	14	19	
05/26/98	83	56	0	59	9	0	14	3.4	647	0.00	0.34	20	15	20	
05/27/98	85	54	0	33	13	0	6	2.0	726	0.00	0.32	20	15	20	
05/28/98	89	58	0	34	11	0	7	2.0	728	0.00	0.36	22	17	22	
05/29/98	89	58	0	30	8	0	10	2.7	704	0.00	0.40	22	17	22	
05/30/98	89	62	0	26	8	0	9	1.7	716	0.00	0.37	24	19	24	
05/31/98	89	57	0	31	7	0	7	1.5	714	0.00	0.35	22	17	22	
05/31/98	81	53	0	44	12	0	11	2.5	653	0.00	9.25	523	407	523	<-AVR

NMSU Weather Data Request #3881
Begining Date: 07/01/98
Ending Date: 07/31/98
Location: Airport, Alb
Format: ENGLISH
Request Date: FRI -- 4 JUN 99 (155), 14:44:48 (MST)

Weather Summary From: C~T13881.CVT
Elevation: 1618 meters

Date	Air Temp (F)			Rel Humid (%)		Soil Temp (F)	Wind Speed (MPH)		Sol Rad (L)	Rain (In)	PET (In)	Heat Units (F) Corn	Cotn	Genr	
												86	86	086	<= Max
												50	55	050	<= Min
MM/DD/YY	MX	MN	AV	MX	MN	AV	MX	AV				50	55	050	<= Base
07/01/98	94	68	0	62	27	0	18	4.4	592	0.02	0.43	27	22	27	
07/02/98	90	66	0	73	28	0	13	2.6	602	0.00	0.30	26	21	26	
07/03/98	91	64	0	97	32	0	17	2.5	637	0.88	0.26	25	20	25	
07/04/98	84	64	0	103	50	0	9	2.3	547	0.28	0.16	24	19	24	
07/05/98	90	66	0	88	32	0	11	2.0	625	0.00	0.25	26	21	26	
07/06/98	91	68	0	80	33	0	11	1.8	580	0.00	0.26	27	22	27	
07/07/98	88	70	0	77	41	0	12	3.1	482	0.00	0.25	28	23	28	
07/08/98	80	64	0	101	50	0	11	2.0	363	0.19	0.13	22	17	22	
07/09/98	79	63	0	104	48	0	10	2.0	294	0.24	0.12	21	16	21	
07/10/98	90	63	0	103	34	0	5	1.4	678	0.00	0.22	25	20	25	
07/11/98	96	67	0	78	21	0	9	1.7	692	0.00	0.34	27	22	27	
07/12/98	98	72	0	56	13	0	10	2.6	699	0.00	0.47	29	24	29	
07/13/98	94	70	0	68	18	0	16	3.8	568	0.00	0.43	28	23	28	
07/14/98	97	66	0	67	14	0	6	1.5	652	0.00	0.37	26	21	26	
07/15/98	95	69	0	52	24	0	21	3.2	635	0.03	0.42	28	23	28	
07/16/98	92	63	0	88	28	0	18	4.6	611	0.22	0.36	25	20	25	
07/17/98	85	61	0	96	37	0	9	1.9	568	0.01	0.20	23	18	23	
07/18/98	90	61	0	89	24	0	7	1.3	695	0.00	0.26	24	19	24	
07/19/98	97	66	0	63	21	0	7	1.8	685	0.00	0.37	26	21	26	
07/20/98	97	70	0	57	18	0	13	2.3	716	0.00	0.42	28	23	28	
07/21/98	94	70	0	60	21	0	12	2.4	685	0.00	0.38	28	23	28	
07/22/98	88	66	0	75	40	0	14	2.4	499	0.20	0.24	26	21	26	
07/23/98	82	64	0	87	50	0	11	2.5	413	0.00	0.16	23	18	23	
07/24/98	78	64	0	97	57	0	10	2.2	289	0.04	0.11	21	16	21	
07/25/98	86	64	0	96	40	0	13	1.8	411	0.28	0.18	25	20	25	
07/26/98	82	65	0	97	53	0	10	1.7	387	0.02	0.13	24	19	24	
07/27/98	81	64	0	97	50	0	9	2.5	439	0.00	0.15	23	18	23	
07/28/98	86	66	0	88	41	0	7	1.6	573	0.14	0.20	26	21	26	
07/29/98	92	63	0	100	28	0	11	2.1	611	0.04	0.26	25	20	25	
07/30/98	92	69	0	65	25	0	19	2.6	647	0.00	0.35	28	23	28	
07/31/98	86	65	0	78	36	0	12	2.6	561	0.00	0.24	26	21	26	
07/31/98	89	66	0	82	33	0	12	2.4	562	2.59	8.40	785	630	785	<-AVR

NMSU Weather Data Request #3880
Begining Date: 06/01/98
Ending Date: 06/30/98
Location: Airport, Alb
Format: ENGLISH
Request Date: FRI -- 4 JUN 99 (155), 14:44:19 (MST)

Weather Summary From: C~T13880.CVT
Elevation: 1618 meters

Date	Air Temp (F)			Rel. Humid (%)		Soil Temp (F)	Wind Speed (MPH)		Sol Rad (L)	Rain (In)	PET (In)	Heat Units (F) Corn	Cotn	Genr	
												86	86	086	<= Max
												50	55	050	<= Min
MM/DD/YY	MX	MN	AV	MX	MN	AV	MX	AV				50	55	050	<= Base
06/01/98	95	60	0	30	7	0	12	2.5	738	0.00	0.46	23	18	23	
06/02/98	95	59	0	22	9	0	12	2.3	718	0.00	0.45	23	18	23	
06/03/98	90	68	0	18	11	0	16	2.3	594	0.00	0.42	27	22	27	
06/04/98	77	58	0	36	13	0	13	3.9	728	0.00	0.34	18	13	18	
06/05/98	80	54	0	37	11	0	11	2.4	752	0.00	0.31	17	13	17	
06/06/98	83	54	0	64	13	0	16	6.0	740	0.00	0.42	19	14	19	
06/07/98	87	59	0	57	7	0	16	4.0	716	0.00	0.42	23	18	23	
06/08/98	81	56	0	32	11	0	10	2.5	738	0.00	0.32	19	14	19	
06/09/98	81	56	0	28	12	0	12	3.1	709	0.00	0.35	19	14	19	
06/10/98	73	53	0	101	18	0	16	3.2	399	0.15	0.18	13	9	13	
06/11/98	77	49	0	99	25	0	9	2.3	654	0.00	0.20	14	11	14	
06/12/98	85	57	0	57	19	0	10	2.7	728	0.00	0.32	21	16	21	
06/13/98	84	63	0	42	8	0	15	4.0	750	0.00	0.42	24	19	24	
06/14/98	84	57	0	41	15	0	13	2.9	676	0.00	0.34	21	16	21	
06/15/98	85	60	0	39	9	0	11	2.7	740	0.00	0.37	23	18	23	
06/16/98	91	60	0	37	9	0	10	2.6	735	0.00	0.41	23	18	23	
06/17/98	83	59	0	31	9	0	14	4.3	718	0.00	0.42	21	16	21	
06/18/98	86	55	0	30	9	0	10	2.6	759	0.00	0.37	21	16	21	
06/19/98	94	56	0	37	8	0	11	2.1	757	0.00	0.41	21	16	21	
06/20/98	93	62	0	29	10	0	11	2.5	745	0.00	0.44	24	19	24	
06/21/98	92	62	0	31	10	0	8	1.7	747	0.00	0.39	24	19	24	
06/22/98	94	61	0	33	8	0	10	2.0	752	0.00	0.42	24	19	24	
06/23/98	94	64	0	31	9	0	12	2.3	721	0.00	0.44	25	20	25	
06/24/98	95	67	0	29	11	0	14	2.9	594	0.00	0.48	27	22	27	
06/25/98	99	62	0	22	9	0	10	2.0	745	0.00	0.48	24	19	24	
06/26/98	97	68	0	28	7	0	11	2.5	757	0.00	0.51	27	22	27	
06/27/98	98	66	0	24	10	0	7	1.6	745	0.00	0.45	26	21	26	
06/28/98	101	67	0	29	7	0	9	1.6	752	0.00	0.49	27	22	27	
06/29/98	102	69	0	30	7	0	7	1.6	742	0.00	0.50	28	23	28	
06/30/98	98	71	0	32	12	0	20	4.7	666	0.00	0.63	29	24	29	
06/30/98	89	60	0	39	11	0	12	2.8	710	0.15	12.17	667	522	667	<-AVR

NMSU Weather Data Request #3882
Begining Date: 08/01/98
Ending Date: 08/31/98
Location: Airport, Alb
Format: ENGLISH
Request Date: FRI -- 4 JUN 99 (155), 14:45:31 (MST)

Weather Summary From: C~T13882.CVT
Elevation: 1618 meters

Date	Air Temp (F)			Rel Humid (%)		Soil Temp (F)	Wind Speed (MPH)		Sol Rad (L)	Rain (In)	PET (In)	Heat Units (F) Corn	Cotn	Genr	
												86	86	086	<= Max
												50	55	050	<= Min
MM/DD/YY	MX	MN	AV	MX	MN	AV	MX	AV				50	55	050	<= Base
08/01/98	83	67	0	90	48	0	10	2.4	454	0.01	0.17	25	20	25	
08/02/98	91	62	0	100	12	0	7	1.9	680	0.00	0.30	24	19	24	
08/03/98	93	62	0	63	17	0	16	2.9	671	0.00	0.39	24	19	24	
08/04/98	81	66	0	67	45	0	16	6.2	544	0.00	0.30	24	19	24	
08/05/98	82	63	0	68	38	0	11	4.4	458	0.00	0.26	23	18	23	
08/06/98	89	62	0	76	27	0	10	2.0	671	0.00	0.28	24	19	24	
08/07/98	94	67	0	59	19	0	8	1.8	671	0.00	0.35	27	22	27	
08/08/98	95	67	0	54	13	0	7	2.0	673	0.00	0.40	27	22	27	
08/09/98	95	67	0	48	17	0	13	2.2	566	0.00	0.39	27	22	27	
08/10/98	90	67	0	55	25	0	12	2.3	482	0.00	0.32	27	22	27	
08/11/98	88	68	0	70	29	0	19	3.2	499	0.00	0.30	27	22	27	
08/12/98	86	64	0	87	36	0	14	3.1	525	0.01	0.24	25	20	25	
08/13/98	88	61	0	97	25	0	17	2.6	566	0.02	0.26	24	19	24	
08/14/98	90	59	0	80	19	0	11	2.8	656	0.00	0.33	23	18	23	
08/15/98	90	64	0	62	19	0	14	2.1	633	0.00	0.32	25	20	25	
08/16/98	92	65	0	60	19	0	9	2.1	647	0.00	0.34	26	21	26	
08/17/98	92	64	0	64	20	0	7	2.1	611	0.00	0.33	25	20	25	
08/18/98	91	68	0	49	21	0	15	2.3	606	0.00	0.36	27	22	27	
08/19/98	92	68	0	73	24	0	14	2.7	633	0.16	0.34	27	22	27	
08/20/98	87	67	0	73	38	0	14	5.7	594	0.00	0.34	27	22	27	
08/21/98	80	68	0	74	47	0	9	2.6	341	0.04	0.18	24	19	24	
08/22/98	90	68	0	75	29	0	7	1.6	611	0.00	0.27	27	22	27	
08/23/98	93	68	0	64	29	0	9	2.1	635	0.00	0.32	27	22	27	
08/24/98	97	70	0	58	20	0	12	2.4	580	0.00	0.40	28	23	28	
08/25/98	91	64	0	98	32	0	14	2.8	513	0.61	0.26	25	20	25	
08/26/98	89	62	0	102	34	0	4	1.4	590	0.00	0.21	24	19	24	
08/27/98	94	67	0	88	29	0	8	1.5	542	0.00	0.26	27	22	27	
08/28/98	88	71	0	66	30	0	16	6.4	499	0.00	0.42	29	24	29	
08/29/98	89	66	0	66	29	0	12	2.7	594	0.00	0.31	26	21	26	
08/30/98	92	65	0	68	24	0	11	2.1	582	0.00	0.31	26	21	26	
08/31/98	90	67	0	53	25	0	10	2.7	582	0.00	0.34	27	22	27	
08/31/98	90	66	0	71	27	0	11	2.7	578	0.85	9.62	791	636	791	<-AVR

NMSU Weather Data Request #3883
Begining Date: 09/01/98
Ending Date: 09/31/98
Location: Airport, Alb
Format: ENGLISH
Request Date: FRI -- 4 JUN 99 (155), 14:46:1 (MST)

Weather Summary From: C~T13883.CVT
Elevation: 1618 meters

Date	Air Temp (F)			Rel Humid (%)		Soil Temp (F)	Wind Speed (MPH)		Sol Rad (L)	Rain (In)	PET (In)	Heat Units (F) Corn	Cotn	Genr	
												86	86	086	<= Max
												50	55	050	<= Min
MM/DD/YY	MX	MN	AV	MX	MN	AV	MX	AV				50	55	050	<= Base
09/01/98	87	66	0	63	28	0	12	3.1	396	0.00	0.29	26	21	26	
09/02/98	87	65	0	72	25	0	14	3.0	556	0.00	0.30	26	21	26	
09/03/98	90	64	0	65	18	0	13	2.8	578	0.00	0.35	25	20	25	
09/04/98	89	64	0	68	20	0	11	3.1	494	0.00	0.33	25	20	25	
09/05/98	89	62	0	52	20	0	7	2.0	501	0.00	0.31	24	19	24	
09/06/98	90	63	0	57	16	0	9	2.2	578	0.00	0.34	25	20	25	
09/07/98	89	64	0	51	23	0	10	2.4	537	0.00	0.32	25	20	25	
09/08/98	88	63	0	54	20	0	10	2.3	475	0.00	0.31	25	20	25	
09/09/98	86	67	0	42	19	0	10	2.3	403	0.00	0.32	27	22	27	
09/10/98	86	66	0	61	30	0	11	2.4	542	0.00	0.28	26	21	26	
09/11/98	88	62	0	71	27	0	12	2.7	570	0.00	0.29	24	19	24	
09/12/98	89	61	0	56	20	0	9	1.5	547	0.00	0.29	24	19	24	
09/13/98	89	67	0	59	20	0	11	2.9	528	0.00	0.35	27	22	27	
09/14/98	89	62	0	52	21	0	17	2.7	563	0.00	0.34	24	19	24	
09/15/98	85	65	0	60	29	0	18	5.6	530	0.00	0.37	25	20	25	
09/16/98	84	58	0	86	26	0	12	2.2	549	0.00	0.23	21	16	21	
09/17/98	85	60	0	74	25	0	9	1.7	506	0.00	0.23	23	18	23	
09/18/98	88	59	0	72	20	0	6	1.8	544	0.00	0.27	23	18	23	
09/19/98	89	62	0	54	14	0	9	2.2	532	0.00	0.33	24	19	24	
09/20/98	86	60	0	36	20	0	9	1.9	480	0.00	0.29	23	18	23	
09/21/98	85	62	0	52	19	0	8	1.8	530	0.00	0.28	24	19	24	
09/22/98	85	59	0	43	21	0	12	2.6	525	0.00	0.31	22	17	22	
09/23/98	87	64	0	65	27	0	12	2.8	482	0.00	0.29	25	20	25	
09/24/98	89	62	0	67	24	0	14	2.7	518	0.00	0.31	24	19	24	
09/25/98	88	67	0	53	18	0	13	3.3	506	0.00	0.37	27	22	27	
09/26/98	85	57	0	33	12	0	6	1.5	539	0.00	0.29	21	16	21	
09/27/98	88	52	0	37	12	0	6	1.7	532	0.00	0.31	19	16	19	
09/28/98	89	58	0	45	16	0	9	2.1	489	0.00	0.32	22	17	22	
09/29/98	81	64	0	88	42	0	14	2.9	246	0.03	0.17	23	18	23	
09/30/98	81	61	0	101	50	0	14	3.6	375	0.03	0.15	21	16	21	
09/30/98	87	62	0	60	23	0	11	2.5	505	0.06	8.92	715	566	715	<-AVR

NMSU Weather Data Request #3884
Begining Date: 10/01/98
Ending Date: 10/31/98
Location: Airport, Alb
Format: ENGLISH
Request Date: FRI -- 4 JUN 99 (155), 14:46:35 (MST)

Weather Summary From: C-T13884.CVT
Elevation: 1618 meters

Date	Air Temp (F)			Rel Humid (%)		Soil Temp (F)	Wind Speed (MPH)		Sol Rad (L)	Rain (In)	PET (In)	Heat Units (F) Corn	Cotn	Genr	
												86	86	086	<= Max
												50	55	050	<= Min
MM/DD/YY	MX	MN	AV	MX	MN	AV	MX	AV				50	55	050	<= Base
10/01/98	75	58	0	87	47	0	13	4.5	301	0.10	0.16	17	12	17	
10/02/98	77	50	0	71	20	0	7	1.8	506	0.00	0.20	14	11	14	
10/03/98	81	49	0	72	17	0	12	2.4	504	0.00	0.24	16	13	16	
10/04/98	73	55	0	68	17	0	12	4.6	458	0.00	0.26	14	9	14	
10/05/98	62	48	0	39	17	0	12	4.5	506	0.00	0.22	6	4	6	
10/06/98	68	40	0	48	15	0	8	1.5	504	0.00	0.17	9	7	9	
10/07/98	74	41	0	58	13	0	7	1.6	485	0.00	0.19	12	10	12	
10/08/98	77	47	0	48	15	0	6	1.1	425	0.00	0.19	14	11	14	
10/09/98	81	49	0	53	19	0	5	1.2	473	0.00	0.21	16	13	16	
10/10/98	82	49	0	56	14	0	7	1.3	473	0.00	0.23	16	14	16	
10/11/98	81	48	0	35	7	0	9	2.0	482	0.00	0.27	16	13	16	
10/12/98	81	52	0	46	14	0	11	2.3	454	0.00	0.26	17	13	17	
10/13/98	81	51	0	70	21	0	6	1.6	403	0.00	0.21	16	13	16	
10/14/98	82	59	0	40	15	0	10	3.0	432	0.00	0.31	21	16	21	
10/15/98	80	51	0	36	7	0	14	2.5	434	0.00	0.28	16	13	16	
10/16/98	67	43	0	60	13	0	14	3.1	454	0.00	0.19	9	6	9	
10/17/98	57	37	0	65	36	0	12	2.9	461	0.00	0.12	4	1	4	
10/18/98	70	35	0	75	22	0	9	1.9	454	0.00	0.16	10	8	10	
10/19/98	68	43	0	97	36	0	12	2.4	236	0.11	0.11	9	7	9	
10/20/98	57	50	0	101	72	0	19	5.3	174	0.29	0.05	4	1	4	
10/21/98	54	49	0	78	65	0	17	8.7	234	0.00	0.10	2	0	2	
10/22/98	57	50	0	82	70	0	11	2.5	158	0.00	0.05	4	1	4	
10/23/98	67	51	0	100	51	0	6	1.6	284	0.00	0.08	9	6	9	
10/24/98	68	51	0	97	44	0	4	1.2	291	0.00	0.09	10	7	10	
10/25/98	72	52	0	96	46	0	16	4.0	315	0.02	0.13	12	9	12	
10/26/98	68	52	0	102	63	0	11	2.1	241	0.18	0.06	10	7	10	
10/27/98	58	43	0	101	69	0	13	2.2	127	0.58	0.03	4	2	4	
10/28/98	61	40	0	99	41	0	7	1.8	401	0.00	0.09	6	3	6	
10/29/98	66	38	0	96	33	0	5	0.9	394	0.00	0.10	8	6	8	
10/30/98	62	45	0	97	58	0	11	1.9	196	0.02	0.06	6	4	6	
10/31/98	54	44	0	101	73	0	7	2.3	193	0.27	0.03	2	0	2	
10/31/98	70	47	0	73	34	0	10	2.6	369	1.57	4.86	322	233	322	<-AVR

NMSU Weather Data Request #3885
Begining Date: 11/01/98
Ending Date: 11/30/98
Location: Airport, Alb
Format: ENGLISH
Request Date: FRI -- 4 JUN 99 (155), 14:47:0 (MST)

Weather Summary From: C~T13885.CVT
Elevation: 1618 meters

Date	Air Temp (F)			Rel Humid (%)		Soil Temp (F)	Wind Speed (MPH)		Sol Rad (L)	Rain (In)	PET (In)	Heat Units (F) Corn	Cotn	Genr	
												86	86	086	<= Max
												50	55	050	<= Min
MM/DD/YY	MX	MN	AV	MX	MN	AV	MX	AV				50	55	050	<= Base
11/01/98	57	44	0	99	60	0	5	1.1	186	0.00	0.04	4	1	4	
11/02/98	59	40	0	99	36	0	9	1.6	282	0.00	0.08	5	2	5	
11/03/98	59	36	0	91	36	0	6	1.2	351	0.00	0.08	5	2	5	
11/04/98	59	37	0	92	38	0	7	1.7	368	0.00	0.09	5	2	5	
11/05/98	56	36	0	100	56	0	7	1.5	258	0.00	0.05	3	1	3	
11/06/98	60	38	0	98	33	0	8	1.8	356	0.00	0.09	5	3	5	
11/07/98	58	42	0	57	26	0	12	2.1	339	0.00	0.12	4	2	4	
11/08/98	62	39	0	68	32	0	10	2.0	232	0.00	0.10	6	4	6	
11/09/98	55	32	0	104	37	0	14	4.9	115	0.12	0.08	3	0	3	
11/10/98	43	26	0	85	34	0	8	2.4	368	0.00	0.07	0	0	0	
11/11/98	47	25	0	82	41	0	6	1.8	229	0.00	0.05	0	0	0	
11/12/98	51	38	0	103	58	0	13	2.5	103	0.10	0.03	1	0	1	
11/13/98	58	33	0	105	36	0	9	2.5	341	0.01	0.09	4	2	4	
11/14/98	65	36	0	90	32	0	5	1.2	337	0.00	0.10	8	5	8	
11/15/98	66	36	0	92	34	0	5	1.6	334	0.00	0.10	8	6	8	
11/16/98	68	39	0	79	29	0	5	1.3	334	0.00	0.12	9	7	9	
11/17/98	65	36	0	86	29	0	10	2.0	301	0.00	0.11	8	5	8	
11/18/98	61	41	0	56	26	0	8	1.5	279	0.00	0.11	6	3	6	
11/19/98	57	36	0	66	26	0	7	2.0	320	0.00	0.10	4	1	4	
11/20/98	52	32	0	55	17	0	6	1.6	267	0.00	0.09	1	0	1	
11/21/98	57	26	0	67	16	0	4	1.1	327	0.00	0.10	4	1	4	
11/22/98	63	31	0	57	23	0	6	1.2	320	0.00	0.11	7	4	7	
11/23/98	66	35	0	72	20	0	3	0.8	317	0.00	0.11	8	6	8	
11/24/98	67	36	0	64	24	0	5	1.3	301	0.00	0.12	9	6	9	
11/25/98	64	37	0	54	19	0	5	1.0	310	0.00	0.12	7	5	7	
11/26/98	66	35	0	53	22	0	3	0.9	301	0.00	0.12	8	6	8	
11/27/98	66	34	0	72	22	0	4	1.1	298	0.00	0.11	8	6	8	
11/28/98	62	39	0	68	37	0	7	1.4	198	0.00	0.09	6	4	6	
11/29/98	52	39	0	100	49	0	10	2.2	103	0.12	0.04	1	0	1	
11/30/98	56	33	0	88	47	0	5	1.1	301	0.00	0.06	3	1	3	
11/30/98	59	36	0	80	33	0	7	1.7	282	0.35	2.70	144	79	144	<-AVR

NMSU Weather Data Request #3886
Begining Date: 12/01/98
Ending Date: 12/31/98
Location: Airport, Alb
Format: ENGLISH
Request Date: FRI -- 4 JUN 99 (155), 14:47:27 (MST)

Weather Summary From: C~T13886.CVT
Elevation: 1618 meters

Date	Air Temp (F)			Rel Humid (%)		Soil Temp (F)	Wind Speed (MPH)		Sol Rad (L)	Rain (In)	PET (In)	Heat Units (F) Corn	Cotn	Genr	
												86	86	086	<= Max
												50	55	050	<= Min
MM/DD/YY	MX	MN	AV	MX	MN	AV	MX	AV				50	55	050	<= Base
12/01/98	60	34	0	93	39	0	4	1.0	294	0.00	0.07	5	3	5	
12/02/98	55	42	0	86	64	0	10	1.6	107	0.00	0.04	3	0	3	
12/03/98	61	41	0	97	45	0	6	1.6	248	0.00	0.07	6	3	6	
12/04/98	60	37	0	96	38	0	9	2.7	255	0.00	0.09	5	3	5	
12/05/98	58	39	0	75	18	0	11	2.4	289	0.00	0.11	4	2	4	
12/06/98	41	29	0	100	35	0	8	1.6	224	0.00	0.04	0	0	0	
12/07/98	36	25	0	104	34	0	8	3.4	265	0.04	0.05	0	0	0	
12/08/98	37	15	0	81	43	0	5	1.7	298	0.00	0.05	0	0	0	
12/09/98	38	19	0	87	45	0	14	2.2	179	0.00	0.04	0	0	0	
12/10/98	39	24	0	82	45	0	16	4.1	229	0.00	0.05	0	0	0	
12/11/98	43	18	0	95	41	0	4	0.9	282	0.00	0.05	0	0	0	
12/12/98	48	22	0	78	35	0	4	0.8	279	0.00	0.06	0	0	0	
12/13/98	53	27	0	76	33	0	6	1.3	282	0.00	0.07	2	0	2	
12/14/98	53	24	0	76	31	0	5	1.1	277	0.00	0.07	2	0	2	
12/15/98	57	26	0	67	27	0	5	1.2	275	0.00	0.08	4	1	4	
12/16/98	57	27	0	75	21	0	12	2.5	279	0.00	0.10	4	1	4	
12/17/98	54	28	0	76	32	0	5	1.1	277	0.00	0.07	2	0	2	
12/18/98	58	27	0	81	28	0	4	1.4	272	0.00	0.08	4	2	4	
12/19/98	54	36	0	83	37	0	15	4.8	177	0.00	0.09	2	0	2	
12/20/98	61	37	0	61	13	0	14	4.2	277	0.00	0.16	6	3	6	
12/21/98	48	23	0	58	28	0	10	4.0	172	0.00	0.08	0	0	0	
12/22/98	35	16	0	63	38	0	13	2.0	277	0.00	0.05	0	0	0	
12/23/98	42	18	0	75	38	0	6	1.3	258	0.00	0.05	0	0	0	
12/24/98	44	21	0	68	19	0	8	1.8	284	0.00	0.07	0	0	0	
12/25/98	49	27	0	49	25	0	8	1.6	282	0.00	0.08	0	0	0	
12/26/98	52	23	0	65	27	0	4	1.0	258	0.00	0.07	1	0	1	
12/27/98	54	27	0	68	21	0	9	1.6	265	0.00	0.09	2	0	2	
12/28/98	58	26	0	62	19	0	12	3.3	246	0.00	0.12	4	2	4	
12/29/98	60	35	0	54	26	0	7	1.4	263	0.00	0.10	5	3	5	
12/30/98	63	33	0	68	30	0	12	1.6	272	0.00	0.10	7	4	7	
12/30/98	51	28	0	77	33	0	8	2.0	255	0.04	2.27	64	24	64	<-AVR

Appendix C

Summary of Penman Equation

Summary of PENMAN'S Equations for Potential Evapotranspiration (Jensen *et al.*. 1990):

List of Symbols Used:

Name	Value	Units	Description
albedo			reflection coefficient, 0.07+0.053*LAI
avpma		mb	maximum air vapor pressure
avpmi		mb	minimum air vapor pressure
cp	0.242	cal/°C/cm^3	specific heat of air
delta		mb/°C	slope of the saturated vapor pressure curve
elev		M	elevation
eop		mm/day	penman potential evaporation
gamma		mb/°C	psychrometric constant
hl		cal/g	latent heat of vaporization
potet		cm/day	penman potential evaporation
pr		Mb	air pressure.
Rl	-64.0	cal/cm^2/day	long wave radiation
Rn		cal/cm^2/day	net radiation
Svpma		Mb	maximum saturated vapor pressure
Svpmi		Mb	minimum saturated vapor pressure
Tempav		°C	average temperature
vpa1		mb	actual vapor pressure at mean temperature
vps1		mb	saturated vapor pressure at mean temperature
windk		km/day	wind speed

Equation for pressure when elevation is in meters:

```
pr = 1013.0 - 0.1055 * elev

windk' = Win_Vel*1.6093
```

correct wind speed at 3.74m height to wind speed at 2.0m height:

```
windk = windk' * (2.0/3.74)^0.20

tempav = (Max_Temp + Min_Temp)/2.0
ap = 7.5*Max_Temp/(Max_Temp+237.3)
svpmi = 6.108*10.**ap
avpmi = svpmi*Min_Humidity/100.
ap = 7.5*Min_Temp/(Min_Temp+237.3)
svpma = 6.108*10.**ap
avpma = svpma*Max_Humidity/100.
vps1 = (svpmi+svpma)/2.0
vpa1 = (avpmi+avpma)/2.0
```

```
albedo = 0.21
hl = 595.0 - 0.51*tempav
```

to calculate net radiation use a modified version of the penman equation and a wind factor referenced to water

```
rn = 0.95*(1.0-albedo)*Solar_Radiation + rl
delta = 33.8639*(0.05904*(0.00739*tempav+0.8072)**7 - 0.0000342)
gamma = cp*pr/(0.622*hl)
```

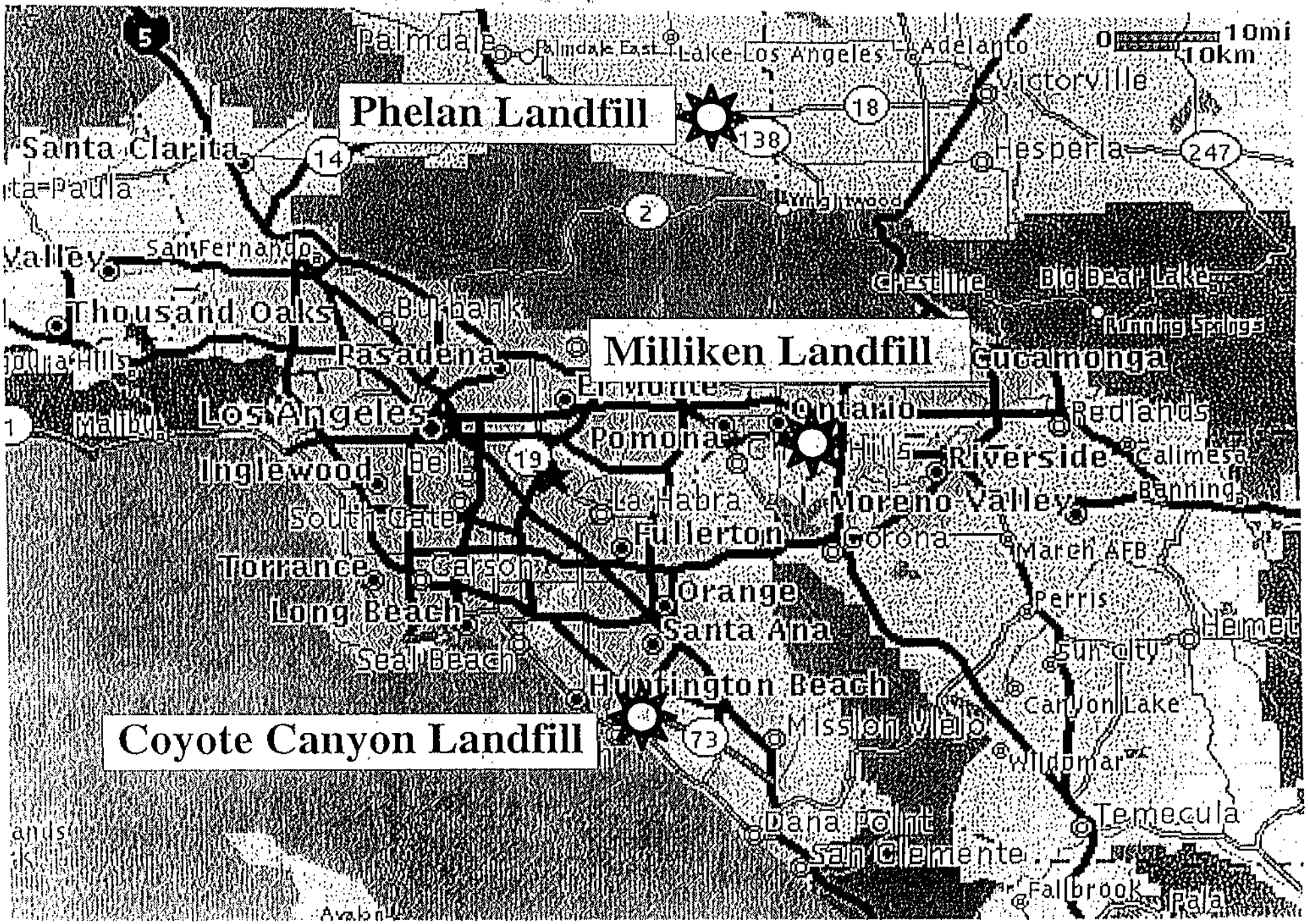
Penman equation calculates the potential evaporation from surface of well watered short grass.

```
ea = 15.36*(1.0+0.0062*windk)*(vps1-vpa1)
eop = ((delta*rn+gamma*ea)/(delta+gamma)) / hl*10.0
```

Appendix D

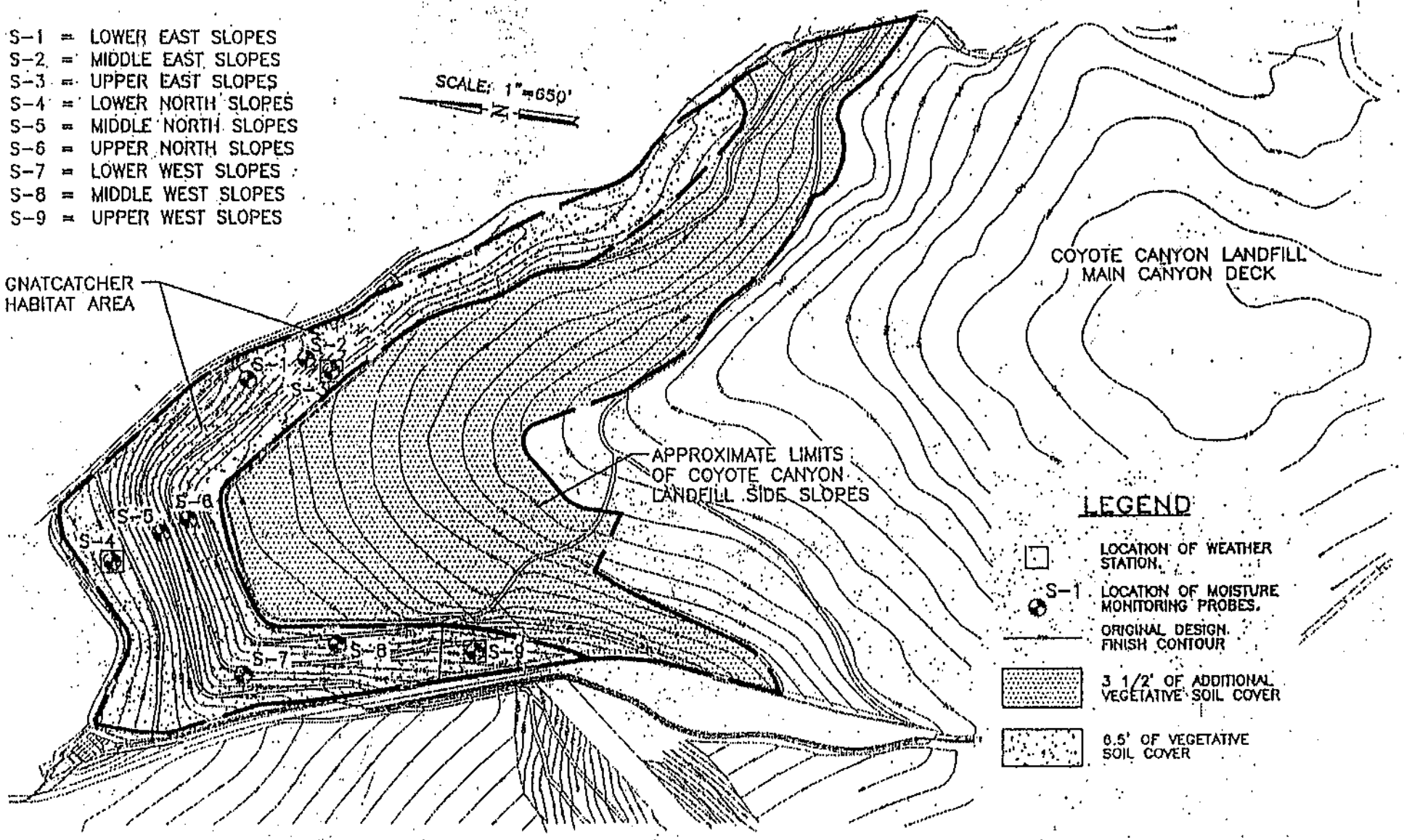
California Sites Field Data for ET Cover Deployments

Alternative Final Covers for Municipal Solid Waste Landfills


Phelan Landfill
Milliken Landfill
Coyote Canyon Landfill
0 10mi
10km
Palmdale
Palmdale East
Lake Los Angeles
Adelanto
Victorville
Hesperia
Lytle Creek
Santa Clarita
Valley
San Fernando
Thousand Oaks
Burbank
Pasadena
Malibu
Los Angeles
Inglewood
Bell
South Gate
Torrance
Carson
Long Beach
Seal Beach
Huntington Beach
Fullerton
La Habra
Pomona
Ontario
Chino Hills
Rialto
Fontana
Rancho Cucamonga
Redlands
Riverside
Calimesa
Banning
Moreno Valley
Corona
March AFB
Perris
Hemet
Sun City
Canyon Lake
Wildomar
Temecula
Orange
Santa Ana
Mission Viejo
Dana Point
San Clemente
Fallbrook
Pala
Crestline
Big Bear Lake
Running Springs
Avalon
5
14
2
18
138
247
19
73

Coyote Canyon Landfill

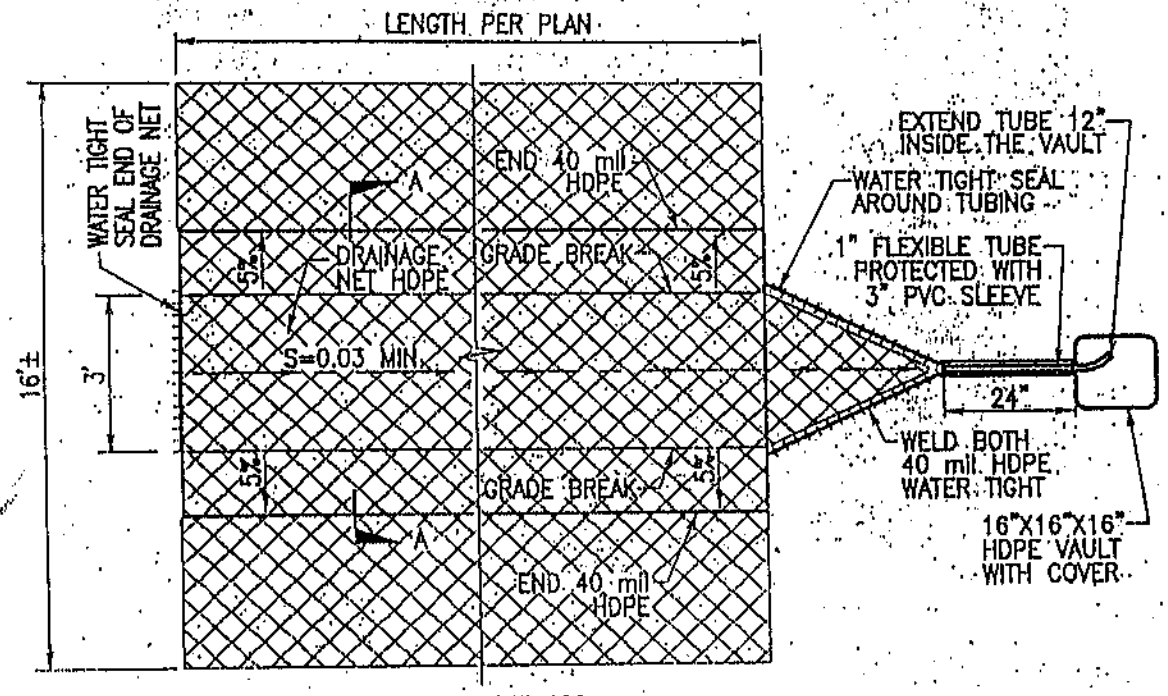
Coyote Canyon Landfill Monitoring



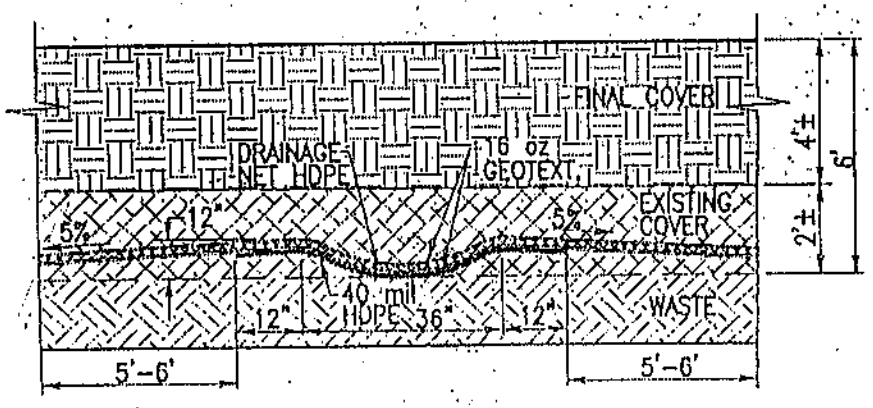
Typical Weather and Soil
Moisture Monitoring Station

Milliken Landfill

Pan Lysimeter Details

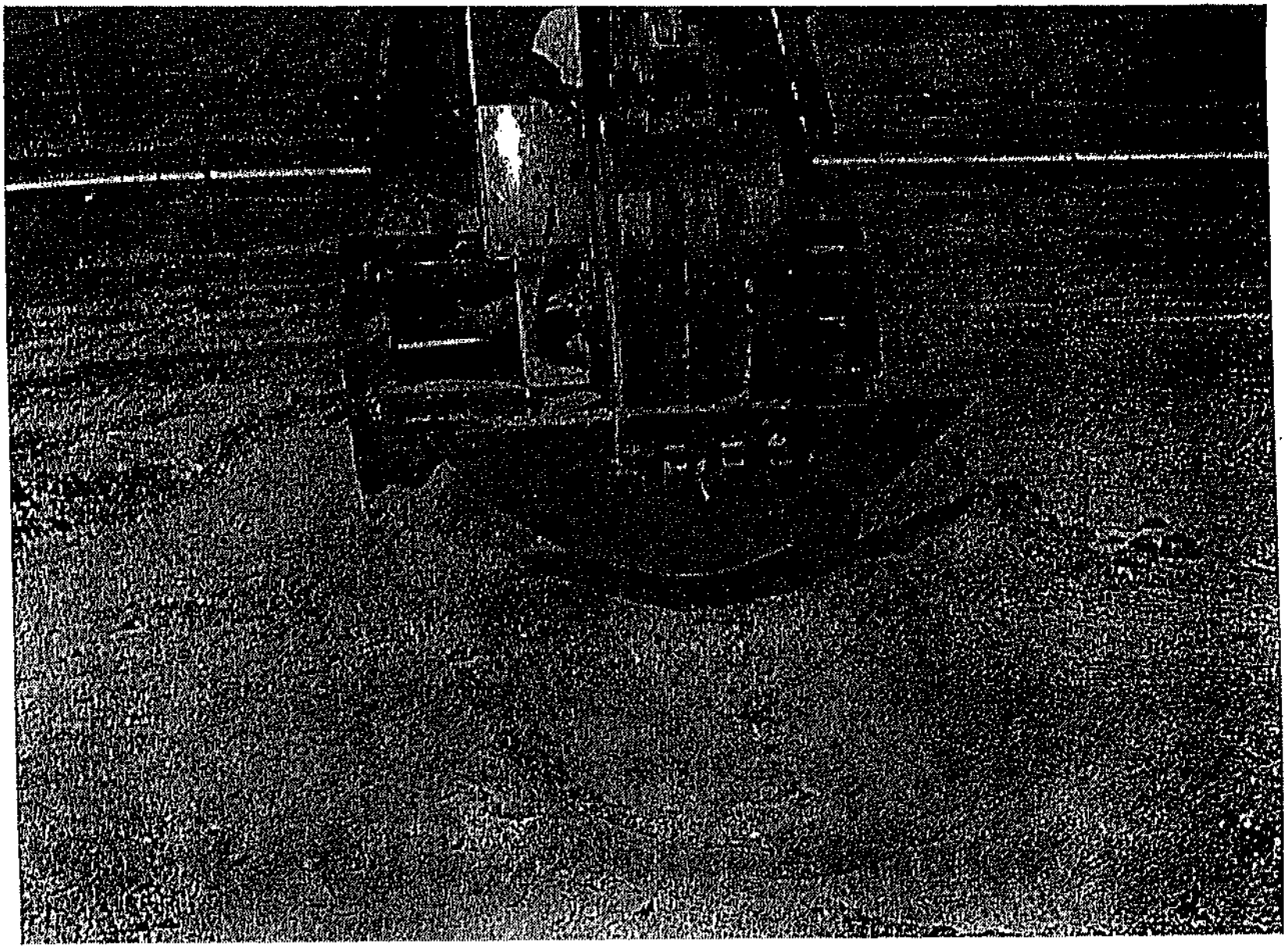


PLAN VIEW

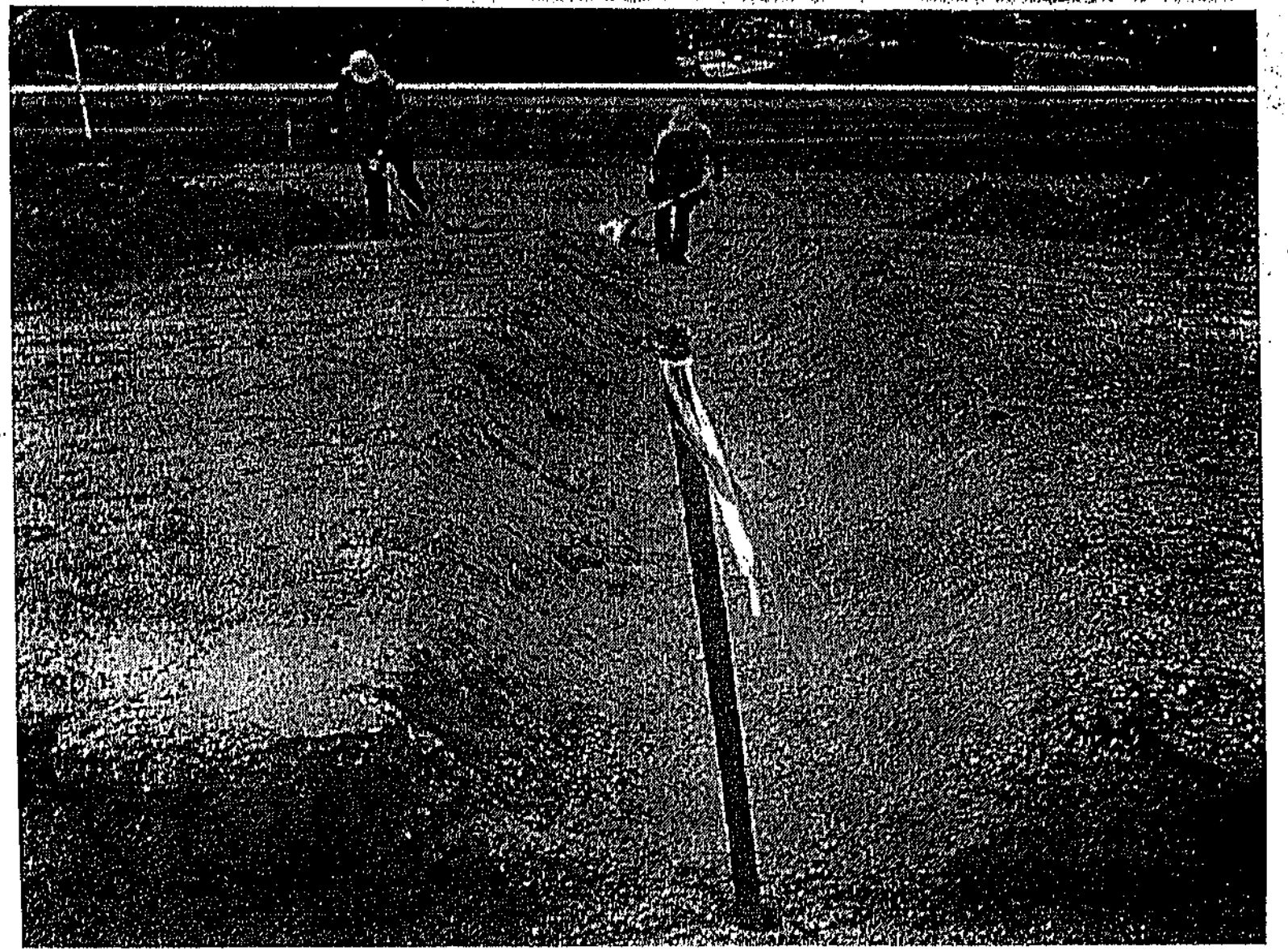


SECTION A-A

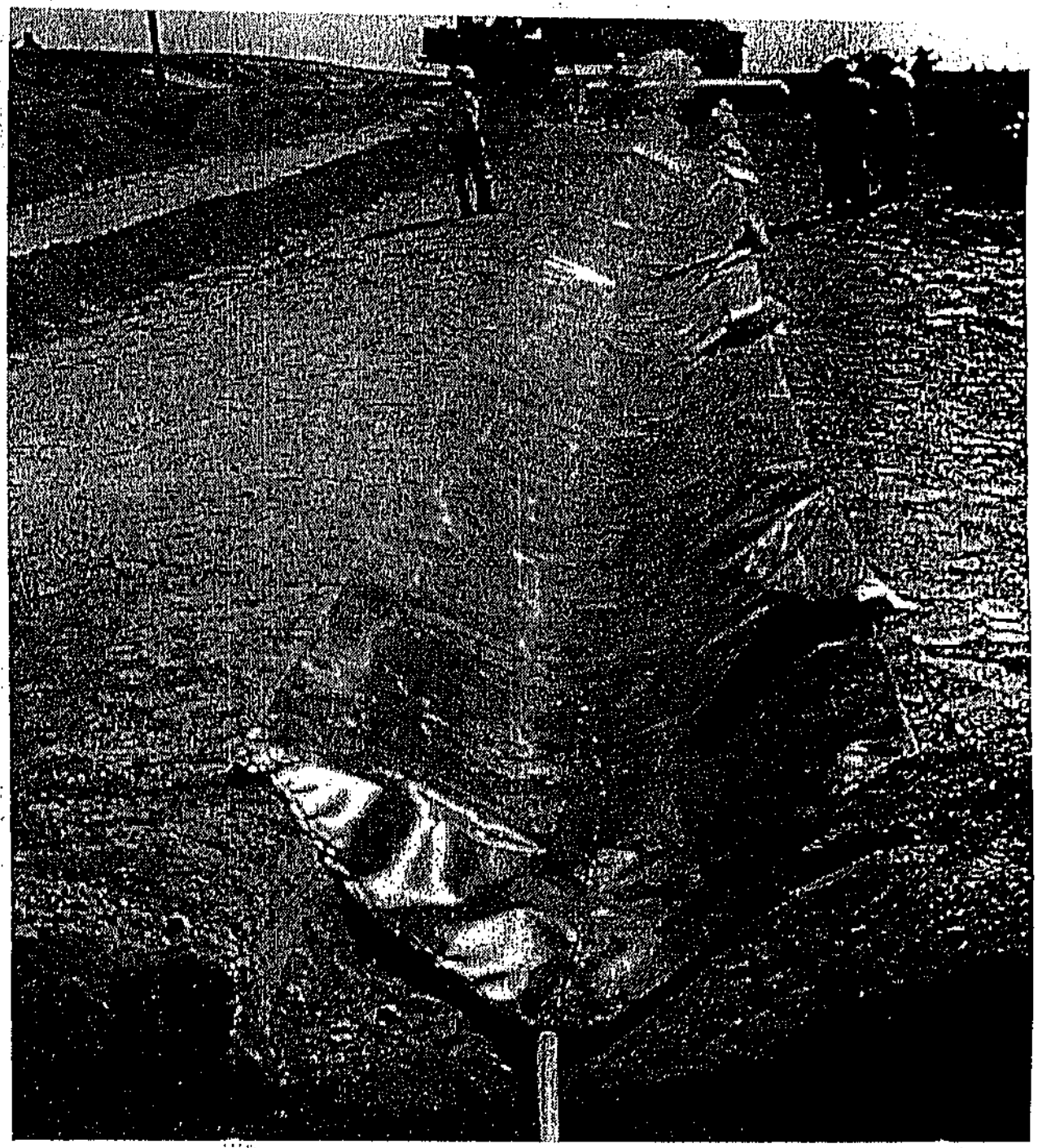
Lysimeter Trench Excavation



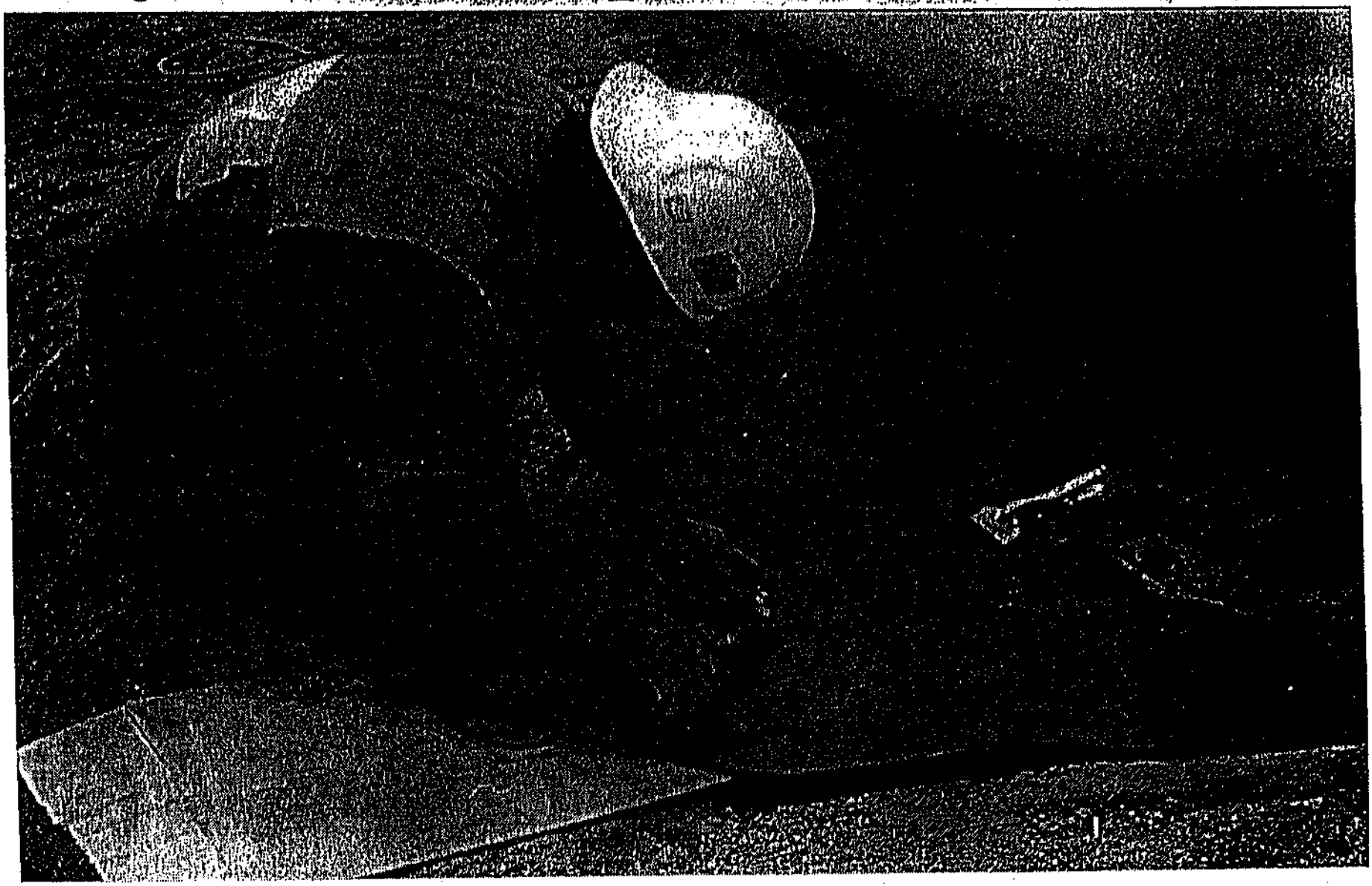
Finished Lysimeter Trench



HDPE Lysimeter Membrane

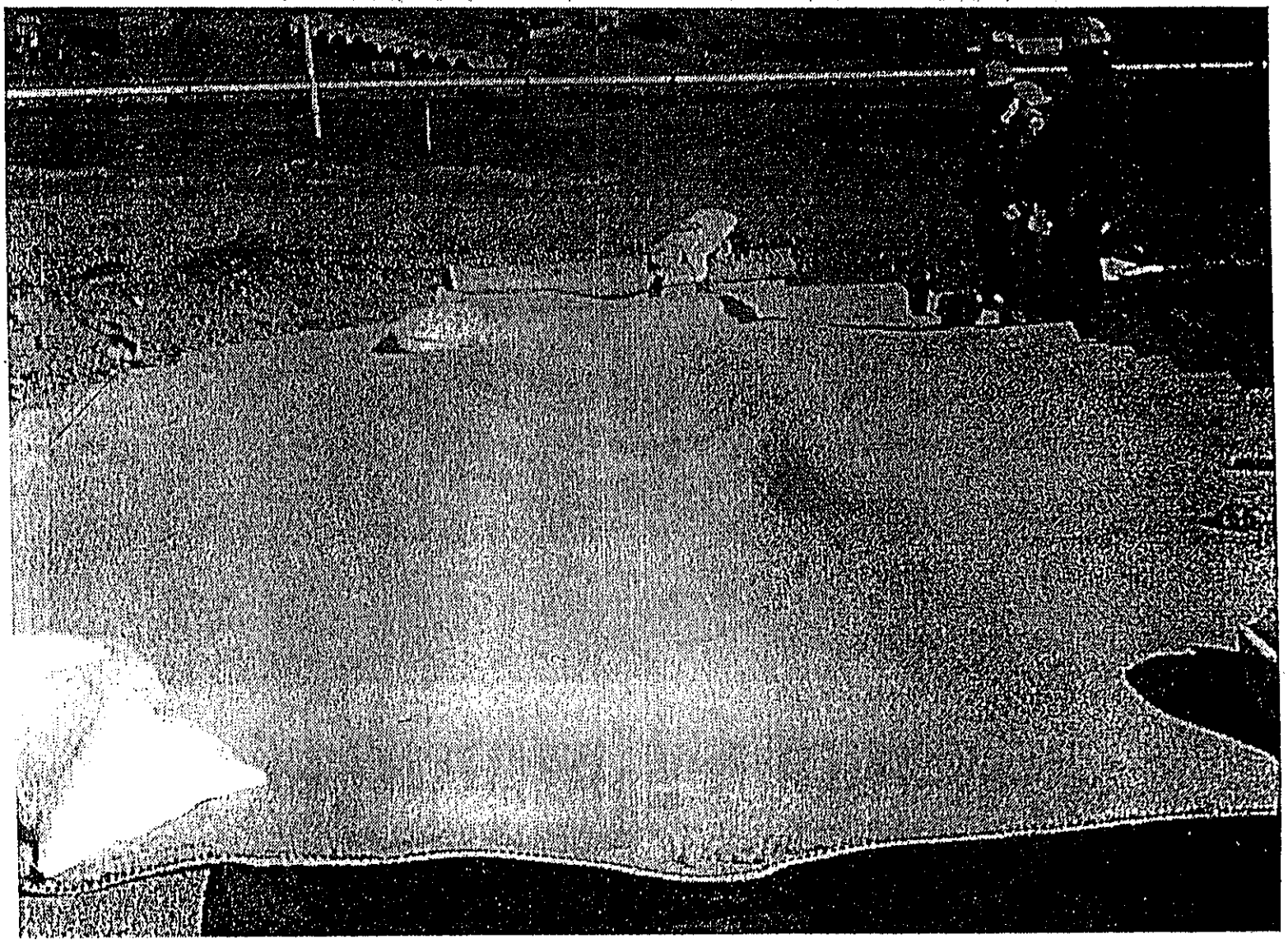


Lysimeter Liquid Collection

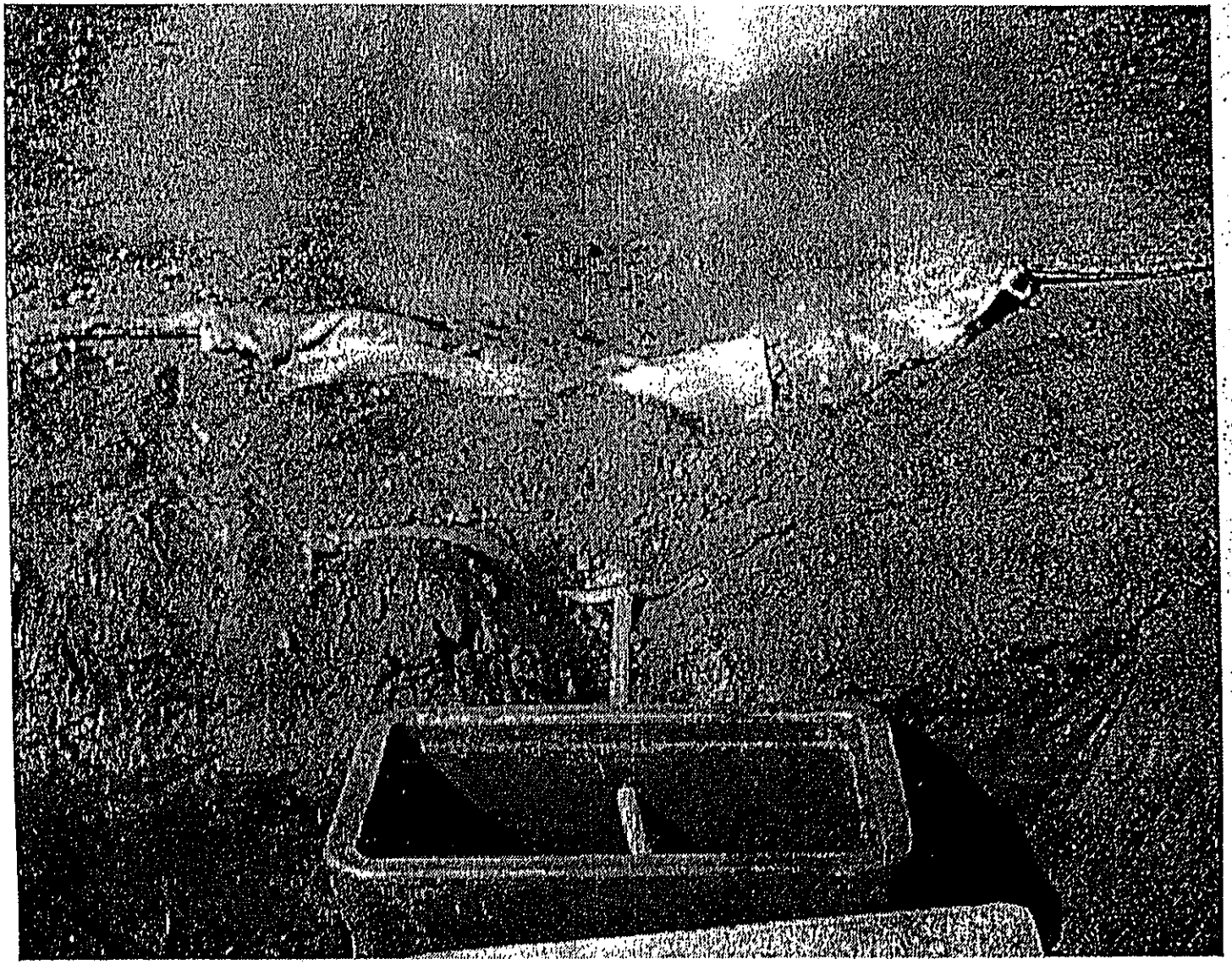


Lysimeter Liquid Collection

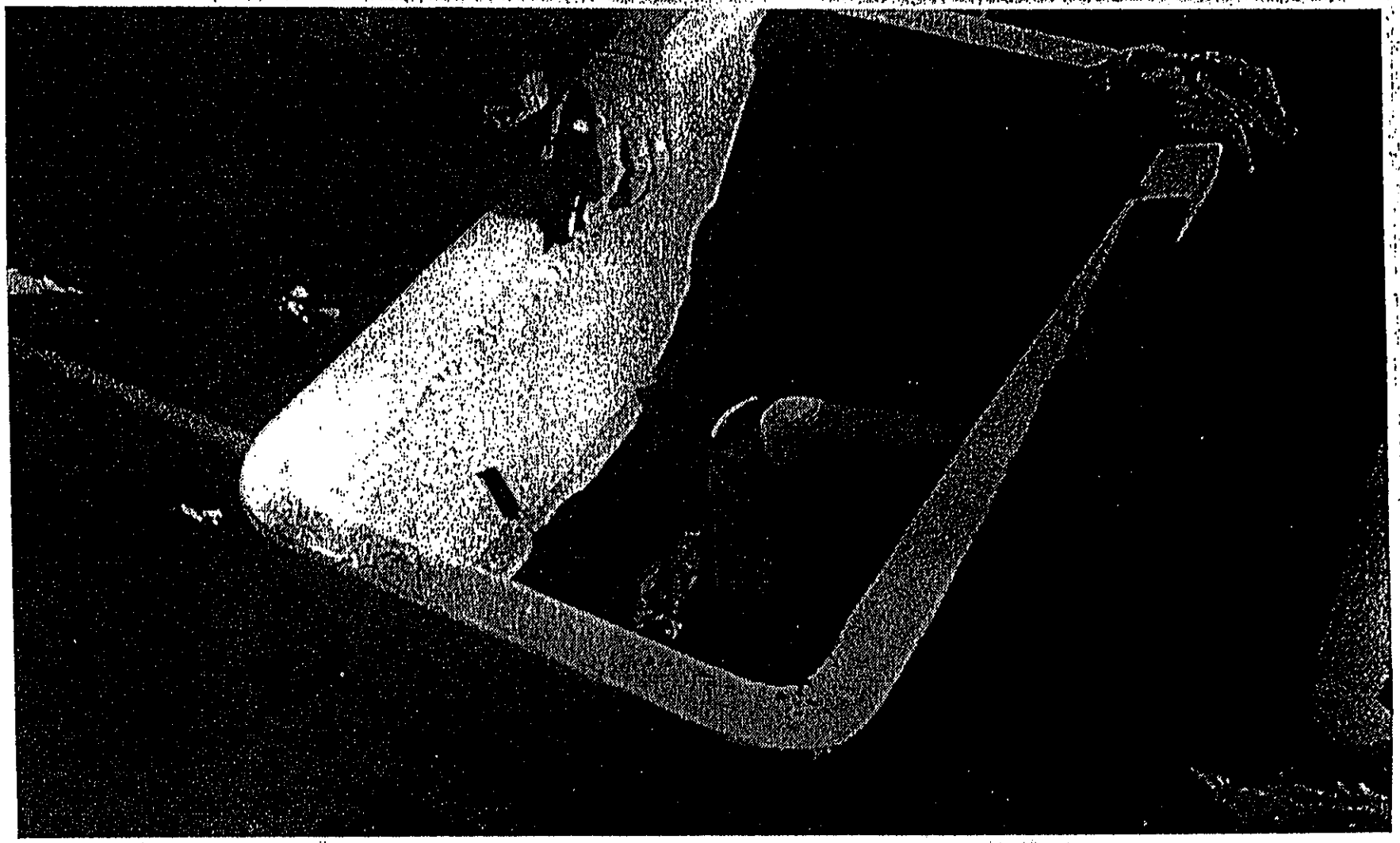
Lysimeter Collection Media



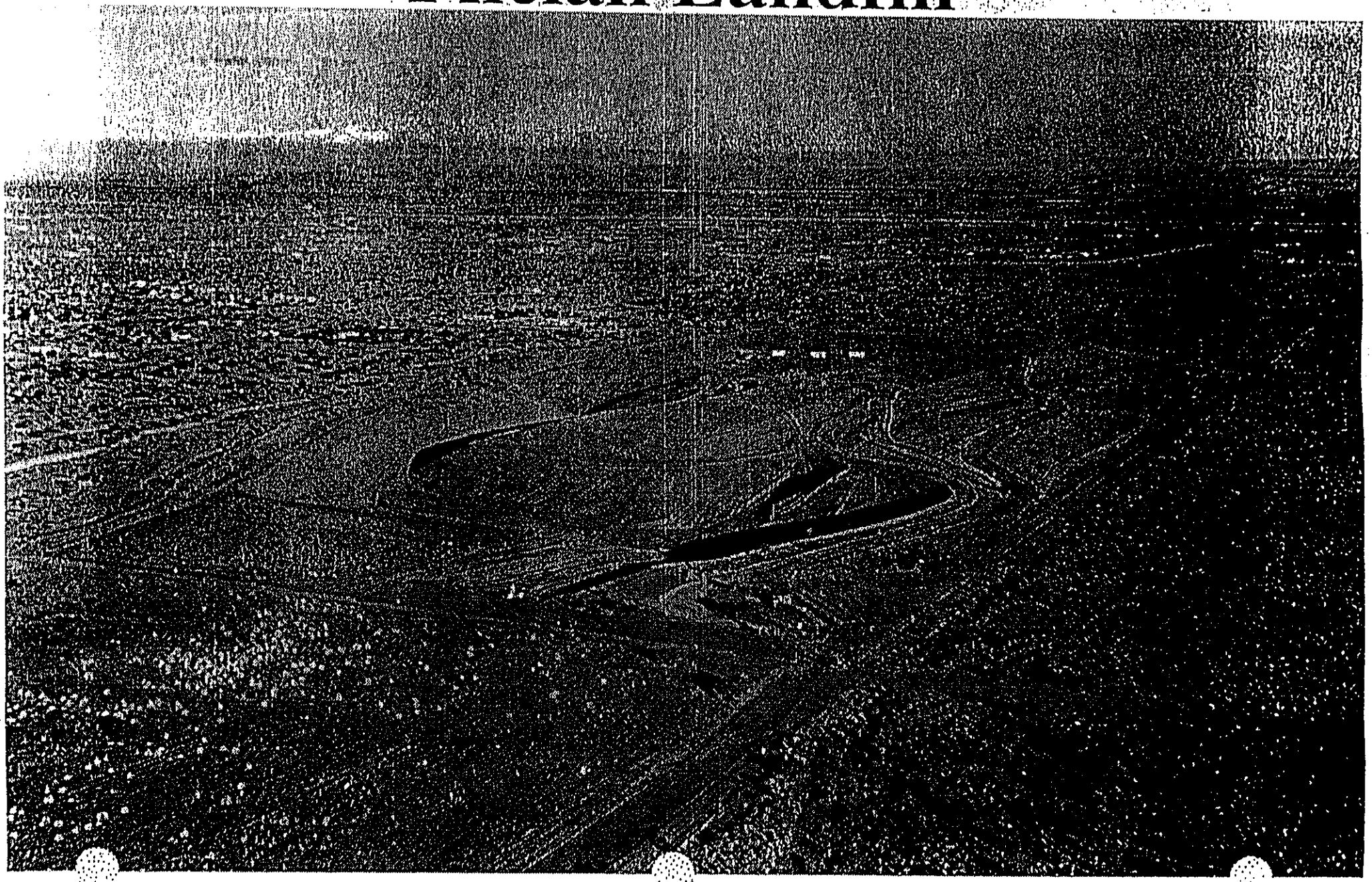
Lysimeter Discharge



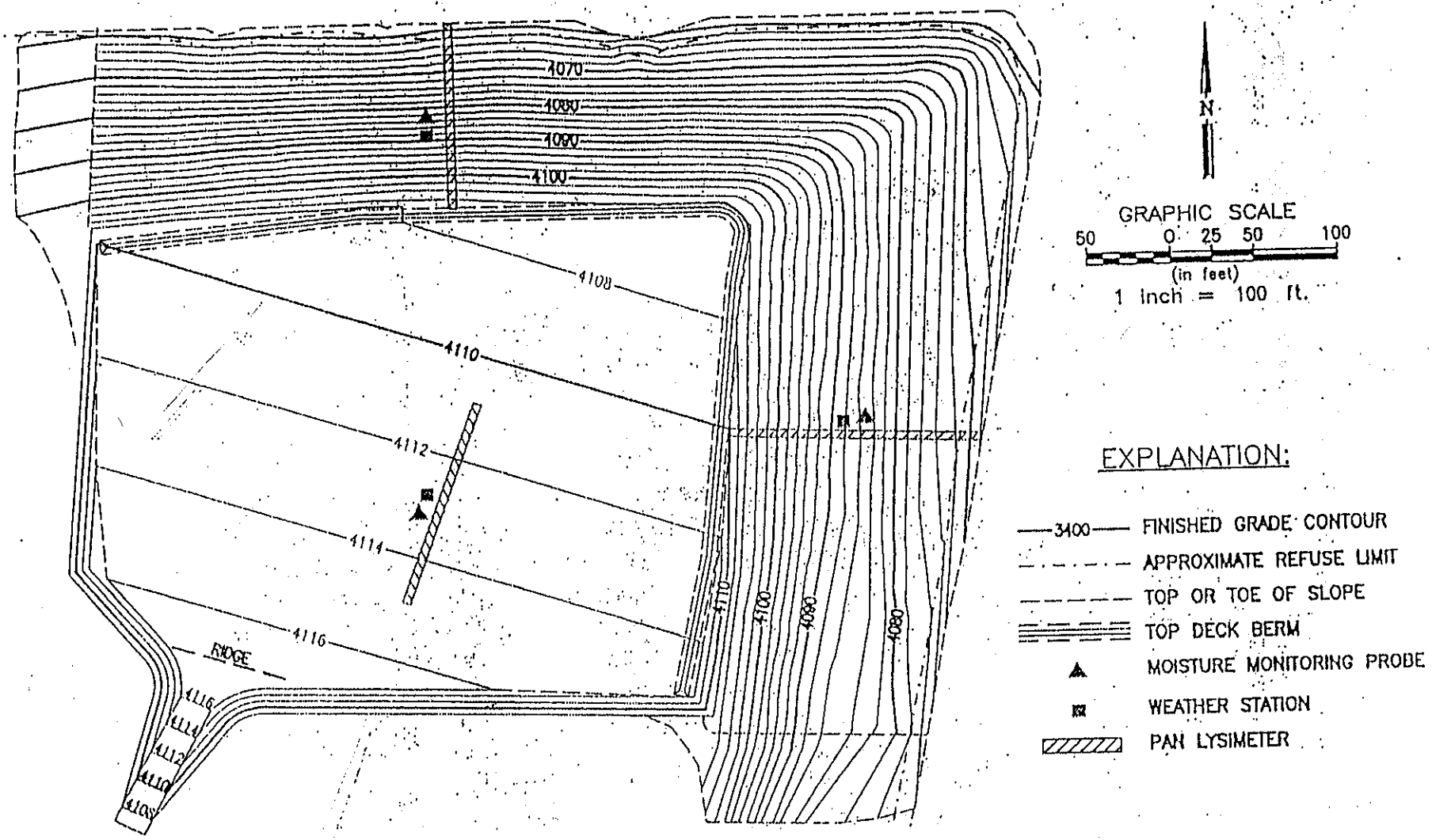
Lysimter Monitoring System



Phelan Landfill



Monitoring Locations

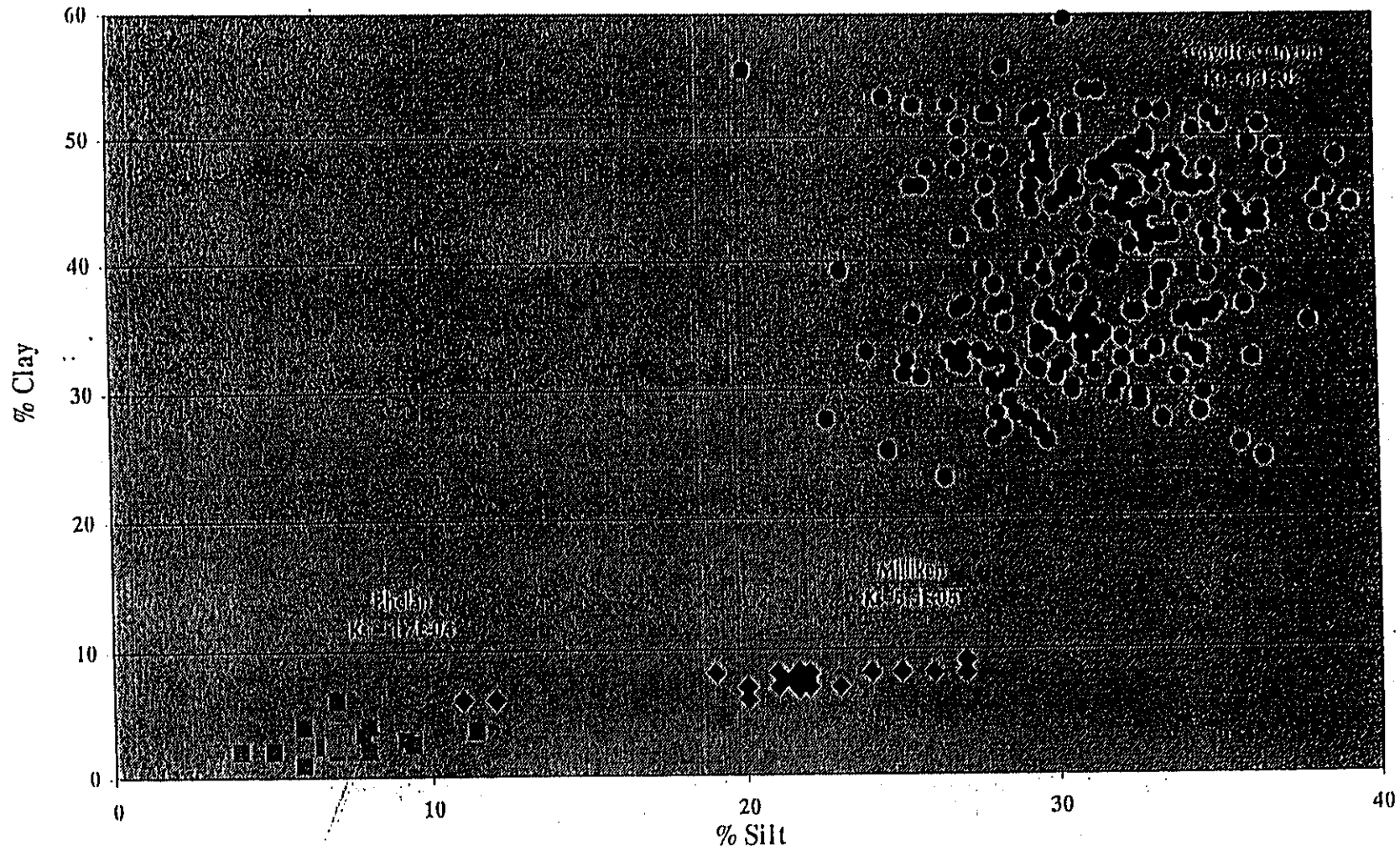


Alternative Final Cover Demonstration Projects

SOIL TYPES

GeoLogic Associates

Alternative Final Cover Soils



Alternative Final Cover Sites Design Hydraulic Conductivity

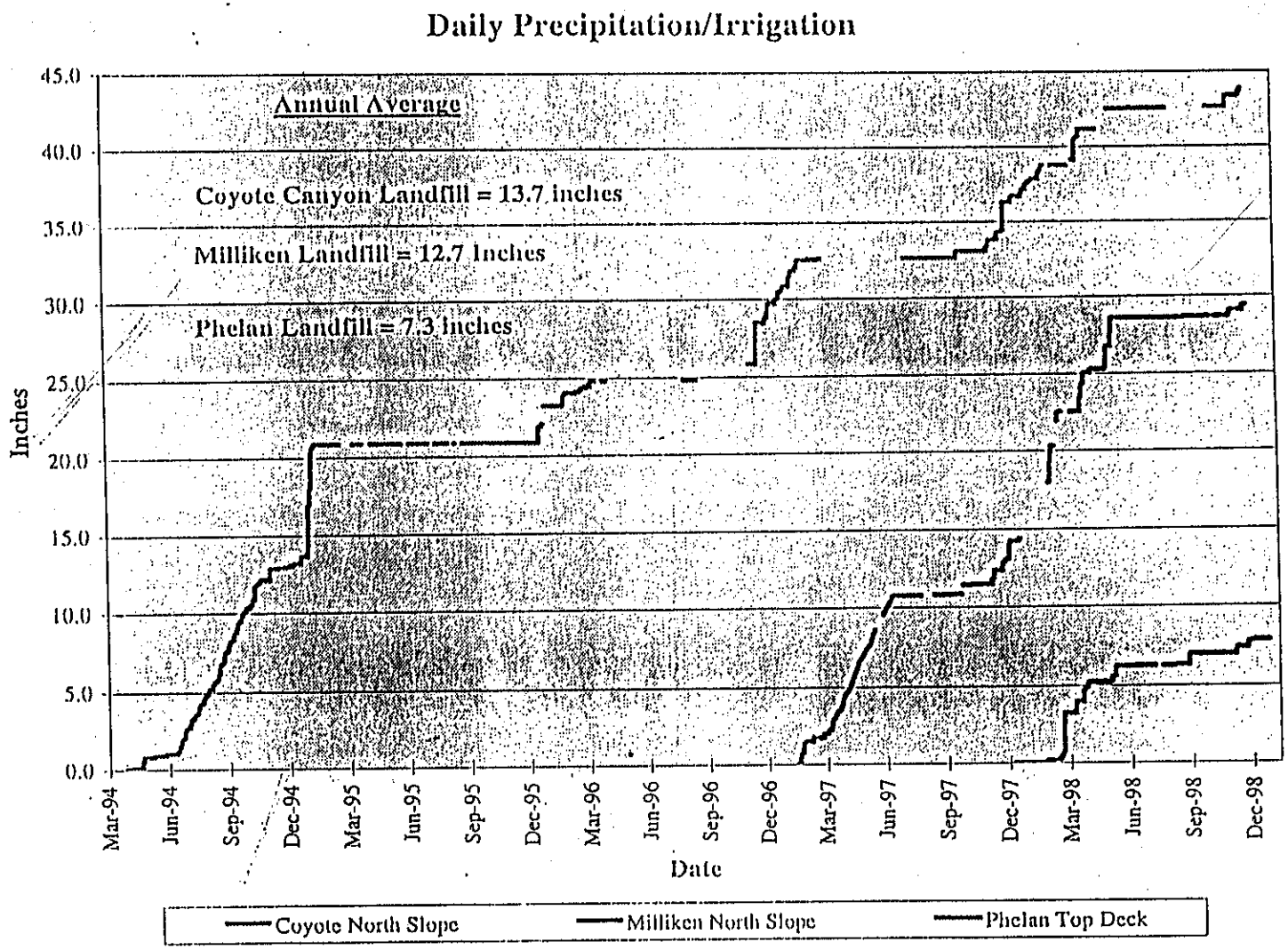
Current Demonstration Projects	Hydraulic Conductivity		
	Minimum Hydraulic Conductivity	Maximum Hydraulic Conductivity	Design Hydraulic Conductivity
Phelan	2.20E-05	3.20E-04	1.70E-04
Milliken	8.60E-07	1.60E-04	5.20E-05
Coyote Canyon	4.30E-07	4.30E-07	4.30E-07

Alternative Final Cover Demonstration Projects

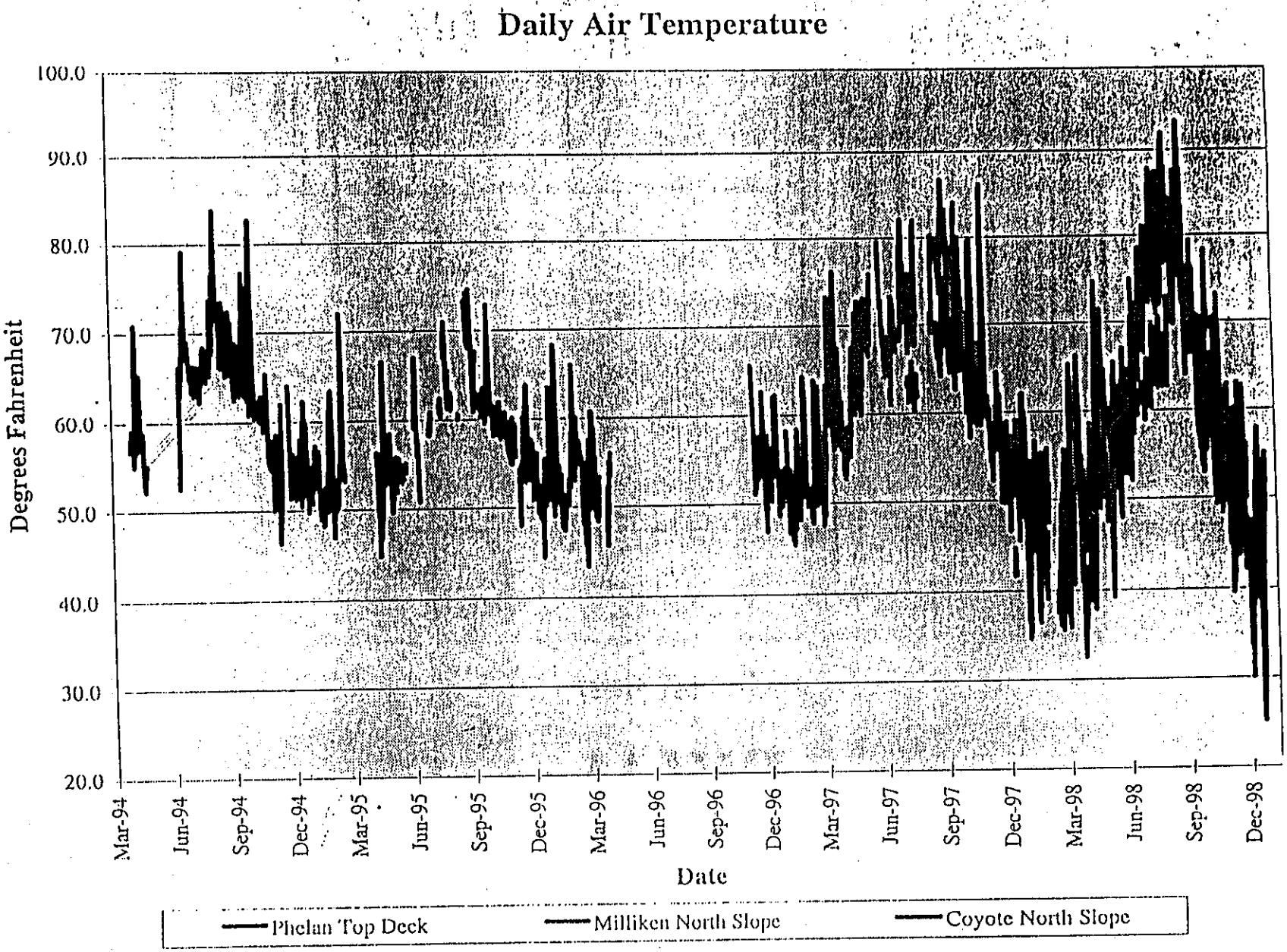
CLIMATIC CONDITIONS

GeoLogic Associates

Rainfall

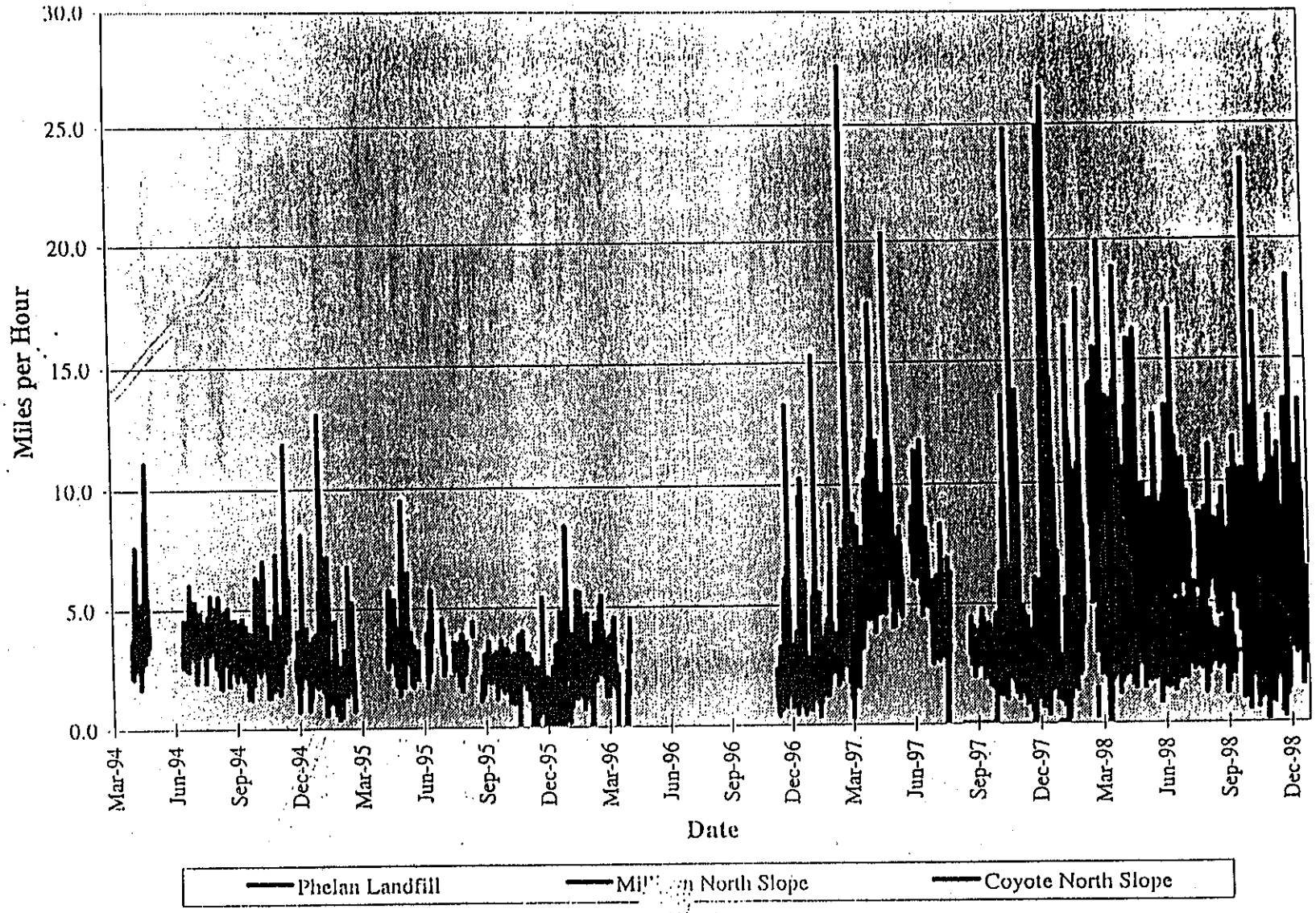

Daily Precipitation/Irrigation
Annual Average
Coyote Canyon Landfill = 13.7 inches
Milliken Landfill = 12.7 Inches
Phelan Landfill = 7.3 inches
Inches
45.0
40.0
35.0
30.0
25.0
20.0
15.0
10.0
5.0
0.0
Mar-94
Jun-94
Sep-94
Dec-94
Mar-95
Jun-95
Sep-95
Dec-95
Mar-96
Jun-96
Sep-96
Dec-96
Mar-97
Jun-97
Sep-97
Dec-97
Mar-98
Jun-98
Sep-98
Dec-98
Date
Coyote North Slope
Milliken North Slope
Phelan Top Deck

Air Temperature

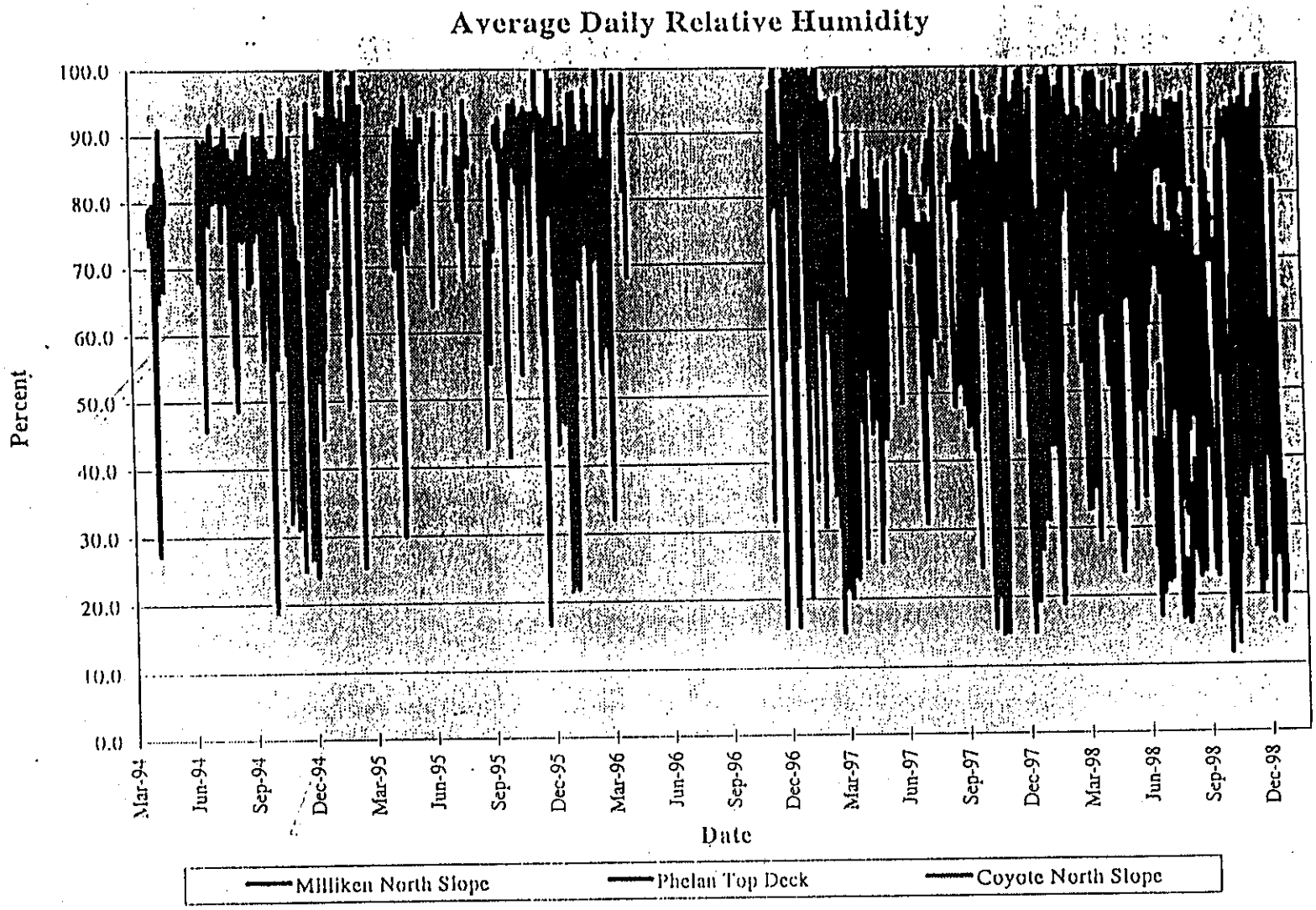


Wind

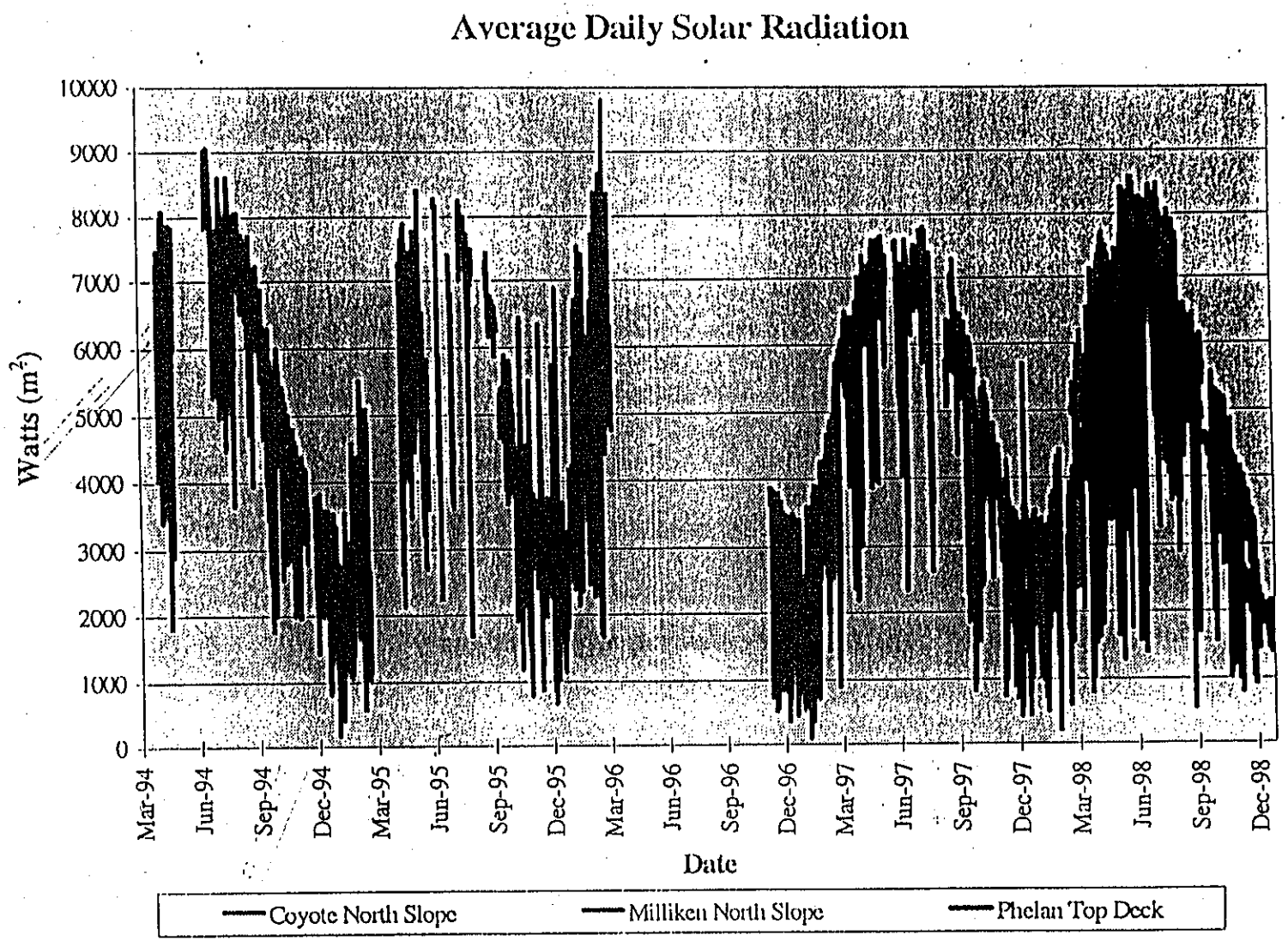
Daily Windspeed



Relative Humidity



Solar Radiation

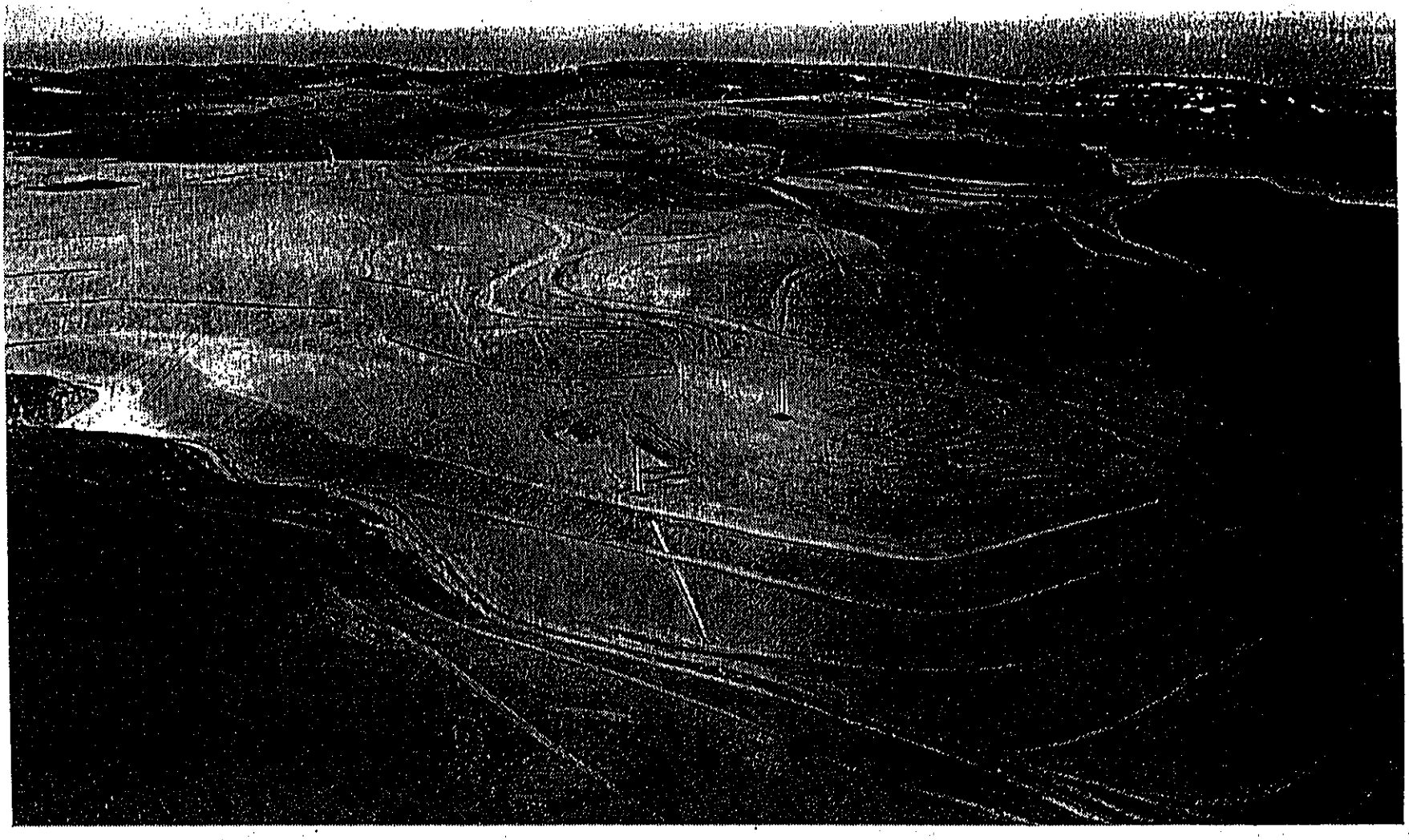


Alternative Final Cover Demonstration Projects

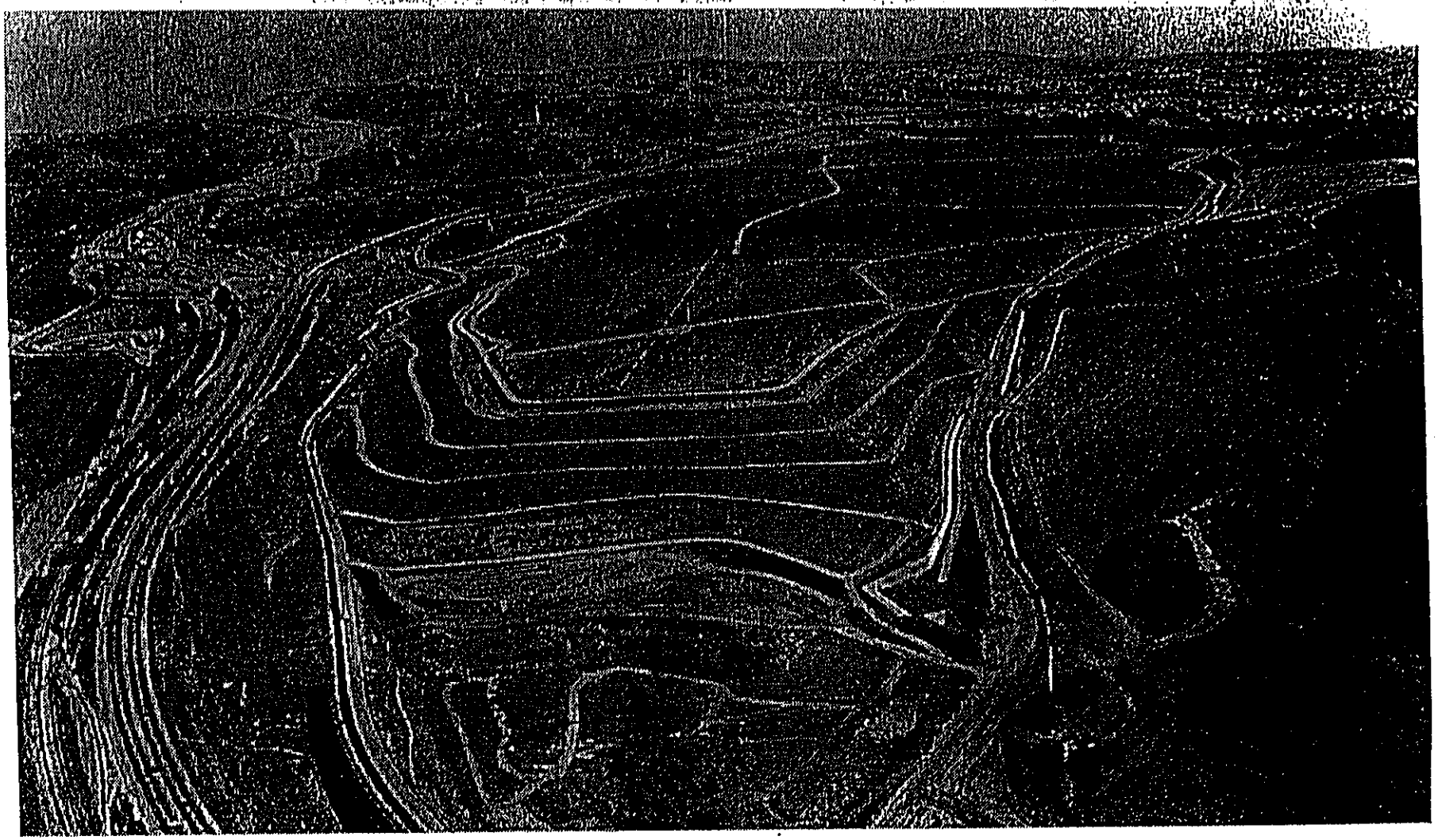
VEGETATIVE COVERS

GeoLogic Associates

Coyote Canyon - 1994

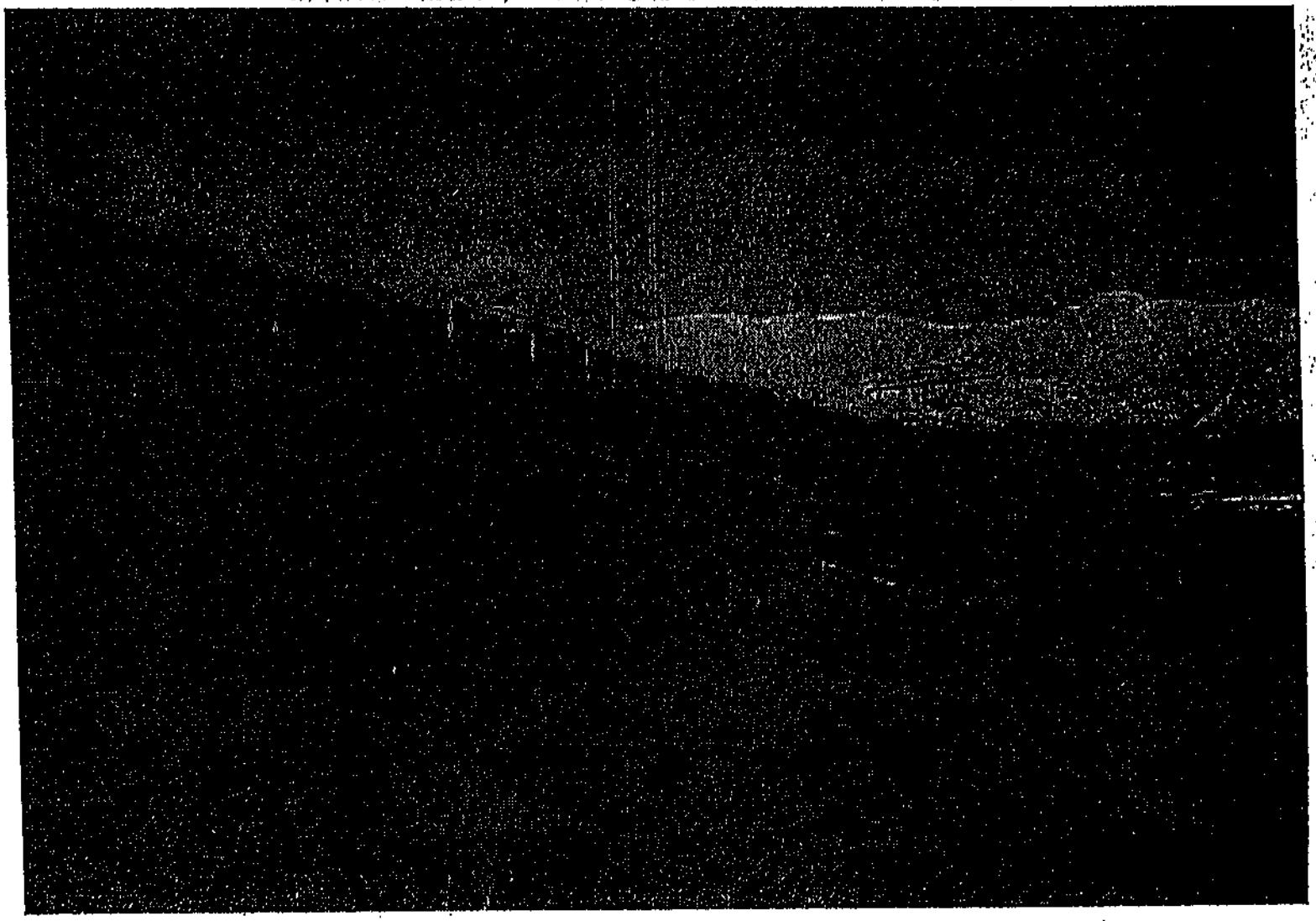


Coyote Canyon - 1996

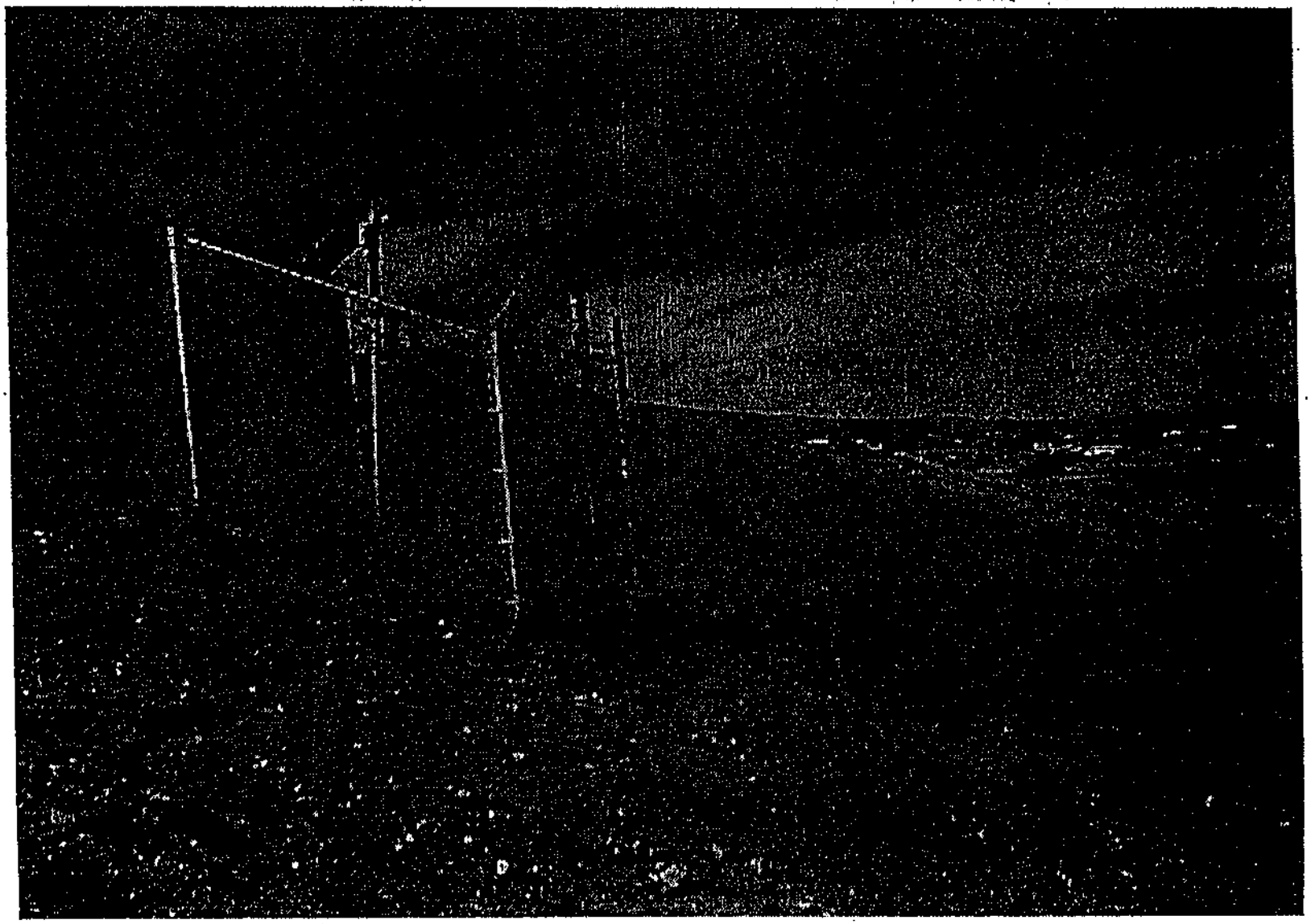


Coyote Canyon North Slope - 1998

Milliken North Slope - 1999



Phelan North Slope - 1999

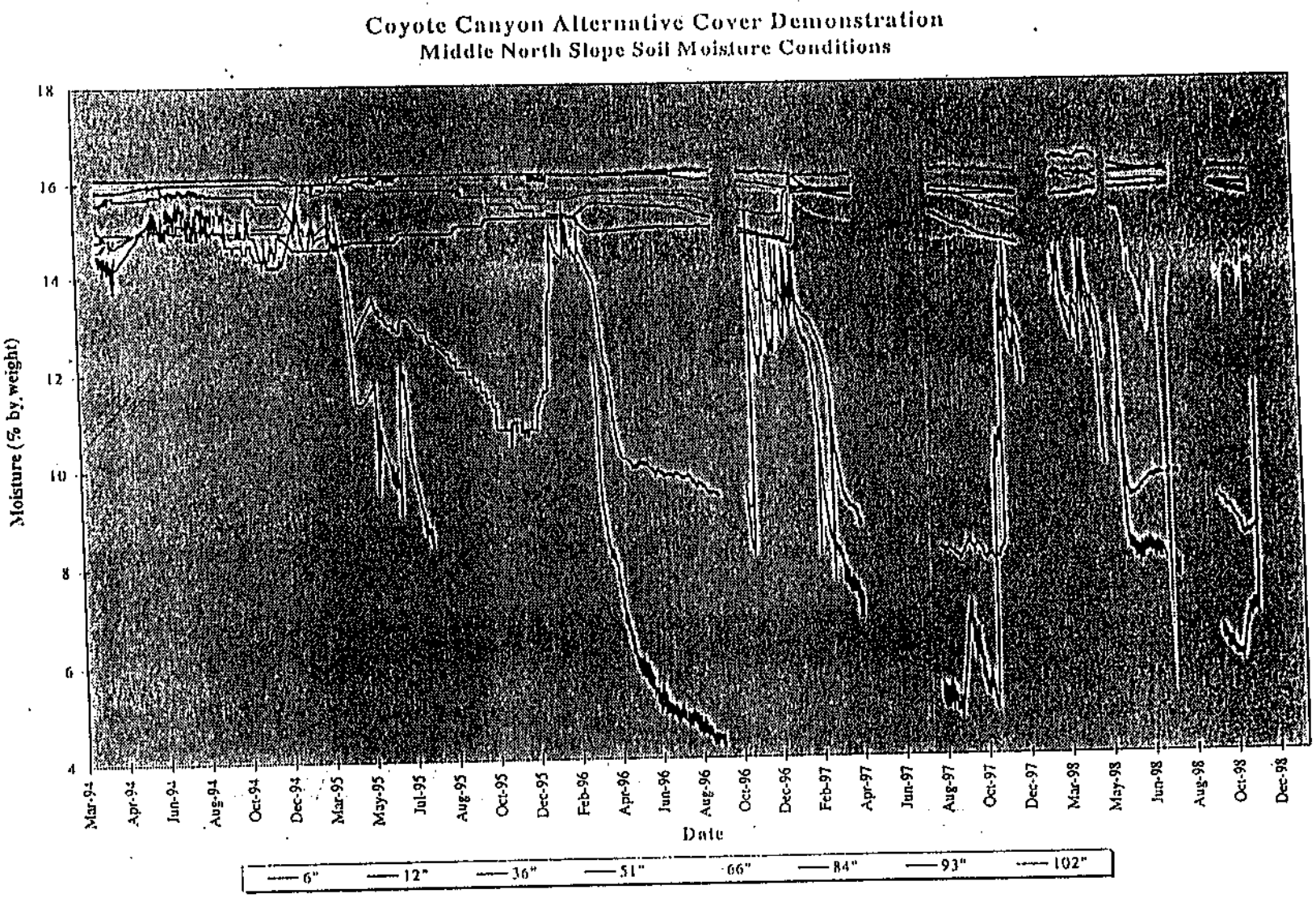


MSW Landfill Demonstrations

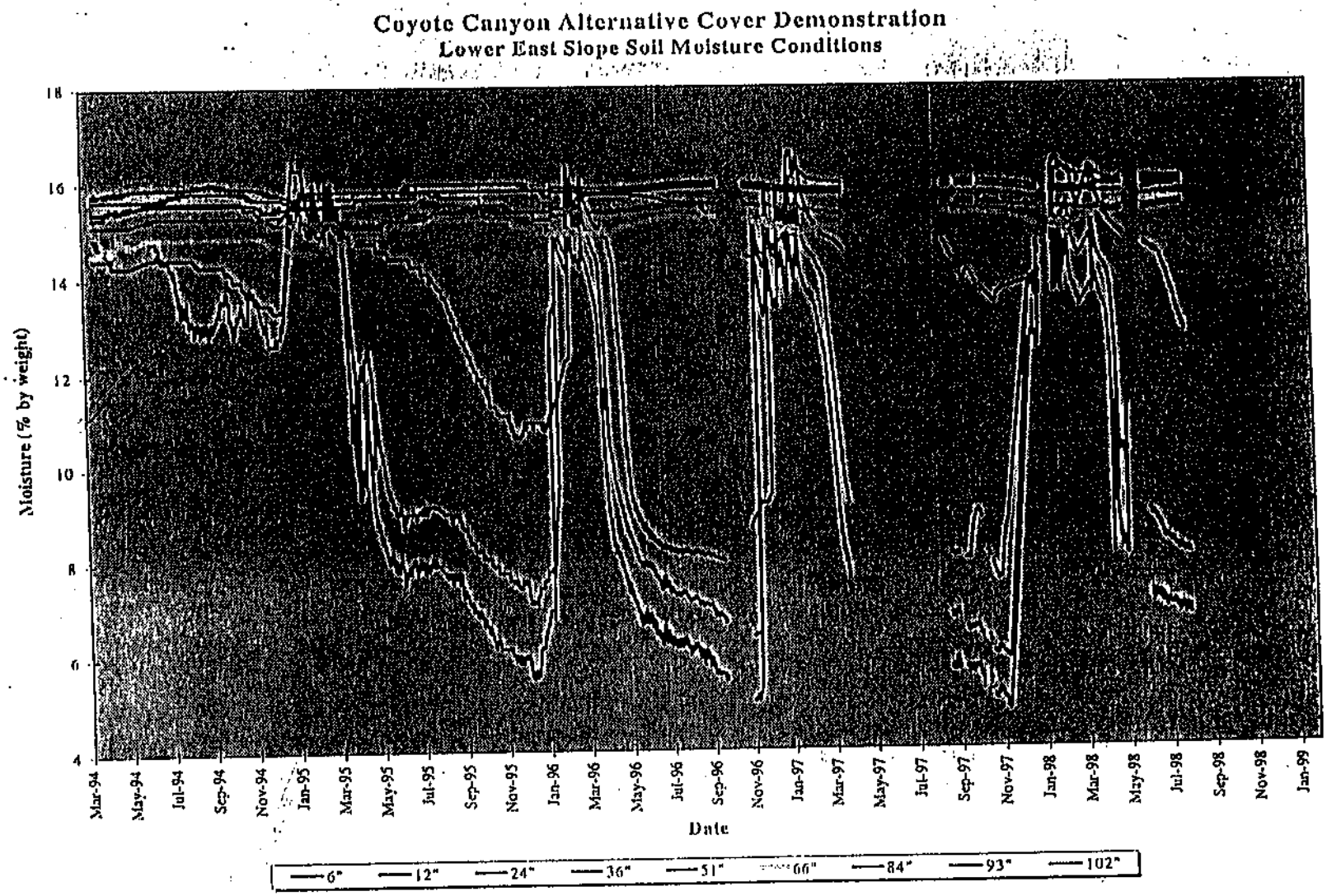
SOIL MOISTURE MONITORING

GeoLogic Associates

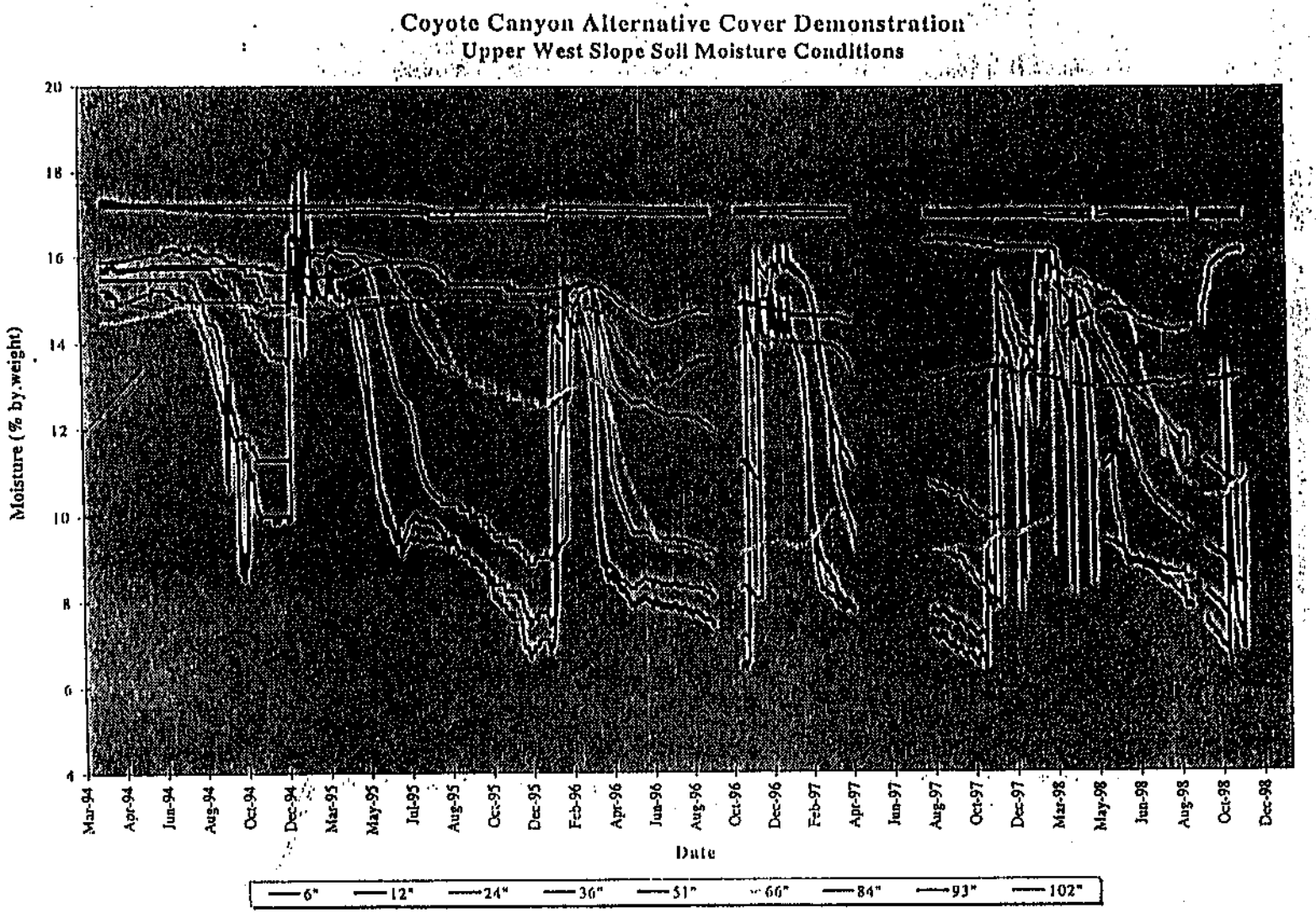
Coyote Canyon Middle North Slope



Coyote Canyon Lower East Slope

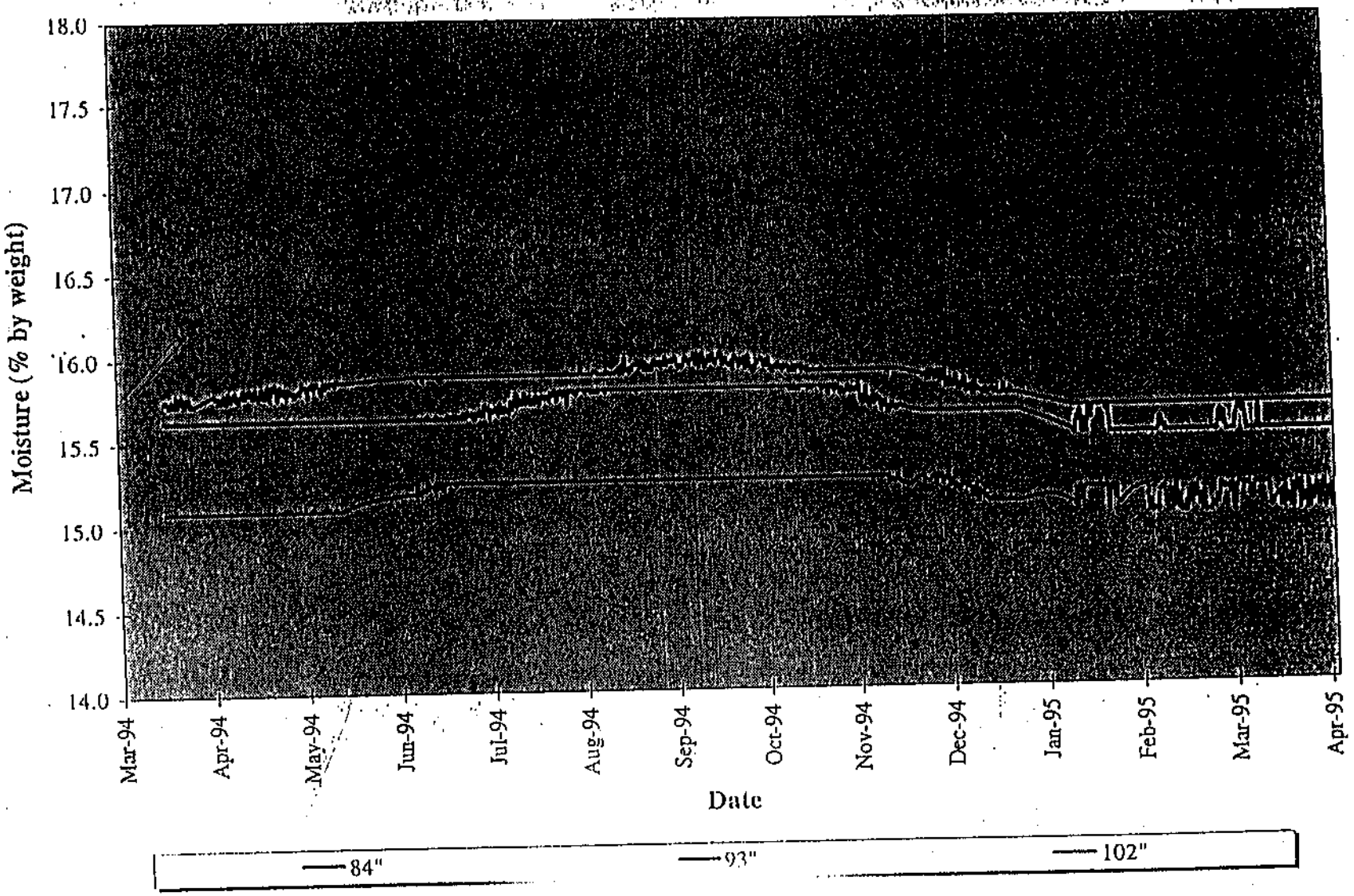


Coyote Canyon Upper East Slope

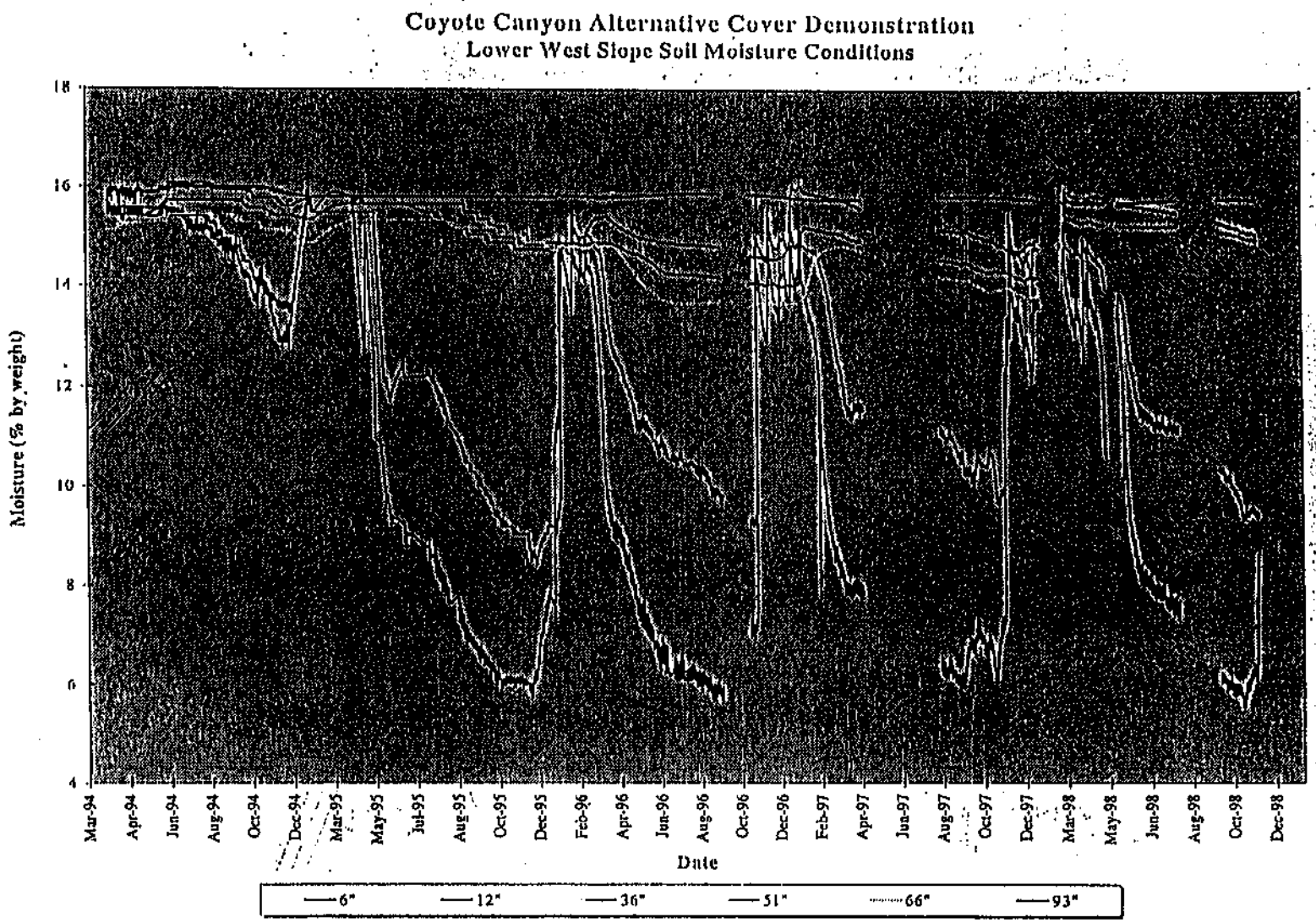


Coyote Canyon Upper East Slope

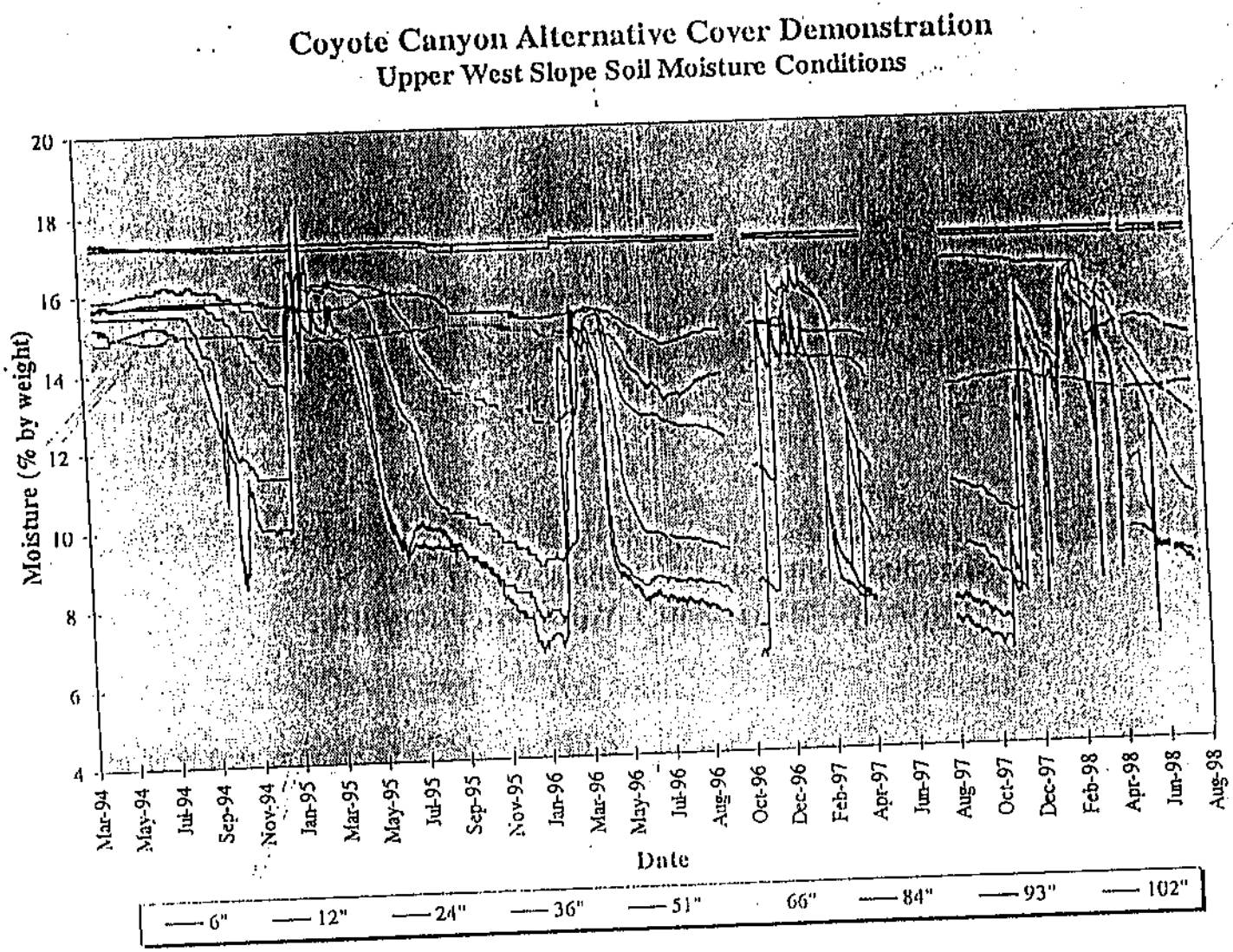
Lower East Slope Clay Moisture Conditions



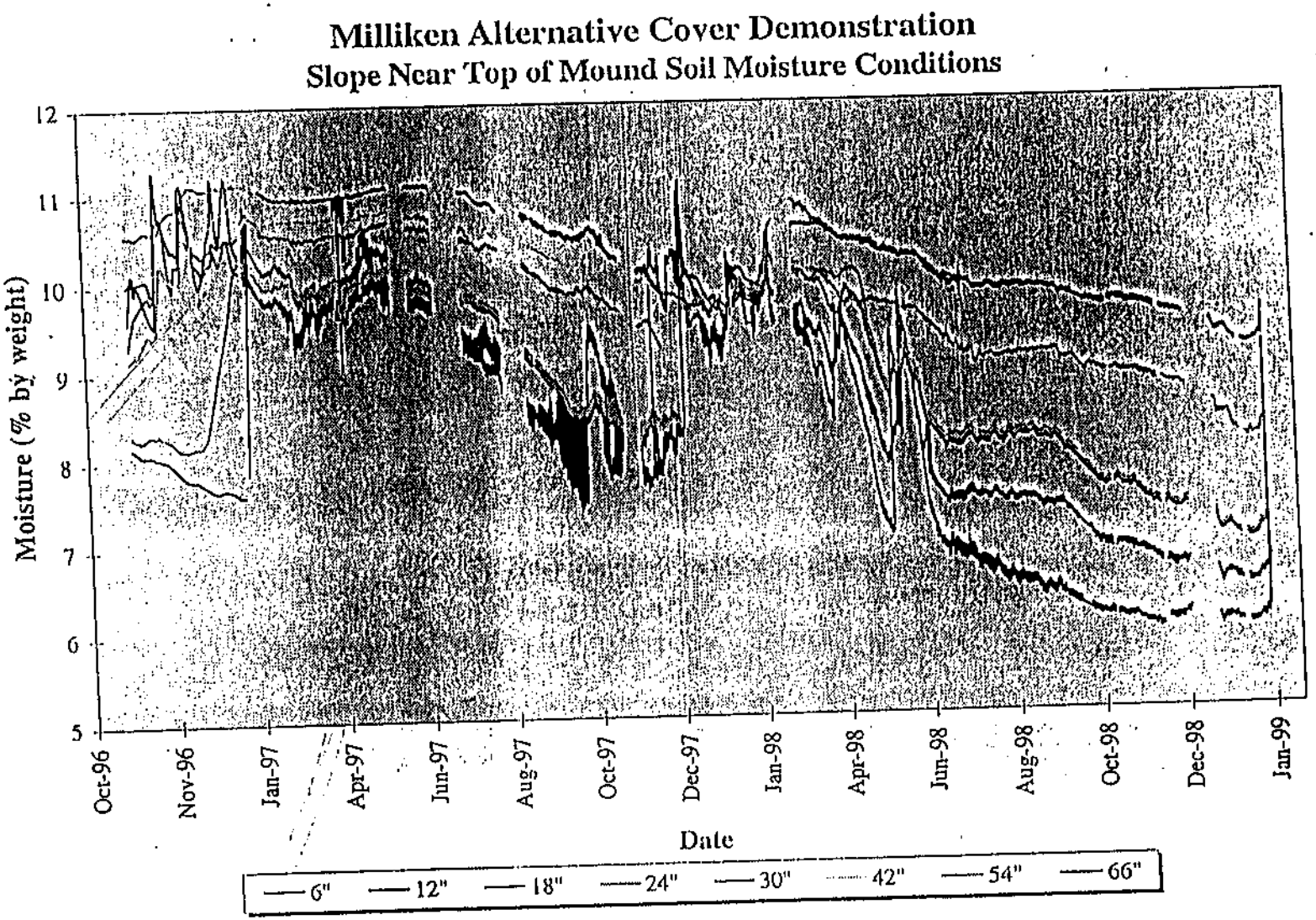
Coyote Canyon Lower West Slope



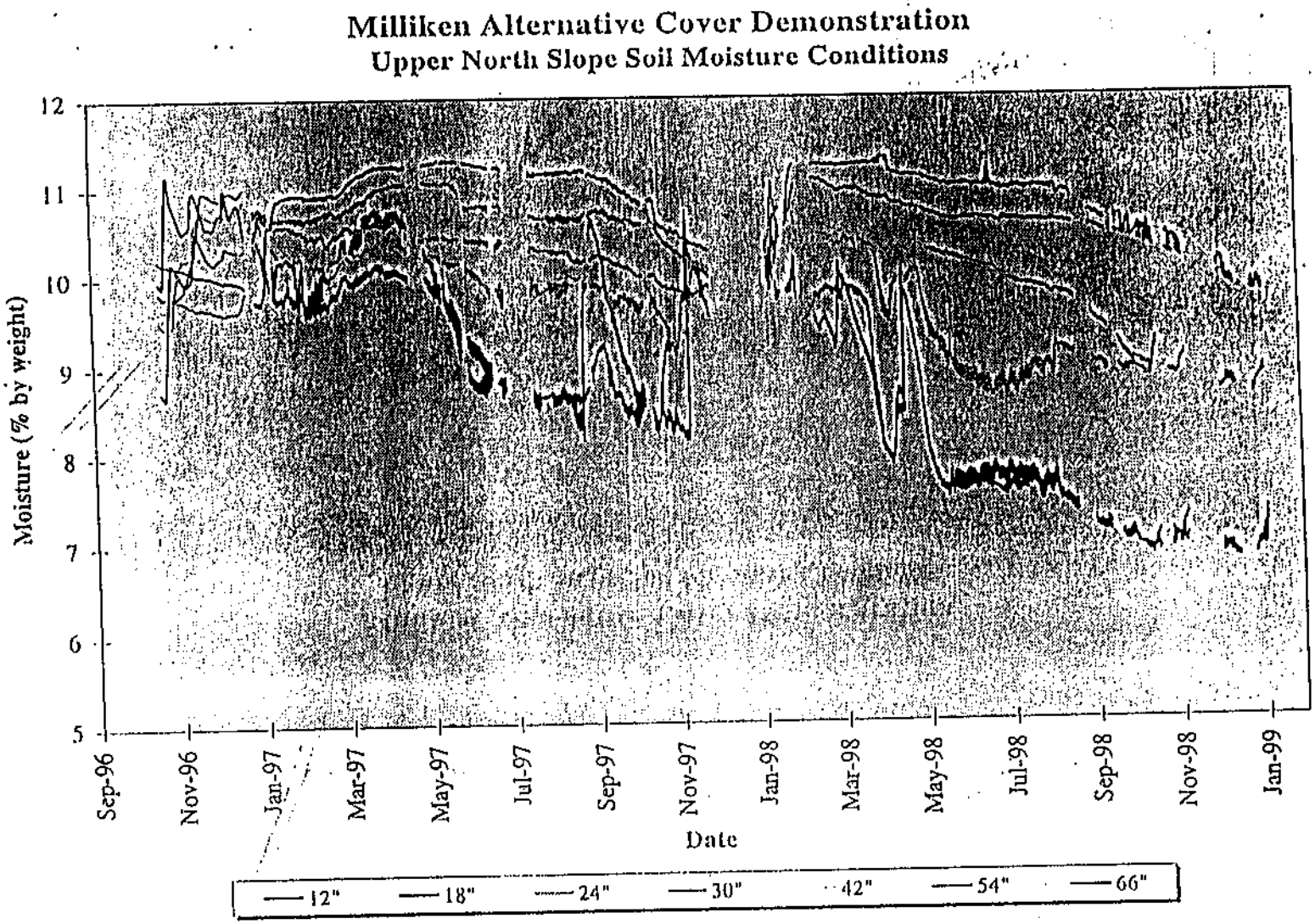
Coyote Canyon Upper West Slope



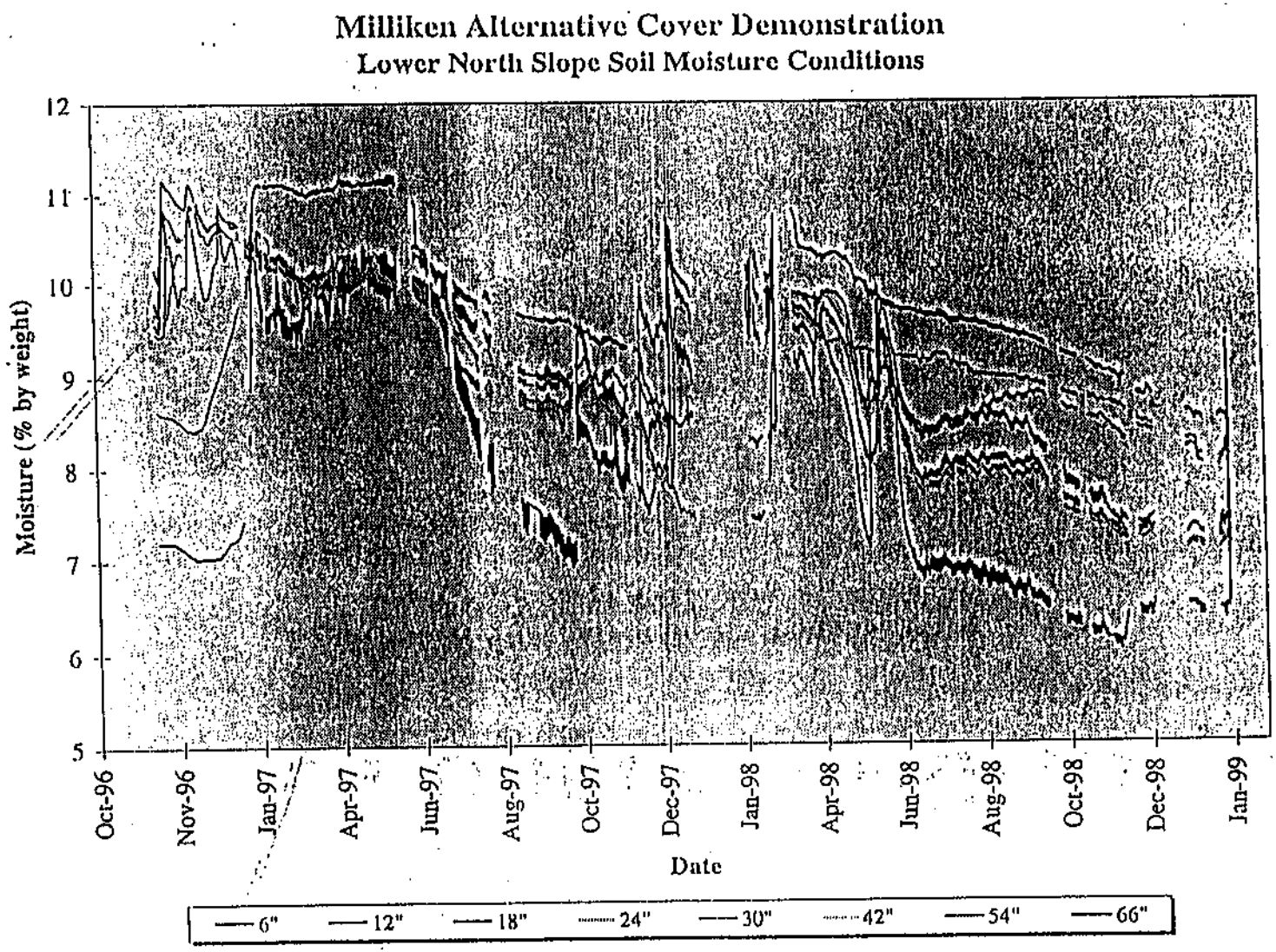
Milliken Northwest Slope



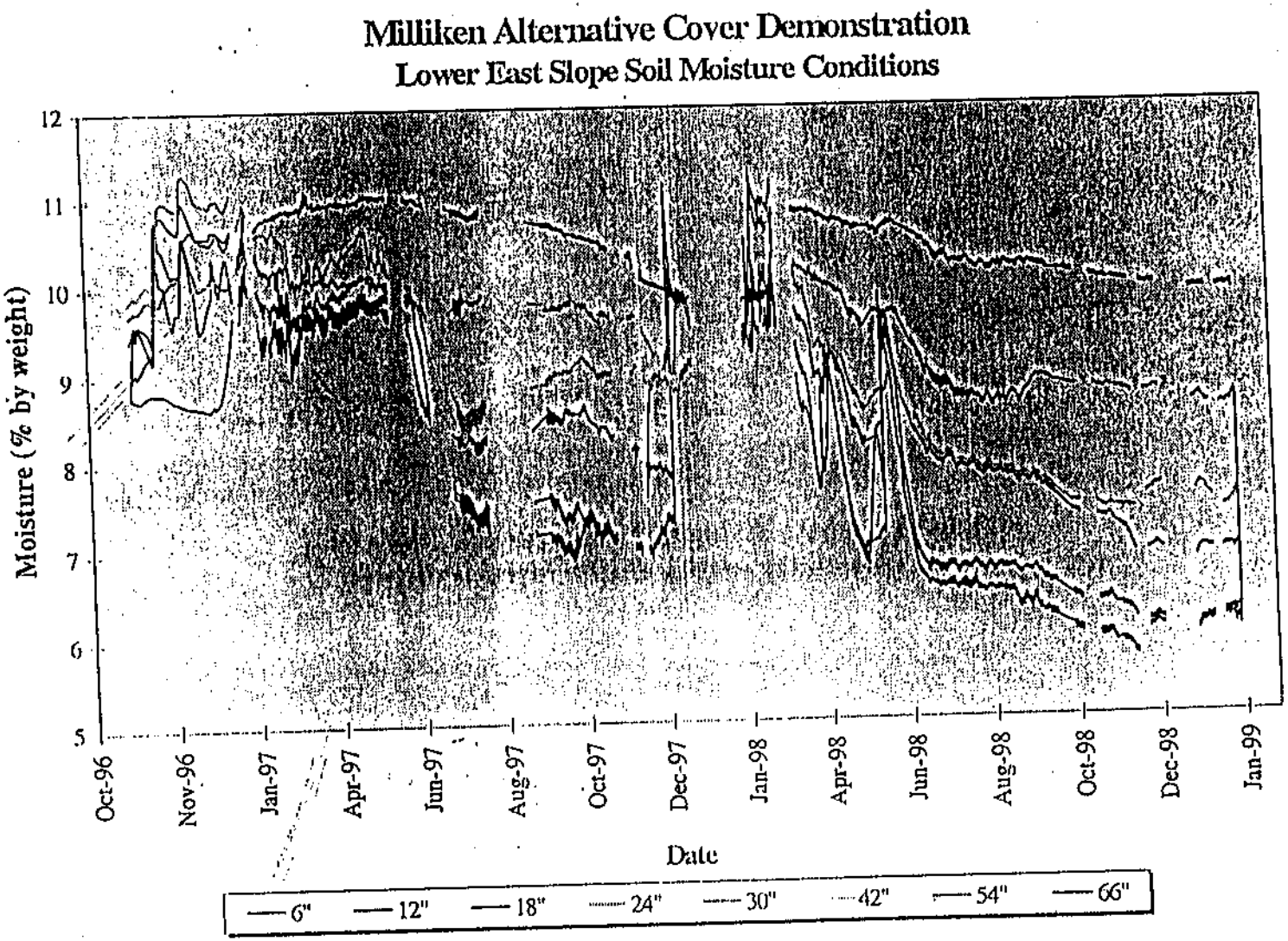
Milliken Upper North Slope



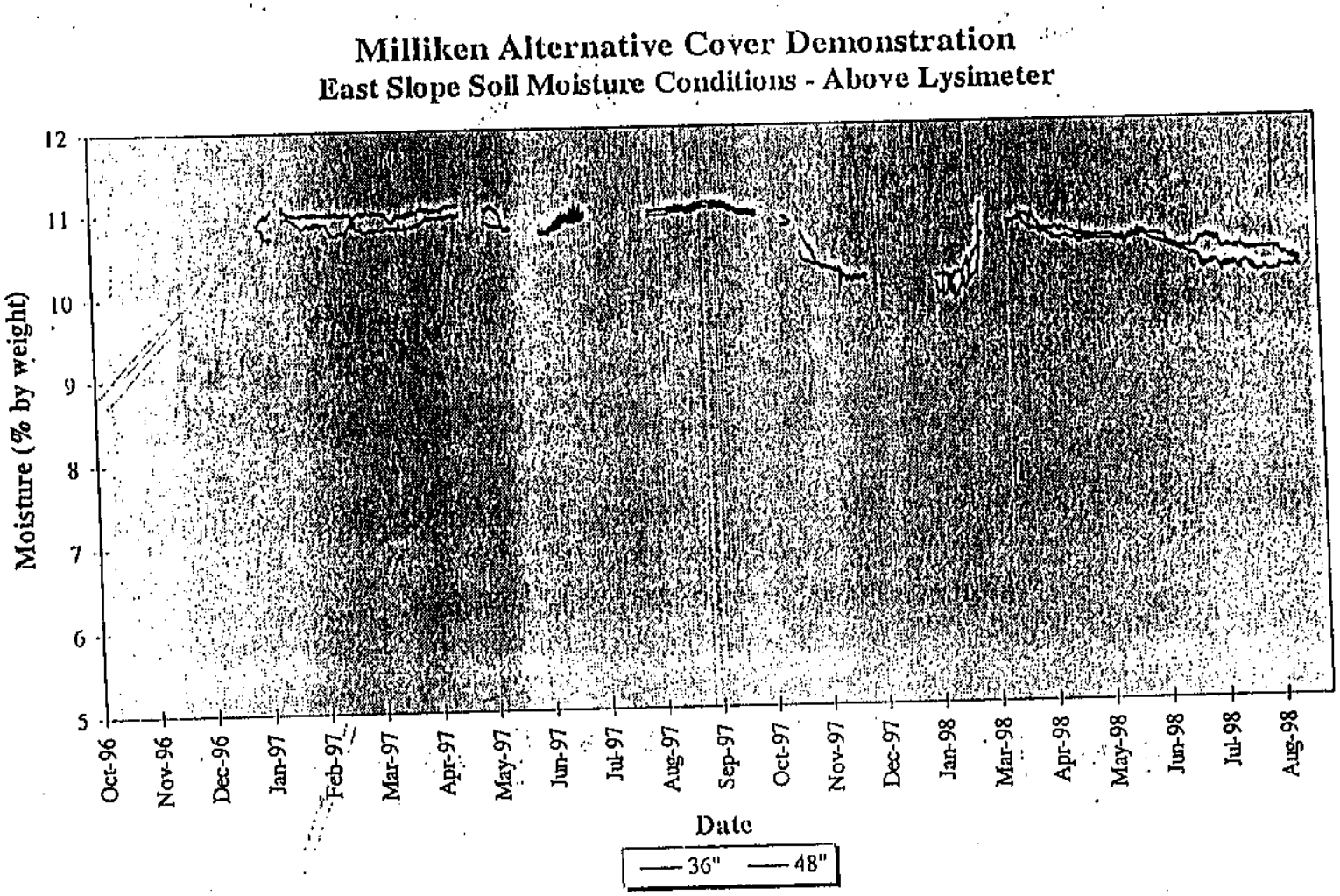
Milliken Lower North Slope



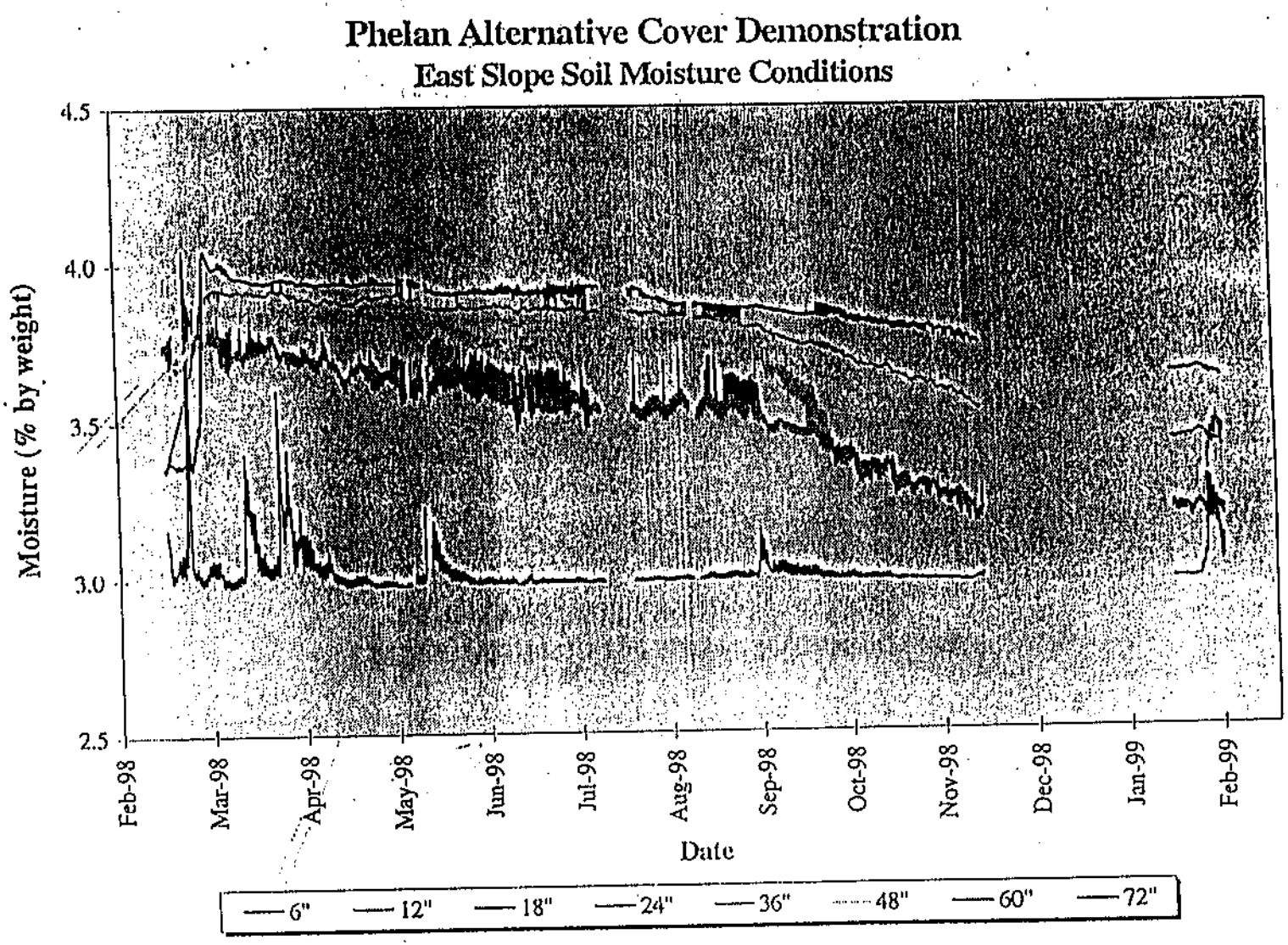
Milliken Lower East Slope



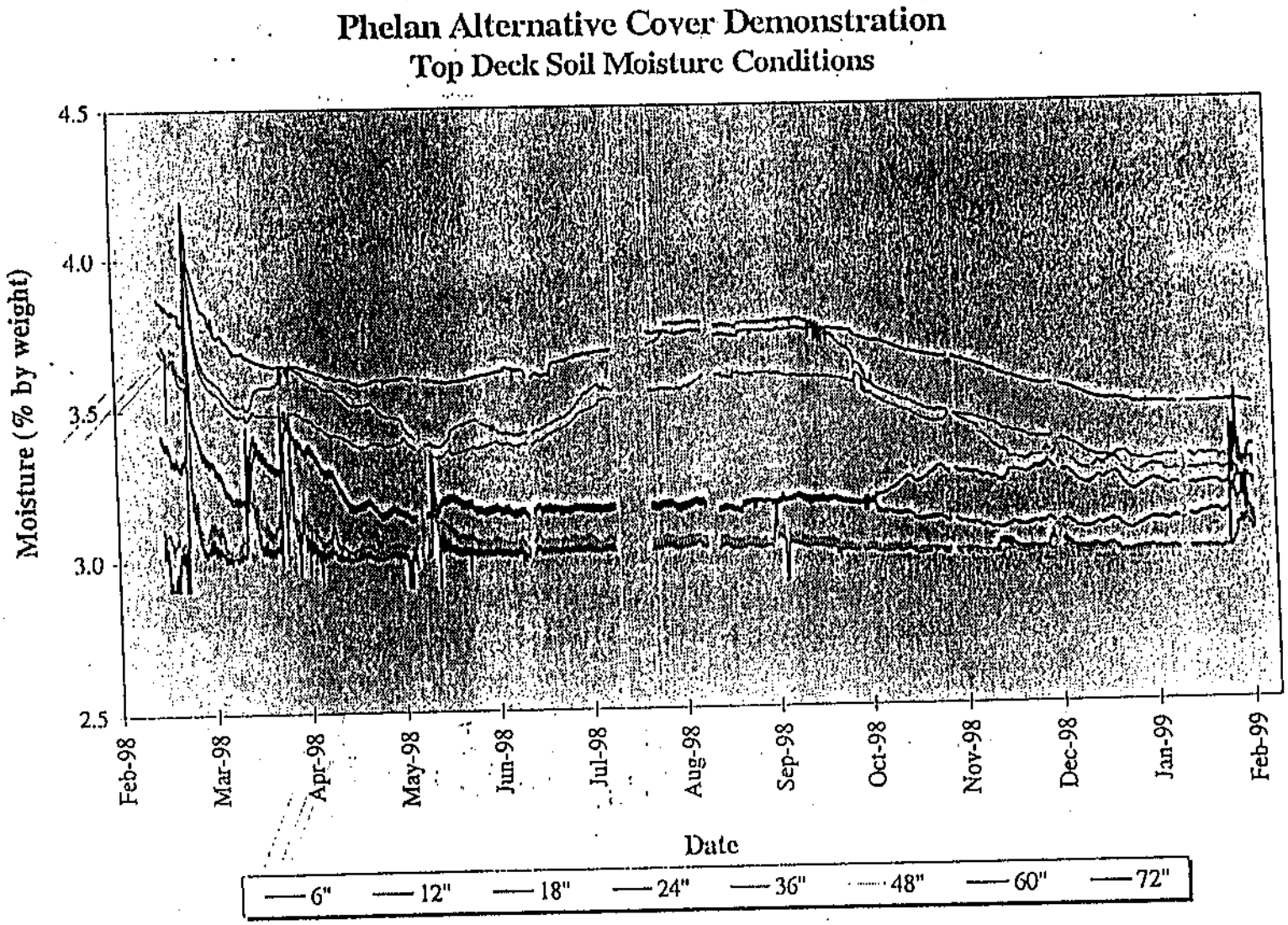
Milliken East Slope Above Lysimeter



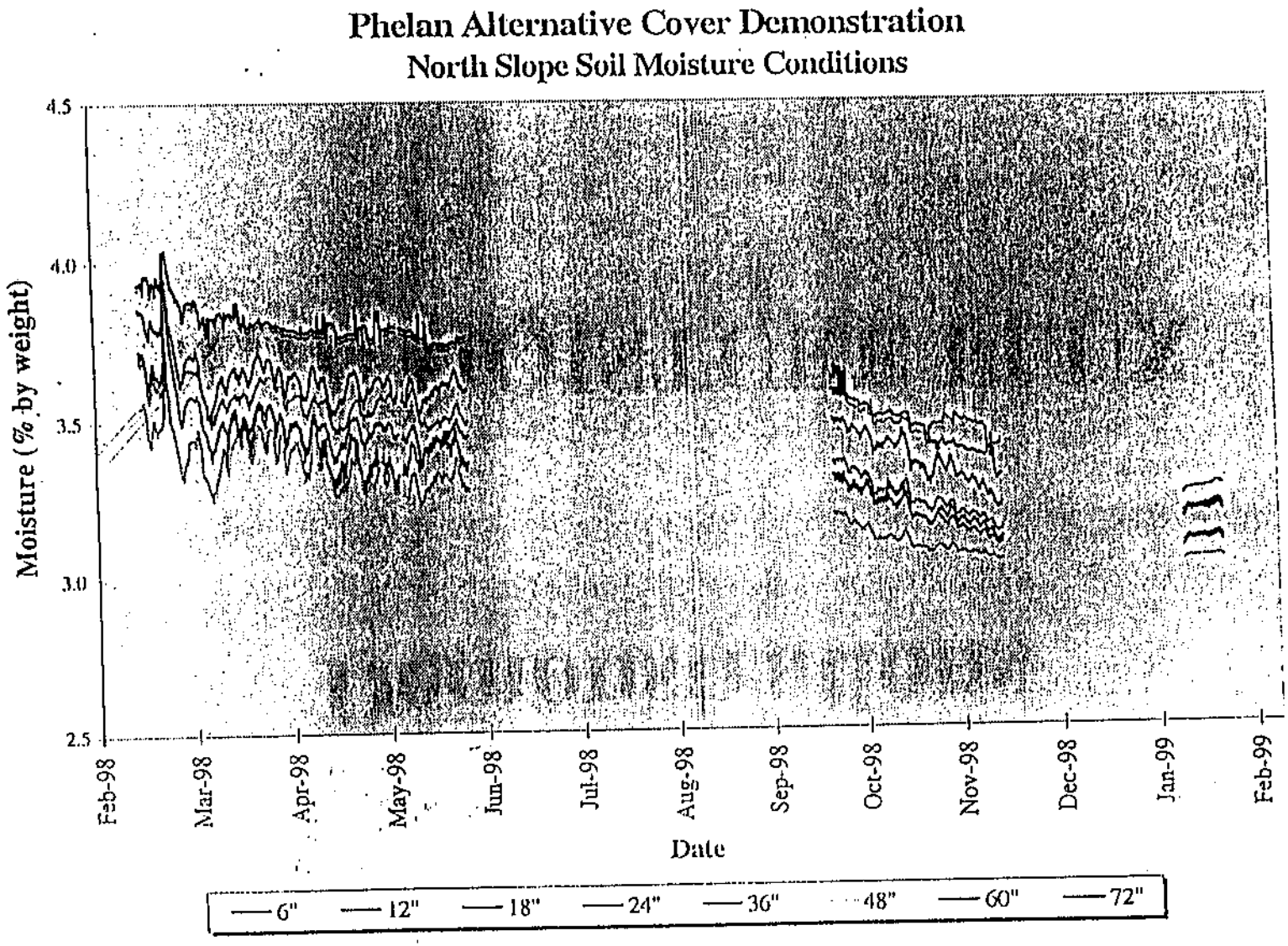
Phelan East Slope



Phelan Top Deck



Phelan North Slope

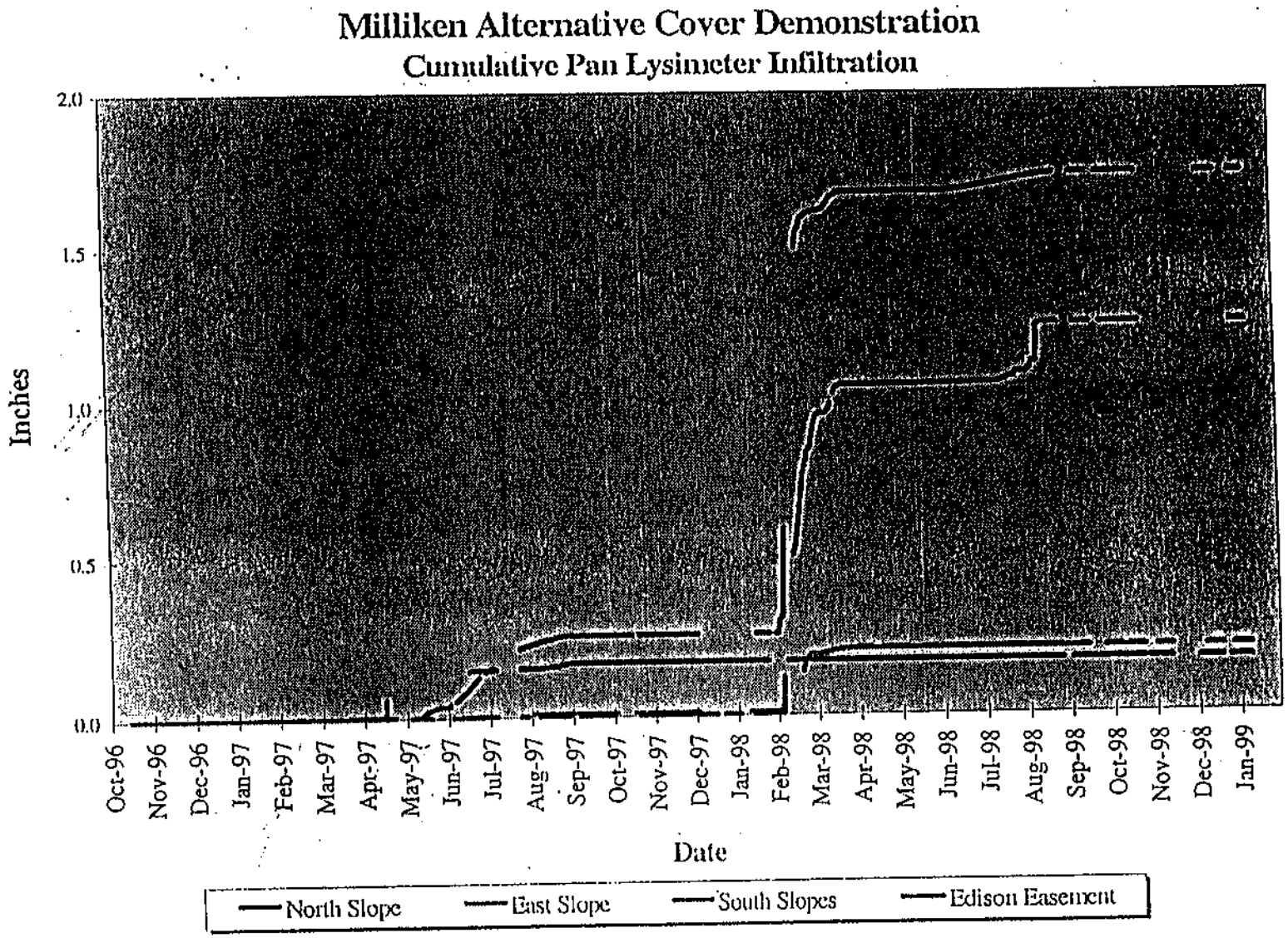


MSW Landfill Demonstrations

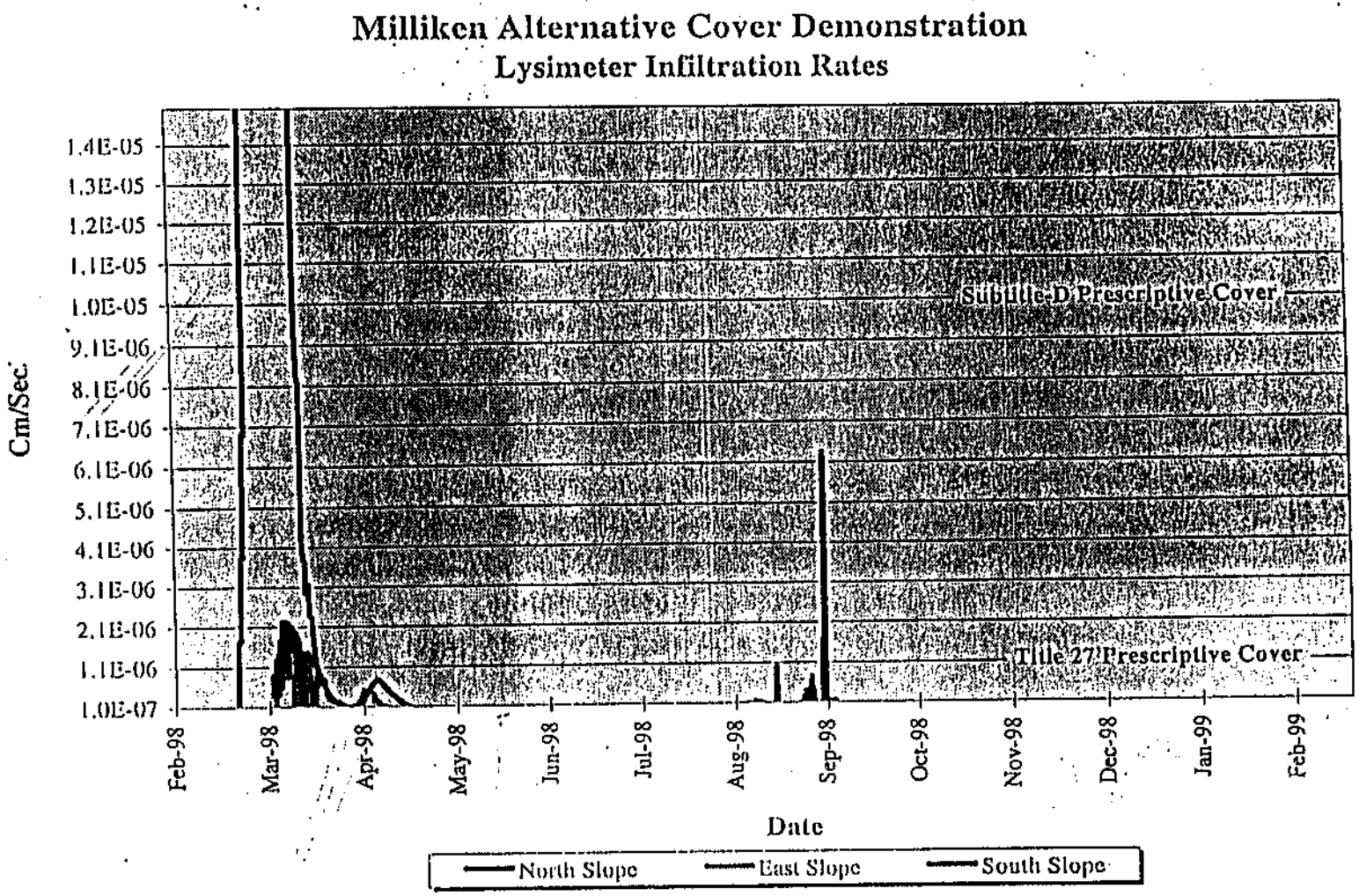
SOIL MOISTURE FLUX

GeoLogic Associates

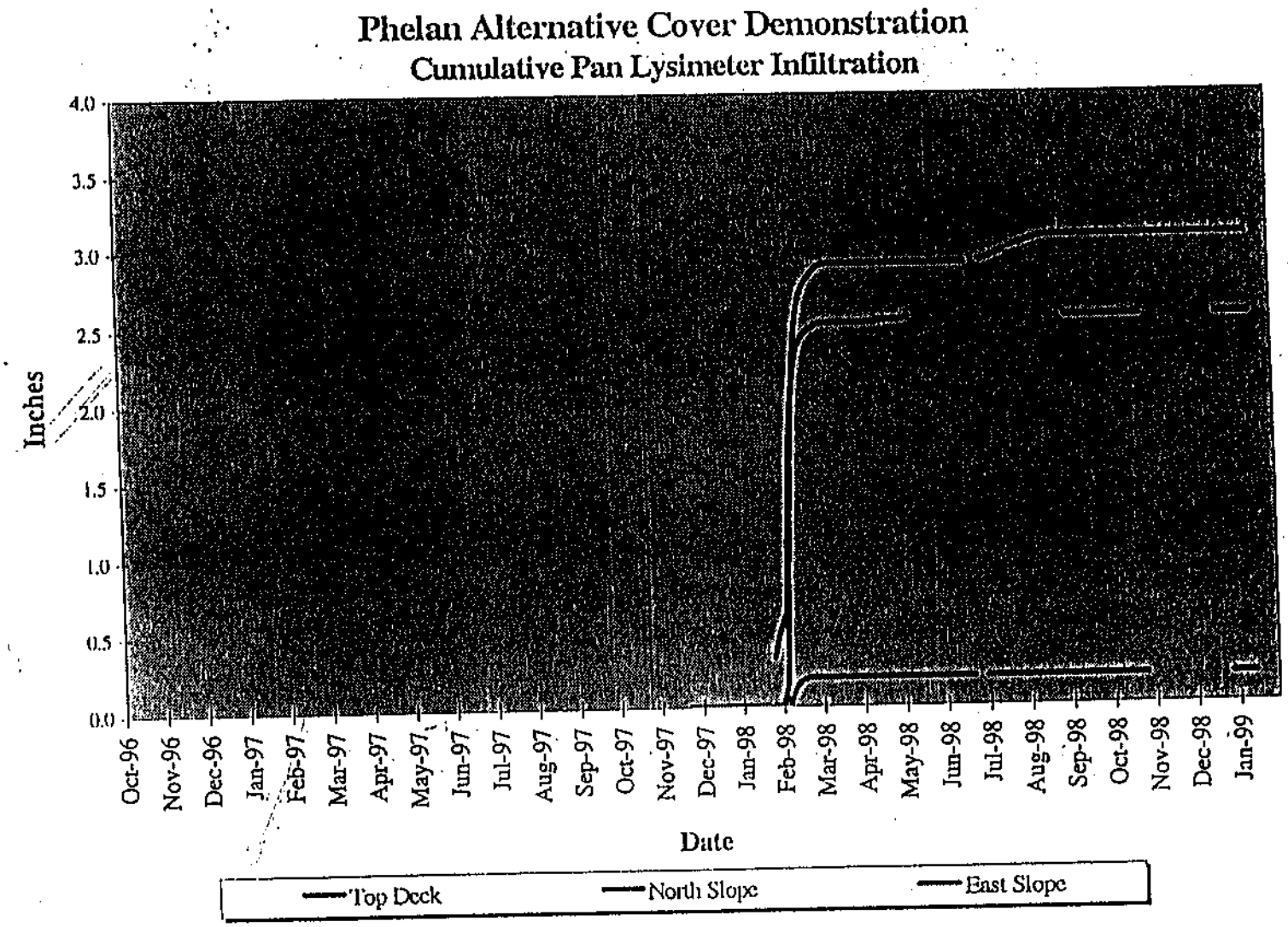
Milliken Lysimeter Data



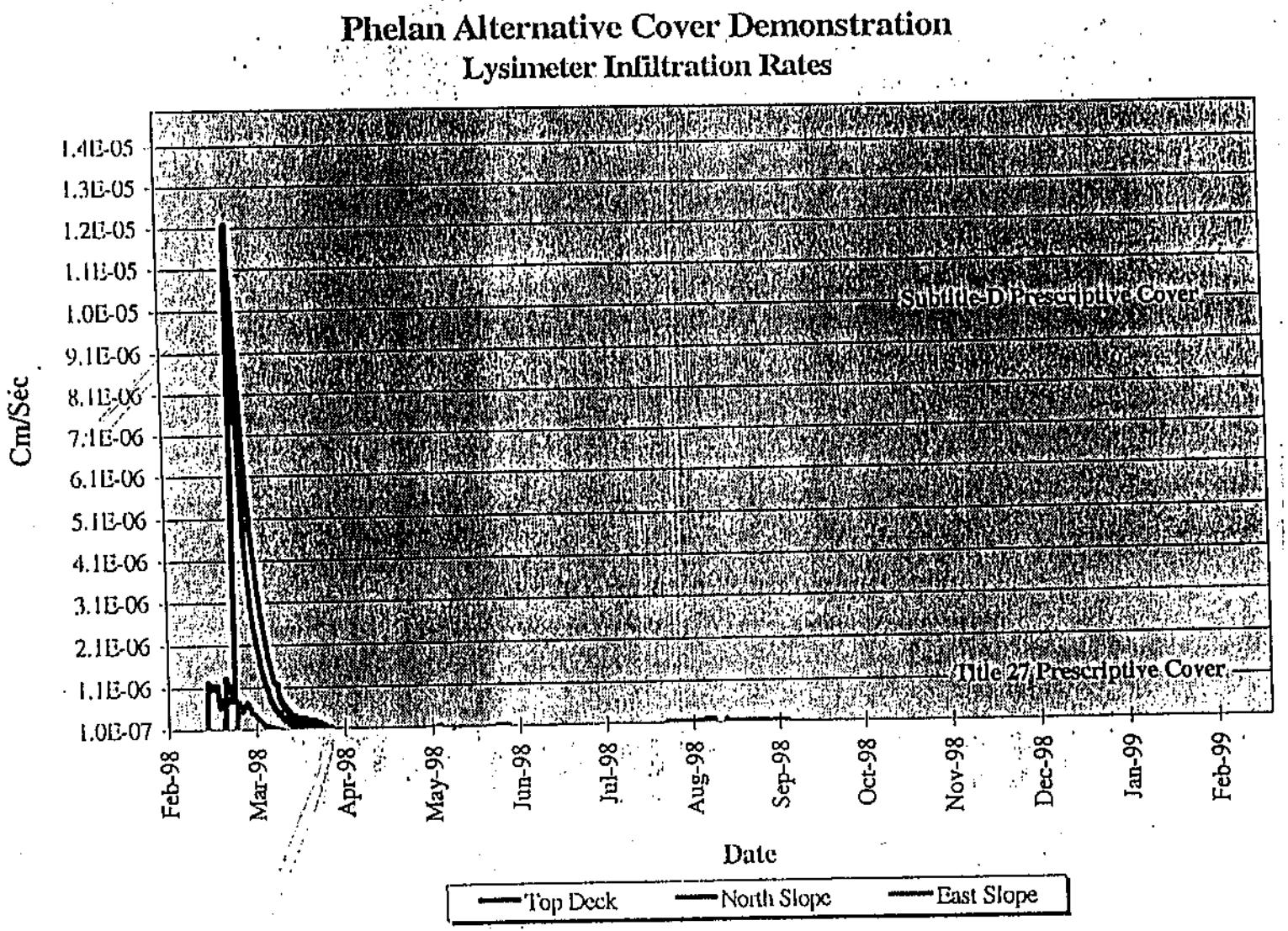
Milliken Lysimeter Flux



Phelan Lysimeter Data



Phelan Lysimeter Flux



Annualized Infiltration

Milliken Landfill

North Slopes = 2.1×10^{-8} cm/sec
East Slopes = 2.5×10^{-9} cm/sec
South Slopes = 1.3×10^{-8} cm/sec
Edison Easement = 2.1×10^{-9} cm/sec

Phelan Landfill

Top Deck = 3.7×10^{-8} cm/sec
North Slopes = 3.1×10^{-8} cm/sec
East Slopes = 2.4×10^{-9} cm/sec

ALTERNATIVE FINAL COVER DEMONSTRATION PROJECT AT THE MILLIKEN LANDFILL SAN BERNARDINO COUNTY, CALIFORNIA

Lass, G.L.[1], Ferriz, H.F.[1], Rivera, A.L.[2]

ABSTRACT

The use of alternative final cover systems in arid areas minimizes problems caused by desiccation- and settlement-induced cracking, enhances vegetation survival, and facilitates post-closure maintenance. Furthermore, the use of these covers is potentially important for several economic and operational reasons. First, since many operating facilities have limited quantities of low permeability material available on-site, an alternative cover allows for an environmentally sound closure without resorting to the costly import of low permeability soils or construction of an expensive synthetic membrane cover. Second, approval of an alternate cover system allows operators to construct a significant portion of the final cover on a given landfill without using the services of an outside contractor. In addition to the obvious advantages of using operations staff to complete closure, this also allows for phased construction of final cover drainage, erosion control and finished vegetative systems as individual areas of a landfill reach design grades. Finally, in rural districts and for small operators an alternative final cover might represent the difference between environmentally sound closure or "walk-away" abandonment of a site.

In January of 1996, the County of San Bernardino Waste System Division and NORCAL/SAN BERNARDINO, INC. presented a proposal to construct a full scale alternative final cover demonstration project at the Milliken Landfill in San Bernardino County, California. The purpose of this project was to evaluate the true field performance of a non-prescriptive cover system that combines the effects of plant transpiration with a moderate-permeability soil cover. In August, 1996, the final cover demonstration project was conditionally approved by the San Bernardino County Department of Environmental Health (the Local Enforcement Agency, LEA) the Regional Water Quality Control Board - Santa Ana Region (RWQCB) and the California Integrated Waste Management Board (CIWMB). Construction of the demonstration project began in September 1996, and was completed in March 1997.

As a part of the closure demonstration project, each anticipated microclimate within the demonstration fill was instrumented with dedicated monitoring devices that measure climatic conditions and the movement of water in the soil column. The ultimate performance of the alternative cover demonstration project will be compared with a performance goal established by the RWQCB, and is expected to provide a basis for approval of similar closures in other arid and semi-arid regions.

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[1] GeoLogic Associates, Inc.
[2] San Bernardino County Waste System Division

CURRENT REGULATION

In California, the final closure of a municipal solid waste landfill is currently under the regulatory authority of several federal, state and local agencies. The primary governing agencies for municipal solid waste disposal include the U.S. EPA, the California Integrated Waste Management Board (CIWMB), the California Water Resources Control Board (CWRCB), the Regional Water Quality Control Boards (RWQCBs), local enforcement agencies (LEAs), and the various divisions of the California Air Resources Control Board. With the exception of the Air Resources Boards, these agencies are concerned, at least in part, with the potential for environmental damage that could result from the infiltration of liquids into an operating and/or closed solid waste facility. The Air Resources Boards and CIWMB are concerned with the potential impacts of surface and lateral emissions of landfill gas.

At present, the three principal regulations governing closure of a solid waste facility are found in: section 40 of the Code of Federal Regulations (40 CFR) Parts 257 and 258; the California Code of Regulations (CCR) Title 14; and CCR Title 23. Pertinent elements of Title 23 and Title 14 are currently being incorporated into a single revised regulation identified as CCR Title 27.

40 CFR Parts 257 and 258

40 CFR Parts 257 and 258 (commonly known as Subtitle D) became effective in October, 1991 and implements the following minimum closure requirements:

> "All owners [and] operators of MSWLF units must install a final cover designed to minimize infiltration and erosion. The infiltration layer must be a minimum of 18 inches of earthen material that has a permeability less than or equal to the permeability of the bottom liner system or natural subsoils, or no greater than $1x10^{-5}$ cm/s, whichever is less. The erosion layer must be a minimum of six inches of earthen material that can sustain native plant growth."

Under Subtitle D, there is no regulatory agency enforcement and, in fact, enforcement is made effective only through public lawsuits. Since Subtitle D is essentially self-regulating, there is no agency that can be approached directly to consider alternatives. Rather, the law provides for consideration of alternatives to the prescribed minimum standards by providing Subtitle D approval status to states that implement standards considered equivalent to, or more rigorous than, Subtitle D. Consideration of alternatives is then left to individual states as follows:

> "The Director of an approved State may allow an alternative cover design if the cover layers achieve the same objectives as the specified design in the final rule."

The State of California was awarded approved status as of October, 1993 and, as a result, it is the State (through the CIWMB, CWRCB and RWQCBs) that is in a position to consider engineered alternatives under Subtitle D.

CCR Title 14

California Code of Regulation (CCR) Title 14 Article 7.8 section 17760 establishes the California Integrated Waste Management Board (CIWMB) as the lead agency for closure of municipal solid waste facilities that had not fully implemented final closure as of November 18, 1989. Section 17772 of Article 7.8 states:

"(b) A minimum thickness and quality of cover material, in accordance with Title 23, CCR, subchapter [now chapter] 15, section 2581(a), shall be placed over the entire surface of the final lift as the site reaches final configuration...

c) Engineered alternatives to the prescriptive standard under subsection (b) shall only be approved when the operator demonstrates, to the satisfaction of the Board and local enforcement agency, that:

(1) The prescriptive standard is not feasible as provided in subsection (d) of this section, and
(2) There is a specific engineered alternative that:
(A) is consistent with the performance goal addressed by the prescriptive standard under subsection (b) of this section, and
(B) affords equivalent protection against water quality impairment.

(d) To establish that compliance with the prescriptive standard of subsection (b) is not feasible ... the operator shall demonstrate that compliance with the prescriptive standard:

(1) Is reasonably and unnecessarily burdensome and will cost substantially more than the criteria in subsection (e) of this section; or
(2) Is impractical and will not promote attainment of applicable performance standards."

CCR Title 23, Chapter 15, Article 8

California Code of Regulation (CCR) Title 23, Chapter 15 ("Chapter 15"), establishes the California Water Resources Control Board (CWRCB) and the California Regional Water Quality Control Boards (RWQCBs) as the lead agencies for closure of municipal solid waste facilities which ceased operation after December 8, 1984 and had fully implemented final closure as of November 18, 1989; and any sites which ceased operation prior to December 8, 1984 at which the CWRCB/RWQCB has evidence of adverse impacts to water quality. The minimum requirements for final closure as included in Article 8 section 2581(a) of Chapter 15 also provide the basis for Title 14 closure standards as they relate to water quality in prescribing:

"(1) Closed landfills shall be provided with not less than two feet of appropriate materials as a foundation layer for the final cover.

(2) Closed landfills shall be provided with not less than one foot of soil containing no waste or leachate, placed on top of the foundation layer and compacted to attain a permeability of either $1x10^{-6}$ cm/s or less, or equal to the permeability of any bottom liner system or underlying natural geologic materials, whichever is less.

(3) Closed landfills shall be provided with not less than one foot of soil, containing no waste or leachate, placed on top of the material described in subsection [2] of this section; the rooting depth of any vegetation planted on the cover shall not exceed the depth to the material described in subsection [2] of this section.

(4) The cover shall be designed and constructed to function with the minimum maintenance possible."

In addition to the minimum standards mentioned above, Article 1 section 2510(b) of Chapter 15 states:

"Unless otherwise specified, alternatives to construction or prescriptive standards contained in this [chapter] may be considered... when the discharger demonstrates that:

(1) The construction of prescriptive standard is not feasible as provided in subsection (c) of this section, and
(2) There is a specific engineered alternative that
(A) is consistent with the performance goal addressed by the particular construction or prescriptive standard, and
(B) affords equivalent protection against water quality impairment."

TECHNICAL RATIONALE FOR FINAL COVER ALTERNATIVES IN ARID REGIONS

Physical failure mechanisms diminish the performance of impermeable covers. These failure mechanisms can include cracking due to desiccation, freeze-thaw, differential settlement, slope instability or slippage, erosion, penetration (roots, burrowing animals), surcharge loads (e.g., soil stockpiles), deformation from earthquakes, and expansion of landfill gas (Koerner and Daniel, 1992). Of these, settlement and desiccation are likely to play a dominant role for deep landfills constructed in arid regions.

The potential for settlement and desiccation related distress to a cover soil depends on the physical properties of the cover soils (including relative compaction and water content), the local climatology and the moisture content of the underlying waste. Water content and percent of coarse material (e.g., sand) appear to be the most important soil characteristics that affect desiccation cracking (Daniel and Wu, 1992), with sandy soils compacted at the lowest possible water content having the lowest potential for shrinkage cracking upon drying. In contrast, clay barriers have the highest potential for desiccation-related distress (Corser and Cranston, 1991). Although the use of synthetic membranes might be a viable solution to the problems of desiccation cracking (particularly in the case of small, well-compacted landfills with gentle slopes), in larger landfills, deformation due to differential settlement, slope failure, or expansion of landfill gas can result in significant distress and loss of performance for these types of systems.

Regardless of its cause, fissuring will affect the integrity and function of a final cover system and, as a result, final covers typically require continuous inspection and maintenance. Although a rigorous post-closure regimen could be effective (as long as the operator or regulatory agency are able to implement it instantaneously on the occurrence of distress), in the long run it is more desirable to construct a low maintenance cover system that takes advantage of natural processes to achieve environmental protection. The combined use of granular soils and native vegetation as an alternative to prescriptive barrier layer covers offers great promise in this regard because granular soils (e.g., silty sands) generally do not support fractures (the deformation being accommodated by grain-to-grain rearrangement rather than fracture), and even when fractures do occur they tend to "heal" rapidly.

Owing to the dramatic "philosophical" shift represented by the use of granular final cover soils in lieu of prescriptive low permeability materials, the governing agencies have indicated that a large scale demonstration project would be required in order to validate the theoretical performance of this type of cover system, and ultimately allow the agencies to approve of the concept. The Milliken Landfill Demonstration Project was developed, proposed and constructed

primarily to address the expressed concerns of the regulatory agencies.

EXPERIMENTAL DESIGN

The Milliken Landfill Alternative Final Cover Demonstration Project involved construction of a complete final cover system over the approximately 22-acre eastern parcel of the Milliken Landfill in western San Bernardino County, California. The project incorporates a cover constructed without using a Chapter 15 prescriptive low permeability (or equivalent geosynthetic layer) but is designed to achieve infiltration control through placement of a non-layered monofill silty sand cover supplemented with a typical indigenous plant community. The cover is being evaluated for its ability to limit infiltration into the underlying waste, and its ability to limit surface emissions for a minimum period of eighteen months.

The eastern parcel of the Milliken Landfill was selected as the demonstration fill area because:

- it is isolated from the active portion of the Milliken Landfill;
- the age of the waste is generally greater than twenty years;
- only interim cover has been placed over the existing waste prism;
- their are no indications of a release to groundwater in an immediately downgradient well;
- an active groundwater corrective action program is anticipated at the site and could be readily extended if impacts are noted in the demonstration area.
- The local climate is semi-arid with an average annual rainfall of approximately 12-inches. In addition, the East Mound includes flat deck and north, south and west slope microclimate conditions.

Initial evaluation of the geometry and minimum physical characteristics of the alternative final cover proposed for this study was completed by modeling an alternative cover composed of a monofill section of silty sands derived from a nearby borrow source. The results of this study suggested that given the climatic conditions typical of the site and region, a monofill cover composed of the available materials could be expected to limit infiltration to less than 0.04% of rainfall if properly vegetated and constructed to a minimum thickness of about six feet. On the basis of this initial modeling, the final cover was constructed as a monofill section using conventional earthwork equipment and techniques. A summary of the physical characteristics of the final cover soils used in the Milliken Landfill Demonstration Project is presented in Table 1.

Table 1. Average As-Built Soil Characteristics

Passing # 200 Sieve (%)	33.5
Finer than 5 microns (%)	9.5
Liquid Limit	15.8
Plastic Limit	NP
Hydraulic Conductivity (cm/s)	$1x10^{-5}$ - $5x10^{-6}$
Maximum Density (pcf)*	129.7
Optimum Moisture (%)*	8.2%
Relative Compaction (%)*	92%
Moisture Content (% by wt.)	8.0%

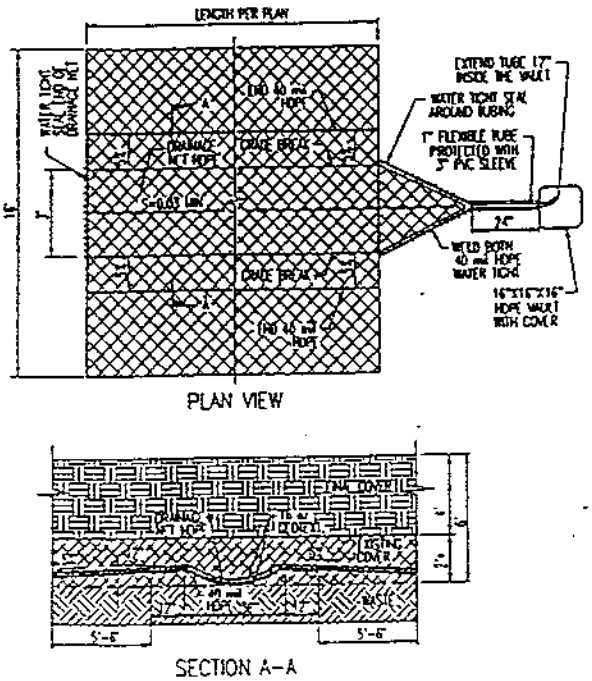
* per ASTM D-1557

The demonstration fill was hydroseeded with native shrubs and grasses, and is being irrigated only during the first summer with only that quantity of water necessary to establish vegetation.

Moisture flow through the demonstration fill is being monitored using soil moisture probes installed at depths of 6", 12", 18", 24", 30", 42", 54" and 66" below the surface. In addition, water flux through the cover is measured directly by collecting it in small-

scale lysimeters that collect the water flowing through a given section of the cover. The lysimeter was designed and constructed to minimize the potential for the lysimeter itself to significantly influence the experimental results (Figure 1).

Figure 1. Details of Pan Lysimeter Collection Systems



To monitor the potential influence of the lysimeter, two soil moisture monitoring probes were placed above each lysimeter immediately adjacent to the full "stacks", which were placed at equivalent positions but beyond the area of potential lysimeter influence.

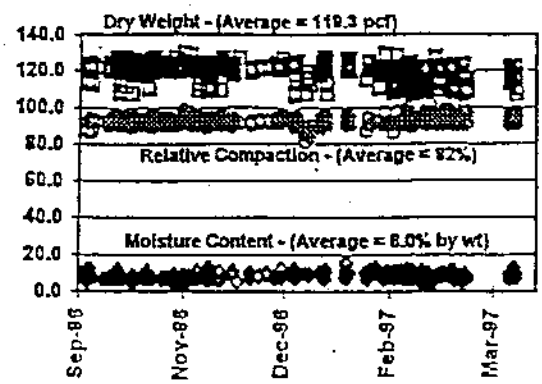
DEMONSTRATION FILL CONSTRUCTION

Prior to construction, the ground surface to receive fill was bladed until it was free of vegetation and uneven features that could prevent uniform compaction. The existing approximately one foot of interim cover materials were then brought to about 110% of optimum moisture content, mixed as required, and compacted to a minimum of 90% of maximum dry density.

A total of four lysimeter sections were then constructed within the foundation layer; one under each of the identified microclimates encompassed by the closure footprint. Each lysimeter was constructed as a vertical "chimney" with a surface area of about 24-inches by the vertical length of the slope. Each lysimeter was placed in the first lift of the foundation layer within a smooth concave surface that was prepared specifically to host the lysimeter collection media. The lysimeters themselves consisted of a 40 mil HDPE geomembrane overlain by a geosynthetic drainage media. Each lysimeter was anchored in trenches along the top of slope, and the lower terminus was channeled to allow for collection and monitoring of infiltration. Each lysimeter drains into a tipping bucket where the total inflow is measured automatically. Following construction of the lysimeters, the overlying lifts of the foundation layer and final cover were placed to avoid damaging the lysimeter.

The alternative cover was constructed with granular soils obtained from a nearby borrow source located approximately 10 miles east of the landfill. These materials were placed in thin lifts with a maximum uncompacted thickness of 6 to 8 inches. Each layer was spread evenly and thoroughly mixed to obtain a near uniform condition in each layer and each lift was compacted to a minimum compaction of 90% at about optimum moisture content as defined by ASTM D-1557 (Figure 2).

Figure 2. As-Built Compaction Characteristics



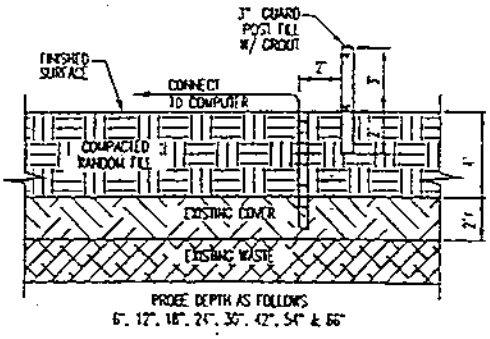
Finally, since moisture control through evaporation and transpiration of selected plants is the main focus of the Milliken Landfill Demonstration Project, the plant species applied to the finished surface included native seasonal grasses, perennial bunch grasses and shallow rooting shrubs. The planting operation included the application of a hydromulch/seed slurry mix and irrigation was instituted solely to establish vegetation in the first year.

PERFORMANCE MONITORING

Since the ultimate purpose of the demonstration project is to validate the theoretical performance of a simple soil/plant system, accurate and real time monitoring of climatic and soil moisture conditions are required. Real time monitoring devices were installed for measuring the parameters needed to assess the performance of the alternative cover system.

To this end, changing weather conditions are monitored by four automated weather stations constructed in each of the microclimates within the demonstration area. These weather stations monitor air temperature, rainfall, wind speed and direction, solar radiation and humidity, and the datalogging software is able to calculate potential evapotranspiration from these parameters. In-situ moisture within the cover section in each of the anticipated microclimates is monitored by a vertical "stack" of calibrated solid state soil moisture monitoring probes embedded within the final cover at depths of 6", 12", 18", 24", 30", 42", 54" and 66" (Figure 3)

Figure 3. Moisture Monitoring Probe Stack Details



Finally, infiltration reaching the lower 12 inches of the foundation layer is measured by a sealed tipping bucket designed and installed to track liquids collecting within the lysimeters. Data are collected from the dedicated on-site monitoring systems on an hourly basis by a datalogger and the datalogger is routinely downloaded by remote communication.

The condition of the vegetation will be monitored visually throughout the term of the project, and both the digital and visual data are reviewed and interpretted on a monthly basis.

MONITORING RESULTS

While it is clearly premature to make broad based conclusions regarding the long term performance of the Milliken Landfill Alternative Final Cover Demonstration Project, sufficient data are available to suggest that the system is performing better

than anticipated. Among the more significant observations made to date are:

1) On the basis of the contrast between soil moisture conditions immediately above and adjacent to the pan lysimeters, it appears that the lysimeters themselves have a locally significant influence on moisture conditions within the final cover section. Although not unexpected, this influence suggests that liquids accumulating within the lysimeters may not be representative of potential infiltration into the landfill but simply the flux expected into a free draining lysimeter. As a result, the lysimeter data must be interpretted carefully so as not to bias conclusions with regard to the true performance of the system.

2) It is clear that ongoing irrigation is creating artificially high and relatively uniform moisture conditions throughout the final cover section and that these conditions are significantly wetter than is observed within non-irrigated areas and would be expected naturally. In fact, the contrast between irrigated and non-irrigated conditions (best illustrated by a comparison of moisture conditions within the non-irrigated power line easement and irrigated slopes) suggests that until the finished surface is well vegetated, irrigation could be problematic and should be closely controlled.

3) The Milliken Landfill Demonstration Project was completed late in the normal winter season, and even with substantial irrigation, the native plant community is struggling to become established. On the basis of this observed performance, it is concluded that fall season seed application would yield a more robust plant community at lower water application rates and a lower risk of infiltration would result.

4) When comparing actual moisture accumulation in the lysimeters with the modeled performance of a lysimeter, it is clear that true system performance is far superior to that modeled.

5) Since modeling suggested that infiltration into the lysimeter would occur, even under non-irrigated conditions, the fact that infiltration has not been observed under irrigated conditions indicates that modeling overestimated flow conditions within the cover.

6) The data generated from the Milliken Landfill Alternative Final Cover Demonstration Project is consistent with and complementary to the data being derived from monitoring of the Coyote Canyon landfill final cover (Lass et. al., 1996). Since the Coyote closure was completed in a temperate climate and the Milliken closure includes a semi-arid environment, these complimentary studies are expected to help define a minimum bracket for environments in which these cover systems could be effective.

ACKNOWLEDGMENTS

The authors of this paper would like to thank the County of San Bernardino and NORCAL/SAN BERNARDINO, INC. for their financial support of this project and acknowledge the substantial cooperation and critical review comments received from the LEA, the RWQCBs (including the Santa Ana, LaHonton and Colorado Regions) and the CIWMB.

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ALTERNATIVE FINAL COVERS FOR LANDFILLS IN ARID AND SEMI-ARID REGIONS - A CASE STUDY

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Abstract

The Coyote Canyon Landfill is an approximately 325-acre California municipal solid waste facility which was operated by the Orange County Integrated Waste Management Department between 1963 and 1991. Between 1992 and 1994 the disposal area was closed in accordance with then current minimum regulatory standards as defined in Titles 14 and 23 of the Code of California Regulation (CCR). These regulations are generally consistent with the now current closure requirements of 40 CFR (Subtitle D) for unlined landfills. The final closure plan for the landfill was modified in 1993 to allow for the development of a threatened species (California Gnatcatcher) habitat over an approximately 100 acre portion of the site. While still incorporating a prescriptive low permeability soil layer at depth, the Gnatcatcher habitat revisions necessitated the construction of a thickened vegetative soil layer to accommodate the coastal sage scrub (Gnatcatcher habitat) plant community.

Owing to the relatively deep root distribution of Coastal Sage Scrub, the California regulatory agencies mandated that the moisture content in the vegetative and barrier layer soils be monitored in order to evaluate their long term performance characteristics. While perhaps not the original intent of the agencies, the data recovered from the monitoring systems installed at the Coyote Canyon Landfill clearly indicate that the performance of the system in this semi-arid climate is governed by evapotranspiration within the vegetative zone. Furthermore, the data also indicate that the prescribed low permeability soil layer does not provide significant protection against water infiltration into the refuse prism.

The conclusion that the unsaturated barrier layer at the Coyote Canyon Landfill provides little, if any, protection against infiltration suggests that current regulatory requirements to construct similar soil barrier layer systems at other landfills in arid and semi-arid regions may be unnecessary and, if constructed, may provide little in the way of true environmental protection.

Introduction

The Coyote Canyon Landfill accepted an estimated 60 million cubic yards of municipal solid waste during its operating life (i.e., between 1963 and 1991). Upon cessation of disposal operations in 1991, the site was formally closed in accordance with then applicable state requirements. Final closure activities included the construction of a final cover system which incorporated a soil barrier layer with a maximum saturated hydraulic conductivity of 1×10^{-6} cm/s and a minimum vegetative soil layer thickness of 2.5 feet (slightly thicker than the 1 foot thickness required by then prescriptive design).

During construction of the final cover system, the San Joaquin Hills Transportation Corridor Agency (TCA) began design and construction of a major north-south Orange County throughway immediately adjacent to the landfill. Since construction was expected to disturb habitat areas of threatened species (California Gnatcatcher) habitat, the TCA approached the Orange County Integrated Waste Management Department (IWMD) with a request to create similar habitat over a portion of the designated open-space area of the closure footprint. In pursuing habitat recovery, the TCA funded both the design and construction of the modified cover and the installation of the monitoring systems which provided the data summarized in this study.

The agencies responsible for closure of the facility included the California Regional Water Quality Control Board-Santa Ana Region (RWQCB), the California Integrated Waste Management Board (CIWMB) and the Orange County Department of Environmental Health (the Local Enforcement Agency or LEA). With regard to the proposed Gnatcatcher modifications to the closure plan, these agencies immediately expressed concern that the deeper root system typical of the coastal sage scrub might cause damage to the underlying barrier layer, and, as a result, the thickness of the vegetative layer was increased to 6.5 feet. Because the agencies also anticipated that the coastal sage scrub might also represent a substantial threat of desiccation to the barrier (due to its root distribution and anticipated efficiency to extract soil moisture) a dedicated soil moisture monitoring system was installed to allow for direct observation of soil moisture conditions within and immediately above the barrier layer. In concept, the system was designed to allow for the artificial introduction of water into the system via surface irrigation if the monitoring data indicated a drying trend in the constructed barrier layer.

Cover Design

The modified final cover system installed over the Gnatcatcher habitat area of the Coyote Canyon Landfill consists of a 6.5 foot thick section of local soils excavated from slope areas adjacent to the landfill. These materials were required no special processing prior to placement and were constructed using standard horizontal lift construction methods and routine "back-rolling" of the slope face.

In contrast, the barrier layer was constructed as a 2.5 foot thick fine-grained layer which required significant processing; including screening of the >3-inch fraction and moisture conditioning to significantly above optimum moisture content. The barrier layer was constructed by over-filling the slopes and trimming them back to the design thickness of 2.5 feet. Finally, construction CQA for the barrier layer was much more rigorous than was completed for the vegetative layer and included routine testing for in-situ moisture and density; Atterberg Limits, grain size distribution and permeability.

Climate and Soil Moisture Monitoring Systems

The moisture monitoring systems installed at the Coyote Canyon Landfill consist of solid state moisture monitoring probes provided by Sensing and Control, Inc. of San Diego, California. The probes were selected because they could be installed during cover construction; thereby allowing for direct measurement of moisture conditions without introducing the comparative uncertainties that might be associated with retrofitted systems (i.e., trenched or boring installations). The probes monitor soil moisture indirectly by monitoring the dielectric constant of the soil and calculating moisture content based on the electronic data. The probes were calibrated directly to the Coyote Canyon soils prior to installation and this initial calibration was field verified approximately one year after installation by excavation of a number of soil borings immediately adjacent to individual probe stations.

Individual soil moisture monitoring probes were installed in "stacks" in each of three anticipated microclimates (i.e., east, west and north facing slopes) and within three distinct slope inclinations within each microclimate. Each probe "stack" was constructed with discrete probes placed at depths of 6", 12", 24", 36", 51", 66", 84", 93" and 102".

In addition to monitoring soil moisture, one stand alone weather station was also constructed in each of the inferred microclimates.

The 81 soil moisture monitoring probes and 3 weather stations have been monitored on an hourly basis since the system came "on-line" in April of 1994.

Climatological Data

Based on the climate data available at the site, climatic conditions typical of the Coyote Canyon Landfill are believed to represent a semi-arid rather than an true arid environment and as such should produce a conservative indication of true arid system performance. More specifically, the Coyote Canyon Landfill:

- receives an average of more than 15 inches of rainfall,
- is subject to maximum daytime summer temperatures that seldom exceed 90° F,
- seldom exhibits daytime summer humidity below 50%, and
- is a canyon fill facility and is thus sheltered from cross desert winds typical of most arid region landfills.

Adding to the departures from a true arid system scenario are the facts that the site was subject to artificial irrigation in the summer

of 1995 as well as an unusually severe 1995 winter (when the site received approximately 15 inches of rain in one two week period and almost 25 inches overall).

Moisture Movement within the Final Cover

Climate Effects - As represented by the dramatic variation in the depth of soil drying within the distinct slope areas (Figures 1 through 3), microclimate conditions have a dramatic effect on soil moisture conditions in the final cover system constructed at the Coyote Canyon Landfill site.

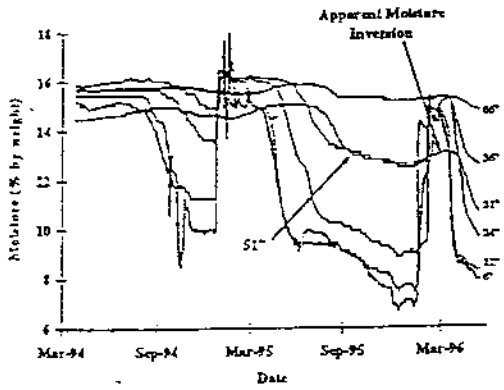

Figure 1. Shallow soil moisture contents in the west slope microclimate.

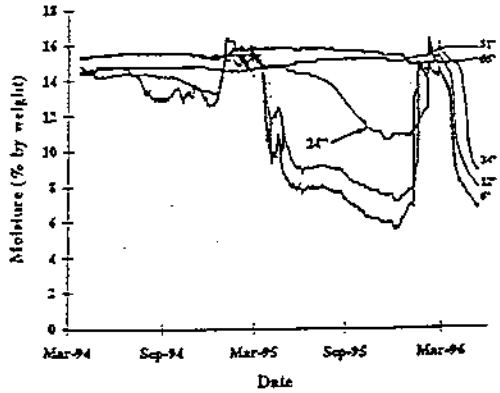

Figure 2. Shallow soil moisture contents in the east slope microclimate.

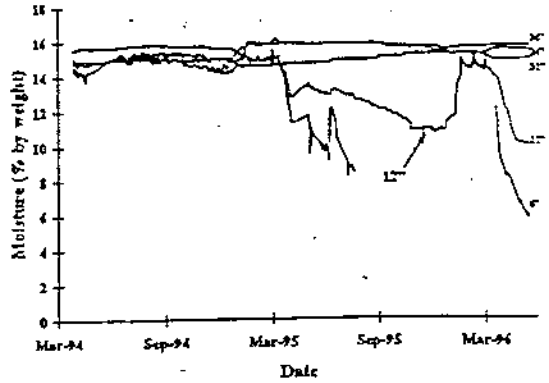

Figure 3. Shallow soil moisture contents in the north slope microclimate.

As can be seen, though these monitoring systems were all placed within an area of only a few acres, the depth of cover soil drying varied from less than 24-inches in the north slope to over 51-inches in the west slope microclimate during the first half of the 1996 summer.

In addition to identifying substantial microclimate effects, the magnitude of drying in the shallow soils (upwards of 50% of initial moisture) clearly that if a prescriptive barrier layer had been placed at shallow depths, it would have been subject to severe desiccation and, as a result, its long term performance characteristics would have been threatened.

Shallow Soil Moisture Variability - Figures 1 through 3 present the seasonal moisture variability that has been observed to date within the relatively shallow section (upper 6') of the Coyote Canyon Landfill final cover system.

In general, the annual net decline in shallow soil moisture content is consistent with the

expectation of drainage and drying of water that was introduced into the soil during construction. This tendency for initial drying is enhanced by improvements in the efficiency of transpiration as the local plant community becomes more established with time.

As shown on these figures, the initial effects of seasonal rainfall are actually short term "events" superimposed on the long term drying trend observed for the shallow soils as a whole. In combination, this rapid seasonal wetting and subsequent drying result in development of a strong upward suction gradient within the Coyote Canyon Landfill final cover system through at least 9 months of a typical year. This gradient effectively controls infiltration by drawing soil water that was introduced during the winter back up to the ground surface where it is released back into the atmosphere. In effect, deep infiltration is largely controlled by seasonal drying that creates a reservoir of dry vegetative zone soils that not only absorb a substantial quantity of infiltration water but also hold it in the soil column and make it available for removal during subsequent dry seasons.

Perhaps the most noteworthy data obtained to date from the Coyote Canyon Landfill moisture monitoring system is presented in the west slope monitoring results. As shown on Figure 1, in 1996 the downward migration of infiltrating surface water reached a depth of at least 36-inches but had little impact on the dry soils noted at 51-inches. The fact that a moisture inversion was maintained at intermediate depths in the Coyote Canyon final cover system indicate that a deep upward soil suction gradient was maintained in this microclimate throughout the year; a condition that would theoretically preclude the downward migration of water beyond a depth of about 51-inches. In fact, given the development of a year round upward gradient in deeper soils, a net drying (negative infiltration) of the landfill is actually expected. Given the similar, though more drawn out, long term drying trends observed within the other microclimate zones monitored at the Coyote Canyon Landfill site, this intermediate soil moisture inversion is expected to develop with time elsewhere at the site.

Finally, the shallow soil moisture data obtained at the Coyote Canyon Landfill site suggest that irrigation of a final cover system is possible without additional infiltration into the landfill. This condition is best evaluated by review of the first year of Coyote Canyon monitoring data when the site received almost 25 inches of irrigation in order to establish the erosion controlling habitat vegetation. In fact, in some of the site microclimates, irrigation actually resulted in development of a shallow moisture inversion with the 12-inch soils being dryer than both the overlying 6-inch deep and underlying 24-inch deep soils. Validation of the existence of a moisture inversion was obtained when the TCA reviewed the success of habitat development after the first summer of irrigation. During their evaluation, they found that the typically deep rooting Coastal Sage Scrub plant community actually established shallow horizontal root systems during the period of irrigation.

The data obtained at the Coyote Canyon Landfill during the initial period of irrigation suggest that a properly engineered, monitored and controlled irrigation system could be constructed to provide shallow rooting plants with water without contributing to deep infiltration.

Deep Soil Moisture Variability - Since summer drying extends to significant depths within the final cover vegetative soil section, this creates a downward soil suction gradient that initially forces the winter wetting front to move quickly into these soils. Once soil moisture is high enough to reestablish equilibrium (and reduce the dry soil suction gradients) moisture movement is severely limited. At depths below the seasonal wetting and drying zone, where the soils remain at a relatively high moisture content throughout the year, the annual soil moisture variability and by inference, the contribution made by winter seasonal infiltration is also very low (Figure 4).

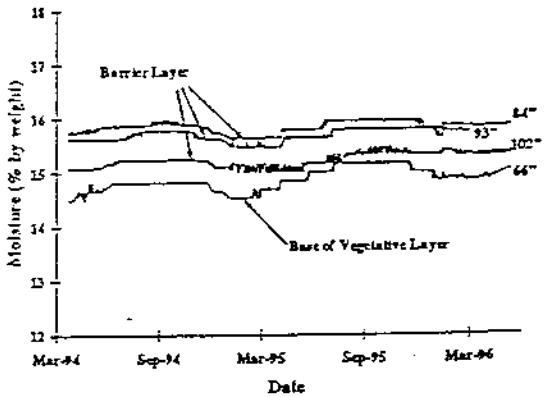

Figure 4. East slope deep soil moisture conditions.

This is not to say that their is no deep moisture influence however. In fact, a very small deep soil seasonal moisture variability (i.e., on the order of 0.25% or less) can be observed to lag seasonal climatic conditions by about 6 months.

Perhaps the most noteworthy condition observed in this deep soil moisture response is the parallel variations observed in both the deep vegetative soils and the barrier layer soils. As would be expected under unsaturated soil conditions, this parallel response suggests that both layers are accepting water delivered from overlying soils as reflected by the increased moisture content. Since unsaturated flow volumes are partially a function of soil moisture, this data also indicates that the additional moisture is actually passing through the barrier soil layer. At depth then, the unsaturated conditions typical of the site, create an environment wherein both layers are acting as drainage layers by accepting water from the shallow (cyclic wetting and drying) zone and transmitting it downward via unsaturated flow. In fact, the prescriptive cover barrier layer is not expected to act as a true barrier to the vertical downward migration of water until it becomes saturated; a condition that is not expected at arid environment landfills like Coyote Canyon.

One final observation should be made with regard to deep soil moisture conditions within the Coyote Canyon Landfill final cover system. While not observed within all of the deep barrier layer monitoring systems, a bottom-up wetting was observed in the probes placed in the east slope areas immediately after completion of construction (Figure 4). This condition indicates that the barrier layer soils were placed in a relatively dry condition in this area and in order to attain soil suction equilibrium with the underlying waste soils they actually pulled moisture out of the landfill. While the total quantity of liquids involved in this wetting is very small, the fact that it occurs at all is important because it suggests that final cover soils actually have the ability to draw moisture from the landfill.

In the case of the deep barrier layer system installed at the Coyote Canyon Landfill, this

bottom-up wetting suggests that the deep barrier layer will draw moisture from depth if top-down drying were to extend this deep; thereby alleviating the original concerns of the regulatory agencies with regard to desiccation. Of course the available data also indicate that the ultimate condition of the barrier layer may actually be unimportant since the performance of the system is ultimately controlled by evapotranspiration in the vegetative zone.

Conclusion

On the basis of the data obtained to date from the climate and moisture monitoring systems installed at the Coyote Canyon Landfill, several significant conclusions can be reached.

First and perhaps most significantly is the conclusion that a majority, if not all of the moisture controlling function of a final cover system constructed in an arid region is accomplished in the vegetative or erosion control zone. In fact, in a true desert environment, sufficient moisture recovery is probably accomplished solely by evaporation at the ground surface to make a prescriptive barrier layer completely ineffective. Enhancement of direct evaporation through the transpiration of engineered plant communities may allow for use of these types of non-barrier layer cover systems in more temperate regions and may also allow for irrigated end-use consideration at some sites.

Second, and nearly as important, is the conclusion that a prescriptive final cover system cannot be designed to accommodate the variety of macro and microclimate conditions typical of most arid region landfill sites. As shown in the Coyote Canyon data, severe desiccation is expected to influence final cover systems to significant though unpredictable depths which are governed largely by unpredictable annual climate and microclimate variability.

Since shallow barrier layers in arid areas are probably subject to severe desiccation, and deep unsaturated soil barriers are not expected to impede the vertical downward migration of soil moisture, it is concluded that prescriptive final cover systems constructed in arid regions will not perform as originally intended.

Recognizing that the vegetative soil layer is the final cover system that actually acts to control infiltration in an arid environment, it is then important to design a final cover that enhances the performance characteristics of this zone. In general this means that alternative final cover designs should be specific to each site, and should be engineered to consider the critical variables of local climate, available soils and if appropriate, anticipated vegetation communities.

The performance advantages and substantial cost savings in both closure and post-closure maintenance that could be realized by construction of monolithic final cover systems should be enough to make these systems a viable alternative to prescriptive barrier layer final covers. It is further concluded that by accepting these types of systems, more sites could be effectively closed and maintained, resulting in improved regularory compliance and environmental protection.

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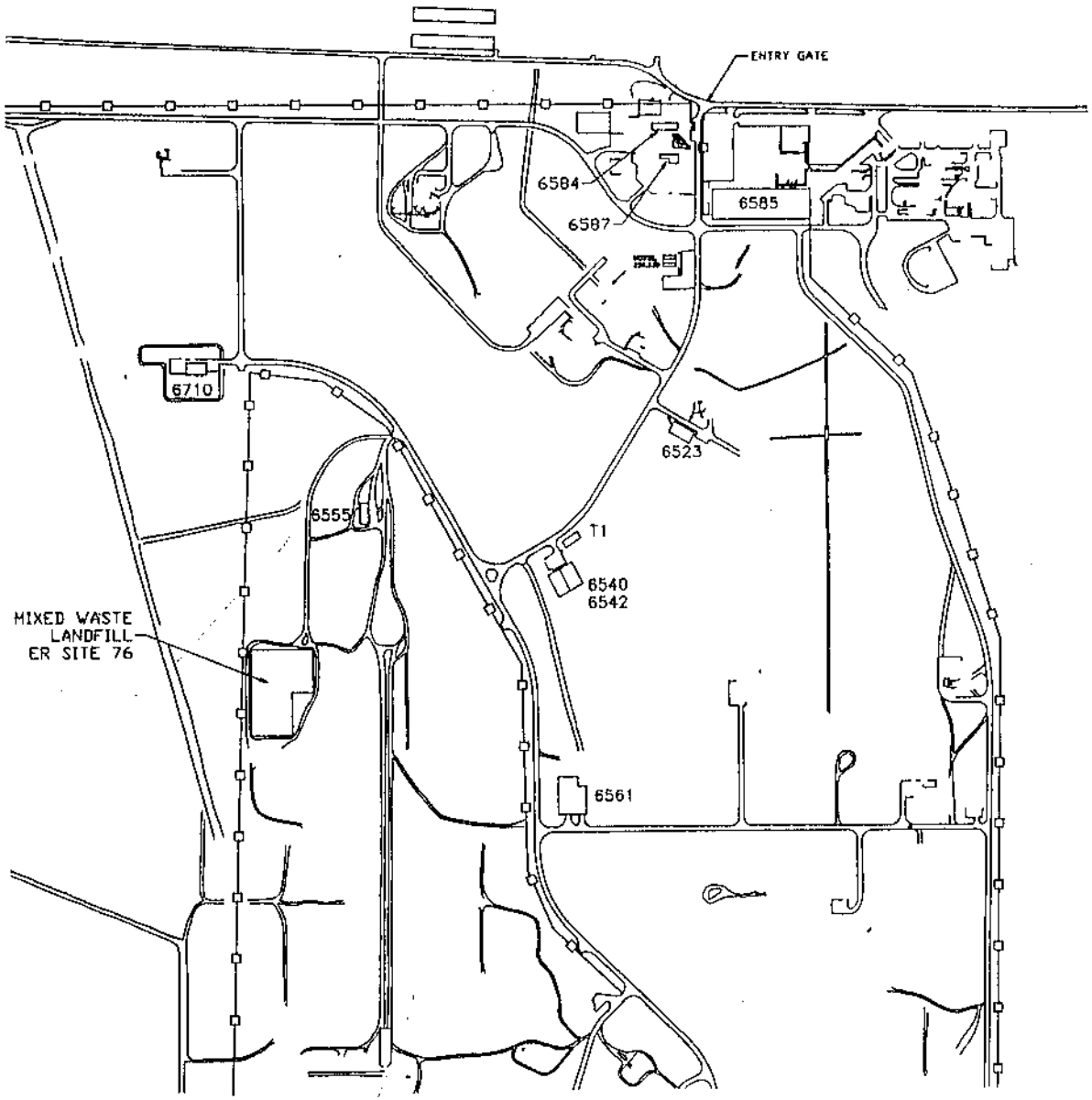
Appendix E

MWL Construction Drawings



LEGEND

ROAD

FENCE

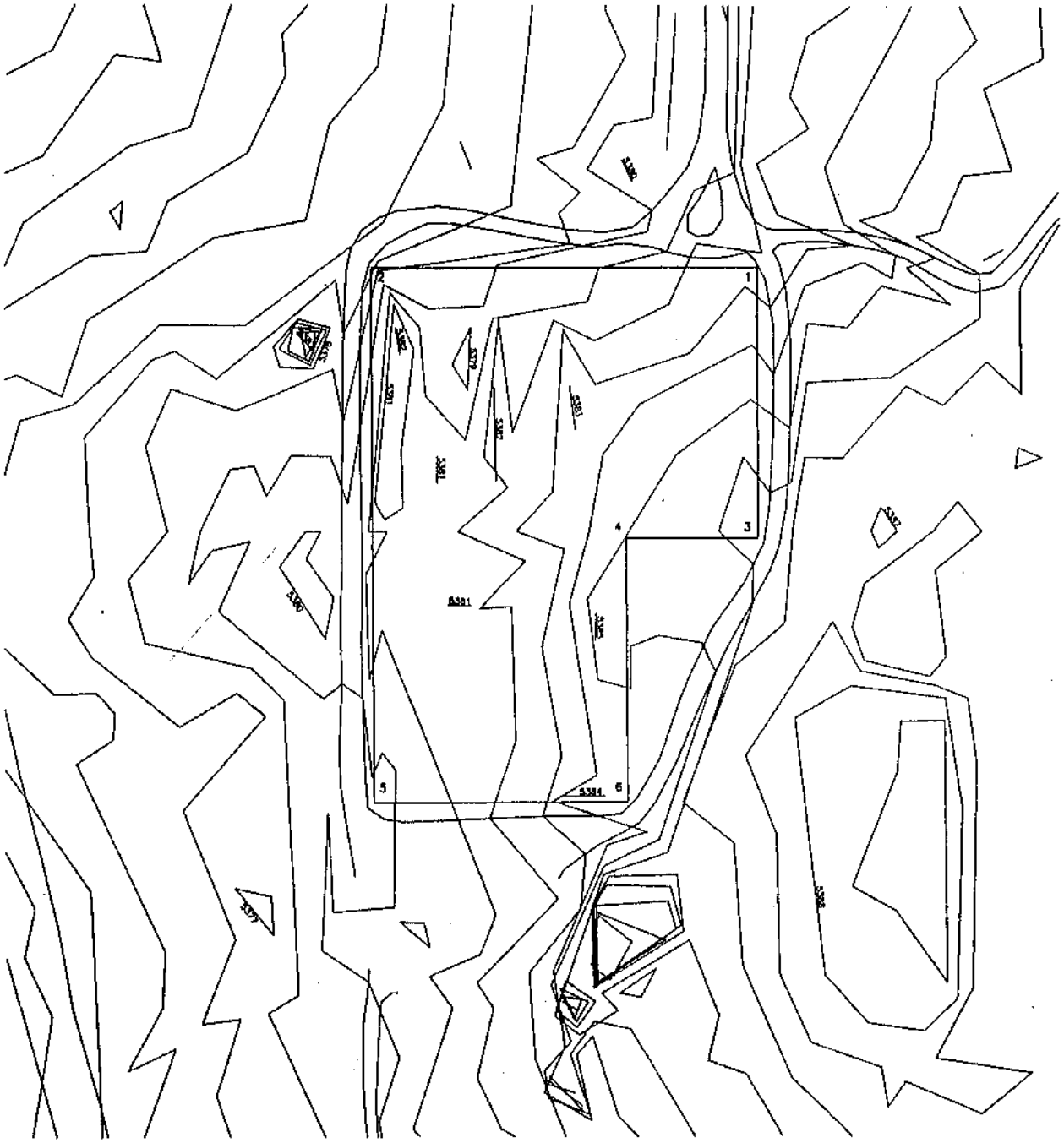
NOTES:

TA III NORTHEAST QUADRANT

DESCRIPTION	
APPLICATION	BY / DATE
DRAWN	
CHECKED	
APPROVED	

MIXED WASTE LANDFILL
COVER DESIGN

E 14213 MWL001 0



LEGEND

ROAD

MIXED WASTE LANDFILL

1 FOOT CONTOUR

MIXED WASTE LANDFILL
STATE PLANE COORDINATES NA1927

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1	1452611.08559	411755.37554
2	1452610.64224	411454.62840
3	1452394.54070	411756.10221
4	1452394.04820	411654.89512
5	1452183.30806	411456.09187
6	1452183.30806	411655.12420

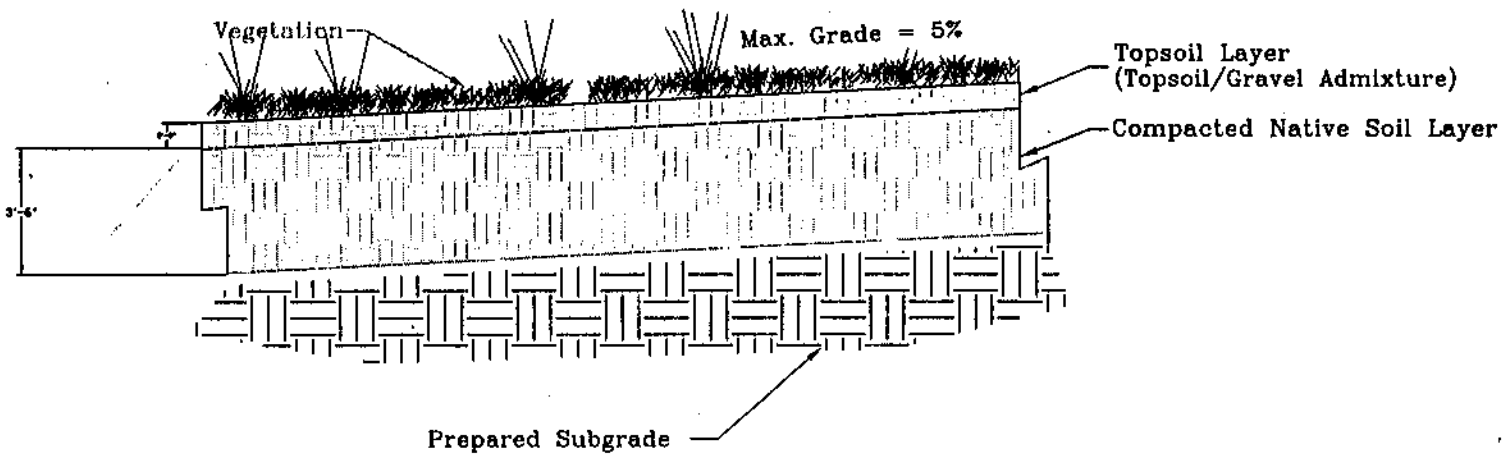
NOTES:

DESCRIPTION		
APPLICATION	BY	DATE
DRAWN		
CHECKED		
APPROVED		

MIXED WASTE LANDFILL
COVER DESIGN
CONSTRUCTION SITE

E 14213 MWL002 0

Mixed Waste Landfill Evapotranspiration Soil Cover Profile



DESCRIPTION		
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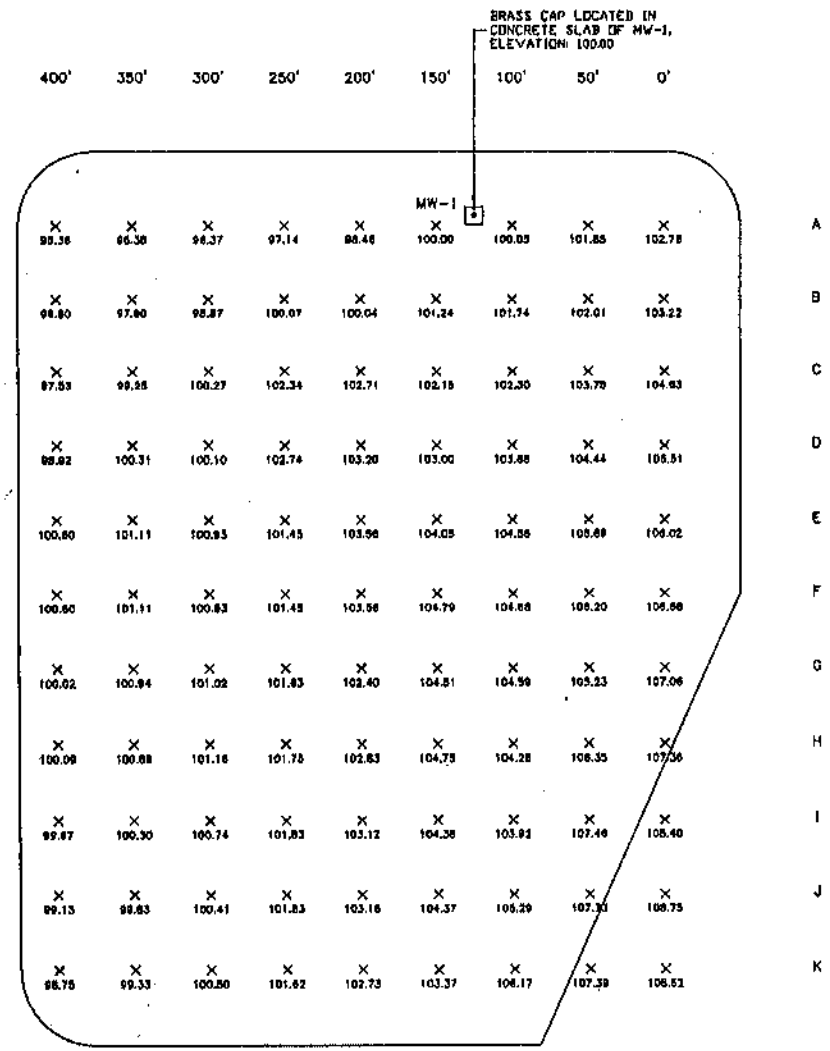
DRAWN		
CHECKED		
APPROVED		

MIXED WASTE LANDFILL
COVER DESIGN
SOIL COVER PROFILE

E 14213 | MWL003 | 0



LEGEND

× SURVEY GRID

MIXED WASTE LANDFILL

COVER BOUNDARY

NOTES:

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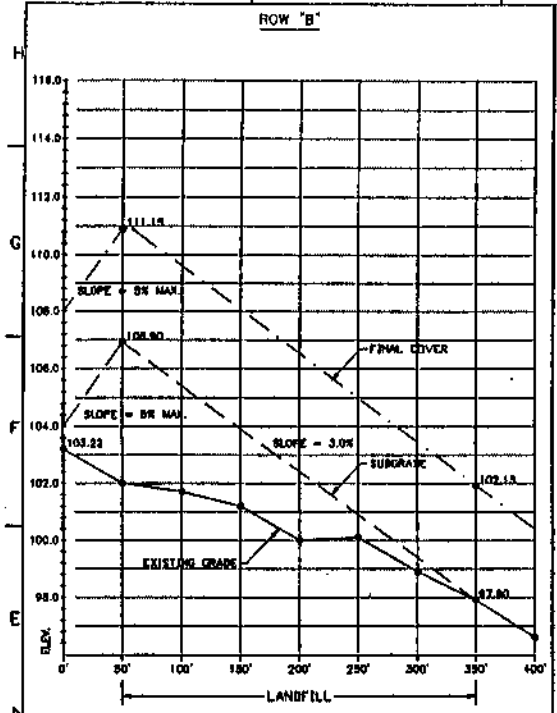
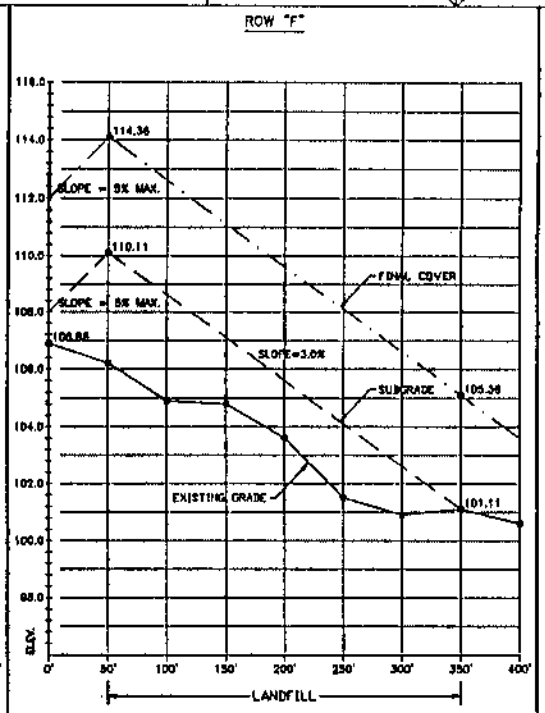
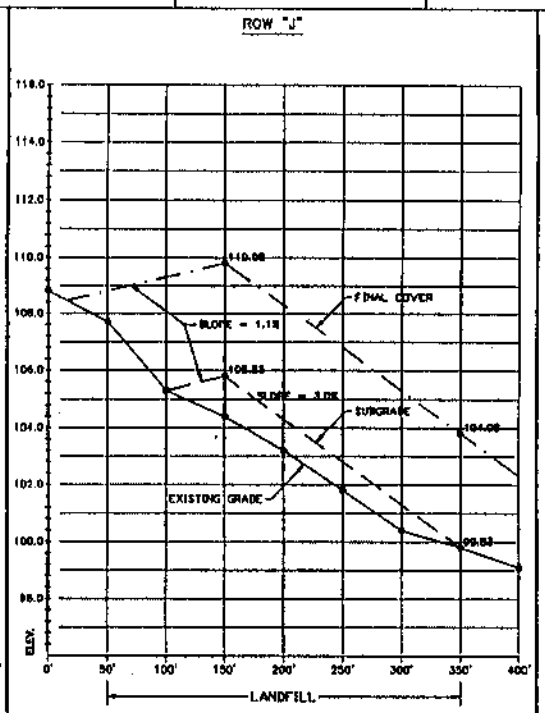
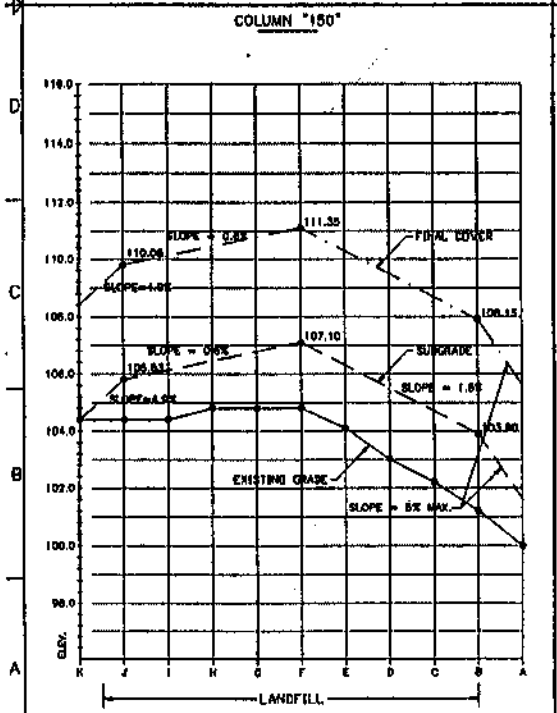
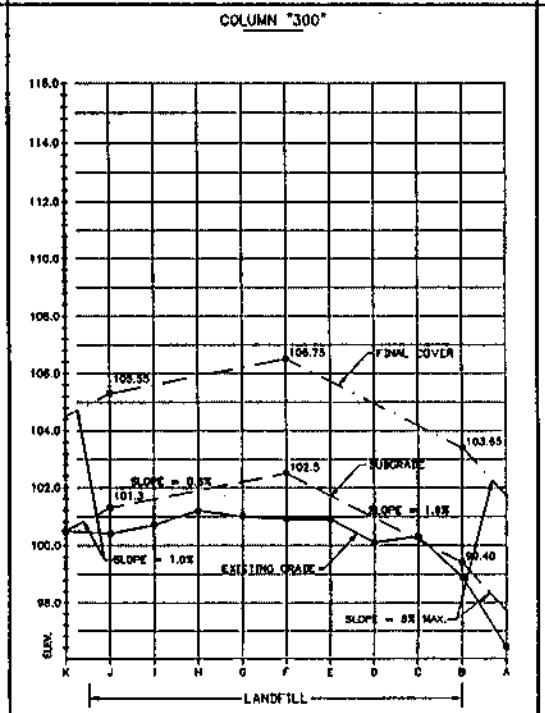
MIXED WASTE LANDFILL COVER DESIGN SURVEY GRID	
E 14213	MWL004











LEGEND

- GRID
- EXISTING SLOPE
- SUBGRADE
- FINAL COVER

NOTES:

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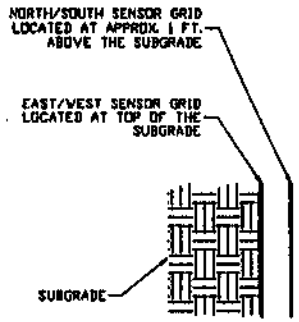
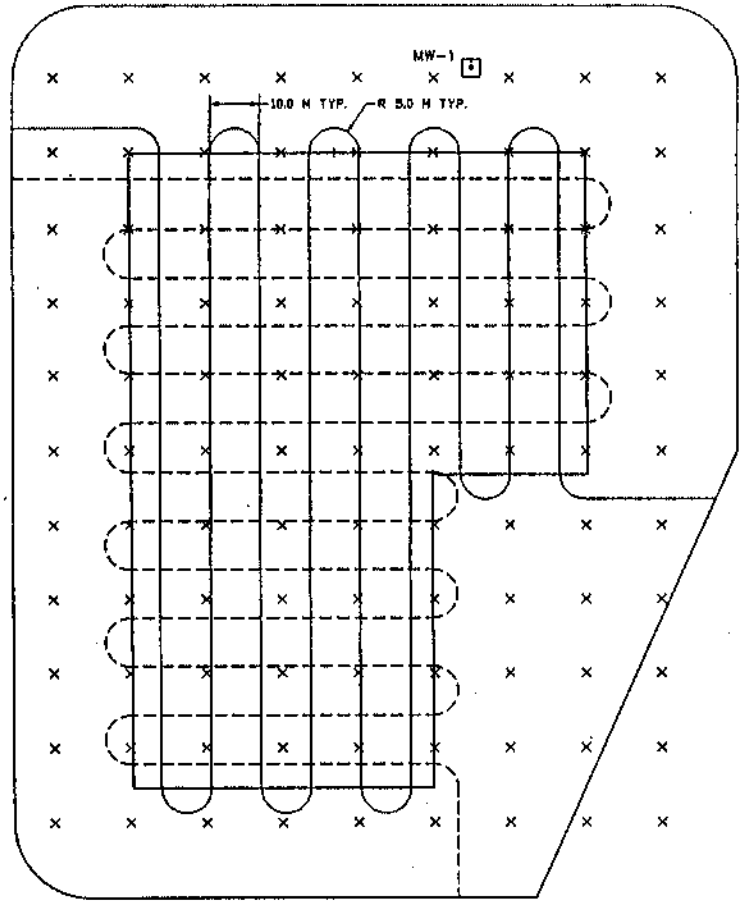
MIXED WASTE LANDFILL COVER DESIGN SECTION PROFILES	
E 14213	MWL005 0



SIDE VIEW DETAIL
NOT TO SCALE



LEGEND

- × SURVEY GRID (50 FT.)
- MIXED WASTE LANDFILL
- COVER BOUNDARY
- N/S SENSOR GRID (1 FT. ABOVE SUBGRADE)
- E/W SENSOR GRID (AT TOP OF SUBGRADE)

NOTES:

N

DESCRIPTION	
MIXED WASTE LANDFILL COVER DESIGN SENSOR GRID	
E 14213	MWL006

Appendix F

MWL Construction Specifications

Sandia National Laboratories

Mixed Waste Landfill

Specifications

8-11-99

prepared by:

Stephen F. Dwyer

SPECIFICATIONS

DIVISION 1	GENERAL REQUIREMENTS
SECTION 01000	OVERVIEW OF MIXED WASTE LANDFILL
SECTION 01300	DESCRIPTIVE SUBMITTALS
DIVISION 2	SITE WORK
SECTION 02110	CLEARING AND GRUBBING
SECTION 02200	EARTHWORK
SECTION 02210	RIPRAP
SECTION 02900	SEEDING

SECTION 01000

OVERVIEW OF MIXED WASTE LANDFILL

The Mixed Waste Landfill (MWL) is a fenced 2.6 acre landfill located at Sandia National Laboratories, Albuquerque (SNLA) in Tech Area 3. The MWL is a Radioactive Materials Management Area (RMMA) and a RCRA land disposal facility. The MWL was operated from March 1959 to December 1988 as the primary disposal site for SNL, NM technical and remote test areas involved in nuclear weapons research and development. The MWL was opened originally as the "Area 3 Low-Level Radioactive Dump" when the existing low-level radioactive dump in Tech Area 2 was closed in March 1959. Approximately 100,000 ft^3 of low-level radioactive waste and minor amounts of mixed waste containing approximately 6300 Ci of activity (at the time of disposal) were disposed of at the MWL. Currently, there is temporary, aboveground storage of containerized, low-level radioactive and mixed wastes at the landfill.

The MWL consists of two distinct disposal areas: the classified area, occupying 0.6 acres, and the unclassified area occupying 2.0 acres. Wastes in the classified area were disposed of in a series of vertical, cylindrical pits. Historical records indicate that early pits were 3 to 5 ft in diameter and 15 ft deep. Later pits were 10 ft in diameter and 25 ft deep. Once pits were filled with waste, they were backfilled with soil then capped with concrete. Wastes in the unclassified area were disposed of in a series of parallel, north-south excavated trenches. Records indicate that trenches were 15 to 25 ft wide, 150 to 180 ft long, and 15 to 20 ft deep. Trenches were reportedly backfilled with soil on a quarterly basis and, once filled with waste, capped with originally excavated soils that had been stockpiled locally.

Wastes disposed in classified area pits included depleted, natural, and enriched uranium, thorium, barium, enriched lithium, liquid scintillation vials and beakers, neutron generator tubes and targets, plutonium-contaminated wastes, and plutonium-contaminated weapons test-debris from the Nevada test site. Between 1959 and 1962, small quantities of radioactively contaminated inorganic acids and organic solvents were disposed of in Pit SP-1, located in the southeast corner of the classified area. Wastes disposed of in unclassified area trenches included construction and demolition materials, contaminated equipment and soils, lead shielding, wood crates, steel drums, shipping casks, cardboard boxes, and dry solids. Wastes disposed of in unclassified area trenches were disposed of at random with no regard to waste source or type.

End of Section 01000

STANDARD SPECIFICATION

SECTION 01300

DESCRIPTIVE SUBMITTALS

PART 1 - GENERAL

1.01 DESCRIPTION OF WORK

Section Includes: This section includes administrative and procedural requirements for submittals required for performance of the work, including:

A. Type A - Shop Drawings

B. Type B - Catalog Data

C. Type C - Installation Instructions

D. Type D - Operating Manual, Maintenance Instructions and Parts List

E. Type E - Internal Wiring Diagrams

F. Type S - Special

1.02 PURPOSE OF SUBMITTAL REVIEW

A. General Contractor Responsibility: The General Contractor's responsibility with respect to submittals shall be to review, stamp, and submit all submittals in the proper format and in a timely manner. The General Contractor shall be responsible for the following items and shall not submit a request for approval of said items but shall be ultimately and solely responsible for them:

1. Field verification and confirmation of all dimensions for proper fit of all materials. Sub-contractors' requests for field verification of dimensions shall be addressed by the General Contractor prior to submitting shop drawings to Sandia National Laboratories (the Sandia Delegated Representative).

2. Field verification and confirmation of quantities of materials.

3. Fabrication processes and techniques of construction.

B. Sandia Delegated Representative Responsibility: Submittals shall be reviewed by the Sandia Delegated Representative for the sole purpose of checking general conformance with the design concepts of the project and general compliance with the contract documents.

Any action shown is subject to the requirements of the contract documents including plans and specifications and does not relieve the General Contractor from compliance with all provisions and requirements therein. Approval of a submittal does not relieve the General Contractor of his responsibility for correcting any errors, which may exist in the submittal or for meeting the requirements of the contract documents.

PART 2 - MATERIALS

2.01 DESCRIPTIVE SUBMITTAL LISTS

A. Submittal Codes: The following abbreviations: Arch., Civ., Struc., Mech., Elec., or Con. - identify the respective Architectural, Civil, Structural, Mechanical, Electrical or Controls discipline for which information is being requested.

B. Reference Numbers: Reference numbers are to be assigned to each submittal.

C. Submittal Types: The descriptive submittal types are used to identify the type of information being requested. They are defined below and are marked on the "Descriptive Submittals" review form.

1. Type A - Shop Drawings: Detailed drawings prepared specifically for the project and used for fabrication and/or assembly of material or equipment.

   a. the Sandia Delegated Representative design/construction drawings shall not be reproduced and used for shop drawings.

   b. Shop drawings shall be prepared accurately and to scale. Encircle deviations from the contract documents.

   c. Shop drawings shall include dimensions, identification of products and materials, notation of special coordination requirements, notation of dimensions established by field measurements and shall indicate compliance with specified standards.

   d. Shop drawings shall be submitted on sheets at least 8-1/2" x 11" (216 mm x 279 mm) but no larger than 24" x 36" (610 mm x 914 mm).

2. Type B - Catalog Data: Manufacturer's published literature describing the salient features of the product (e.g. size, weight, performance, code conformance, capacity, physical size, pictures, ratings, and construction features). Clearly highlight specified items and optional features such that there is no misunderstanding as to what precisely is being proposed.

3. Type C - Installation Instructions: Manufacturer's information explaining the preparation and installation of material and equipment, including:

a. Outline drawings showing major components and dimensional service connection points.

b. Service connection requirements such as electrical fuse or circuit breaker size and type, pipe size and type, air duct, critical ambient conditions (cooling, heating), foundation requirements, and special precautions.

c. Adjustment requirements that must precede operation, including initial alignment procedures, leveling, purging, charging, and lubrication.

4. Type D - Operating Manual, Maintenance Instructions, and Parts List: Complete calibration procedures and operating instructions including all necessary pre-start up checks and safety precautions.

a. Provide instructions for step-by-step preventive maintenance and minor field repairs that will ensure optimum dependable performance, longevity, and life cycle cost.

b. Provide manufacturer's compiled parts list for maintenance and repair.

c. Provide a symptom, diagnostic, and corrective action schedule.

5. Type E - Internal Wiring Diagrams: Internal wiring and elementary (ladder) diagram for factory pre-wired equipment.

a. Include control diagrams that show the relative position of each component as a system diagram.

b. Include any additional information requested in the Mechanical and Electrical specifications for a particular product.

6. Type S - Special: Special information, samples and others as indicated.

a. Include actual color, texture, and pattern when submitting samples.

b. Indicate product sources and availability as well as manufacturer's name.

D. Asbestos Free and Lead Paint Free Certification Submittal: It is required that all products used on the construction project be "free of asbestos" and "free of lead paint." In addition to the above submittal types, for every product on which a submittal is requested, the Contractor shall also submit written certification from the product manufacturer stating that the products to be used on this project are "free of asbestos" and "free of lead paint."

PART 3 - EXECUTION

3.01 SUBMITTAL PROCEDURES

A. Coordination: Coordinate preparation and processing of submittals with performance of construction activities. Transmit each submittal in advance of performance of related construction activities.

1. Coordinate each submittal with fabrications, purchasing, testing, delivery, other submittals and related activities that require sequential activity.

2. Coordinate transmittal of different types of submittals for related materials so processing will not be delayed by the need to review related submittals concurrently.

   The Sandia Delegated Representative reserves the right to withhold action on a submittal requiring review of related submittals until the related submittal information is received.

B. Review Time: The Sandia Delegated Representative may take two weeks for initial review. The Sandia Delegated Representative may also take additional time if processing must be delayed to permit review of related subsequent submittals. Allow additional time for processing of re-submittals.

C. Submittal Packaging: Bindable submittals, for each discipline, shall be three hole punched and bound into a card stock binder with flexible metal clips:

1. The submittal binder shall be stamped on the lower right hand corner of the cover with an approximately 4" x 4" (102 mm x 102 mm) identification stamp as described below:

   "Discipline: _____" (e.g., Arch., etc.)

   "Contract Number: _____" (e.g., TW-0030)

   "Descriptive Submittal Reference Number: _____" (e.g., 1 through 15 and 19 through 22)

   "General Contractor Information:"

   "Company Name: _____"

   "Company Phone Number: _____"

   "General Contractor Reviewer Signature: _____"

   "General Contractor Reviewer Printed Name: _____"

2. The General Contractor shall submit descriptive submittals to the Sandia Delegated Representative only after General Contractor review. The General Contractor's Reviewer shall sign his name on the identification stamp on the cover of the binder indicating General Contractor's approval of the submittal and acknowledgment as to the appropriateness of the material or information submitted for use in construction.

Unstamped, unsigned, or otherwise incomplete submittals shall not be accepted by the Sandia Delegated Representative.

3. Submittals shall be grouped together with related products of the same discipline when possible (e.g., Finishes - vinyl floor tile, floor tile adhesive, vinyl base, ceiling tile, ceiling tile grid, carpet tile, carpet tile adhesive, ceramic tile, ceramic tile adhesive). The requested submittal types for a particular item should always be complete and submitted together. Do not submit one type of submittal apart from other types of submittals for the same product. Each submittal shall be legible and grouped together in the following order for each product requested:

   a. Asbestos and Lead Paint Free Certification(s)

   b. Submittal Type A - Shop Drawings. Fold shop drawings down to 8-1/2" x 11" (216 mm x 279 mm) and insert into submittal package.

   c. Submittal Type B - Catalog Data

   d. Submittal Type C - Installation Instructions

   e. Submittal Type D - Operating Manual, Maintenance Instructions and Parts List

   f. Submittal Type E - Internal Wiring Diagrams

   g. Submittal Type S - Special: (Only bindable special submittals including color charts and fabric swatch charts.) Unbindable special submittals shall be submitted under separate cover and per product specification.

D. SUBMITTAL DELIVERY: For all types of submittals except samples, transmit the number of submittals needed for the General Contractor's purposes plus two (2) copies to be retained by the Sandia Delegated Representative. Submittals received from sources other than the General Contractor shall not be accepted. Incomplete, improperly packaged and/or submittals which have not been stamped by the General Contractor shall be returned without action. When submitting samples, submit two (2) sets of samples for review unless otherwise requested.

1. Deliver descriptive submittals to the Sandia Delegated Representative within 15 calendar days after the Notice to Proceed, except: 1) as may be stipulated elsewhere in this Contract, or 2) for "original drawing(s)" prepared by the General Contractor for specialty systems, such as: HVAC Controls, fire protection sprinklers and/or lightning protection system, which shall be delivered within 30 calendar days after the Notice to Proceed.

2. Material and/or equipment shall not be installed until requested submittals pertaining to said material and/or equipment have been approved.

E. SUBMITTAL REVIEW: Submittals will be reviewed and stamped with a self-explanatory action stamp. The stamp will be appropriately marked, as follows, to indicate the action taken:

1. Final Unrestricted Release: When submittals are marked **"Approved"**, that part of the work covered by the submittal may proceed provided it complies with requirements of the contract documents; final acceptance will depend upon that compliance. The term **"Approved"** shall only indicate that there are no exceptions taken to the submittal.

2. Final But Restricted Release: When submittals are marked **"Approved Except as Noted,"** that part of the work covered by the submittal may proceed provided it complies with notations or corrections on the submittal and requirements of the contract documents; final acceptance will depend upon that compliance.

3. Returned for Resubmittal: When submittal is marked **"Not Approved, Revise and Resubmit"**, do not proceed with that part of the work covered by the or prepare a new submittal in accordance with the notations and resubmit without delay. Repeat as necessary to obtain a different action mark.

PART 4 - ITEMS TO BE SUBMITTED

4.01 ITEMS TO BE SUBMITTED

The following items are to be submitted as a minimum:

Type / Item	A	B	C	D	E	S
Seed		•	•			
Fertilizer		•	•			
Mulch		•	•			Including tackifier
Soil Compaction Techniques		•	•			
Soil/Gravel Mixing Method		•	•			Gravel PSD
Riprap		•				
Equipment		•				All equip. to be used, where, & how.
Biointrusion Layer (Galvanized Fencing)		•	•			Also include seaming & overlap descriptions

END OF SECTION 01300

SECTION 02110

CLEARING AND GRUBBING

Part 1 - DESCRIPTION

1.0 This work consists of clearing, grubbing, removing, and disposing of vegetation and debris within the limits of the right of way, easement areas borrow pits, and other areas shown in the Contract or required by the work. Vegetation and objects designated to remain shall be preserved free from injury or defacement.

Part 2 - CONSTRUCTION REQUIREMENTS

2.0 The SNLA Delegated Representative will designate all trees shrubs, plants, and other objects to remain. Any object that is designated to remain and is damaged shall be repaired or replaced as directed by the SNLA Delegated Representative, at the Contractor's expense. Clearing and grubbing shall extend to the toe of fill or the top of cut slopes, unless otherwise designated. All surface objects, trees, stumps, roots, and other protruding obstructions not designated to remain shall be cleared and grubbed, including mowing, as required. Undisturbed stumps, roots, and nonperishable solid objects located two feet or more below subgrade or embankment slope may remain in place. In areas to be rounded at the tops of backslopes stumps shall be removed to at least two feet below the surface of the final slope line.

Except in areas to be excavated, all holes resulting from the removal of obstructions shall be backfilled with suitable material and compacted in accordance with section 02200.

Burning of perishable material will not be permitted. They must be hauled off and disposed of in an acceptable landfill.

No material or debris shall be disposed of within the project limits without the written permission of the SNLA Delegated Representative. Material or debris that are disposed of within the project limits shall be buried to a depth of at least two-feet beneath the subgrade soil and the surface shall be reshaped to match the adjacent ground line. The Contractor shall make all arrangements to obtain written permission from property owners for disposal locations outside the limits and view of the project. Copies of this written agreement shall be furnished to the SNLA Delegated Representative before the disposal area is used.

The Contractor shall scalp the areas within the excavation or embankment grading limits. Mowed sod need not be removed where the embankment to be

constructed is four feet or more in height. Scalping shall include the removal from the ground surface of brush, roots, sod, grass, residue of agricultural crops, sawdust, and other vegetable matter.

END OF SECTION 02110

SECTION 02200

EARTHWORK

PART 1 - GENERAL

1.1 SCOPE

A. This Specification Section describes the requirements for the following:

1. The earthwork related to the following operations:

   a. Dust control.

   b. Excavation of materials from the site and construction of the cover system.

   c. Construction of the final cover systems.

   d. Subgrade preparation for the covers and permanent drainage ditches.

   e. Finish grading of the site.

2. Furnishing and installing displacement monuments as shown on the Contract Drawings.

1.2 RELATED WORK

A. Section 01300 Descriptive Submittals

B. Section 02110 Clearing and Grubbing

C. Section 02900 Seeding.

1.3 DEFINITIONS

A. Excavation: Excavation is defined as excavation required to reach the lines and grades indicated on the Contract Drawings or specified herein. It shall include excavation of topsoil, silt, clay, sand, gravel, talus, soft or disintegrated rock, boulders or detached pieces of solid rock.

B. Contaminated Materials Excavation: There are no contaminated materials at this site.

C. Uncontaminated Materials Excavation: Excavation of uncontaminated materials including topsoil, silt, clay, sand, gravel, talus, soft or disintegrated rock, boulders

and removal of detached pieces of solid rock carried out to reach lines and grades indicated on the Contract Drawings or specified herein. This excavation shall include excavations for cover, drainage ditches, and finish grading.

D. Overexcavation: Overexcavation is defined as excavation carried out beyond the lines and grades indicated on the Contract Drawings or in the Contract Specifications.

E. Percent Maximum Density: Percent maximum density is a percentage of the maximum density obtained by the test procedure presented in ASTM D698, as applicable.

F. Topsoil: Topsoil is the existing surface soil stripped to a depth of six-inches and consisting of natural, friable soil representative of productive soils in the vicinity. Topsoil shall be free of any admixture of subsoil, foreign matter, objects larger than two-inches in any dimension, toxic substances, and any material or substance that may be harmful to plant growth. *This soil is to be excavated, stockpiled, and eventually refilled as the top six-inches of all disturbed areas the topsoil was originally removed from.*

G. Subgrade Preparation: Subgrade preparation includes fine grading and compaction of excavations for the landfill cover systems including drainage ditches, backfills, and cover upon which bedding materials, riprap, or other features are to be constructed.

H. Cover: Cover shall consist of soil from selected borrow areas placed as shown on the Contract Drawings.

1.4 APPLICABLE PUBLICATIONS

A. The Publications listed below form a part of this Specification to the extent referenced. The Publications are referred to in the text by the basic designation only:

1. American Society for Testing and Materials (ASTM):

C33-85 Specifications for Concrete Aggregates

D422-63 Method for Particle-Size Analysis of Soils

D698-91 Test methods for Moisture-Density Relations of Soils and Soil-Aggregate Mixtures Using 5.5 lb. (2.49-kg) Rammer and 12-in. (305-mm) Drop

D1140-92 Test Method for Amount of Material in Soils Finer than the No. 200 (75-um) Sieve

D1556-90 Test method for Density of Soil in Place by the Sand-Cone Method

D2216-80 Test Method for Laboratory Determination of Water (Moisture) Content of Soil, Rock, and Soil-Aggregate Mixtures

D2487-93 Test Method for Classification of Soils for Engineering Purposes

D2922-91 Test Methods for Density of Soil and Soil-Aggregate in Place by Nuclear methods (Shallow Depth)

D4318-93 Test Method for Liquid Limit, Plastic Limit, and Plasticity Index of Soils

1.5 QUALITY ASSURANCE

A. The Contractor is responsible for meeting all requirements set forth in the contract documents. The SNLA Delegated Representative will take soil samples and perform moisture-density, gradation and other tests to ascertain that the work is being performed in compliance with these Specifications. Samples may be taken at the place of excavation, stockpiles, or on the fill itself. The SNLA Delegated Representative will conduct the density and other tests on the fill and related laboratory testing as frequently as the SNLA Delegated Representative considers necessary. The Contractor shall remove surface material and render assistance as necessary to enable sampling and testing.

B. Methods of Sampling and Testing:

1. In-Place Density: ASTM D1556 or D2922

2. Liquid Limit, Plastic Limit and Plasticity Index: ASTM D4318

3. Particle Size Analysis: ASTM D422

4. Percentage Passing No. 200 Sieve: ASTM D1140

5. Moisture Content: ASTM D2216, D2922

6. Laboratory Moisture-Density Relations: ASTM D698

7. Soil Classification: ASTM D2487

C. Suitability of Materials: The suitability of all materials for foundations and backfill will be approved by the SNLA Delegated Representative . Fill soil will be approved material from on-site cut excavations from selected borrow areas.

D. The SNLA Delegated Representative may direct that inspection trenches or test pits be cut into fills to determine that the Specifications have been met. Such trenches or pits will be of limited depth and size, and shall be backfilled with the material excavated therefrom, or other fill material meeting the requirements for the zones cut into. Backfill shall be compacted to a density at least equal to that of the contiguous fill .

E. Inspection trenches or test pits, and the refilling of the same, shall be at the Contractor's expense.

PART 2 - PRODUCTS

2.1 FILL SOILS

A. General:

1. Fill soil materials shall be obtained from on-site cut excavations from selected borrow areas.

2. The Contractor shall make his own determination of any processing that may be required, and shall perform testing as required to meet the Specifications for the various construction materials.

3. The SNLA Delegated Representative shall be granted access to each proposed source to collect samples for testing. The SNLA Delegated Representative may perform additional tests to determine if the materials meet the requirements specified herein.

4. Approval will be based on evidence of compliance with the requirements specified herein.

B. Gradations: Gradations specified shall be as determined after delivery to the MWL site or after cut has been made and material is ready to be refilled.

C. Fill Materials (Soil) Requirements:

1. General: Fill materials for general fill shall conform to the following requirements:

a. All materials except peat (PT), organic clay or organic silt (OL or 0H) as classified by ASTM D2487 and other materials free from roots, organic matter, trash, debris, frozen materials, and stones generally not larger than 2-inches in diameter. A sieve is to be used to ensure compliance with this maximum particle size constraint.

b. Fill material, except for demolition debris and except for clearing and stripping debris, shall not contain any visible organic material or other deleterious substances.

c. All soils used in the landfill cover test plots shall be obtained from on-site cut excavations from selected borrow areas. It is the contractor's responsibility to verify cut excavations are adequate to supply enough fill soil.

d. SOIL REQUIREMNTS specific to the landfill cover are as follows (also refer to Table 2.1):

1. TOPSOIL/VEGETATION LAYER

This topsoil is to be taken from designated borrow areas directly west of the MWL. This layer is to have a minimum thickness of 9 inches. This layer is to be topsoil obtained from these selected borrow areas mixed with gravel. The method used to mix the topsoil and gravel must be submitted and approved prior to mixing. This method must ensure complete mixing of the soil and gravel. The gravel is to be nominally 2-inch (recommended gradation to be 1 to 3 inches) diameter rounded stone. Crushed base coarse gravel is also acceptable. This gravel is to be *clean* with no more than 5% passing the #4 sieve. The ratio of gravel to topsoil is to be 33% by weight (0.33 = dry weight of pea gravel / loose dry weight of topsoil). This soil is not to be compacted other than that received due to equipment traffic during placement. If this top 9 inches is compacted too densely by equipment traffic, it is to be scarified at the discretion of the Sandia Delegated Representative. The surface is to be scarified prior to seeding.

2. COMPACTED SOIL LAYER:

This soil is to be taken from designated borrow areas directly west of the MWL. The overall thickness of the cover is to have a minimum thickness of 4-feet. The bottom 42-inches of soil shall be placed in lifts not to exceed a 6-inch compacted thickness. Each lift is to be compacted based on laboratory testing of the borrow soil using the Standard Proctor Method (ASTM D698). These results are shown in Appendix I, Sheet GT-2. For installation of this compacted soil layer, acceptable initial density ranges are between 80% to 90% of the maximum dry density. This equates to a unit weight range of about 92 pcf to 104 pcf. The allowable initial gravimetric moisture content range is to be less than 13%, but preferably

less than 9%. Each lift is to be scarified to a depth of 1 to 2 inches prior to the placement of the subsequent lift.

3. SUBGRADE SOIL LAYER:

This soil is to be taken from stockpiled soil located near the CAMU site located southeast of the MWL at Sandia National Laboratories in Tech Area 3. The overall thickness of the cover is to vary. Refer to the project drawings located in Appendix E. Each installed lift shall not exceed a 6-inch compacted thickness. Each lift is to be compacted based on laboratory testing of the borrow soil using the Standard Proctor Method (ASTM D698). These results are shown in Appendix I, Sheet GT-4. For installation of this compacted soil layer, acceptable initial density ranges are between 95% to 110% of the maximum dry density. This equates to a unit weight range of about 114 pcf to 133 pcf. It is *preferred* that this soil be compacted dry of optimum (less than 12% gravimetric moisture content). Each lift is to be scarified to a depth of 1 to 2 inches prior to the placement of the subsequent lift.

Soil Property	Topsoil	Compacted Native Soil	Subgrade Soil
Soil Classification			
Unified Soil Classification System	Silty Clayey Sand (SC-SM)	Silty Clayey Sand (SC-SM)	Silty Clayey Sand (SC-SM) or Silty Sand (SM)
USDA Textural Classification	Fine Sandy Loam	Fine Sandy Loam	Fine Sandy Loam
Plasticity Index (max.)	10	10	-
Approximate PSD (soil only)	Not including gravel admixture		
% passing #10 sieve	96 (NCT)	96 (NCT)	87 (NCT)
% passing #40 sieve	93 (NCT)	93 (NCT)	79 (NCT)
% passing #200 sieve	30 (NCT)	30 (NCT)	29 (NCT)
% finer than 0.0012	14(NCT)	14 (NCT)	11 (NCT)
Lift Thickness (max.)	-	6 inches	6 inches
Max. Object Size	3 inches	2 inches	2 inches
Installed Unit Weight			

Min	Not compacted	92 pcf	114 pcf
Max	Not compacted	104 pcf	133 pcf
Installed Moisture Content (gravimetric)			
Min	-	-	-
Max	-	13%, 9% preferred	12% preferred

** NCT = Not a Construction Tolerance*

Table 2.1: Acceptable Soil Properties for Construction of MWL Cover System

2.2 EQUIPMENT

All equipment to be used on the project must be submitted to and approved by the SNLA Designated Representative.

A. Compaction equipment:

1. Kneading – must be approved prior to use by the SNLA Delegated Representative to prevent possible damage to installed instrumentation.

2. Smooth Roll Vibratory—prior to use of vibration equipment, this must be approved by the SNLA Delegated Representative to prevent possible damage to installed instrumentation.

PART 3 - EXECUTION

3.1 DUST CONTROL

A. Dust control shall consist of furnishing water supply, required equipment, additives, accessories and incidentals, and applying water during the completion of the Contract, as required by the SNLA Delegated Representative . A minimum moisture content of four percent shall be maintained in the upper 6-inches of the roadbeds at all times.

B. Water shall be applied by means of pressure-type distributors or pipelines equipped with a spray system or hoses with nozzles that will insure a uniform application of water.

C. All equipment used for the application of water shall be equipped with a positive means of shut-off.

D. Unless otherwise permitted by the SNLA Delegated Representative or unless all the water is applied by means of pipe lines, at least one mobile unit with a

minimum capacity of 5,000 gallons shall be available for applying water on the project at all times.

E. If the Contractor uses chemical additives in water, furnishing and applying the additives shall be at the Contractor's expense.

F. The use, location of application, and the amount and type of additives proposed for use by the Contractor must be submitted to and approved by the SNLA Delegated Representative prior to their use.

3.2 EXCAVATION

A. Preparation:

1. Required lines, levels, contours and datum shall be identified before the start of excavation.

B. General:

1. At all times during excavation, the Contractor shall conduct his operations in such a manner as to prevent freestanding water and contamination of uncontaminated materials. The Contractor shall, as a minimum, maintain positive grade to safeguard against such problems.

2. The Contractor shall perform required excavation to the lines and grades indicated on the Contract Drawings. He shall remove all excavated material from the excavation site and dispose of it.

3. Unsuitable or low-density subgrade material not readily capable of in-place compaction shall be excavated as directed by the SNLA delegated representative and disposed of as a topsoil.

4. Adequate working space for safety of personnel shall be provided within the limits of the excavation.

5. All unstable material, large stones, debris and incompressible soils shall be removed from bottoms of the excavation to a minimum depth of 12-inches.

6. Except as otherwise noted, care shall be exercised to preserve the material below and beyond the lines of all excavation. Where excavation is carried below grade, the Contractor shall backfill to the required grade or to indicated invert grade, as specified, and recompact the backfill to meet the existing conditions.

7. Excavation for the convenience of the Contractor shall conform to the limits approved by the SNLA Delegated Representative and shall be at no additional expense to SNLA.

8. Where practicable, suitable materials removed from excavation shall be used as fill or backfill.

C. Materials Excavation:

1. General: Materials excavation shall include excavations of materials from the various areas of the site. The excavated materials shall be used as fill in various areas of the site including the construction of berms, dikes, general fill, roadway fill, structure fill, backfill, and fill for the final grading of the site, as required. Excavated material may be stockpiled for later use.

2. Drainage Swales Excavation:

   a. General: Swales shall be cut accurately to the cross sections and grades where indicated. All roots, stumps, rock, and foreign matter in the sides and bottom of swales shall be trimmed and dressed or removed to conform to the slope, grade, and shape of section indicated. Care shall be taken not to excavate ditches below the grades indicated. Excessive ditch excavation shall be backfilled to grade with satisfactory, thoroughly compacted material. Ditches shall be maintained until final acceptance of the work. Except the north and east swale excavation may be extended to provide adequate fill for the cover construction.

   b. Permanent Drainage Swales:
   Ditches shall be excavated true to line and grade. Any erosion, which occurs to ditch excavation before placing erosion protection materials, shall be repaired with compacted backfill. All such repairs shall be at Contractor's expense.

   The top six-inches of the subgrade shall be compacted as specified in Article 3.4 below. After compaction has been completed, finish grading shall be done in such a manner that the sideslopes are rendered smooth surfaces. All rocks, brush, roots, large clods, and other objects shall be removed.

   c. The area to be excavated must be cleared and grubbed in accordance with section 02110. All topsoil will be stockpiled for later use.

D. Embankment Materials:

1. Materials excavated from the site, including excavations for trenches, and drainage ditches, shall be used as fill for construction of various features including site grading, or stockpiled for later use, or wasted in the spoil area, as specified in this Section and is required by the SNLA Delegated Representative.

2. Where used in fills, such material shall be transported directly from the excavation and placed in its final position in such fills whenever possible. If required by the Contractor's schedule, the material may be placed temporarily in stockpiles at approved locations. Material in stockpile shall be protected from contamination of any kind that would render it unsuitable for use in fills.

E. Unsatisfactory or Excess Materials: Unsatisfactory and excess excavated uncontaminated material generated during the work and not approved for use in the work shall be disposed of in the designated stockpile/spoil areas as directed by the SNLA Delegated Representative.

F. Garbage, refuse, debris, oil, and any waste material which is generated by the Contractor and is harmful to the environment or offensive to the area shall be removed from the job site and disposed of offsite in a manner approved by the authority having jurisdiction over the disposal site.

G. All operations in the stockpile/spoil areas throughout the work shall be in strict conformity with the requirements of this Section.

3.3 FILL CONSTRUCTION

A. General Requirements:

1. Fill materials shall be placed and compacted to the lines and grades shown on the Contract Drawings.

2. If any portion of the materials does not meet the specified requirements, the Contractor shall remove such material and replace it with fill materials meeting the specification at no additional cost.

B. Placing Requirements:

1. Existing MWL surface preparation prior to placement of initial subgrade soil material: Prior to placement of Materials, the in-place density of the top 12-inches of the area receiving the fill shall be at least 95 percent of maximum dry density as determined by ASTM D698. All compaction is to be performed as dry as possible. Soil properties found in Appendix I, sheet GT-2 may be used for determination of this density requirement. If necessary, the

surface shall be plowed, borrowed materials mixed, materials added or removed and compacted to obtain the specified densities.

2. Fill materials may require moisture conditioning (wetting or drying) prior to compaction.

3. Fill materials shall be placed in continuous and approximately horizontal layers for their full length and width unless otherwise specified.

4. The method of dumping and spreading the materials shall ensure uniform distribution of the material.

5. The loose thickness of each layer of materials shall not be greater than that required to achieve the required compaction, and in no case shall exceed 12-inches for the fill and 9-inches for the barrier materials. These thicknesses are dependent on the compaction equipment to be used. The kneading foot length must be substantially less than the loose lift thickness so as not to damage any instrumentation placed in prior lift.

6. The Contractor shall place material to the grade shown in the project drawings in Appendix E. No fill shall be placed on any area where ponding has been allowed to occur. Where ponding has occurred and the fill material is required to be placed, the water shall be removed and the materials reprocessed to meet acceptable requirements.

7. Materials shall not be placed on frozen subgrade or embankment material foundations, nor shall frozen material be used as fill.

C. Compaction / Remolding Requirements:

1. All lift surfaces must maintain a uniform slope.

2. If the rolled surface of any layer of the fill in place is too wet for proper compaction of the layer of fill material to be placed thereon, it shall be removed, allowed to dry or worked with harrow, scarifier, or other suitable equipment to reduce the water content to the required amount, and then recompacted before the next succeeding layer of fill is placed.

3. Fill placed at densities lower than the specified minimum density or at moisture contents outside the specified acceptable range of moisture content shall be reworked to meet the density and moisture requirements or removed and replaced by acceptable fill compacted to meet these requirements.

D. Field Quality Control:

1. General: The SNLA Delegated Representative will take samples and perform tests throughout the construction period, and the Contractor shall cooperate in providing access for the SNLA Delegated Representative to areas where testing is to be performed and shall schedule his placing to avoid interference with the testing operations.

2. Tests: The contractor will be responsible for performing his own tests to ensure compliance with all contract provisions. Copies of these tests are to be provided to the Sandia Delegated Representative. The SNLA Delegated Representative will also perform tests. The Contractor must make allowances for these tests at no additional cost to Sandia. Refer to the ALCD QA plan for approximate number and type of tests to be performed by SNLA personnel.

3.4 Subgrade Preparation for Permanent Drainage Ditches.

The top six-inches of the subgrade of each permanent drainage ditch shall be compacted to a minimum of 95 percent of maximum density as determined by ASTM D698. After compaction has been completed, fine finishing shall be done in such a manner that the side-slopes are smooth surfaces. All rocks, brush, roots, large clods, and other objects shall be removed before placement of the bedding materials.

END OF SECTION 02200

SECTION 02210

RIPRAP

PART 1 - GENERAL

1.1 SCOPE

This Specification Section describes the requirements for furnishing and placing riprap and bedding materials for the cover and permanent drainage ditches.

1.2 RELATED WORK

A. Section 01300 Descriptive Submittals.

B. Section 02200 Earthwork: Subgrade preparations.

1.3 APPLICABLE PUBLICATIONS

A. The publications listed below form a part of this Specification to the extent referenced. The publications are referred to in the text by the basic designation only.

1. American Society for Testing and Materials (ASTM):

C88-83 Test Method for Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate

C127-84 Test Method for Specific Gravity and Absorption of Coarse Aggregate

C131-81 Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine

C295-85 Practice for Petrographic Examination of Aggregates for concrete

C535-81 Test Method for Resistance to Degradation of Large-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine

PART 2 - Products

2.1 MATERIALS

A. Material Sources: Erosion protection materials shall be obtained from sources approved by the SNLA Delegated Representative. Every change in source of materials shall require approval from the SNLA Delegated Representative.

1. Approval of the source as a borrow area does not mean that all materials excavated will meet the requirements of this Specification. Processing or selective quarrying may be necessary to meet the quality requirements of this Section.

2. The basis for approval of the sources proposed by the Contractor shall be a site inspection report by an engineering geologist or geotechnical engineer which will include, as a minimum, an evaluation of soundness, hardness, and durability for three samples representative of the proposed source.

B. All materials shall be free from radioactive or other contamination.

C. Rip rap materials:

1. Individual pieces shall be dense, sound, resistant to abrasion, and shall be free from cracks, seams, and other defects as shown in the petrographic examination.

2. The shape of at least seventy- percent of the material, by weight, shall be such that the minimum dimension is not less than one third of the maximum dimension. No crushed stones may be used because the sharp edges may damage the liners. Preferably rounded to semi-rounded stones will be used. Broken concrete may not be used as riprap.

3. Quality:

Tests	Designation	Requirements
Specific Gravity (Saturated Surface Dry Basis)	ASTM C127	Not less than 2.45
Absorption	ASTM C127	Not more than 1.5 percent.
Soundness	ASTM C88	$NaS0_4$ Test: Not more than 5 percent loss of weight after 5 cycles.
Abrasion	ASTM C131	Not more than 35 percent (Los Angeles Machine) loss of weight after 500

		revolutions. Ratio of weight loss after 100 revolutions to loss after 500 revolutions shall not exceed 30 percent.
Abrasion	ASTM C535	Not more than 50 percent (Los Angeles Machine) loss of weight after 1000 revolutions. Ratio of weight loss after 200 revolutions to loss after 1000 revolutions shall not exceed 20 percent.
Petrographic	ASTM C295	The Contractor shall furnish a report for review by the Engineer.

4. The riprap shall be sized as follows: maximum size stone of 8-inches, median size stone of 5-inches, minimum layer thickness of 12-inches. The size of an individual stone shall be determined by measuring its long dimension.

   Gradation is to be well graded with *at least* 50% of the gradation between the maximum size stone and the median size stone. The remaining riprap materials shall be reasonably well graded within the following limits:

U.S. Standard Sieve Size (Square Openings) Material Size	Percent Passing (by weight)
4"	100
2"	30 - 95
1"	20 - 50
#4	0 - 10
100	0 - 5

PART 3 - EXECUTION

3.1 PLACEMENT AND COMPACTION

A. Subgrade preparation (for drainage ditches, etc.) shall conform to Specification Section 02200.

B. Where the required layer thickness is 12-inches or less, the material shall be spread in one layer.

C. The riprap will not require compaction.

D. Riprap material shall be placed so that the larger pieces are uniformly distributed and the smaller pieces serve to fill the spaces between them to provide well-keyed, densely placed layers of riprap of the specified thicknesses.

E. Riprap material may be placed by end dumping and may be spread by bulldozers or other suitable equipment. The material shall not be dropped from a height exceeding two-feet above the riprap material, nor in a manner to cause fracture, displacement, or damage to the material being placed or already in place. In no case shall the riprap be dropped directly on the liners but shall be dumped on already placed riprap and then pushed into its final position.

F. Construction equipment other than spreading and placement equipment shall not be allowed to move over the placed riprap material layers.

3.2 TOLERANCES

A. The material layers shall be placed to the limits and thicknesses shown on the Contract Drawings within the following tolerances:

1. Top of bedding material shall be within 0.1 foot of elevations shown on the Contract Drawings.

2. The minimum in-place thickness shall not be more than 100 percent of the thickness shown.

3. The maximum in-place thickness shall not be more than 135 percent of the thickness shown.

4. Local irregularities will be permitted provided that such irregularities do not form noticeable mounds, ridges, swales, or depressions.

3.3 FIELD QUALITY CONTROL

A. The placement of the materials shall be monitored to ensure that the following requirements are met:

1. The correct type of material is being placed.

2. The material being placed is clean and free of unsuitable material.

3. The material is being loaded, transported, and placed in a manner which minimizes segregation.

4. Deviations from minimum and maximum thickness shall not exceed 50 percent of the maximum rock size.

5. The material is being placed to line and grade within the tolerances and limits designated in Article 3.2 above.

B. All unsatisfactory materials shall be removed to the satisfaction of the SNLA Designated Representative and replaced with acceptable materials at no additional cost.

C. The SNLA Designated Representative may require that material which has become segregated or not placed according to the above requirements to be regraded or adjusted, using appropriate equipment, to conform with the tolerances and limits given above, at no additional cost.

END OF SECTION 02210

SECTION 02900

SEEDING

PART 1 - GENERAL

1.1 SCOPE

This Specification Section covers seeding. All surface area after installation of the MWL Cover System and all adjacent exposed or disturbed areas not covered by riprap shall be seeded as required to control erosion.

1.2 MATERIAL STORAGE

A. Seeds shall be stored in sealed waterproof containers in a cool, dry location and shall be kept out of direct sunlight until ready for use.

B. Fertilizer shall be delivered and stored in waterproof containers that show the chemical analysis and name of manufacturer.

PART 2 - MATERIALS

2.1 SEED MIX

A. Permanent Cover: The following seed mix shall be used for seeding of final grades:

Seed Species	Seeding Rate Pure Live Seed (Pounds per Acre)
Blue Grama	1
Indian Ricegrass	3
Galleta	3
Sand Dropseed	1
Needle and Thread	4

2.2 ACCEPTANCE OF SEED

Final acceptance of seed will be made by the SNLA Delegated Representative based on the following:
Seed shall be furnished separately or in mixture in standard sealed containers with the following information provided by the seed vendor on each seed container label: (1) seed name;. (2) lot number; (3) net weight; (4) percentages of purity and of germination; (5) seed coverage, in acres, on a pure live seed basis; and (6) percentage of maximum weed seed content clearly marked for each kind of seed. Seeds shall be packaged by the vendor in even acre coverage containers. The Contractor shall furnish the SNLA Delegated Representative duplicate copies of a statement by the vendor, certifying that each lot of seed has been tested by a recognized laboratory for seed testing within six months of date of delivery. This statement shall include: (1) name and address of laboratory: (2) date of test; (3) lot number for each kind of seed; and (4) results of tests as to name, percentages of purity and of germination, and percentage of weed content for each kind of seed furnished, and in case of a mixture, the proportions of each kind of seed.

2.3 FERTILIZER

Fertilizer shall be applied at 10 pounds per acre and shall have a 10-10-10 nutrient composition. Fertilizer shall be furnished in new, clean, and sealed containers with the name, weight, and guaranteed analysis of contents clearly marked. A liquid form of fertilizer containing the minimum percentage of available nutrients may be used.

2.4 MULCH

Hydro-mulch shall be applied over all seeded areas and shall consist of cereal straw. Cereal straw shall be from grain crops that are free from noxious weeds, mold, or other objectionable material. A tackifier shall also be used with the mulch. Final acceptance of mulch will be by the SNLA Designated Representative.

2.5 WATER

Water used in the planting or care of vegetation shall be free of oils, acids, alkalis, salts or any substance injurious to plant life.

PART 3 - EXECUTION

3.1 PREPARATION

A. Timing:

1. During Construction (Temporary Cover): No temporary seeding will be required.

2. Final Grades (Permanent Cover):

   a. All disturbed areas not covered by gravel or riprap shall be seeded by using the seed mix specified in Article 2.1 above. The areas to be seeded include all disturbed areas in this contract, as well as, the adjacent area (approximately equal surface area) disturbed in the Phase I contract. Final seeding shall be completed as soon as practical after completion of final grading. Seeding materials shall not be applied during windy weather, when the ground is excessively wet or frozen, or when snow is present.

   b. Before applying seed for permanent cover of a given area, the area shall be graded as shown on the Drawings, with surfaces sloping gradually toward drainage courses and no enclosed low spots where water can accumulate. Areas to be seeded that have been damaged by erosion or other causes shall be restored prior to seeding and then cultivated to provide a reasonably firm but friable seedbed. A minimum of six-inches of surface soil (topsoil gravel admixture) shall be in a loose condition at the time of seed application.

3.2 APPLICATION

A. Seed for permanent cover shall be applied by a rangeland drill to a depth of 0.5 to 0.75 inch. To the greatest extent possible, seeding shall be oriented along (parallel to) land contours.

3.3 CARE DURING CONSTRUCTION

The Contractor shall be responsible for protecting and caring for areas seeded before final acceptance of the work. The Contractor shall repair any damage to seeded areas caused by erosion or construction operations without additional compensation.

3.4 PLANT ESTABLISHMENT

Seeding must take place prior to July 1. Reseeding the following year may be required as determined by the Designated Sandia representative if the initial seeding effort is not adequate. This will be at the expense of SNLA.

END OF SECTION 02900

Appendix G

Run-On Calculations

Runoff Calculations : (Rational Method)

Reference: Civil Engineering Reference Manual, 5 th Ed.

$Q_p = CIA_d$ {Rational Formula}

where: Q_p = flow quantity (ft^3/sec)
C = Rational Runoff Coefficient
A_d = drainage area (acres)
I = rainfall intensity (in/hr)

$A_d \cong 500' \times 500' = 250{,}000$ sf ≈ 6 acres
(per Sandia ER DWG #999999A132)

C = 0.35 (100-year event)
From City of Albuquerque
Development Process Manual,
Vol. 2, Design Criteria
Section 22.2, Hydrology (1997 Revision)
Table A-11 (p. 22-17)

I = 2.046 in/hr (25-year event)
Use 100-year event
$\therefore I = 2.046 \times .29 \times 60/5 =$ 7.12 in/hr
29% of 1 hour using 5 minute peak storm event

$Q_p = 0.35\ (7.12)(6) \approx$ 15 cfs undisturbed soil

For disturbed soil areas, use C = 0.64
$Q_p = 0.64\ (7.12)(6) \approx$ 27 cfs disturbed soil

Appendix H

QA Plan for Construction of the MWL Cover System

This report is undergoing review for publication as a SAND Document.
09/03/99

Mixed Waste Landfill (MWL)

Quality Assurance Plan

August 11, 1999

Prepared by Stephen F. Dwyer

MWL QA Plan

The Quality Assurance (QA) plan for the MWL covers three areas in the installation phase: construction, materials, and field conditions. All areas require the same care to detail in order to ensure acceptable results.

Materials QA

1. Soils

1.1 Before any soil can be used in the construction of the soil layers, ASTM soil tests must be performed in order to document that the soil meets certain criteria established in the project specifications. Therefore, the following tests will be performed:

Quality	Test	Frequency
Soil Classification	Unified or USDA	1 per borrow site
Percent Gravel (topsoil layer)	ASTM D422	5
PSD	ASTM 422-63	2 per borrow site
Soil Density	ASTM 2922-91	1 per 10,000 sf/ per lift
	ASTM 1556-90	1 per 40,000 sf/ per lift
Water Content	ASTM2922-91	1 per 10,000 sf/ per lift
	ASTM D4643	1 per 40,000 sf/ per lift
PI	ASTM D4318	2 per lift
Lift Thickness	Field Measure	1 per 10,000sf/ per lift
Max. Clod/Stone Size	Observation	Continuous

The contractor will be required to submit proof of compliance in the form of documented test results. SNL personnel will perform the tests. The soil samples for the tests will be taken from the equipment used to spread the lifts. The samples must be properly identified with the following information:

- Date
- Plot #
- Lift identification
- Test to be performed

1.2 The results of each test must meet the following requirements in order for the soil to be deemed suitable:

Soil Property	Topsoil (exclusive of gravel mix)	Compacted Native Soil	Subgrade Soil
Soil Classification			

Unified Soil Classification System	Silty Clayey Sand (SC-SM)	Silty Clayey Sand (SC-SM)	Silty Clayey Sand (SC-SM) or Silty Sand (SM)
USDA Textural Classification	Fine Sandy Loam	Fine Sandy Loam	Fine Sandy Loam
Plasticity Index (max.)	10	10	-
Approximate PSD (soil only)	Not including gravel admixture		
% passing #10 sieve	90 to 100	90 to 100	80 to 100
% passing #40 sieve	85 to 100	85 to 100	70 to 100
% passing #200 sieve	20 to 40	20 to 40	20 to 40
Max. Object Size	2-inches	2-inches	2-inches
Max. Lift Thickness	-	6-inches	6-inches
Installed Unit Weight			
Min	Not compacted	92 pcf	114 pcf
Max	Not compacted	104 pcf	133 pcf
Installed Moisture Content (gravimetric)			
Min	-	-	-
Max	-	13%, 9% preferred	12% preferred

Table 2.1: Acceptable Soil Properties for Construction of MWL Cover System

The results must be presented as per ASTM requirements and have the following labeling:

- Date
- Plot #
- Lift identification

1.3 Grain Size Distribution

Before the soil is wet, the soil in question must pass the requirements of percentage fines and percentage gravel. If the first sample does not meet requirements, two more samples must be taken and pass before lifts may be placed. If one of the secondary samples fails the criteria, the soil must be discarded and prepared again. Any stone or clod larger than 2" (3" for top gravel

admixture layer) must be removed from the pre-compacted lift and disposed of properly.

1.4 Water Content

The water content of the soil to be used for the compacted soil layers will be checked according to ASTM D4643. One soil sample will be removed from the soil to be used in the placement of each lift and dried in the microwave oven. If the first sample does not meet requirements, two more samples must be taken and pass before lifts may be placed. If one of the secondary samples fails the criteria, the soil must be prepared again.

1.5 Atterberg Limits

Soil must be removed and labeled as per previous instructions for the Atterberg Limit test. The Atterberg Limit test requires a soil preparation period of approximately 24 hours. Lifts may be placed before the test results are obtained. Therefore, the lifts constructed with the tested soil must be properly identified. If the soil does not meet specifications, the lift in question must be removed and prepared again.

1.6 Soil Classification

Upon completion of the soil tests, the soil must be classified per the USCS classification system. The resulting soil must have the following classification: SM.

Organics should not be present in the soil used for subgrade layer construction.

Construction QA

1. Subgrade

1.1. Density Requirements

1.1.1. The subgrade of all plots must be placed with similar specifications. The subgrade must be compacted to at least 95% to 110% of maximum dry density per ASTM D698.

1.2. Testing Procedure

1.2.1. Two ASTM density tests will be performed on the subgrades. ASTM 2922 will be performed with a frequency of 5/subgrade. ASTM 2922, which is a nuclear method, will be verified with ASTM 1556. ASTM 1556 will be performed with a frequency of 1/ subgrade.

1.2.2. Test sample locations will be determined by a grid pattern. The grid will separate each cover's subgrade into ten sixty foot by twenty foot rectangles. Samples will be taken approximately in the center of each adjacent diagonal rectangle (see Figure 1).

1.2.3. In order for the subgrade to be acceptable, 4 of the 5 readings must have an average dry density between 95% and 110% of maximum dry density. However, none of the readings may be 5 pcf below 95% of maximum dry density.

1.3. Outliers and Repairs

1.3.1. If one of the samples is 5 pcf below specifications, three more readings should be taken close to the sample point of the original test. If the average of the three results meet specifications and none of the readings are 5 pcf below specifications; the area in question may be left as is. If one of the secondary tests fails, however, a large area of unacceptable compaction may exist. Therefore, further tests must be conducted in order to identify the area. Once the area is identified, the soil must be repaired to meet specifications.

1.5. Elevations and Grading

1.5.1. Upon completion of the subgrade, the elevations and slope of the subgrade must be field verified. A drawing with specified field elevations must be submitted and approved before installation can continue.

1.5.2. If elevation stakes are used in construction, all must be removed. Preferably, a numbering system should be used to account for all of the stakes placed and removed during construction.

2. Compacted Native Soil Layer

2.1. Lift Placement

2.1.1. The lifts for the compacted native soil layer must be placed with a maximum compacted lift thickness of 6-inches (nominally a loose thickness of 9-inches).

2.1.2. A ruler will be used to measure the lift thickness at the ends of every other lift at 50-foot intervals. The data will be recorded for construction documentation purposes.

2.1.3. After the placement of each lift, the contractor must allow time for soil tests and placement of instrumentation where required.

2.2. Density Requirements

2.2.1. Each lift must be compacted to at least 80% to 90% of maximum dry density.

2.2.2. The number of passes will be observed and recorded on the placement of every other lift.

2.3. Testing Procedure

2.3.1. Two ASTM density tests will be performed on the lifts. ASTM 2922 will be performed with a frequency of 5/lift. ASTM 2922, which is a nuclear method, will be verified with ASTM 1556. ASTM 1556 will be performed with a frequency of 1/lift.

2.3.2. Test sample locations will be determined by a grid pattern. The grid will separate the MWL into 100-foot by 100-foot squares. Samples will be taken approximately in the center of each adjacent diagonal.

2.3.3. In order to prevent samples from being taken one on top of the other, the sampling pattern will be separated into two sets of adjacent diagonal rectangles. From Figure 3, the rectangles marked with "1" are sampled after the placement of one lift; the rectangles marked "2" are sampled when the following lift is placed and compacted. Samples will be taken from alternating sets of rectangles for each lift, until layer installation is complete.

2.3.4. In order for a lift to be acceptable, 4 of the 5 readings must have an average dry density between 80% and 90% of maximum dry density. However, none of the readings may be 5 pcf below 80% and 90% of maximum dry density.

2.3.5. If one of the samples has a dry density 5 pcf below 80% or 5 pcf above 90% of maximum dry density, three more readings should be taken close to the original test. If the average of the three results meet specifications and none is 5 pcf below 80% or 5 pcf above 90% of maximum dry density, the area in question may be left as is. If one of the secondary tests fails, however, a large area of unacceptable compaction may exist. Therefore, further tests must be conducted in order to identify the area. Once the area is identified, the soil must be repaired to meet specifications.

2.4. Water Content

2.4.1. In order to ensure that the soil is compacted dry of optimum, two ASTM tests will be performed to determine the water content of the soil in each lift. ASTM D3017 will be performed with a frequency of 5/lift. ASTM D2216 will be performed with a frequency of 1/lift. ASTM D2216 is used primarily to verify the results of ASTM D3017, which is a nuclear test.

2.4.2. Sampling will be performed in the same pattern as for density tests.

2.3.3. In order for a lift to be acceptable, 4 of the 5 readings must have water content of dry of optimum.

2.3.4. If more than one of the samples has water content outside of the range, three more readings should be taken close to the sample with the largest deviation. If the three results meet specifications, the area in question may be left as is. If one of the secondary tests fails, however, a large area of unacceptable water content may exist. Therefore, further tests must be conducted in order to identify the area. Once the area is identified, the soil must be repaired to meet specifications.

2.5. Lift Scarification

2.5.1. The surface of each lift must be scarified after the lift has passed the density and moisture content requirements.

2.5.2. Scarification of the lift will be documented with photos or video recordings.

2.6. Elevations

2.6.1. Upon completion of the layer, the elevations and slope of the layer must be field verified. A drawing with specified field elevations must be submitted and approved before installation can continue.

2.6.2. If elevation stakes are used in construction, all must be removed. Preferably, a numbering system should be used to account for all of the stakes placed and removed during construction.

Field QA

Key meetings are essential to the successful construction of the MWL Closure System. These meetings will include a pre-bid meeting held prior to bidding of the contract, a pre-construction meeting possibly held in conjunction with a resolution meeting after the contract is awarded but prior to the start of actual construction activities.

The pre-bid meeting will be used to discuss the QA Plan and resolve differences of opinion before the project is let for bidding. It will also give the bidders a chance to ask questions about potential problems that can therefore be rectified early on. The resolution and pre-construction meetings will be used to open lines of communication, review construction plans and specifications, emphasize the critical aspects of a project necessary to ensure proper quality, begin planning and coordination of tasks, and anticipate any problems that might cause difficulties or delays in construction. They will also allow for the review of the QA Plan, to make sure that the responsibility and authority of each individual is clearly understood, where procedures to resolve construction problems are established. Periodic progress meetings will be held at the job site. These meetings will be helpful in maintaining lines of communication, resolving problems, identifying action items, and improving overall quality management.

Daily Inspection Reports will be prepared that include information about work accomplished, tests and observations made, and descriptions of the adequacy of the work that was performed. Daily Summary Reports will provide a chronological framework for identifying and recording all other reports and aid in tracking what was done and by whom. Inspection and Testing Report will note field observations, results of field tests, and results of laboratory tests performed on- or off-site. These observations will take the form of notes, charts, sketches, or photographs, or a combination of these. Problem Identification and Corrective Measures Reports will identify and record fixes of problems with material or workmanship that did not meet the requirements of the plans, and specifications. Drawings of Record ('as-built' drawings) will be prepared and continually updated to document actual field installations. Final Documentation and Certification will take the form of a final report that includes all of the aforementioned.

1. Meeting Logs
   1.1. Logs will be kept of all meetings.
   1.2. Each log will record the following information:
      1.2.1. Date of meeting
      1.2.2. Purpose of meeting

1.2.3. Summary of meeting
1.2.4. Resolutions reached
1.2.5. People Attending

2. Daily Logs

2.1. Daily logs are required throughout the cover installation period.

2.2. The logs will record the following information:

2.2.1. Date
2.2.2. Weather Conditions
2.2.3. Work performed

2.3. The logs must record all changes in weather.

2.3.1. Any stoppage in construction due to weather changes must be noted along with provisions used to protect all materials and completed works.
2.3.2. When construction begins again, all materials and completed works must be inspected for damage. Damage must be recorded along with the measures used to repair the damage.

2.4 The logs will record the number of the videotape or tapes used to record the day's events.

3. Video Logs

3.1. Video recordings will be taken of the entire installation process.

3.2. Each videotape should be labeled with a distinct number, date recorded, and a description of what was recorded.

3.3. The videos should pay particular attention to damages and the repairs of damages.

Appendix I

Soil Properties from Field and Laboratory Testing

Report on
Soils Testing for the Mixed-Waste Landfill Cover Project, Sandia National Laboratories, Tech Area III

Prepared by the
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Introduction

Sandia National Laboratories (SNL) is currently in the design stages for the closure of the Mixed Waste Landfill in Technical Area III, SNL, Albuquerque, New Mexico. This design is a part of the site environmental restoration for the Mixed Waste Landfill. SNL has contracted with the University of New Mexico (UNM), Department of Civil Engineering to provide soil testing and analysis, and computer modeling as a part of this design effort. The soil testing includes two basic soil types: one from a borrow site west of the Mixed Waste Landfill (MW) and a second from a borrow pile at the CAMU area. Both of the soil types are located in SNL Tech Area III.

The information that follows provides the report on soil testing and analysis that is the first phase of the UNM project. An additional report on computer modeling will be submitted as a separate document. The text of this report contains summaries of all of the soils testing performed. Appendix A - Geotechnical Testing to this report contains the measurement and analysis pages from the soils testing procedures.

Sample collection

One 0.04 cu meter (1.4 cu ft) soil sample was collected from each of four sites at the proposed MW west borrow area. The soil samples were collected from a depth of 0.15 m to 0.45 m. One 0.04 cu meter sample was collected from the CAMU borrow pile at the screened soil area, and one 0.04 cu meter sample was collected from the CAMU unscreened borrow pile. The sample collection was performed by UNM personnel on April 26-27, 1999.

Sample Preparation

Half of the MW borrow samples from the four sample sites were combined in a mechanical mixer. This became the MW-West-Borrow-Mixed sample. The combined sample was placed in four 0.02 cu meter (0.7 cu ft) buckets, with designations MW-Mixed-Bk#1, 2, 3 and 4. The samples from the CAMU screened and unscreened samples (MW-CAMU-Screened or Unscreened) came directly from the field sampling containers.

In-situ Density

The field testing of in-situ density was completed using a sand cone apparatus during April 26 and 27. Testing followed the procedures in ASTM D 1556-90, "Test Method for Density and Unit Weight of Soil In Place by the Sand Cone Method." Testing was performed at the four soil sampling sites, with in-situ density at depths of 0.15 to 0.25 m and 0.30 to 0.40 m evaluated at each site. Laboratory testing, apparatus calibration and in-situ density analysis was completed on May 5. Table A contains a summary of the sampling locations and the measured in-situ dry densities.

Table A - Soil Sampling Locations and In-Situ Densities

Location			In-Situ Dry Density	
Designation	Latitude	Longitude	at 0.15 to 0.25 m	at 0.30 to 0.40 m
1 (east)	34 deg 59.52 min N	106 deg 32.81 min W	1.38 g/cc	1.55 g/cc
2 (north)	34 deg 59.65 min N	106 deg 32.82 min W	1.56 g/cc	1.50 g/cc
3 (south)	34 deg 59.49 min N	106 deg 32.82 min W	1.51 g/cc	1.68 g/cc
4 (west)	34 deg 59.57 min N	106 deg 32.84 min W	1.55 g/cc	1.56 g/cc
		Average of all 8 =	1.54 g/cc	
		Average in-situ moisture content (gravimetric) =	9.5 %	

Testing records and analysis for the in-situ density are located on page GT-1 in Appendix A - Geotechnical Testing.

Proctors

A Standard Proctor of the MW-West-Borrow-Mix soil was initiated on May 3 and completed on May 4. A second Standard Proctor of the MW-West-Borrow-Mix soil was completed on May 19. The Proctor for the CAMU soil (unscreened) was completed on May 20. This material was tested using the portion passing through an 18.85 mm sieve as required by the ASTM procedures for a 10.1-cm diameter Proctor mold. Less than 2 percent of the CAMU material was retained on the 18.85 mm sieve. Standard Proctor testing was performed in accordance with ASTM D 698-91, "Test Method for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft^3 (600 kN•m/m^3))." Table B contains a summary of the results of the Proctor testing.

Table B - Summary of Standard Proctor (Compaction) Testing

Sample Designation	At Maximum		At 90 % of Maximum	
	Maximum Dry Density	Optimum Moisture	Dry Density	Moisture Content
MW-West-Mixed-C1	1.85 g/cc	13.0 %	1.66 g/cc	8.5 %
MW-West-Mixed-C2	1.865 g/cc	12.5 %	1.68 g/cc	8.3 %
MW-CAMU-Unscreened-C2	1.93 g/cc	11.5 %	1.74 g/cc	7.2 %

Records and analysis for the Standard Proctor testing are located on pages GT-2 through GT-4 in Appendix A - Geotechnical Testing. Page PH-1 of Appendix B shows a photograph of the mechanical Proctor hammer that was used with the compaction tests on this project.

Specific Gravity

Specific gravity tests of the MW-West-Borrow-Mix soil and the CAMU soil (screened and unscreened) were completed on May 21. These tests are required to finalize the grain size distribution (hydrometer) tests, and to determine the porosity for the saturated conductivity tests and the unsaturated soil characteristics. Specific gravity testing was performed in accordance with ASTM D 854-92, "Test Method for Specific Gravity of Soils." Table C contains a summary of the results of the specific gravity testing.

Table C - Summary of Specific Gravity Testing

Sample Designation	Specific Gravity	Sample Designation	Specific Gravity
MW-Mix-Bk#2-SG-1	2.68	MW-Mix-Bk#2-SG-2	2.71
MW-Mix-Bk#4-SG-3	2.69	MW-Mix-Bk#4-SG-4	2.66
MW-CAMU-Scr-SG-1	2.68	MW-CAMU-Scr-SG-2	2.68
MW-CAMU-Unscr-SG-3	2.69	MW-CAMU-Unscr-SG-4	2.69

Records and analysis for the specific gravity testing are located on pages GT-5 through GT-12 in Appendix A - Geotechnical Testing.

Grain Size Distribution

Tests on the MW-West-Borrow-Mix soil and the CAMU soil (screened and unscreened) were initiated on May 12. Two sieve analysis tests each from the MW-West-Borrow-Mix soil and the CAMU soil (screened and unscreened) were completed on May 17. Four hydrometer tests (two for the MW-West-Borrow-Mix soil and one of each from the CAMU screened and unscreened soils) were initiated on May 20 and completed on May 21. Grain size testing was performed in accordance with ASTM D 422-63, "Method for Particle-Size Analysis of Soils." Table D contains a summary of the results of the sieve and hydrometer testing.

Table D - Summary of Grain Size Distribution (Sieve and Hydrometer) Testing

Sample Designation	% Passing #10 Sieve (2 mm)	% Passing #40 Sieve (0.425 mm)	% Passing #200 Sieve (0.075 mm)	% Finer than 0.0012 mm (Computed)
MW-Mixed-Bk#2-Hyd-1 (MW-S-1)	97.77	94.35	32.89	14.4
MW-Mixed-Bk#4-Hyd-2 (MW-S-2b)	96.49	93.10	30.82	14.0
MW-CAMU-Screened-Hyd-4 (MW-CAMU-Screened-A & B)	90.75 (Average)	82.10 (Average)	32.11 (Average)	13.2
MW-CAMU-Unscreened-Hyd-3 (MW-CAMU-Not Screened-C & D)	87.47 (Average)	79.50 (Average)	29.07 (average)	11.5

Records and analysis for the grain size testing are located on pages GT-13 through GT-30 in Appendix A - Geotechnical Testing. These pages in Appendix A also contain the grain size distributions plotted in graphical form (pages GT-16, -20, -25 and -30).

Atterberg Limits (LL, PL & PI)

The Liquid Limit and Plastic Limit tests on the MW-West-Borrow-Mix soil and the CAMU soil (screened and unscreened) were initiated on May 22, and completed on May 23. Atterberg limits testing was performed in accordance with ASTM D 4318-95, "Test Method for Liquid Limit, Plastic Limit, and Plasticity Index of Soils." Table E contains a summary of the Atterberg Limits testing.

Table E - Summary of Atterberg Limits (LL, PL and PI) Testing

Sample Designation	Liquid Limit (LL)	Plastic Limit (PL)	Plasticity Index (PI)
MW-Mixed-Bk#2-ATT-1	23.0	17.7	5.3
MW-Mixed-Bk#4-ATT-2	23.3	17.7	5.6
MW-CAMU-Screened-ATT-3	28.3	18.9	4.9
MW-CAMU-Unscreened-ATT-4	23.4	19.8	3.6

Records and analysis for the Atterberg Limits tests are located on pages GT-31 through GT-34 in Appendix A - Geotechnical Testing

Calcium Carbonate Levels

The apparatus for the Calcium Carbonate Test was obtained by UNM specifically for this project. Material processing for these tests was initiated on May 22, the apparatus was calibrated on May 25, and testing was completed by May 26. Calcium Carbonate testing was performed in accordance with ASTM D 4373-84, "Standard Test Method for Calcium Carbonate Content of Soils." The MW-West-Borrow soil was tested using separate samples from the 0.15 to 0.25 m and

the 0.30 to 0.40 m depths. These separate samples came from the in-situ density tests. The Calcium Carbonate testing is summarized in Table F

Table F - Summary of Calcium Carbonate Testing

Sample Designation	% Calcium Carbonate	Sample Designation	% Calcium Carbonate
MW-Mix-Bk#2-CC-1	1.3	MW-Mix-Bk#2-CC-2	0.9
MW-Mix-Bk#4-CC-1	1.2	MW-Mix-Bk#4-CC-2	0.8
MW-CAMU-Screened-CC-1	4.7	MW-CAMU-Screened-CC-2	5.4
MW-CAMU-Unscreened-CC-1	9.7	MW-CAMU-Unscreened-CC-2	11.3
MW-Sites 1 to 4 at 15 to 25 cm	< 0.5	MW-Sites 1 to 4 at 30 to 40 cm	2.2

Records and analysis for the Calcium Carbonate testing are located on pages GT-35 through GT-44 in Appendix A - Geotechnical Testing. The Rapid Calcium Carbonate Analyzer and precision balance that was used for these tests is shown on the photograph at page PH-2 of Appendix B.

Permeability

Two falling headwater, rising tailwater, double ring compaction mold permeameter tests were initiated on May 9. These tests were for the MW-West-Borrow-Mix soil at densities of 1.548 and 1.684 g/cc. By May 14 the sample at 1.684 g/cc had a stable outflow after seven reading cycles. By May 17 the sample at 1.548 g/cc had a stable outflow after 17 reading cycles. Tests of the MW-West-Borrow-Mix soil (at 1.654 g/cc) and MW-CAMU-unscreened soil (at 1.663 g/cc) were initiated on May 18. The MW-West-Borrow-Mix soil had a stable outflow on May 27 after 9 reading cycles. The CAMU unscreened sample had a stable outflow on May 28 after 10 reading cycles. All samples were screened with a 9.423 mm (3/8 inch) sieve as required by the ASTM procedure. All testing used a double ring permeameter procedure so that "inside" and "outside" saturated hydraulic conductivity values can be measured. The "inside" values are reported as the sample saturated hydraulic conductivity because these values minimize effects of the compaction mold edge. Permeability testing was performed in accordance with ASTM D 5856-95, "Standard Test Method for Measurement of Hydraulic Conductivity of Porous Material Using a Rigid-Wall, Compaction-Mold Permeameter." Table G summarizes the saturated hydraulic conductivity testing.

Table G - Summary of Permeability (Saturated Hydraulic Conductivity) Testing

Sample Designation	Dry Unit Weight of Soil (g/cm³)	Porosity	Saturated Hydraulic Conductivity (cm/s)
MW-Borrow-Mix-SHC-1	1.684	0.373	0.000122
MW-Borrow-Mix-SHC-2	1.548	0.423	0.000445
MW-Borrow-Mix-SHC-3	1.654	0.384	0.000198
MW-CAMU-Unscreened-SHC-1	1.663	0.382	0.000216

Records and analysis for the saturated hydraulic conductivity testing are located on pages GT-45 through GT-58 in Appendix A - Geotechnical Testing. The Double Ring Compaction Mold Permeameter that was used for the permeability tests is shown on the photograph at page PH-2 of Appendix B.

Unsaturated Soil Characteristics

Four desorption hanging column tests with densities of 1.54 ± 0.004 g/cc and 1.60 ± 0.006 g/cc (two tests for each density) were started on May 6. On May 26 the last measurement for this report was completed at a final suction of 150 cm. Two desorption hanging column tests at a density of 1.66 ± 0.010 g/cc were started on May 7; on May 27 these tests were at a final suction of 150 cm. The desorption hanging columns initially used a measurement cycle of one day; a two-day cycle was used as the soil samples become drier with a lower hydraulic conductivity. This is a somewhat shortened schedule that was necessary to complete testing by May 28. Further monitoring with longer reading cycles may be warranted with future samples.

Two sorption hanging column tests at a density of 1.60 ± 0.003 g/cc were started on May 10; the two sorption samples were air-dried to an initial moisture near the expected residual moisture (3.4 % volumetric moisture). On May 17 the two sorption samples were stabilized at the first applied suction of 200 cm. On May 27 the sorption samples were being monitored at a suction of 140 cm but the moisture measurements were not stable. All the hanging column tests remain in place to allow for future monitoring.

Six pressure plate desorption tests were started on May 10; two tests each were initiated at the densities of 1.54 ± 0.006, 1.60 ± 0.003 and 1.66 ± 0.006 g/cc. The pressure plate tests were programmed to measure desorption at 0.33 bars (field capacity) and 11 to 15 bars (near the wilting point). On May 17, the pressure plate samples had stable moisture at a pressure of 0.33 bars. On May 25 the samples were at an applied pressure of 11 bars, but moisture stability had not been attained.

Results of the desorption hanging column tests were evaluated using a Microsoft Excel spreadsheet. The 0.33 bar values from the pressure plate test were also added to this test data. The suction pressure and moisture content values obtained from the spreadsheet were analyzed using the RETC computer program (M.Th. van Genuchten, F.J. Leij and S.R. Yates, 1991, *The RETC Code for Quantifying the Hydraulic Functions of Unsaturated Soils*, U.S. Salinity Laboratory, Riverside, California, Document EPA/600/2-91/065) to obtain best fit parameters for the van Genuchten moisture characteristic equation. The standard parameter restriction of m=1-1/n was used with this analysis. All the remaining van Genuchten equation variables were set as fitting parameters. The van Genuchten parameters (with m=1-1/n) computed from the RETC program are recorded on Table H. For all six test data sets, the RETC program computed a residual moisture (Theta-R) of zero.

Table H - van Genuchten Equation Parameters (with m=1-1/n)

Sample Designation	Dry Density (g/cc)	Theta-R (residual)	alpha (1/cm)	n	Theta-S (saturated)	RETC fitting R^2
HC_MW_Mixed_HC-1	1.538	0.0000	0.01627	1.61314	0.43119	0.9430
HC_MW_Mixed_HC-2	1.544	0.0000	0.01046	1.63634	0.40408	0.9866
HC_MW_Mixed_HC-3	1.594	0.0000	0.01350	1.62408	0.41344	0.9703
HC_MW_Mixed_HC-4	1.601	0.0000	0.01185	1.60531	0.40204	0.9782
HC_MW_Mixed_HC-5	1.650	0.0000	0.00969	1.62792	0.39015	0.9491
HC_MW_Mixed_HC-6	1.657	0.0000	0.01020	1.63027	0.39021	0.9550

The fitting residual (R^2) for the van Genuchten equation with m=1-1/n was somewhat low indicating a relatively poor fit of the desorption test data. This equation fitting did not clearly follow the distinct air entry value that appeared with the test results. The RETC program also has the capability to determine Brooks and Corey soil characteristic equation parameters. Initial trials of RETC using this equation indicated that the fit to the test results was better than with the van Genuchten equation with m=1-1/n. Testing showed that the residual moisture values (Theta-R) could be set to physically realistic values with little loss of fitting precision. Based on the determination of the USDA soil classification (as subsequently discussed), the residual moisture can be set from the default values of the HELP computer program (P.R. Schroeder, C.M. Lloyd, P.A. Zappi and N.M. Aziz, 1994, *The Hydraulic Evaluation of Landfill Performance (HELP) Model, User's Guide for Version 3,* Risk Reduction Engineering Laboratory, Office of Research and Development, U. S. Environmental Protection Agency, Report Number: EPA/600/R-94/168a). The residual moisture has not been established directly by testing currently completed, but based on the fine sandy loam (USDA textural classification) that constitutes the MW-West-Borrow-Mixed soil, the residual moisture is estimated to be 0.0352. Future results from pressure plate tests may allow this value to be refined. The Brooks and Corey parameters that were computed from the RETC program are recorded on Table I.

Table I - Brooks and Corey Equation Parameters

Sample Designation	Dry Density (g/cc)	Theta-R (residual)	alpha (1/cm)	n	Theta-S (saturated)	RETC fitting R^2
HC_MW_Mixed_HC-1	1.538	0.0352	0.02678	0.50533	0.41537	0.9862
HC_MW_Mixed_HC-2	1.544	0.0352	0.02133	0.42394	0.39217	0.9853
HC_MW_Mixed_HC-3	1.594	0.0352	0.02517	0.45779	0.40025	0.9926
HC_MW_Mixed_HC-4	1.601	0.0352	0.02238	0.43808	0.38864	0.9870
HC_MW_Mixed_HC-5	1.650	0.0352	0.01995	0.42449	0.37923	0.9917
HC_MW_Mixed_HC-6	1.657	0.0352	0.02036	0.43709	0.37867	0.9900

The van Genuchten parameters can be computed with the RETC program using variable m and n parameters. This releases the m=1-1/n restriction that is commonly used with the van Genuchten equation and allows the equation to more precisely fit some data sets. When variable m and n parameters in the van Genuchten equation were applied using the RETC program, the computed soil characteristic curve was very close to the curve computed with the Brooks and Corey equation for the MW-West-Borrow-Mixed soil. When using the RETC program with variable

m and n parameters, the residual moisture was set to a value of 0.0352. This value comes from the HELP program default parameters for the fine sandy loam (USDA textural classification) that constitutes the MW-West-Borrow-Mixed soil. The van Genuchten parameters (with variable m and n) that were computed from the RETC program are shown in Table J.

Table J - van Genuchten Equation Parameters (with variable m and n)

Sample Designation	Dry Density (g/cc)	Theta-R (residual)	alpha (1/cm)	n	Theta-S (saturated)	m	RETC fitting R^2
HC_MW_Mixed_HC-1	1.538	0.0352	0.02706	13.96401	0.41618	0.03562	0.9855
HC_MW_Mixed_HC-2	1.544	0.0352	0.01736	2.95293	0.39770	0.17406	0.9920
HC_MW_Mixed_HC-3	1.594	0.0352	0.02444	10.29196	0.40059	0.04587	0.9934
HC_MW_Mixed_HC-4	1.601	0.0352	0.02200	5.12033	0.39215	0.08810	0.9893
HC_MW_Mixed_HC-5	1.650	0.0352	0.01953	16.60282	0.37923	0.02616	0.9922
HC_MW_Mixed_HC-6	1.657	0.0352	0.01996	12.86025	0.37889	0.03475	0.9907

Photographs of the hanging column and pressure plate apparatus are located on pages PH-3 and PH-4 of Appendix B. Records and analysis for the hanging column and pressure plate tests are located on pages GT-59 through GT-86 in Appendix A - Geotechnical Testing. The spreadsheets for the six desorption tests are also in Appendix A at pages GT-87 through GT-98. This spreadsheet data includes a plot of the tested moisture characteristic values, and function plots for the van Genuchten equation with m=1-1/n, the van Genuchten equation with variable m and n, and the Brooks and Corey equation.

Soil Classification

The Unified Soil Classification System (USCS, ASTM D 2487-92, "Standard Classification of Soils for Engineering Purposes (Unified Soil Classification System)") was used to classify the MW-West-Borrow-Mix soil and the CAMU soil (screened and unscreened). The measured values for classification determination and the USCS classification are summarized in Table K.

Table K - Soil Classification by the USCS Method

Sample Designation	% Passing #200 Sieve	% Passing #4 Sieve	Liquid Limit (LL)	Plasticity Index (PI)	USCS Classification Group Name
MW-West-Borrow-Mix	30.8 to 32.9	97.6 to 99.0	23.0 to 23.3	5.3 to 5.6	Silty Clayey Sand (SC-SM)
MW-CAMU-Screened	32.0 to 32.2	96.4 to 96.5	23.8	4.9	Silty Clayey Sand (SC-SM)
MW-CAMU-Unscreened	29.0 to 29.1	93.6 to 93.8	23.4	3.6	Silty Sand (SM)

The United States Department of Agriculture (USDA) textural triangle can be used to determine a USDA soil classification from the twelve major textural classes of the USDA system. See *Supplement to Soil Classification System (7th Approximation)*, Soil Conservation Service (now

the Natural Resources Conservation Service), USDA, Second Printing, March 1967 or R. B. Brown, *Soil Texture*, 1997, University of Florida, Cooperative Extension Service, Institute of Food and Agricultural Sciences, Fact Sheet SL-29, http://edis.ifas.ufl.edu/pdffiles/SS/SS16900.pdf. Some of the USDA textural classes are further divided by the proportions of particle sizes within the major textural class. For sandy loam soils there are four subclasses. The measured values for classification determination and the USDA textural classification are summarized in Table L.

Table L - Soil Textural Classification by the USDA Method

Sample Designation	% Finer than 0.002 mm (USDA Clay)	% Between 0.002 mm and 0.05 mm (USDA Silt)	% Between 0.05 mm and 0.10 mm (USDA Very Fine Sand)	% Between 0.10 mm and 0.25 mm (USDA Fine Sand)	USDA Textural Classification
MW-West-Borrow-Mix	16.0 to 16.5	7.5 to 9.0	12.0 to 16.1	49.4 to 51.4	Fine Sandy Loam
MW-CAMU-Screened	14.5	7.5	18.0	39.4	Fine Sandy Loam
MW-CAMU-Unscreened	13.0	8.5	13.5	41.9	Fine Sandy Loam

Implementation of Soils Testing Results

It is anticipated that the properties of the soils as determined in this report will provide guidance for the continuing design of the Mixed Waste Landfill Cover at SNL Tech Area III. Soil properties from this report will be incorporated into the ongoing computer modeling that is being completed by UNM. Some testing initiated under this project, such as pressure plate desorption tests and hanging column sorption tests, were not finalized within the time for scheduled completion of this report. As these tests are finalized, supplemental reports on soil properties will be prepared.

Appendix A

Geotechnical Testing

The following pages contain the data sheets for the soils testing performed by the University of New Mexico, Department of Civil Engineering, Geoenvironmental Laboratory.

The following test data is located in Appendix A:

Test Procedure	Page Number
Field Density Tests - Sand Cone Method	GT-1
Compaction Test (Standard Proctor)	GT-2 to GT-4
Specific Gravity Determination	GT-5 to GT-12
Sieve Analysis, Hydrometer Analysis and Grain Size Distribution	GT-13 to GT-30
Atterberg Limits: Liquid Limit, Plastic Limit and Plasticity Index	GT-31 to GT-34
Calcium Carbonate Content	GT-35 to GT-44
Hydraulic Conductivity Test	GT-45 to GT-58
Hanging Column Test	GT-59 to GT-74
Pressure Plate Test	GT-75 to GT-86
MS Excel Spreadsheet for Hanging Column Test and Moisture Characteristic Curves	GT-87 to GT-98

University of New Mexico
Department of Civil Engineering
Geoenvironmental Laboratory

Field Density Tests - Sand Cone Method

Computations of Dry Bulk Density of Soil, and Moisture Content, for
Test Samples Taken at the SNL Mixed Waste Landfill - West Borrow
On April 26 and 27, 1999

Field scale: Ohaus (25Kg capacity)
Sand Cone: Soiltest
Sand: to ASTM C-778 (20-30) U.S. Silica Company

Sample Location =	1 (east)	1 (east)	2 (north)	2 (north)	3 (south)	3 (south)	4 (west)	4 (west)	
Depth (inches) =	6 to 10	12 to 16	6 to 10	12 to 16	6 to 10	12 to 16	6 to 10	12 to 16	
Notation =	Density	Density	Density	Density	Density	Density	Density	Density	
Type of Test =	Sand Cone	Sand Cone	Sand Cone	Sand Cone	Sand Cone	Sand Cone	Sand Cone	Sand Cone	
Condition =	Undisturbed	Undisturbed	Undisturbed	Undisturbed	Undisturbed	Undisturbed	Undisturbed	Undisturbed	
Pan Number =	MW-1A	MW-1B	MW-2A	MW-2B	MW-3A	MW-3B	MW-4A	MW-4B	Average
Wt. Pan (g) =	245.45	244.54	245.67	245.81	244.42	244.96	245.24	246.01	
Wt. Sample + Bag (g) =	1095.66	1262.30	1337.84	1339.35	1237.69	1385.22	1114.00	1670.67	
Wt. Sample + Pan (g) =	1326.50	1492.52	1569.31	1571.23	1468.20	1616.15	1341.14	1902.78	
Wt. Bag (g) =	12.99	13.01	13.11	13.01	13.02	13.01	13.04	13.10	
Wt. moist. lost from Bag (g) =	1.62	1.31	1.09	0.92	0.89	1.02	5.06	0.80	
Wt. Dry Soil + Pan (g) =	1188.38	1383.70	1464.77	1491.15	1367.30	1517.51	1238.02	1772.11	
Wt. Moisture (g) =	138.12	108.82	104.54	80.08	100.90	98.64	103.12	130.67	
Wt. Dry Soil (g) =	942.93	1139.16	1219.10	1245.34	1122.88	1272.55	992.78	1526.10	
Grav. Moisture Content (%) =	14.65	9.55	8.58	6.43	8.99	7.75	10.39	8.56	9.36
Wt. of Dry soil from Hole (g) =	944.34	1140.36	1220.10	1246.20	1123.70	1273.50	997.36	1526.84	
Sand Cone Initial Wt. (g) =	5875.00	6267.00	6041.00	5799.00	6515.00	6679.00	6691.00	6930.00	
Sand Cone Final Wt. (g) =	2960.00	3271.00	2973.00	2654.00	3506.00	3651.00	3846.00	3546.00	
Wt. Sand in Hole + Cone (g) =	2915.00	2996.00	3068.00	3145.00	3009.00	3028.00	2845.00	3384.00	
Wt. of Sand in Cone (g) =	1810.50	1810.50	1810.50	1810.50	1810.50	1810.50	1810.50	1810.50	
Wt. of Sand in Hole (g) =	1104.50	1185.50	1257.50	1334.50	1198.50	1217.50	1034.50	1573.50	
Bulk Density of Sand (g/cm^3) =	1.6113	1.6113	1.6113	1.6113	1.6113	1.6113	1.6113	1.6113	
Volume Excavation (cm**3) =	685.47	735.74	780.43	828.21	743.81	755.60	642.03	976.54	
Bulk Density - Dry (g/cm**3) =	1.3777	1.5499	1.5634	1.5047	1.5107	1.6854	1.5535	1.5635	1.5386
Bulk Density - Dry (lb/ft**3) =	86.00	96.76	97.60	93.93	94.31	105.22	96.98	97.61	96.05

Field Moisture Tests:

Sample Location =	1 (east)	1 (east)	2 (north)	2 (north)	3 (south)	3 (south)	4 (west)	4 (west)	
Can Number =	MW-1A	MW-1B	MW-2A	MW-2B	MW-3A	MW-3B	MW-4A	MW-4B	
Wt. Wet Sample + Can (g) =	94.57	96.98	100.38	86.04	92.25	92.13	95.56	94.91	
Wt. Dey Sample + Can (g) =	83.71	90.23	93.59	81.07	85.66	86.85	88.43	88.49	
Wt. Can (g) =	15.34	15.36	15.05	15.65	16.40	15.36	15.28	15.52	
Wt. Moisture (g) =	10.86	6.75	6.79	4.97	6.59	5.28	7.13	6.42	
Wt. Dry Soil (g) =	68.37	74.87	78.54	65.42	69.26	71.49	73.15	72.97	
Grav. Moisture Content (%) =	15.88	9.02	8.65	7.60	9.51	7.39	9.75	8.80	9.57

File: Field_Density_MW_West_Borrow.wpd

University of New Mexico
Department of Civil Engineering
Geoenvironmental Laboratory

Compaction Test (Standard Proctor)
Hammer Weight = 2.495 Kg (5.5 lb)
Drop = 0.305 m (12 in), No. Layers = 3

Sample No. MW-West-Mixed-C1 Project SNL Mixed Waste Landfill Cover

Location Mix of Sites 1, 2, 3 & 4 Boring No. _____

Depth of Sample 15 to 40 cm Date of Test 5/03/99

Tested by C. Anderson No. of Blows Per Layer 25 Mold Diam. 10.16 cm

Description of Sample MW West Borrow, from Bucket #1 - Mixed sites 1, 2, 3 & 4

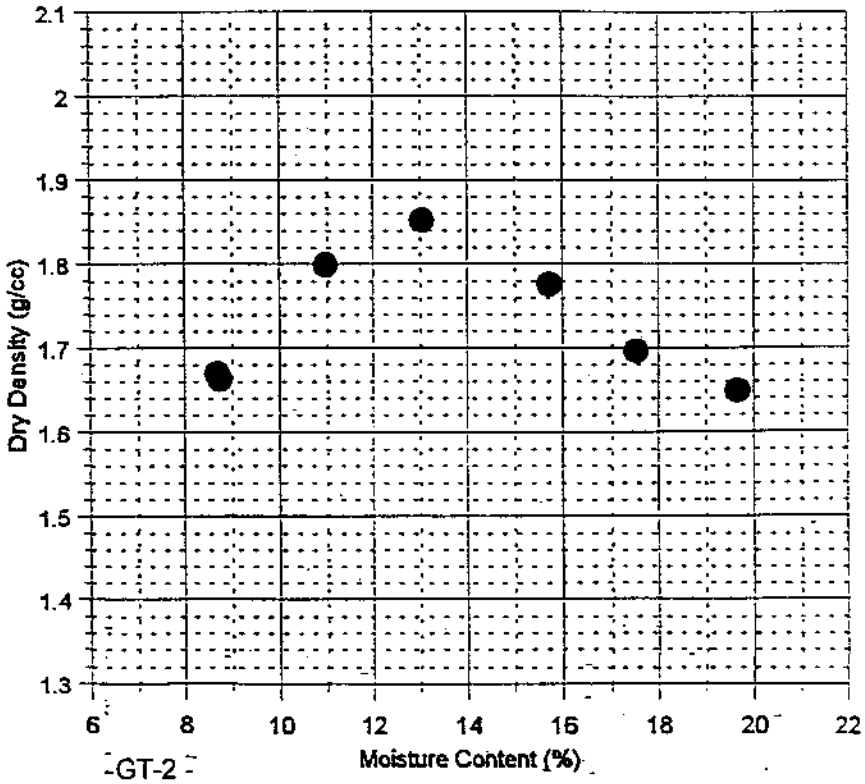
A	Trial		1	2	3	4	5	6	7
B	Wt. of Mold + Comp. Soil (g)		3746.5	3752.8	3924.4	4015.8	3979.7	3921.4	3902.4
C	Wt. of Mold (g)		2040.1	2040.1	2040.1	2040.1	2040.1	2040.1	2040.1
D	Wt. of Compacted Soil (g)		1706.4	1712.7	1884.3	1975.7	1939.6	1881.3	1862.3
E	Wet Density, γ_{wet} (g/cm³)		1.8078	1.8145	1.9963	2.0931	2.0549	1.9931	1.973
F	MOISTURE	Moisture Can No.	MW-C-1	MW-C-2	MW-C-3	MW-C-4	MW-C-5	MW-C-6	MW-C-7
G		Wt. of Can (g)	21.47	21.49	21.07	20.93	21.20	21.64	21.51
H		Wt. of Can + Wet Soil (g)	92.93	80.78	106.71	105.62	119.23	119.69	117.10
I		Wt. of Can + Dry Soil (g)	87.19	76.05	98.25	95.85	105.92	105.08	101.41
J		Wt. of Water (g)	5.74	4.73	8.46	9.77	13.31	14.61	15.69
K		Wt. of Dry Soil (g)	65.72	54.56	77.18	74.92	84.72	83.44	79.9
L		Moisture Content (%)	8.73	8.67	10.96	13.04	15.71	17.51	19.64
M	Dry Density, γ_d (g/cm³)		1.663	1.670	1.799	1.852	1.776	1.696	1.649
N	Dry Density, γ_d (lb/ft³)		103.8	104.2	112.3	115.6	110.9	105.9	103.0

Notes: E = D / 943.9 (for 4 inch mold) and E = D / 2123.8 (for 6 inch mold), M = (E X 100) / (L + 100), N = M X 62.428

Max. Dry Density, γ_d (g/cm³)	1.85
Max. Dry Density, γ_d (lb/ft³)	115.5
Optimum Moisture (%)	13.0

At 90 % of Optimum	
Dry Density, γ_d (g/cm³)	1.665
Dry Density, γ_d (lb/ft³)	103.9
Moisture Content (%)	8.5

At 85 % of Optimum	
Dry Density, γ_d (g/cm³)	1.57
Dry Density, γ_d (lb/ft³)	98
Moisture Content (%)	6.7



File: Compact_MW_Mixed_C1.wpd

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Geoenvironmental Laboratory

Compaction Test (Standard Proctor)
Hammer Weight = 2.495 Kg (5.5 lb)
Drop = 0.305 m (12 in), No. Layers = 3

Sample No. MW-West-Mixed-C2 Project SNL Mixed Waste Landfill Cover

Location Mix of Sites 1, 2, 3 & 4 Boring No. _____

Depth of Sample 15 to 40 cm Date of Test 5/19/99

Tested by C. Anderson No. of Blows Per Layer 25 Mold Diam. 10.16 cm

Description of Sample MW West Borrow, from Bucket #4 - Mixed sites 1, 2, 3 & 4

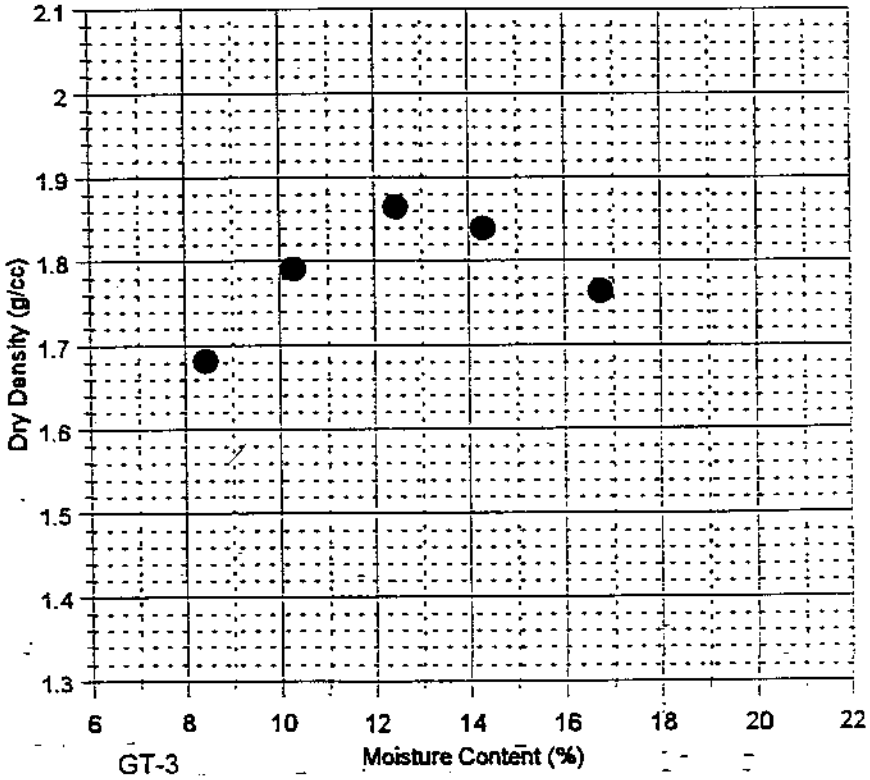
A	Trial		1	2	3	4	5	6	7
B	Wt. of Mold + Comp. Soil (g)		3760.5	3903.6	4019.3	4025.1	3983.8	End	
C	Wt. of Mold (g)		2039.9	2039.9	2039.9	2039.9	2039.9		
D	Wt. of Compacted Soil (g)		1720.4	1863.7	1979.4	1985.2	1943.7		
E	Wet Density, γ_{wet} (g/cm³)		1.8227	1.9745	2.097	2.1032	2.0592		
F	MOISTURE	Moisture Can No.	MW-C-1	MW-C-2	MW-C-3	MW-C-4	MW-C-5		
G		Wt. of Can (g)	21.60	21.59	20.93	21.11	21.05		
H		Wt. of Can + Wet Soil (g)	94.70	113.98	109.42	108.20	118.12		
I		Wt. of Can + Dry Soil (g)	89.03	105.37	99.62	97.31	104.21		
J		Wt. of Water (g)	5.67	8.61	9.8	10.89	13.91		
K		Wt. of Dry Soil (g)	67.43	83.78	78.69	76.2	83.16		
L		Moisture Content (%)	8.41	10.28	12.45	14.29	16.73		
M	Dry Density, γ_d (g/cm³)		1.681	1.790	1.865	1.840	1.764		
N	Dry Density, γ_d (lb/ft³)		105.0	111.8	116.4	114.9	110.1		

Notes: E = D / 943.9 (for 4 inch mold) and E = D / 2123.8 (for 6 inch mold), M = (E X 100) / (L + 100), N = M X 62.428

Max. Dry Density, γ_d (g/cm³)	1.865
Max. Dry Density, γ_d (lb/ft³)	116.4
Optimum Moisture (%)	12.5

At 90 % of Optimum	
Dry Density, γ_d (g/cm³)	1.678
Dry Density, γ_d (lb/ft³)	104.8
Moisture Content (%)	8.3

At 85 % of Optimum	
Dry Density, γ_d (g/cm³)	1.585
Dry Density, γ_d (lb/ft³)	99.0
Moisture Content (%)	6.4



File: Compact_MW_Mixed_C2.wpd

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Geoenvironmental Laboratory

Compaction Test (Standard Proctor)
Hammer Weight = 2.495 Kg (5.5 lb)
Drop = 0.305 m (12 in), No. Layers = 3

Sample No. MW-CAMU-Unscreened-C1 Project SNL Mixed Waste Landfill Cover

Location CAMU Borrow Pile Boring No. _____

Depth of Sample Borrow Pile Date of Test 5/19-20/99

Tested by C. Anderson No. of Blows Per Layer 25 Mold Diam. 10.16 cm

Description of Sample MW CAMU Unscreened. Material not passing 3/4 sieve removed per ASTM (1.86%)

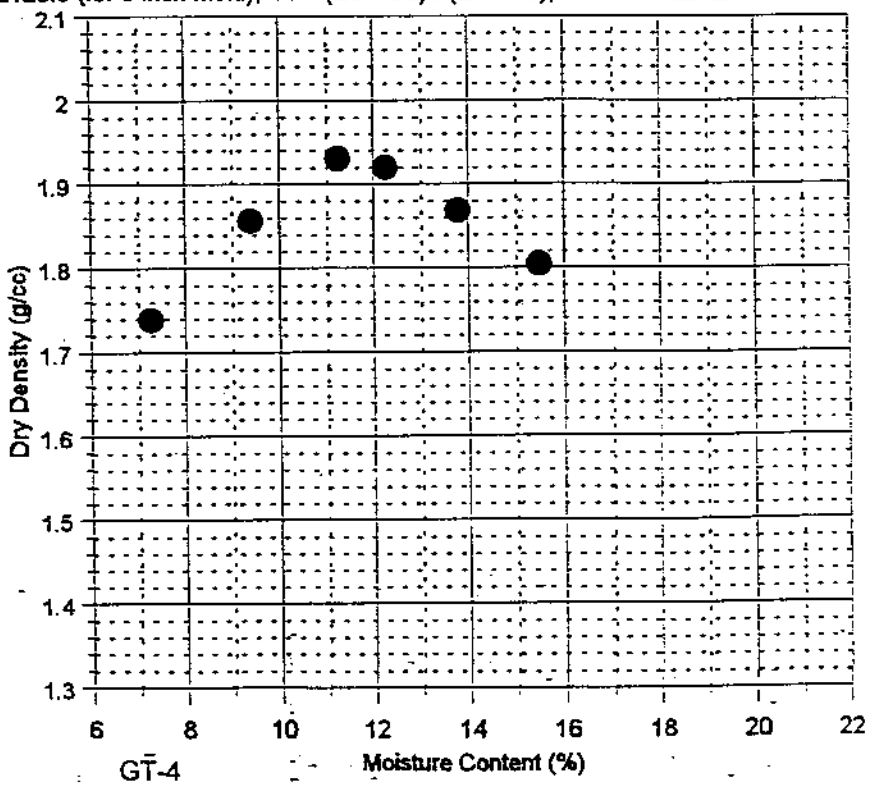
A	Trial	1	2	3	4	5	6	7
B	Wt. of Mold + Comp. Soil (g)	3801.1	3958.0	4068.2	4075.4	4047.5	4007.4	End
C	Wt. of Mold (g)	2040.6	2040.6	2040.6	2040.6	2040.6	2040.6	
D	Wt. of Compacted Soil (g)	1760.5	1917.4	2027.6	2034.8	2006.9	1966.8	
E	Wet Density, γ_{wet} (g/cm³)	1.8651	2.0314	2.1481	2.1557	2.1262	2.0837	
F	MOISTURE: Moisture Can No.	MW-CAMU-1	MW-CAMU-2	MW-CAMU-3	MW-CAMU-4	MW-CAMU-5	MW-CAMU-6	
G	Wt. of Can (g)	15.54	16.39	13.55	15.37	14.98	15.29	
H	Wt. of Can + Wet Soil (g)	87.88	114.75	104.61	114.22	123.81	114.71	
I	Wt. of Can + Dry Soil (g)	82.99	106.32	95.42	103.43	110.64	101.39	
J	Wt. of Water (g)	4.89	8.43	9.19	10.79	13.17	13.32	
K	Wt. of Dry Soil (g)	67.45	89.93	81.87	88.06	95.66	86.1	
L	Moisture Content (%)	7.25	9.37	11.23	12.25	13.77	15.47	
M	Dry Density, γ_d (g/cm³)	1.739	1.857	1.931	1.920	1.869	1.805	
N	Dry Density, γ_d (lb/ft³)	108.6	115.9	120.6	119.9	116.7	112.7	

Notes: E = D / 943.9 (for 4 inch mold) and E = D / 2123.8 (for 6 inch mold), M = (E X 100) / (L + 100), N = M X 62.428

Max. Dry Density, γ_d (g/cm³)	1.931
Max. Dry Density, γ_d (lb/ft³)	120.6
Optimum Moisture (%)	11.5

At 90 % of Optimum	
Dry Density, γ_d (g/cm³)	1.738
Dry Density, γ_d (lb/ft³)	108.5
Moisture Content (%)	7.2

At 85 % of Optimum	
Dry Density, γ_d (g/cm³)	1.641
Dry Density, γ_d (lb/ft³)	102.5
Moisture Content (%)	5.8



File: Compact_MW_CAMU_Unscreened_C1.wpd

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Specific Gravity Determination

Sample No. MW-Mix-Bk#2-SG-1 Project SNL Mixed Waste Landfill Cover

Tested by C. Anderson Date of Test 5/20/99

Sample Identification: MW-Borrow-West-Mix of Sites 1, 2, 3 & 4, from Bucket #2, Sieve #4

Calibration of Pycnometer

(1)	Pycnometer identification	1
(2)	Weight of dry, clean Pycnometer, W_p (g)	107.04
(3)	Weight of pycnometer + water, W_{pw} (g)	355.91
(4)	Observed temperature of water, T_i (°C)	24.9

Specific Gravity Determination

Weight of Pycnometer + soil + water, W_{pws} (g)	382.73	
Temperature, T_x (°C)	26.6	
Weight of Pycnometer + Water at T_x, W_{pw} (at T_x) (g)	355.80	
Evaporating Dish(es) No.	Hyd-1	Hyd-2
Weight of Evaporating Dish(es), W_d	156.60 (g)	74.81 (g)
Weight of Evaporating Dish(es) + Oven Dried Soil, W_{ds}	176.51 (g)	97.85 (g)
Weight of Solids, W_s (g)	42.95	
Conversion Factor, K (Table 1, ASTM D854)	0.99842	
Specific Gravity of Soil, G_s	2.68	

$$G_s = \frac{K^* W_s}{W_s + W_{pw}(at\ T_x) - W_{pws}} = \frac{(0.99842)^*(42.95)}{(42.95)+(355.80)-(382.73)}$$

$$W_{pw}(at\ T_x) = \frac{density\ of\ water\ at\ T_x}{density\ of\ water\ at\ T_i}\left[W_{pw}(at\ T_i) - W_p\right] + W_p$$

$$= \frac{(0.9966533)}{(0.9971022)}\left[\underline{355.91} - \underline{107.04}\right] + \underline{107.04}$$

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Specific Gravity Determination

Sample No. MW-Mix-Bk#2-SG-2 Project SNL Mixed Waste Landfill Cover

Tested by C. Anderson Date of Test 5/20/99

Sample Identification: MW-Borrow-West-Mix of Sites 1, 2, 3 & 4, from Bucket #2, Sieve #4

Calibration of Pycnometer

(1)	Pycnometer identification	$\overline{2}$
(2)	Weight of dry, clean Pycnometer, W_p (g)	114.22
(3)	Weight of pycnometer + water, W_{pw} (g)	363.05
(4)	Observed temperature of water, T_i (°C)	24.9

Specific Gravity Determination

Weight of Pycnometer + soil + water, W_{pws} (g)	390.78	
Temperature, T_x (°C)	26.1	
Weight of Pycnometer + Water at T_x, W_{pw} (at T_x) (g)	362.97	
Evaporating Dish(es) No.	Hyd-3	Hyd-4
Weight of Evaporating Dish(es), W_d	154.75 (g)	72.67 (g)
Weight of Evaporating Dish(es) + Oven Dried Soil, W_{ds}	196.56 (g)	74.91 (g)
Weight of Solids, W_s (g)	44.05	
Conversion Factor, K (Table 1, ASTM D854)	0.99857	
Specific Gravity of Soil, G_s	2.71	

$$G_s = \frac{K^* W_s}{W_s + W_{pw}(at\ T_x) - W_{pws}} = \frac{(0.99857)^*(44.05)}{(44.05)+(362.97)-(390.78)}$$

$$W_{pw}(at\ T_x) = \frac{density\ of\ water\ at\ T_x}{density\ of\ water\ at\ T_i}\left[W_{pw}(at\ T_i) - W_p\right] + W_p$$

$$= \frac{(0.9967886)}{(0.9971022)}\left[\underline{363.05} - \underline{114.22}\right] + \underline{114.22}$$

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Specific Gravity Determination

Sample No. MW-Mix-Bk#4-SG-3 Project SNL Mixed Waste Landfill Cover

Tested by C. Anderson Date of Test 5/20/99

Sample Identification: MW-Borrow-West-Mix of Sites 1, 2, 3 & 4, from Bucket #4, Sieve #4

Calibration of Pycnometer

(1)	Pycnometer identification	3
(2)	Weight of dry, clean Pycnometer, W_p (g)	105.31
(3)	Weight of pycnometer + water, W_{pw} (g)	354.24
(4)	Observed temperature of water, T_i (°C)	25.0

Specific Gravity Determination

Weight of Pycnometer + soil + water, W_{pws} (g)	382.40	
Temperature, T_x (°C)	26.0	
Weight of Pycnometer + Water at T_x, W_{pw} (at T_x) (g)	354.17	
Evaporating Dish(es) No.	Hyd-5	Hyd-6
Weight of Evaporating Dish(es), W_d	147.44 (g)	73.08 (g)
Weight of Evaporating Dish(es) + Oven Dried Soil, W_{ds}	182.36 (g)	83.03 (g)
Weight of Solids, W_s (g)	44.87	
Conversion Factor, K (Table 1, ASTM D854)	0.9986	
Specific Gravity of Soil, G_s	2.69	

$$G_s = \frac{K^* W_s}{W_s + W_{pw}(at\ T_x) - W_{pws}} = \frac{(0.9986)^*(44.87)}{(44.87)+(354.17)-(382.40)}$$

$$W_{pw}(at\ T_x) = \frac{density\ of\ water\ at\ T_x}{density\ of\ water\ at\ T_i}\left[W_{pw}(at\ T_i) - W_p\right] + W_p$$

$$= \frac{(0.9968156)}{(0.9970770)}\left[\underline{354.24} - \underline{105.31}\right] + \underline{105.31}$$

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Specific Gravity Determination

Sample No. MW-Mix-Bk#4-SG-4 Project SNL Mixed Waste Landfill Cover

Tested by C. Anderson Date of Test 5/20/99

Sample Identification: MW-Borrow-West-Mix of Sites 1, 2, 3 & 4, from Bucket #4, Sieve #4

Calibration of Pycnometer

(1)	Pycnometer identification	$\overline{4}$
(2)	Weight of dry, clean Pycnometer, W_p (g)	113.41
(3)	Weight of pycnometer + water, W_{pw} (g)	362.19
(4)	Observed temperature of water, T_i (°C)	24.9

Specific Gravity Determination

Weight of Pycnometer + soil + water, W_{pws} (g)	390.53	
Temperature, T_x (°C)	25.7	
Weight of Pycnometer + Water at T_x, W_{pw} (at T_x) (g)	362.14	
Evaporating Dish(es) No.	Hyd-7	Hyd-8
Weight of Evaporating Dish(es), W_d	123.67 (g)	148.00 (g)
Weight of Evaporating Dish(es) + Oven Dried Soil, W_{ds}	145.60 (g)	171.51 (g)
Weight of Solids, W_s (g)	45.44	
Conversion Factor, K (Table 1, ASTM D854)	0.99869	
Specific Gravity of Soil, G_s	2.66	

$$G_s = \frac{K^* W_s}{W_s + W_{pw}(at\ T_x) - W_{pws}} = \frac{(0.99869)^*(45.44)}{(45.44)+(362.14)-(390.53)}$$

$$W_{pw}(at\ T_x) = \frac{density\ of\ water\ at\ T_x}{density\ of\ water\ at\ T_i}\left[W_{pw}(at\ T_i) - W_p\right] + W_p$$

$$= \frac{(0.9968940)}{(0.9971022)}\left[\underline{362.19} - \underline{113.41}\right] + \underline{113.41}$$

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Specific Gravity Determination

Sample No. MW-CAMU-Scr-SG-1 Project SNL Mixed Waste Landfill Cover

Tested by C. Anderson Date of Test 5/20/99

Sample Identification: MW-CAMU Borrow Pile - Screened, Sieve #4

Calibration of Pycnometer

(1)	Pycnometer identification	$\overline{5}$
(2)	Weight of dry, clean Pycnometer, W_p (g)	118.21
(3)	Weight of pycnometer + water, W_{pw} (g)	367.00
(4)	Observed temperature of water, T_i (°C)	25.0

Specific Gravity Determination

Weight of Pycnometer + soil + water, W_{pws} (g)	393.88	
Temperature, T_x (°C)	25.7	
Weight of Pycnometer + Water at T_x, W_{pw} (at T_x) (g)	366.95	
Evaporating Dish(es) No.	Hyd-9	Hyd-10
Weight of Evaporating Dish(es), W_d	134.25 (g)	160.90 (g)
Weight of Evaporating Dish(es) + Oven Dried Soil, W_{ds}	151.07 (g)	186.99 (g)
Weight of Solids, W_s (g)	42.91	
Conversion Factor, K (Table 1, ASTM D854)	0.99869	
Specific Gravity of Soil, G_s	2.68	

$$G_s = \frac{K^* W_s}{W_s + W_{pw}(at\ T_x) - W_{pws}} = \frac{(0.99869)^*(42.91)}{(42.91)+(366.95)-(393.88)}$$

$$W_{pw}(at\ T_x) = \frac{density\ of\ water\ at\ T_x}{density\ of\ water\ at\ T_i}\left[W_{pw}(at\ T_i) - W_p\right] + W_p$$

$$= \frac{(0.9968940)}{(0.9970770)}\left[\underline{367.00} - \underline{118.21}\right] + \underline{118.21}$$

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Specific Gravity Determination

Sample No. MW-CAMU-Scr-SG-2 Project SNL Mixed Waste Landfill Cover

Tested by C. Anderson Date of Test 5/20/99

Sample Identification: MW-CAMU Borrow Pile - Screened, Sieve #4

Calibration of Pycnometer

(1)	Pycnometer identification	$\overline{6}$
(2)	Weight of dry, clean Pycnometer, W_p (g)	111.07
(3)	Weight of pycnometer + water, W_{pw} (g)	359.95
(4)	Observed temperature of water, T_i (°C)	25.1

Specific Gravity Determination

Weight of Pycnometer + soil + water, W_{pws} (g)	387.76	
Temperature, T_x (°C)	26.0	
Weight of Pycnometer + Water at T_x, W_{pw} (at T_x) (g)	359.89	
Evaporating Dish(es) No.	Hyd-11	Hyd-12
Weight of Evaporating Dish(es), W_d	140.32 (g)	141.52 (g)
Weight of Evaporating Dish(es) + Oven Dried Soil, W_{ds}	150.81 (g)	175.49 (g)
Weight of Solids, W_s (g)	44.46	
Conversion Factor, K (Table 1, ASTM D854)	0.9986	
Specific Gravity of Soil, G_s	2.68	

$$G_s = \frac{K^* W_s}{W_s + W_{pw}(at\ T_x) - W_{pws}} = \frac{(0.9986)^*(44.46)}{(44.46)+(359.89)-(387.76)}$$

$$W_{pw}(at\ T_x) = \frac{density\ of\ water\ at\ T_x}{density\ of\ water\ at\ T_i}\left[W_{pw}(at\ T_i) - W_p\right] + W_p$$

$$= \frac{(0.9968156)}{(0.9970509)}\left[\ \underline{359.95} - \underline{111.07}\ \right] + \underline{111.07}$$

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Specific Gravity Determination

Sample No. MW-CAMU-Unscr-SG-3 Project SNL Mixed Waste Landfill Cover

Tested by C. Anderson Date of Test 5/21/99

Sample Identification: MW-CAMU Borrow Pile - Unscreened, Sieve #4

Calibration of Pycnometer

(1)	Pycnometer identification	1
(2)	Weight of dry, clean Pycnometer, W_p (g)	107.04
(3)	Weight of pycnometer + water, W_{pw} (g)	355.91
(4)	Observed temperature of water, T_i (°C)	24.9

Specific Gravity Determination

Weight of Pycnometer + soil + water, W_{pws} (g)	385.07	
Temperature, T_x (°C)	26.3	
Weight of Pycnometer + Water at T_x, W_{pw} (at T_x) (g)	355.82	
Evaporating Dish(es) No.	MW-Hyd-1	MW-Hyd-2
Weight of Evaporating Dish(es), W_d	161.83 (g)	177.01 (g)
Weight of Evaporating Dish(es) + Oven Dried Soil, W_{ds}	189.51 (g)	195.82 (g)
Weight of Solids, W_s (g)	46.49	
Conversion Factor, K (Table 1, ASTM D854)	0.99851	
Specific Gravity of Soil, G_s	2.69	

$$G_s = \frac{K^* W_s}{W_s + W_{pw}(at\ T_x) - W_{pws}} = \frac{(0.99851)^*(46.49)}{(46.49)+(355.82)-(385.07)}$$

$$W_{pw}(at\ T_x) = \frac{density\ of\ water\ at\ T_x}{density\ of\ water\ at\ T_i}\left[W_{pw}(at\ T_i) - W_p\right] + W_p$$

$$= \frac{(0.9967345)}{(0.9971022)}\left[\underline{355.91} - \underline{107.04}\right] + \underline{107.04}$$

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Specific Gravity Determination

Sample No. MW-CAMU-Unscr-SG-4 Project SNL Mixed Waste Landfill Cover

Tested by C. Anderson Date of Test 5/21/99

Sample Identification: MW-CAMU Borrow Pile - Unscreened, Sieve #4

Calibration of Pycnometer

(1)	Pycnometer identification	$\overline{2}$
(2)	Weight of dry, clean Pycnometer, W_p (g)	114.22
(3)	Weight of pycnometer + water, W_{pw} (g)	363.05
(4)	Observed temperature of water, T_i (°C)	24.9

Specific Gravity Determination

Weight of Pycnometer + soil + water, W_{pws} (g)	391.80	
Temperature, T_x (°C)	26.2	
Weight of Pycnometer + Water at T_x, W_{pw} (at T_x) (g)	362.96	
Evaporating Dish(es) No.	MW-Hyd-3	MW-Hyd-4
Weight of Evaporating Dish(es), W_d	132.19 (g)	181.10 (g)
Weight of Evaporating Dish(es) + Oven Dried Soil, W_{ds}	152.54 (g)	206.65 (g)
Weight of Solids, W_s (g)	45.9	
Conversion Factor, K (Table 1, ASTM D854)	0.99854	
Specific Gravity of Soil, G_s	2.69	

$$G_s = \frac{K^* W_s}{W_s + W_{pw}(at\ T_x) - W_{pws}} = \frac{(0.99854)^*(45.90)}{(45.90)+(362.96)-(391.80)}$$

$$W_{pw}(at\ T_x) = \frac{density\ of\ water\ at\ T_x}{density\ of\ water\ at\ T_i}\left[W_{pw}(at\ T_i) - W_p\right] + W_p$$

$$= \frac{(0.9967615)}{(0.9971022)}\left[\underline{363.05} - \underline{114.22}\right] + \underline{114.22}$$

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Sieve Analysis

Sample No. MW-S-1 Project SNL MW Landfill Cover

Tested by C. Anderson Date of Test 05/16/99

Sample Identification MW - Borrow - West - Mixed Sites 1, 2, 3 & 4 - Sample from Bucket #2

Sample Condition	Wt. Sample + Pan (g)	Wt. Pan (g)	Wt. Sample (g)
Wet sample	1733.01	244.42	1488.59
Dry sample	1614.18	244.42	1369.76
Sample retained after washing #200 sieve (dry)	1186.16	244.65	941.51
Percent Grav. Moisture in Wet sample [w] =			8.68
Weight loss from washing (< #200 sieve) =			428.25

Sieve	Size (mm)	Sieve Weight (g)	Sieve + Material (g)	Weight Retained (g)	Weight Passing (g)	Percent Passing
3.0"	75.0					
2.0"	50.0					
1.5"	38.1					
1.0"	25.0					
¾"	18.85	641.62	641.66	0.04	1370.65	100.00
d"	9.423	623.25	628.49	5.24	1365.41	99.61
No. 4	4.75	538.63	546.80	8.17	1357.24	99.02
No. 10	2.0	449.83	466.98	17.15	1340.09	97.77
No. 20	.850	415.08	438.16	23.08	1317.01	96.08
No. 40	.425	391.10	414.87	23.77	1293.24	94.35
No. 60	.250	341.69	408.74	67.05	1226.19	89.46
No. 140	.106	365.39	1004.13	638.74	587.45	42.86
No. 200	.075	333.24	469.93	136.69	450.76	32.89
Pan		496.83	519.34	22.51	0.00	0.00
	Total Wt. retained on sieves =			942.44		
	Wt. loss from washing (< #200 sieve) =			428.25		
	Total dry weight of sample =			1370.69		

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Hydrometer Analysis

Sample No. MW-Mixed-Bk #2-Hyd-1 Project SNL MW Landfill Cover

Tested by C. Anderson Date of Test 05/20/99

Sample Identification: MW - Borrow - West - Sites 1, 2, 3, & 4 Mixed (Bucket #2)

[A] Hygroscopic Moisture Correction Factor

(1)	Container Identification	MW-Mixed-Hyd-1
(2)	Weight of Container + Air Dried Soil	184.42 g
(3)	Weight of Container + Oven Dried Soil	174.71 g
(4)	Weight of Container	49.20 g
(5)	Weight of Water [(2) $ (3)] g	9.71
(6)	Weight of Oven Dried Soil [(3) $ (4)] g	125.51
(7)	Weight of Air Dried Soil [(2) $ (4)] g	135.22
(8)	Hygroscopic Moisture Content [((5) / (6)) x 100]	7.736
(9)	Hygroscopic Moisture Correction Factor [(6) / (7)]	0.9282

[B] Hydrometer Sample Preparation

(10)	Percentage of Sample Passing the #10 Sieve (from sieve analysis)	97.77
(11)	Container Identification	MW-HYD-1
(12)	Weight of Container + Air Dried Soil for Hydrometer Analysis	276.94 g
(13)	Weight of Container	161.87 g
(14)	Weight of Air Dried Soil for Hydrometer Analysis [(12) $ (13)]	115.07
(15)	Hygroscopic Moisture Correction Factor [(9)]	0.9282
(16)	Weight of Oven Dried Soil for Hydrometer Analysis [(14) x (15)]	106.81
(17)	Calculated Weight of Total Hydrometer Analysis Sample (W) [((16)/(10)) x 100]	109.24
(18)	Type of Hydrometer Used - Soiltest p/n CL-277A, #90-17741	ASTM 152H
(19)	Specific Gravity of Soil (G)	2.685
(20)	Amount of 4% Sodium Mataphosphate Dispersing Agent Used	125 cm³

[C] Hydrometer Composite Correction:

Temperature (°C)	24.4	23.4	21.0			
Composite Correction	8.0	9.0	10.0			

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Hydrometer Analysis

Sample No. MW-Mixed-Bk#2-Hyd-1

Project SNL MW Landfill Cover

Tested by C. Anderson

Date of Test 05/20/99

Sample Identification: MW - Borrow - West - Sites 1, 2, 3, & 4 Mixed (Bucket #2)

[D] Hydrometer Measurement

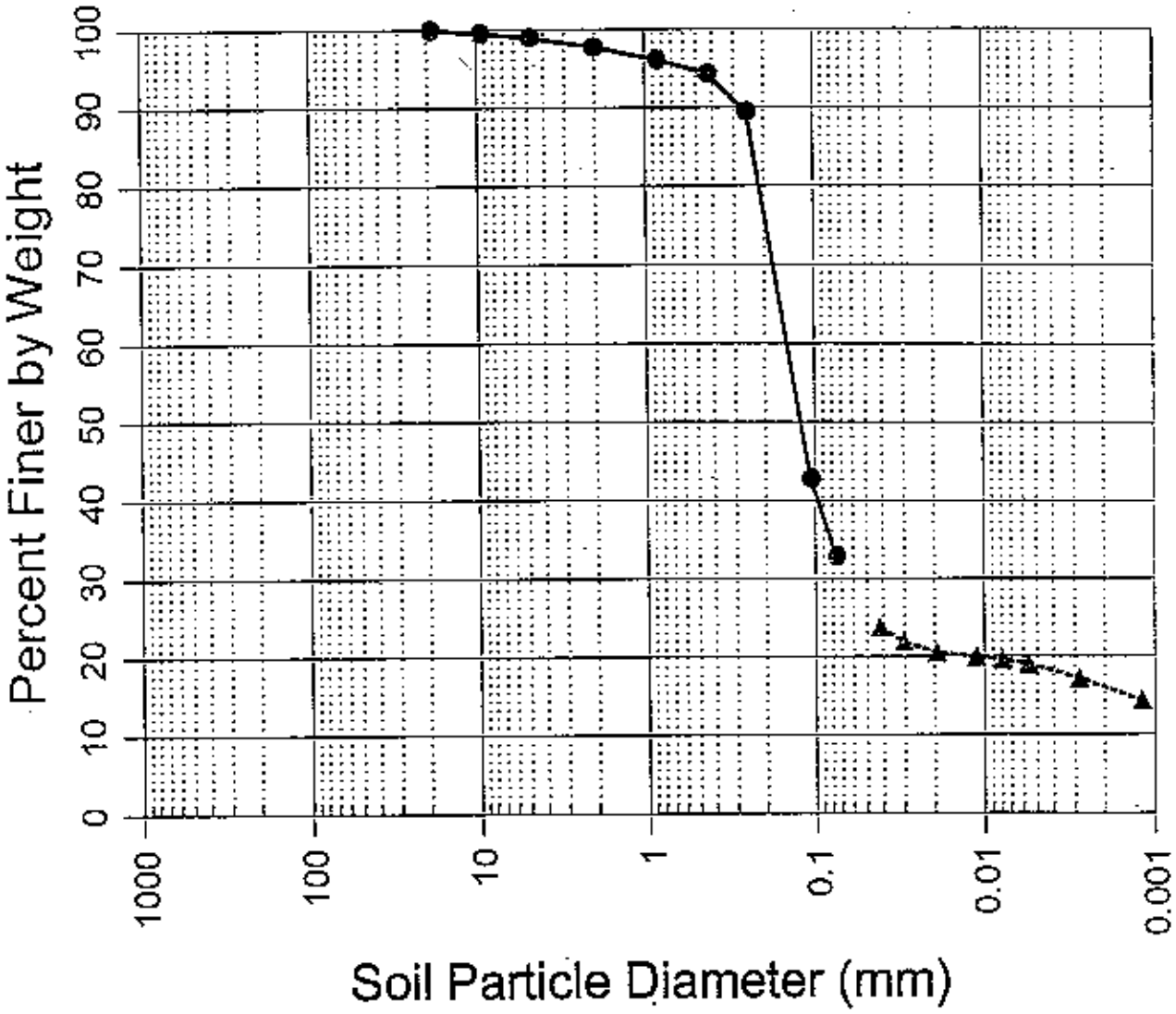
W = 109.24 [17] a = 0.9930 [ASTM D 422, Table 1]

Date	Time	Elapsed Time [T] (min)	Actual Hydrometer Reading	Comp. Corr.	Hydrometer Reading with Comp. Corr. [R]	Temp (°C)	Effective Depth of Hydrometer [L] (cm)	[K] ASTM D 422, Table 3	[D] (mm)	Percent Finer [P]
05/20	8:59PM	0				24.9				
	9:00	1	34.0	7.905	26.095	24.9	12.02	0.0128	0.0442	23.72
	9:01	2	33.0	7.905	25.095	24.9	12.18	0.0128	0.0315	22.81
	9:04	5	31.0	7.905	23.095	24.9	12.51	0.0128	0.0202	20.99
	9:09	10	30.5	7.905	22.595	24.9	12.59	0.0128	0.0143	20.54
05/20	11:15PM	0				24.1				
	11:17	2	32.5	8.350	24.150	24.1	12.34	0.0129	0.0320	21.95
	11:20	5	31.0	8.406	22.594	24.0	12.59	0.0129	0.0205	20.54
	11:30	15	30.5	8.461	22.039	23.9	12.68	0.0129	0.0119	20.03
	11:45	30	30.0	8.461	21.539	23.9	12.77	0.0129	0.0084	19.58
05/21	12:15	60	29.5	8.517	20.983	23.8	12.86	0.0129	0.0060	19.07
	3:25	250	28.0	8.963	19.037	23.0	13.18	0.0130	0.0030	17.30
	11:15	1440	26.0	10.188	15.812	20.8	13.71	0.0134	0.0013	14.37

Notes: Obtain [L] from ASTM D 422, Table 2; $[D] = [K] \times ([L] / [T])^{0.5}$
[P] = ([R] x a / W) x 100 for Hydrometer Type 152H

GRAIN SIZE DISTRIBUTION

Mixed Waste Landfill Cover - W. Borrow Mixed - Bucket #2



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Sieve Analysis

Sample No. MW-S-2b

Project SNL MW Landfill Cover

Tested by C. Anderson

Date of Test 05/17/99

Sample Identification MW - Borrow - West - Mixed Sites 1, 2, 3 & 4 - Sample from Bucket #4

Sample Condition	Wt. Sample + Pan (g)	Wt. Pan (g)	Wt. Sample (g)
Wet sample	1745.67	246.79	1498.88
Dry sample	1624.93	246.79	1378.14
Sample retained after washing #200 sieve (dry)	1238.35	246.70	991.65
Percent Grav. Moisture in Wet sample [w] =			8.76
Weight loss from washing (< #200 sieve) =			386.49

Sieve	Size (mm)	Sieve Weight (g)	Sieve + Material (g)	Weight Retained (g)	Weight Passing (g)	Percent Passing
3.0"	75.0					
2.0"	50.0					
1.5"	38.1					
1.0"	25.0					100.00
¾"	18.85	641.62	659.73	18.11	1360.71	98.69
d"	9.423	623.24	626.24	3.00	1357.71	98.47
No. 4	4.75	538.64	550.06	11.42	1346.29	97.64
No. 10	2.0	449.71	465.61	15.90	1330.39	96.49
No. 20	.850	415.06	438.21	23.15	1307.24	94.81
No. 40	.425	391.11	414.67	23.56	1283.68	93.10
No. 60	.250	341.67	406.33	64.66	1219.02	88.41
No. 140	.106	365.60	1058.38	692.78	526.24	38.17
No. 200	.075	333.21	434.46	101.25	424.99	30.82
Pan		496.74	535.24	38.50	0.00	0.00
	Total Wt. retained on sieves =			992.33		
	Wt. loss from washing (< #200 sieve) =			386.49		
	Total dry weight of sample =			1378.82		

File: SIEVE_MW_S_2b.wpd

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Hydrometer Analysis

Sample No. MW-Mixed-Bk #4-Hyd-2 Project SNL MW Landfill Cover

Tested by C. Anderson Date of Test 05/20/99

Sample Identification: MW - Borrow - West - Sites 1, 2, 3, & 4 Miixed (Bucket #4)

[A] Hygroscopic Moisture Correction Factor

(1)	Container Identification	MW-Mixed-Hyd-2
(2)	Weight of Container + Air Dried Soil	171.11 g
(3)	Weight of Container + Oven Dried Soil	162.49 g
(4)	Weight of Container	48.97 g
(5)	Weight of Water [(2) S (3)] g	8.62
(6)	Weight of Oven Dried Soil [(3) S (4)] g	113.52
(7)	Weight of Air Dried Soil [(2) S (4)] g	122.14
(8)	Hygroscopic Moisture Content [((5) / (6)) x 100]	7.593
(9)	Hygroscopic Moisture Correction Factor [(6) / (7)]	0.9294

[B] Hydrometer Sample Preparation

(10)	Percentage of Sample Passing the #10 Sieve (from sieve analysis)	96.49
(11)	Container Identification	MW-HYD-2
(12)	Weight of Container + Air Dried Soil for Hydrometer Analysis	296.29 g
(13)	Weight of Container	177.05 g
(14)	Weight of Air Dried Soil for Hydrometer Analysis [(12) S (13)]	119.24
(15)	Hygroscopic Moisture Correction Factor [(9)]	0.9294
(16)	Weight of Oven Dried Soil for Hydrometer Analysis [(14) x (15)]	110.82
(17)	Calculated Weight of Total Hydrometer Analysis Sample (W) [((16)/(10)) x 100]	114.86
(18)	Type of Hydrometer Used - Soiltest p/n CL-277A, #90-17741	ASTM 152H
(19)	Specific Gravity of Soil (G)	2.685
(20)	Amount of 4% Sodium Mataphosphate Dispersing Agent Used	125 cm³

[C] Hydrometer Composite Correction:

Temperature (°C)	24.4	23.4	21.0			
Composite Correction	8.0	9.0	10.0			

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Hydrometer Analysis

Sample No. MW-Mixed-Bk#4-Hyd-2 Project SNL MW Landfill Cover

Tested by C. Anderson Date of Test 05/20/99

Sample Identification: MW - Borrow - West - Sites 1, 2, 3, & 4 Mixed (Bucket #4)

[D] Hydrometer Measurement

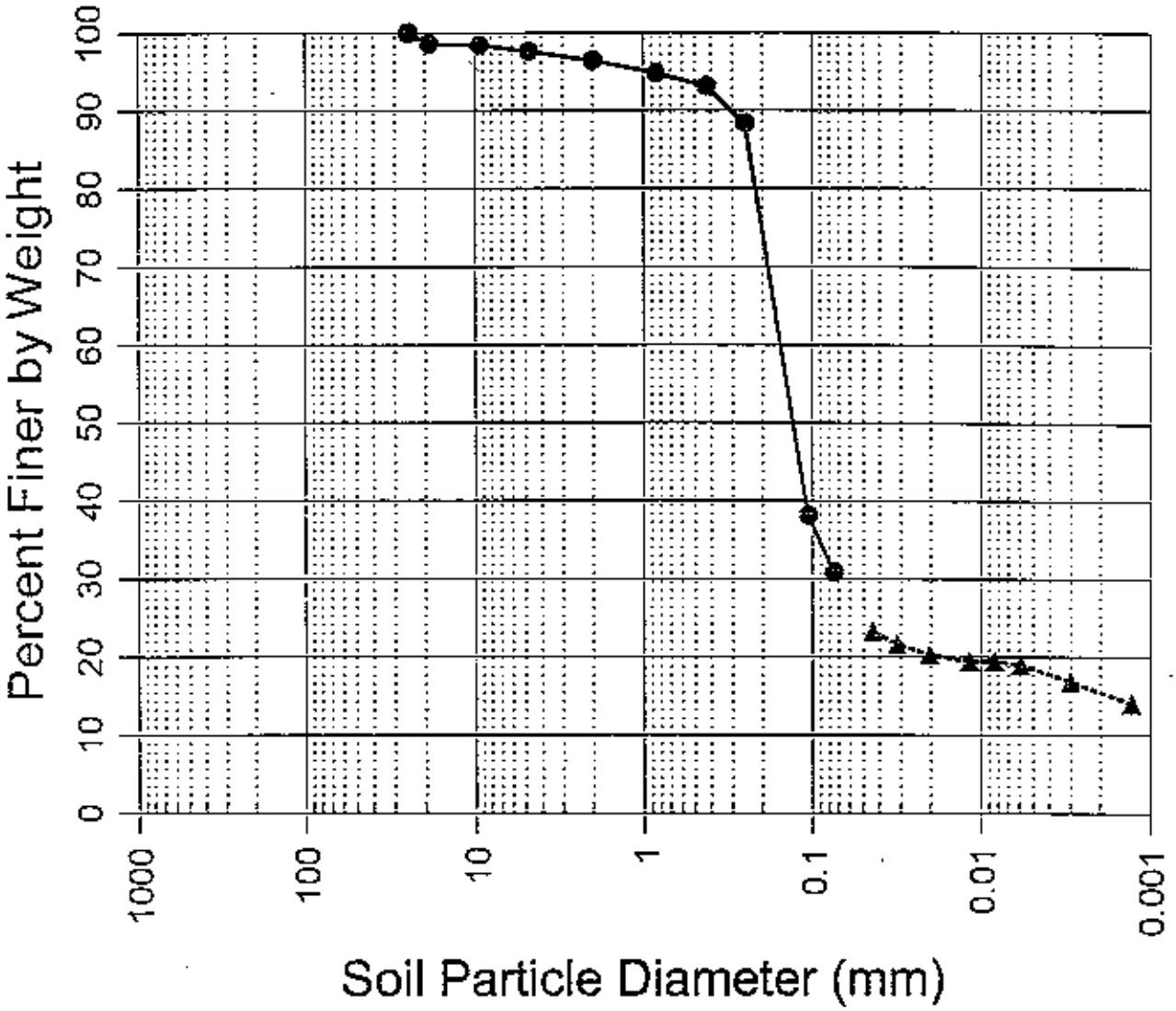
W = 114.86 [17] a = 0.9930 [ASTM D 422, Table 1]

Date	Time	Elapsed Time [T] (min)	Actual Hydrometer Reading	Comp. Corr.	Hydrometer Reading with Comp. Corr. [R]	Temp (°C)	Effective Depth of Hydrometer [L] (cm)	[K] ASTM D 422, Table 3	[D] (mm)	Percent Finer [P]
05/20	9:20PM	0				24.6				
	9:21	1	35.0	8.072	26.928	24.6	11.88	0.0128	0.0441	23.28
	9:22	2	32.5	8.072	24.428	24.6	12.29	0.0128	0.0317	21.12
	9:25	5	31.5	8.072	23.428	24.6	12.46	0.0128	0.0202	20.26
	9:30	10	30.0	8.072	21.928	24.6	12.70	0.0128	0.0144	18.96
05/20	11:23PM	0				24.0				
	11:25	2	33.5	8.406	25.094	24.0	12.18	0.0129	0.0318	21.70
	11:28	5	32.0	8.461	23.539	23.9	12.44	0.0129	0.0203	20.35
	11:38	15	31.0	8.461	22.539	23.9	12.60	0.0129	0.0118	19.49
	11:53	30	31.0	8.517	22.483	23.8	12.61	0.0129	0.0084	19.44
05/21	12:23	60	30.5	8.517	21.983	23.8	12.69	0.0129	0.0059	19.01
	3:33	250	28.5	8.963	19.537	23.0	13.09	0.0130	0.0030	16.89
	11:23PM	1440	26.5	10.188	16.312	20.8	13.62	0.0134	0.0013	14.10

Notes: Obtain [L] from ASTM D 422, Table 2; $[D] = [K] \times ([L] / [T])^{0.5}$
[P] = ([R] x a / W) x 100 for Hydrometer Type 152H

GRAIN SIZE DISTRIBUTION

Mixed Waste Landfill Cover - W. Borrow Mixed - Bucket #4



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Sieve Analysis

Sample No. MW-CAMU-Screened-A Project SNL MW Landfill Cover

Tested by C. Anderson Date of Test 05/16/99

Sample Identification MW - CAMU - Borrow - Screened

Sample Condition	Wt. Sample + Pan (g)	Wt. Pan (g)	Wt. Sample (g)
Wet sample	1813.04	245.48	1567.56
Dry sample	1644.74	245.48	1399.26
Sample retained after washing #200 sieve (dry)	1258.69	245.40	1013.29
Percent Grav. Moisture in Wet sample [w] =			12.03
Weight loss from washing (< #200 sieve) =			385.97

Sieve	Size (mm)	Sieve Weight (g)	Sieve + Material (g)	Weight Retained (g)	Weight Passing (g)	Percent Passing
3.0"	75.0					
2.0"	50.0					
1.5"	38.1					
1.0"	25.0					
¾"	18.85	641.62	641.62	0.00	1400.35	100.00
d"	9.423	623.23	634.77	11.54	1388.81	99.18
No. 4	4.75	538.62	576.56	37.94	1350.87	96.47
No. 10	2.0	449.77	531.72	81.95	1268.92	90.61
No. 20	.850	415.04	488.96	73.92	1195.00	85.34
No. 40	.425	391.12	438.64	47.52	1147.48	81.94
No. 60	.250	341.68	379.49	37.81	1109.67	79.24
No. 140	.106	365.52	895.67	530.15	579.52	41.38
No. 200	.075	333.22	464.10	130.88	448.64	32.04
Pan		496.79	559.46	62.67	0.00	0.00
	Total Wt. retained on sieves =			1014.38		
	Wt. loss from washing (< #200 sieve) =			385.97		
	Total dry weight of sample =			1400.35		

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Sieve Analysis

Sample No. MW-CAMU-Screened-B

Project SNL MW Landfill Cover

Tested by C. Anderson

Date of Test 05/16/99

Sample Identification MW - CAMU - Borrow - Screened

Sample Condition	Wt. Sample + Pan (g)	Wt. Pan (g)	Wt. Sample (g)
Wet sample	1655.05	245.63	1409.42
Dry sample	1503.23	245.63	1257.6
Sample retained after washing #200 sieve (dry)	1149.93	245.57	904.36
Percent Grav. Moisture in Wet sample [w] =			12.07
Weight loss from washing (< #200 sieve) =			353.24

Sieve	Size (mm)	Sieve Weight (g)	Sieve + Material (g)	Weight Retained (g)	Weight Passing (g)	Percent Passing
3.0"	75.0					
2.0"	50.0					
1.5"	38.1					
1.0"	25.0					
¾"	18.85	641.62	641.62	0.00	1258.55	100.00
d"	9.423	623.23	636.31	13.08	1245.47	98.96
No. 4	4.75	538.63	570.29	31.66	1213.81	96.45
No. 10	2.0	449.75	519.58	69.83	1143.98	90.90
No. 20	.850	414.98	481.55	66.57	1077.41	85.61
No. 40	.425	391.13	433.18	42.05	1035.36	82.27
No. 60	.250	341.67	375.85	34.18	1001.18	79.55
No. 140	.106	365.52	820.21	454.69	546.49	43.42
No. 200	.075	333.22	474.68	141.46	405.03	32.18
Pan		496.78	548.57	51.79	0.00	0.00
	Total Wt. retained on sieves =			905.31		
	Wt. loss from washing (< #200 sieve) =			353.24		
	Total dry weight of sample =			1258.55		

File: SIEVE_MW_CAMU_Screened_B.wpd

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Hydrometer Analysis

Sample No. MW-CAMU-Screened-Hyd-4 Project SNL MW Landfill Cover

Tested by C. Anderson Date of Test 05/20/99

Sample Identification: CAMU - Borrow - Screened Pile

[A] Hygroscopic Moisture Correction Factor

(1)	Container Identification	MW-CAMU-Hyd-4
(2)	Weight of Container + Air Dried Soil	174.79 g
(3)	Weight of Container + Oven Dried Soil	162.76 g
(4)	Weight of Container	48.57 g
(5)	Weight of Water [(2) $ (3)] g	12.03
(6)	Weight of Oven Dried Soil [(3) $ (4)] g	114.19
(7)	Weight of Air Dried Soil [(2) $ (4)] g	126.22
(8)	Hygroscopic Moisture Content [((5) / (6)) x 100]	10.535
(9)	Hygroscopic Moisture Correction Factor [(6) / (7)]	0.9047

[B] Hydrometer Sample Preparation

(10)	Percentage of Sample Passing the #10 Sieve (from sieve analysis)	90.755
(11)	Container Identification	MW-HYD-4
(12)	Weight of Container + Air Dried Soil for Hydrometer Analysis	301.37 g
(13)	Weight of Container	181.13 g
(14)	Weight of Air Dried Soil for Hydrometer Analysis [(12) $ (13)]	120.24
(15)	Hygroscopic Moisture Correction Factor [(9)]	0.9047
(16)	Weight of Oven Dried Soil for Hydrometer Analysis [(14) x (15)]	108.78
(17)	Calculated Weight of Total Hydrometer Analysis Sample (W) [((16)/(10)) x 100]	119.86
(18)	Type of Hydrometer Used - Soiltest p/n CL-277A #90-17741	ASTM 152H
(19)	Specific Gravity of Soil (G)	2.68
(20)	Amount of 4% Sodium Mataphosphate Dispersing Agent Used	125 cm^3

[C] Hydrometer Composite Correction:

Temperature (°C)	24.4	23.4	21.0			
Composite Correction	8.0	9.0	10.0			

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Hydrometer Analysis

Sample No. MW-CAMU-Screened-Hyd-4 Project SNL MW Landfill Cover

Tested by C. Anderson Date of Test 05/20/99

Sample Identification: CAMU - Borrow - Screened Pile

[D] Hydrometer Measurement

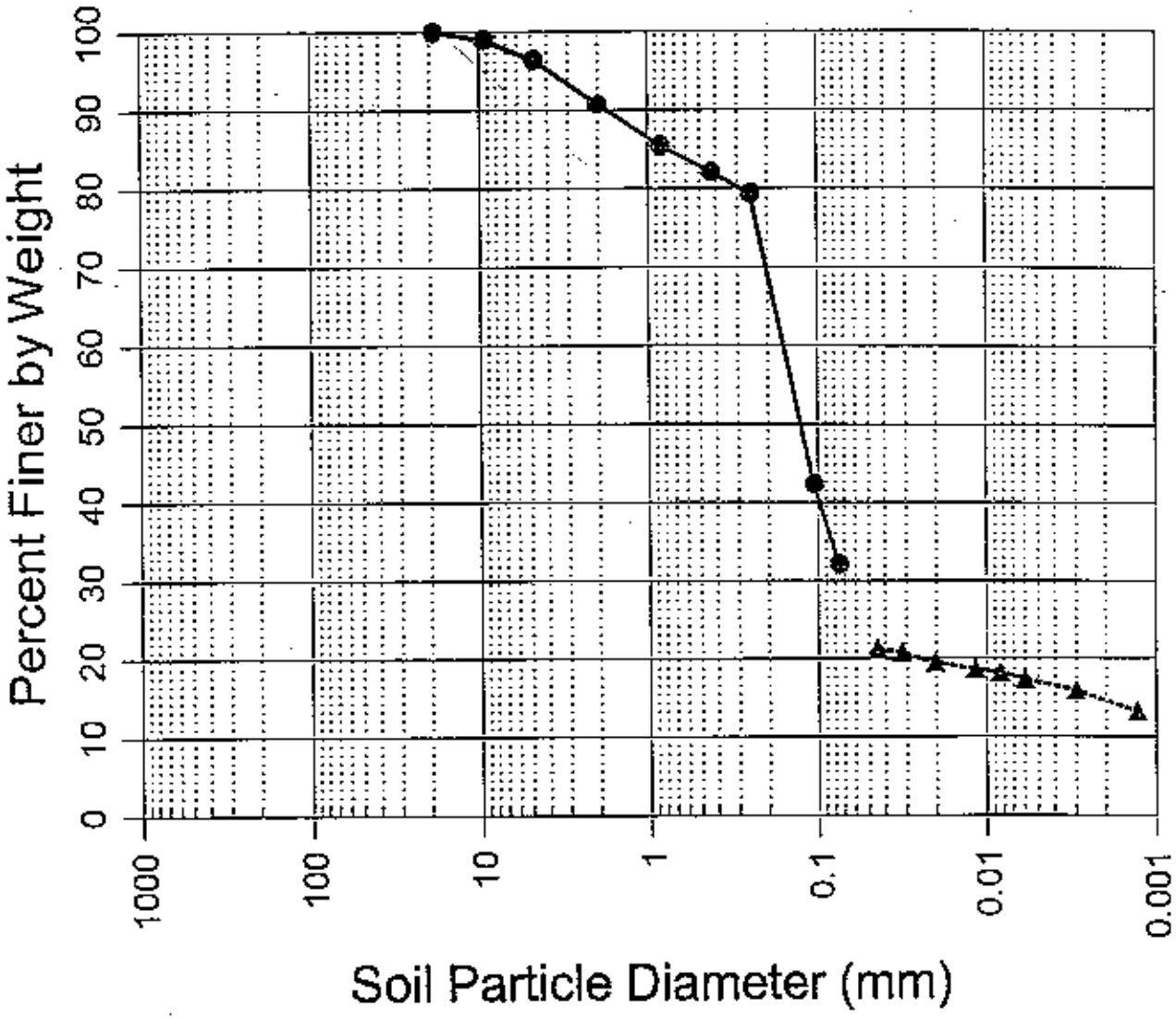
W = 119.86 [17] a = 0.9940 [ASTM D 422, Table 1]

Date	Time	Elapsed Time [T] (min)	Actual Hydrometer Reading	Comp. Corr.	Hydrometer Reading with Comp. Corr. [R]	Temp (°C)	Effective Depth of Hydrometer [L] (cm)	[K] ASTM D 422, Table 3	[D] (mm)	Percent Finer [P]
05/20	10:05PM	0				24.4				
	10:06	1	34.0	8.183	25.817	24.4	12.06	0.0128	0.0446	21.41
	10:07	2	32.0	8.183	23.817	24.4	12.39	0.0128	0.0320	19.75
	10:10	5	31.5	8.239	23.261	24.3	12.48	0.0129	0.0203	19.29
	10:20	15	30.5	8.239	22.261	24.3	12.65	0.0129	0.0118	18.46
05/20	11:49PM	0				24.0				
	11:51	2	33.5	8.406	25.094	24.0	12.18	0.0129	0.0318	20.81
	11:54	5	32.0	8.406	23.594	24.0	12.43	0.0129	0.0203	19.57
05/21	12:04	15	31.0	8.461	22.539	23.9	12.60	0.0129	0.0118	18.69
	12:19	30	30.5	8.517	21.983	23.8	12.69	0.0129	0.0084	18.23
	12:49	60	29.5	8.517	20.983	23.8	12.86	0.0129	0.0060	17.40
	3:59	250	28.0	8.796	19.204	23.3	13.15	0.0130	0.0030	15.93
	11:49PM	1440	26.0	9.965	16.035	21.2	13.67	0.0133	0.0013	13.30

Notes: Obtain [L] from ASTM D 422, Table 2; $[D] = [K] \times ([L] / [T])^{0.5}$
$[P] = ([R] \times a / W) \times 100$ for Hydrometer Type 152H

GRAIN SIZE DISTRIBUTION

Mixed Waste Landfill Cover - CAMU - Screened Borrow Pile



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Sieve Analysis

Sample No. MW-CAMU-Not Screened-C

Project SNL MW Landfill Cover

Tested by C. Anderson

Date of Test 05/17/99

Sample Identification MW - CAMU - Borrow - Not Screened

Sample Condition	Wt. Sample + Pan (g)	Wt. Pan (g)	Wt. Sample (g)
Wet sample	1749.87	245.18	1504.69
Dry sample	1639.37	245.18	1394.19
Sample retained after washing #200 sieve (dry)	1269.70	245.10	1024.6
Percent Grav. Moisture in Wet sample [w] =			7.93
Weight loss from washing (< #200 sieve) =			369.59

Sieve	Size (mm)	Sieve Weight (g)	Sieve + Material (g)	Weight Retained (g)	Weight Passing (g)	Percent Passing
3.0"	75.0					
2.0"	50.0					
1.5"	38.1					
1.0"	25.0					100.00
¾"	18.85	641.64	652.26	10.62	1384.24	99.24
d"	9.423	623.25	641.99	18.74	1365.50	97.90
No. 4	4.75	538.67	598.51	59.84	1305.66	93.61
No. 10	2.0	449.75	536.40	86.65	1219.01	87.39
No. 20	.850	415.05	483.62	68.57	1150.44	82.48
No. 40	.425	391.11	431.83	40.72	1109.72	79.56
No. 60	.250	341.71	379.15	37.44	1072.28	76.87
No. 140	.106	365.59	937.16	571.57	500.71	35.90
No. 200	.075	333.24	429.62	96.38	404.33	28.99
Pan		496.79	531.53	34.74	0.00	0.00
	Total Wt. retained on sieves =			1025.27		
	Wt. loss from washing (< #200 sieve) =			369.59		
	Total dry weight of sample =			1394.86		

File: SIEVE_MW_CAMU_NotScreened_C.wpd

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Sieve Analysis

Sample No. MW-CAMU-Not Screened-D

Project SNL MW Landfill Cover

Tested by C. Anderson

Date of Test 05/17/99

Sample Identification MW - CAMU - Borrow - Not Screened

Sample Condition	Wt. Sample + Pan (g)	Wt. Pan (g)	Wt. Sample (g)
Wet sample	1917.25	245.61	1671.64
Dry sample	1796.92	245.61	1551.31
Sample retained after washing #200 sieve (dry)	1387.11	245.86	1141.25
Percent Grav. Moisture in Wet sample [w] =			7.76
Weight loss from washing (< #200 sieve) =			410.06

Sieve	Size (mm)	Sieve Weight (g)	Sieve + Material (g)	Weight Retained (g)	Weight Passing (g)	Percent Passing
3.0"	75.0					
2.0"	50.0					
1.5"	38.1					
1.0"	25.0					
¾"	18.85	641.62	641.62	0.00	1552.08	100.00
d"	9.423	623.24	666.79	43.55	1508.53	97.19
No. 4	4.75	538.64	591.37	52.73	1455.80	93.80
No. 10	2.0	449.72	546.60	96.88	1358.92	87.55
No. 20	.850	415.06	494.28	79.22	1279.70	82.45
No. 40	.425	391.09	437.59	46.50	1233.20	79.45
No. 60	.250	341.69	381.06	39.37	1193.83	76.92
No. 140	.106	365.58	980.94	615.36	578.47	37.27
No. 200	.075	333.21	459.35	126.14	452.33	29.14
Pan		496.78	539.05	42.27	0.00	0.00
	Total Wt. retained on sieves =			1142.02		
	Wt. loss from washing (< #200 sieve) =			410.06		
	Total dry weight of sample =			1552.08		

File: SIEVE_MW_CAMU_NotScreened_D.wpd

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Hydrometer Analysis

Sample No. MW-CAMU-Unscreened-Hyd-3 Project SNL MW Landfill Cover

Tested by C. Anderson Date of Test 05/20/99

Sample Identification: CAMU - Borrow - Unscreened Pile

[A] Hygroscopic Moisture Correction Factor

(1)	Container Identification	MW-CAMU-Hyd-3
(2)	Weight of Container + Air Dried Soil	176.65 g
(3)	Weight of Container + Oven Dried Soil	168.55 g
(4)	Weight of Container	49.18 g
(5)	Weight of Water [(2) S (3)] g	8.10
(6)	Weight of Oven Dried Soil [(3) S (4)] g	119.37
(7)	Weight of Air Dried Soil [(2) S (4)] g	127.47
(8)	Hygroscopic Moisture Content [((5) / (6)) x 100]	6.786
(9)	Hygroscopic Moisture Correction Factor [(6) / (7)]	0.9365

[B] Hydrometer Sample Preparation

(10)	Percentage of Sample Passing the #10 Sieve (from sieve analysis)	87.47
(11)	Container Identification	MW-HYD-3
(12)	Weight of Container + Air Dried Soil for Hydrometer Analysis	252.73 g
(13)	Weight of Container	132.22 g
(14)	Weight of Air Dried Soil for Hydrometer Analysis [(12) S (13)]	120.51
(15)	Hygroscopic Moisture Correction Factor [(9)]	0.9365
(16)	Weight of Oven Dried Soil for Hydrometer Analysis [(14) x (15)]	112.85
(17)	Calculated Weight of Total Hydrometer Analysis Sample (W) [((16)/(10)) x 100]	129.02
(18)	Type of Hydrometer Used - Soiltest p/n CL-277A, #90-17741	ASTM 152H
(19)	Specific Gravity of Soil (G)	2.69
(20)	Amount of 4% Sodium Mataphosphate Dispersing Agent Used	125 cm^3

[C] Hydrometer Composite Correction:

Temperature (°C)	24.4	23.4	21.0			
Composite Correction	8.0	9.0	10.0			

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Hydrometer Analysis

Sample No. MW-CAMU-Unscreened-Hyd-3 Project SNL MW Landfill Cover

Tested by C. Anderson Date of Test 05/20/99

Sample Identification: CAMU - Borrow - Unscreened Pile

[D] Hydrometer Measurement

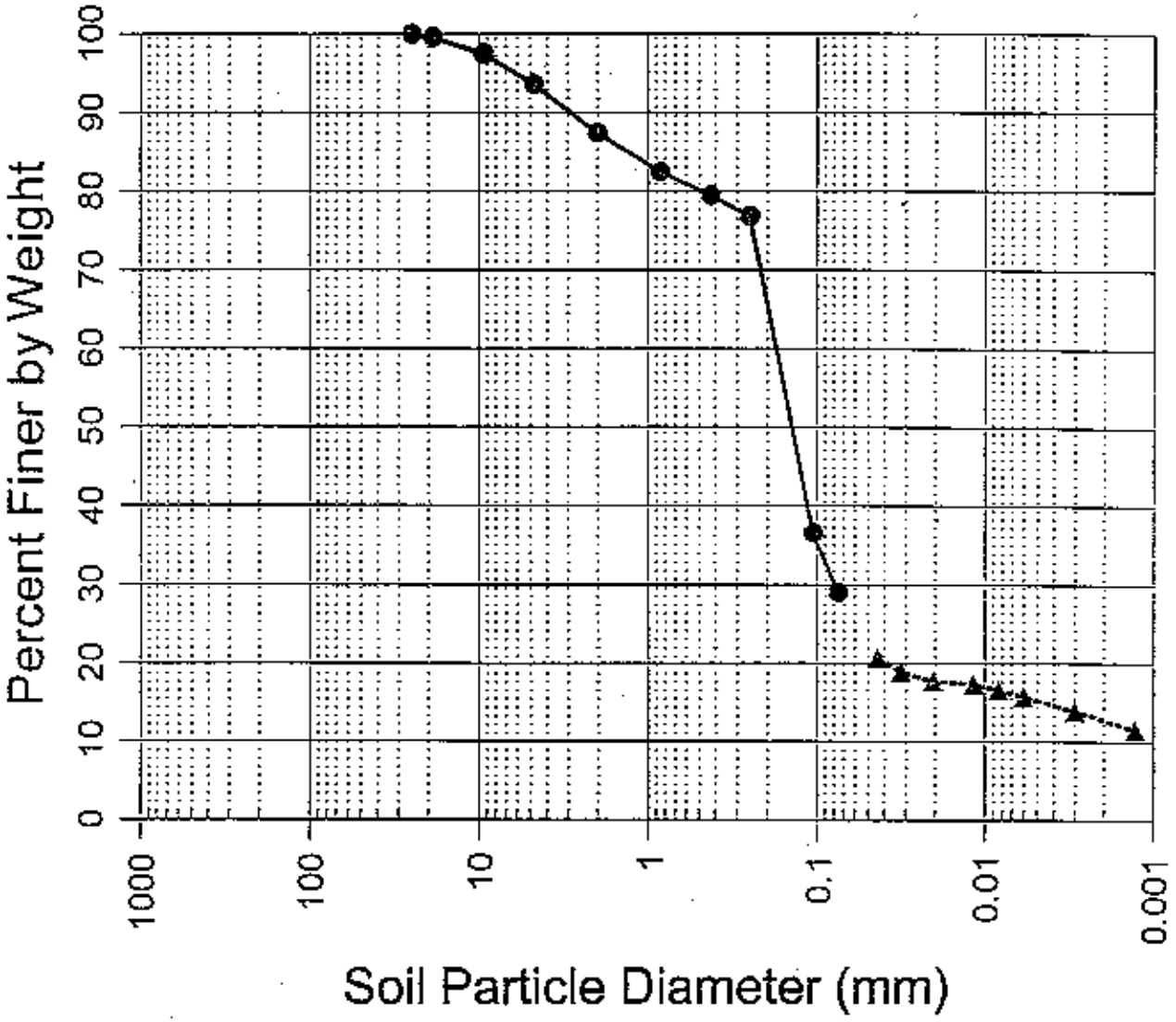
W = 129.02 [17] a = 0.9920 [ASTM D 422, Table 1]

Date	Time	Elapsed Time [T] (min)	Actual Hydrometer Reading	Comp. Corr.	Hydrometer Reading with Comp. Corr. [R]	Temp (°C)	Effective Depth of Hydrometer [L] (cm)	[K] ASTM D 422, Table 3	[D] (mm)	Percent Finer [P]
05/20	9:40PM	0				24.6				
	9:41	1	35.0	8.072	26.928	24.6	11.88	0.0128	0.0440	20.70
	9:42	2	32.5	8.072	24.428	24.6	12.29	0.0128	0.0317	18.78
	9:45	5	31.5	8.072	23.428	24.6	12.46	0.0128	0.0202	18.01
	9:50	10	30.5	8.127	22.373	24.5	12.63	0.0128	0.0144	17.20
05/20	11:42PM	0				24.0				
	11:44	2	33.0	8.406	24.594	24.0	12.26	0.0129	0.0319	18.91
	11:47	5	31.5	8.406	23.094	24.0	12.51	0.0129	0.0204	17.76
	11:57	15	31.0	8.461	22.539	23.9	12.60	0.0129	0.0118	17.33
05/21	12:12	30	30.0	8.461	21.539	23.9	12.77	0.0129	0.0084	16.56
	12:42	60	29.0	8.517	20.483	23.8	12.94	0.0129	0.0060	15.75
	3:52	250	27.0	8.851	18.149	23.2	13.32	0.0130	0.0030	13.95
	11:42PM	1440	25.0	9.965	15.035	21.2	13.83	0.0133	0.0013	11.56

Notes: Obtain [L] from ASTM D 422, Table 2; $[D] = [K] \times ([L] / [T])^{0.5}$
$[P] = ([R] \times a / W) \times 100$ for Hydrometer Type 152H

GRAIN SIZE DISTRIBUTION

Mixed Waste Landfill Cover - CAMU - Unscreened Borrow Pile



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Atterberg Limits:
Liquid Limit, Plastic Limit and Plasticity Index Determination

Sample No. MW-Mixed_BK#2-ATT-1 Project SNL Mixed Waste Landfill Cover

Tested by C. Anderson Date of Test 5/23/99

Sample Identification: MW - West Borrow - Mixed Sites 1, 2, 3 & 4 - Bucket #2 - Sieve #40

Liquid Limit Measurement

Determination No.		1	2	3
Number of Drops, N		33	27	22
Log_{10} (Number of Drops), $Log_{10}(N)$		1.519	1.431	1.342
Moisture Can Number		MW-L-4	MW-L-5	MW-L-6
Wt. of Can + Moist Soil, W_1	(g)	38.45	37.78	42.07
Wt. of Can + Dry Soil, W_2	(g)	35.28	34.46	38.06
Weight of Can, W_C	(g)	21.14	19.90	20.90
Weight of Water, W_w	(g)	3.17	3.32	4.01
Weight of Dry Soil, W_s	(g)	14.14	14.56	17.16
Grav. Moisture Content, w	(%)	22.42	22.80	23.37
One-Point Method Factor, $k = (N/25)^{0.121}$		1.0342	1.0094	0.9847
One-Point Liquid Limit - Method B (ASTM D 4318)		23.2	23.0	23.0
Liquid Limit, LL (from the flow curve at 25 drops equiv.) =				23.0

Plastic Limit Measurement

Determination No.		1	2
Moisture Can Number		MW-P-3	MW-P-4
Wt. of Can + Moist Soil, W_1	(g)	23.52	21.93
Wt. of Can + Dry Soil, W_2	(g)	23.15	21.57
Weight of Can, W_C	(g)	21.14	19.46
Weight of Water, W_w	(g)	0.37	0.36
Weight of Dry Soil, W_s	(g)	2.01	2.11
Grav. Moisture Content, w	(%)	18.41	17.06
Plastic Limit, PL (Average of w_1 and w_2)	(%)	17.7	

Plasticity Index Determination

Plasticity Index = Liquid Limit – Plastic Limit = 23.0 (LL) – 17.7 (PL) = 5.3 (PI) %

File: LL_PL_MW_Mixed_BK2_ATT-1.wpd

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Atterberg Limits:
Liquid Limit, Plastic Limit and Plasticity Index Determination

Sample No. MW-Mixed BK#4-ATT-2

Project SNL Mixed Waste Landfill Cover

Tested by C. Anderson

Date of Test 5/23/99

Sample Identification: MW - West Borrow - Mixed Sites 1, 2, 3 & 4 - Bucket #4 - Sieve #40

Liquid Limit Measurement

Determination No.		1	2	3
Number of Drops, N		35	24	21
Log_{10} (Number of Drops), $Log_{10}(N)$		1.544	1.380	1.322
Moisture Can Number		MW-L-1	MW-L-2	MW-L-3
Wt. of Can + Moist Soil, W_1	(g)	44.39	41.04	41.35
Wt. of Can + Dry Soil, W_2	(g)	40.10	37.01	37.20
Weight of Can, W_C	(g)	21.19	19.63	19.79
Weight of Water, W_w	(g)	4.29	4.03	4.15
Weight of Dry Soil, W_s	(g)	18.91	17.38	17.41
Grav. Moisture Content, w	(%)	22.69	23.19	23.84
One-Point Method Factor, $k = (N/25)^{0.121}$		1.0416	0.9951	0.9791
One-Point Liquid Limit - Method B (ASTM D 4318)		23.6	23.1	23.3
Liquid Limit, LL (from the flow curve at 25 drops equiv.) =				23.3

Plastic Limit Measurement

Determination No.		1	2
Moisture Can Number		MW-P-1	MW-P-2
Wt. of Can + Moist Soil, W_1	(g)	23.2	22.75
Wt. of Can + Dry Soil, W_2	(g)	22.89	22.30
Weight of Can, W_C	(g)	21.10	19.81
Weight of Water, W_w	(g)	0.31	0.45
Weight of Dry Soil, W_s	(g)	1.79	2.49
Grav. Moisture Content, w	(%)	17.32	18.07
Plastic Limit, PL (Average of w_1 and w_2)	(%)	17.7	

Plasticity Index Determination

Plasticity Index = Liquid Limit – Plastic Limit = 23.3 (LL) – 17.7 (PL) = 5.6 (PI) %

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Atterberg Limits:
Liquid Limit, Plastic Limit and Plasticity Index Determination

Sample No. MW-CAMU-Screened-ATT-3 Project SNL Mixed Waste Landfill Cover

Tested by C. Anderson Date of Test 5/23/99

Sample Identification: MW -CAMU-Screened Borrow Pile - Sieve #40

Liquid Limit Measurement

Determination No.		1	2	3
Number of Drops, N		35	25	17
Log_{10} (Number of Drops), $Log_{10}(N)$		1.544	1.398	1.230
Moisture Can Number		MW-L-7	MW-L-8	MW-L-9
Wt. of Can + Moist Soil, W_1	(g)	44.45	40.77	41.34
Wt. of Can + Dry Soil, W_2	(g)	40.02	36.66	37.39
Weight of Can, W_C	(g)	20.88	19.46	21.17
Weight of Water, W_w	(g)	4.43	4.11	3.95
Weight of Dry Soil, W_s	(g)	19.14	17.2	16.22
Grav. Moisture Content, *w*	(%)	23.15	23.90	24.35
One-Point Method Factor, $k = (N/25)^{0.121}$		1.0416	1.0000	0.9544
One-Point Liquid Limit - Method B (ASTM D 4318)		24.1	23.9	23.2
Liquid Limit, LL (from the flow curve at 25 drops equiv.) =				23.8

Plastic Limit Measurement

Determination No.		1	2
Moisture Can Number		MW-P-5	MW-P-6
Wt. of Can + Moist Soil, W_1	(g)	23.14	23.50
Wt. of Can + Dry Soil, W_2	(g)	22.86	23.09
Weight of Can, W_C	(g)	21.37	20.93
Weight of Water, W_w	(g)	0.28	0.41
Weight of Dry Soil, W_s	(g)	1.49	2.16
Grav. Moisture Content, *w*	(%)	18.79	18.98
Plastic Limit, PL (Average of w_1 and w_2)	(%)	18.9	

Plasticity Index Determination

Plasticity Index = Liquid Limit – Plastic Limit = 23.8 (LL) – 18.9 (PL) = 4.9 (PI) %

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Atterberg Limits:
Liquid Limit, Plastic Limit and Plasticity Index Determination

Sample No. MW-CAMU-Unscreened-ATT-4 Project SNL Mixed Waste Landfill Cover

Tested by C. Anderson Date of Test 5/23/99

Sample Identification: MW -CAMU-Unscreened Borrow Pile - Sieve #40

Liquid Limit Measurement

Determination No.		1	2	3
Number of Drops, N		32	27	20
Log_{10} (Number of Drops), $Log_{10}(N)$		1.505	1.431	1.301
Moisture Can Number		MW-L-10	MW-L-11	MW-L-12
Wt. of Can + Moist Soil, W_1	(g)	38.65	41.43	43.97
Wt. of Can + Dry Soil, W_2	(g)	35.29	37.30	39.70
Weight of Can, W_C	(g)	20.77	19.56	21.34
Weight of Water, W_w	(g)	3.36	4.13	4.27
Weight of Dry Soil, W_s	(g)	14.52	17.74	18.36
Grav. Moisture Content, w	(%)	23.14	23.28	23.26
One-Point Method Factor, $k = (N/25)^{0.121}$		1.0303	1.0094	0.9734
One-Point Liquid Limit - Method B (ASTM D 4318)		23.8	23.5	22.6
Liquid Limit, LL (from the flow curve at 25 drops equiv.) =				23.4

Plastic Limit Measurement

Determination No.		1	2
Moisture Can Number		MW-P-7	MW-P-8
Wt. of Can + Moist Soil, W_1	(g)	21.79	23.14
Wt. of Can + Dry Soil, W_2	(g)	21.47	22.79
Weight of Can, W_C	(g)	19.78	21.09
Weight of Water, W_w	(g)	0.32	0.35
Weight of Dry Soil, W_s	(g)	1.69	1.7
Grav. Moisture Content, w	(%)	18.93	20.59
Plastic Limit, PL (Average of w_1 and w_2)	(%)	19.8	

Plasticity Index Determination

Plasticity Index = Liquid Limit – Plastic Limit = 23.4 (LL) – 19.8 (PL) = 3.6 (PI) %

File: LL_PL_MW_CAMU_Unscreened_ATT-4.wpd

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Calcium Carbonate Content

Sample No. MW-Mixed BK#2-CC-1 Project SNL Mixed Waste Landfill Cover

Tested by C. Anderson Date of Test 5/25/99

Sample Identification: MW-West Borrow. Sites 1, 2, 3 & 4 Mixed - from Bucket #2

Calibration of Rapid Carbonate Analyzer

(1)	Carbonate Analyzer identification					UNM-RCA#1
(2)	Date of calibration					5/25/99
(3)	Calibration Measurement A			Calibration Measurement B		
	Weight of $CaCO_3$ (g)	Tare (g)	CO_2 Pressure (kPa)	Weight of $CaCO_3$ (g)	Tare (g)	CO_2 Pressure (kPa)
	0.2019	0.0007	14.2	0.2047	0.0032	13.2
	0.4049	0.0022	26.5	0.4011	0.0072	26.5
	0.6069	0.0021	39.0	0.6088	0.0058	39.0
	0.8039	0.0036	51.3	0.8093	0.0086	52.0
	1.0064	0.0030	55.2	1.0076	0.0087	56.6

Analyzer Calibration Equation:

Weight of $CaCO_3$(g) = [0.0154] X [CO_2 Pressure (kPa)]

Soil Measurement Sample Container No. HYD-1

Test No.	Weight of dry sample (g)	Tare (g)	CO_2 Pressure (kPa)	Computed Weight of $CaCO_3$ (g)	Percentage of $CaCO_3$
1	4.0107	0.0023	4.1	0.06310458	1.57
2	6.0092	0.0041	3.8	0.05845686	0.97
				Average Percentage =	1.3

Note: Sample is pulverized with a mortar and pestle to pass all particles through a No. 40 (0.42 mm) sieve.

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Calcium Carbonate Content

Sample No. MW-Mixed BK#2-CC-2 Project SNL Mixed Waste Landfill Cover

Tested by C. Anderson Date of Test 5/25/99

Sample Identification: MW-West Borrow, Sites 1, 2, 3 & 4 Mixed - from Bucket #2

Calibration of Rapid Carbonate Analyzer

(1)	Carbonate Analyzer identification					UNM-RCA#1
(2)	Date of calibration					5/25/99
(3)	Calibration Measurement A			Calibration Measurement B		
	Weight of $CaCO_3$ (g)	Tare (g)	CO_2 Pressure (kPa)	Weight of $CaCO_3$ (g)	Tare (g)	CO_2 Pressure (kPa)
	0.2019	0.0007	14.2	0.2047	0.0032	13.2
	0.4049	0.0022	26.5	0.4011	0.0072	26.5
	0.6069	0.0021	39.0	0.6088	0.0058	39.0
	0.8039	0.0036	51.3	0.8093	0.0086	52.0
	1.0064	0.0030	55.2	1.0076	0.0087	56.6

Analyzer Calibration Equation:

Weight of $CaCO_3$(g) = [0.0154] X [CO_2 Pressure (kPa)]

Soil Measurement Sample Container No. HYD-2

Test No.	Weight of dry sample (g)	Tare (g)	CO_2 Pressure (kPa)	Computed Weight of $CaCO_3$ (g)	Percentage of $CaCO_3$
1	4.0030	0.0060	2.0	0.0307076	0.77
2	6.0077	0.0066	4.2	0.06457836	1.07
				Average Percentage =	0.9

Note: Sample is pulverized with a mortar and pestle to pass all particles through a No. 40 (0.42 mm) sieve.

File: Cal_Car_MW_Mixed_BK2_cc2.wpd

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Calcium Carbonate Content

Sample No. MW-Mixed_BK#4-CC-1 Project SNL Mixed Waste Landfill Cover

Tested by C. Anderson Date of Test 5/25/99

Sample Identification: MW-West Borrow, Sites 1, 2, 3 & 4 Mixed - from Bucket #4

Calibration of Rapid Carbonate Analyzer

(1)	Carbonate Analyzer identification					UNM-RCA#1
(2)	Date of calibration					5/25/99
(3)	Calibration Measurement A			Calibration Measurement B		
	Weight of $CaCO_3$ (g)	Tare (g)	CO_2 Pressure (kPa)	Weight of $CaCO_3$ (g)	Tare (g)	CO_2 Pressure (kPa)
	0.2019	0.0007	14.2	0.2047	0.0032	13.2
	0.4049	0.0022	26.5	0.4011	0.0072	26.5
	0.6069	0.0021	39.0	0.6088	0.0058	39.0
	0.8039	0.0036	51.3	0.8093	0.0086	52.0
	1.0064	0.0030	55.2	1.0076	0.0087	56.6

Analyzer Calibration Equation:

Weight of $CaCO_3$(g) = [0.0154] X [CO_2 Pressure (kPa)]

Soil Measurement Sample Container No. HYD-3

Test No.	Weight of dry sample (g)	Tare (g)	CO_2 Pressure (kPa)	Computed Weight of $CaCO_3$ (g)	Percentage of $CaCO_3$
1	4.0036	0.0060	3.0	0.0461076	1.15
2	6.0084	0.0059	4.8	0.07382914	1.23
				Average Percentage =	1.2

Note: Sample is pulverized with a mortar and pestle to pass all particles through a No. 40 (0.42 mm) sieve.

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Calcium Carbonate Content

Sample No. MW-Mixed BK#4-CC-2

Project SNL Mixed Waste Landfill Cover

Tested by C. Anderson

Date of Test 5/25/99

Sample Identification: MW-West Borrow, Sites 1, 2, 3 & 4 Mixed - from Bucket #4

Calibration of Rapid Carbonate Analyzer

(1)	Carbonate Analyzer identification					UNM-RCA#1
(2)	Date of calibration					5/25/99
(3)	Calibration Measurement A			Calibration Measurement B		
	Weight of $CaCO_3$ (g)	Tare (g)	CO_2 Pressure (kPa)	Weight of $CaCO_3$ (g)	Tare (g)	CO_2 Pressure (kPa)
	0.2019	0.0007	14.2	0.2047	0.0032	13.2
	0.4049	0.0022	26.5	0.4011	0.0072	26.5
	0.6069	0.0021	39.0	0.6088	0.0058	39.0
	0.8039	0.0036	51.3	0.8093	0.0086	52.0
	1.0064	0.0030	55.2	1.0076	0.0087	56.6

Analyzer Calibration Equation:

Weight of $CaCO_3$(g) = [0.0154] X [CO_2 Pressure (kPa)]

Soil Measurement

Sample Container No. HYD-4

Test No.	Weight of dry sample (g)	Tare (g)	CO_2 Pressure (kPa)	Computed Weight of $CaCO_3$ (g)	Percentage of $CaCO_3$
1	4.0083	0.0032	2.1	0.03229072	0.81
2	6.0058	0.0010	3.3	0.0508046	0.85
				Average Percentage =	0.8

Note: Sample is pulverized with a mortar and pestle to pass all particles through a No. 40 (0.42 mm) sieve.

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Calcium Carbonate Content

Sample No. MW-CAMU-Screened-CC-1 Project SNL Mixed Waste Landfill Cover

Tested by C. Anderson Date of Test 5/25/99

Sample Identification: MW-CAMU Borrow pile - Screened

Calibration of Rapid Carbonate Analyzer

(1)	Carbonate Analyzer identification					UNM-RCA#1
(2)	Date of calibration					5/25/99
(3)	Calibration Measurement A			Calibration Measurement B		
	Weight of $CaCO_3$ (g)	Tare (g)	CO_2 Pressure (kPa)	Weight of $CaCO_3$ (g)	Tare (g)	CO_2 Pressure (kPa)
	0.2019	0.0007	14.2	0.2047	0.0032	13.2
	0.4049	0.0022	26.5	0.4011	0.0072	26.5
	0.6069	0.0021	39.0	0.6088	0.0058	39.0
	0.8039	0.0036	51.3	0.8093	0.0086	52.0
	1.0064	0.0030	55.2	1.0076	0.0087	56.6

Analyzer Calibration Equation:

Weight of $CaCO_3$(g) = [0.0154] X [CO_2 Pressure (kPa)]

Soil Measurement Sample Container No. HYD-5

Test No.	Weight of dry sample (g)	Tare (g)	CO_2 Pressure (kPa)	Computed Weight of $CaCO_3$ (g)	Percentage of $CaCO_3$
1	4.0020	0.0023	12.2	0.18784458	4.69
2	6.0037	0.0027	18.6	0.28639842	4.77
				Average Percentage =	4.7

Note: Sample is pulverized with a mortar and pestle to pass all particles through a No. 40 (0.42 mm) sieve.

File: Cal_Car_MW_CAMU_Screened_cc1.wpd

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Calcium Carbonate Content

Sample No. MW-CAMU-Screened-CC-2

Project SNL Mixed Waste Landfill Cover

Tested by C. Anderson

Date of Test 5/25/99

Sample Identification: MW - CAMU Borrow pile - screened

Calibration of Rapid Carbonate Analyzer

(1)	Carbonate Analyzer identification					UNM-RCA#1
(2)	Date of calibration					5/25/99
(3)	Calibration Measurement A			Calibration Measurement B		
	Weight of $CaCO_3$ (g)	Tare (g)	CO_2 Pressure (kPa)	Weight of $CaCO_3$ (g)	Tare (g)	CO_2 Pressure (kPa)
	0.2019	0.0007	14.2	0.2047	0.0032	13.2
	0.4049	0.0022	26.5	0.4011	0.0072	26.5
	0.6069	0.0021	39.0	0.6088	0.0058	39.0
	0.8039	0.0036	51.3	0.8093	0.0086	52.0
	1.0064	0.0030	55.2	1.0076	0.0087	56.6

Analyzer Calibration Equation:

Weight of $CaCO_3$(g) = [0.0154] X [CO_2 Pressure (kPa)]

Soil Measurement

Sample Container No. HYD-6

Test No.	Weight of dry sample (g)	Tare (g)	CO_2 Pressure (kPa)	Computed Weight of $CaCO_3$ (g)	Percentage of $CaCO_3$
1	4.0059	0.0032	14.2	0.21863072	5.46
2	6.0049	0.0030	21.0	0.3233538	5.38
				Average Percentage =	5.4

Note: Sample is pulverized with a mortar and pestle to pass all particles through a No. 40 (0.42 mm) sieve.

File: Cal_Car_MW_CAMU_Screened_cc2.wpd

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Calcium Carbonate Content

Sample No. MW-CAMU-Unscreened-CC-1 Project SNL Mixed Waste Landfill Cover

Tested by C. Anderson Date of Test 5/25/99

Sample Identification: MW - CAMU Borrow pile - Unscreened

Calibration of Rapid Carbonate Analyzer

(1)	Carbonate Analyzer identification					UNM-RCA#1
(2)	Date of calibration					5/25/99
(3)	Calibration Measurement A			Calibration Measurement B		
	Weight of $CaCO_3$ (g)	Tare (g)	CO_2 Pressure (kPa)	Weight of $CaCO_3$ (g)	Tare (g)	CO_2 Pressure (kPa)
	0.2019	0.0007	14.2	0.2047	0.0032	13.2
	0.4049	0.0022	26.5	0.4011	0.0072	26.5
	0.6069	0.0021	39.0	0.6088	0.0058	39.0
	0.8039	0.0036	51.3	0.8093	0.0086	52.0
	1.0064	0.0030	55.2	1.0076	0.0087	56.6

Analyzer Calibration Equation:

Weight of $CaCO_3$(g) = [0.0154] X [CO_2 Pressure (kPa)]

Soil Measurement Sample Container No. HYD-7

Test No.	Weight of dry sample (g)	Tare (g)	CO_2 Pressure (kPa)	Computed Weight of $CaCO_3$ (g)	Percentage of $CaCO_3$
1	4.0059	0.0022	25.3	0.38958612	9.73
2	6.0061	0.0016	37.8	0.58209536	9.69
				Average Percentage =	9.7

Note: Sample is pulverized with a mortar and pestle to pass all particles through a No. 40 (0.42 mm) sieve.

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Calcium Carbonate Content

Sample No. MW-CAMU-Unscreened-CC-2 Project SNL Mixed Waste Landfill Cover

Tested by C. Anderson Date of Test 5/25/99

Sample Identification: MW - CAMU Borrow pile - Unscreened

Calibration of Rapid Carbonate Analyzer

(1)	Carbonate Analyzer identification					UNM-RCA#1
(2)	Date of calibration					5/25/99
(3)	Calibration Measurement A			Calibration Measurement B		
	Weight of $CaCO_3$ (g)	Tare (g)	CO_2 Pressure (kPa)	Weight of $CaCO_3$ (g)	Tare (g)	CO_2 Pressure (kPa)
	0.2019	0.0007	14.2	0.2047	0.0032	13.2
	0.4049	0.0022	26.5	0.4011	0.0072	26.5
	0.6069	0.0021	39.0	0.6088	0.0058	39.0
	0.8039	0.0036	51.3	0.8093	0.0086	52.0
	1.0064	0.0030	55.2	1.0076	0.0087	56.6

Analyzer Calibration Equation:

Weight of $CaCO_3$(g) = [0.0154] X [CO_2 Pressure (kPa)]

Soil Measurement Sample Container No. HYD-8

Test No.	Weight of dry sample (g)	Tare (g)	CO_2 Pressure (kPa)	Computed Weight of $CaCO_3$ (g)	Percentage of $CaCO_3$
1	4.0086	0.0030	29.2	0.4496338	11.22
2	5.0038	0.0036	36.7	0.56512456	11.29
				Average Percentage =	11.3

Note: Sample is pulverized with a mortar and pestle to pass all particles through a No. 40 (0.42 mm) sieve.

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Calcium Carbonate Content

Sample No. MW-Sites 1 to 4 at 15 to 25 cm

Project SNL Mixed Waste Landfill Cover

Tested by C. Anderson

Date of Test 5/25/99

Sample Identification: MW-West Borrow, Sites 1, 2, 3 & 4 mixed at 15 to 25 cm from surface

Calibration of Rapid Carbonate Analyzer

(1)	Carbonate Analyzer identification					UNM-RCA#1
(2)	Date of calibration					5/25/99
(3)	Calibration Measurement A			Calibration Measurement B		
	Weight of $CaCO_3$ (g)	Tare (g)	CO_2 Pressure (kPa)	Weight of $CaCO_3$ (g)	Tare (g)	CO_2 Pressure (kPa)
	0.2019	0.0007	14.2	0.2047	0.0032	13.2
	0.4049	0.0022	26.5	0.4011	0.0072	26.5
	0.6069	0.0021	39.0	0.6088	0.0058	39.0
	0.8039	0.0036	51.3	0.8093	0.0086	52.0
	1.0064	0.0030	55.2	1.0076	0.0087	56.6

Analyzer Calibration Equation:

Weight of $CaCO_3$(g) = [0.0154] X [CO_2 Pressure (kPa)]

Soil Measurement

Sample Container No. HYD-9

Test No.	Weight of dry sample (g)	Tare (g)	CO_2 Pressure (kPa)	Computed Weight of $CaCO_3$ (g)	Percentage of $CaCO_3$
1	4.0035	0.0038	< 2 **	< 0.03074148	< 0.77
2	10.0073	0.0059	<2 **	< 0.03070914	< 0.31

** No value registered on meter

Average Percentage = < 0.5

Note: Sample is pulverized with a mortar and pestle to pass all particles through a No. 40 (0.42 mm) sieve.

File: Cal_Car_MW_sites_1to4_15to25cm_ccl.wpd

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Calcium Carbonate Content

Sample No. MW-Sites 1 to 4 at 30 to 40 cm Project SNL Mixed Waste Landfill Cover

Tested by C. Anderson Date of Test 5/26/99

Sample Identification: MW-West Borrow, Sites 1, 2, 3 & 4 mixed at 30 to 40 cm from surface

Calibration of Rapid Carbonate Analyzer

(1)	Carbonate Analyzer identification					UNM-RCA#1
(2)	Date of calibration					5/25/99
(3)	Calibration Measurement A			Calibration Measurement B		
	Weight of $CaCO_3$ (g)	Tare (g)	CO_2 Pressure (kPa)	Weight of $CaCO_3$ (g)	Tare (g)	CO_2 Pressure (kPa)
	0.2019	0.0007	14.2	0.2047	0.0032	13.2
	0.4049	0.0022	26.5	0.4011	0.0072	26.5
	0.6069	0.0021	39.0	0.6088	0.0058	39.0
	0.8039	0.0036	51.3	0.8093	0.0086	52.0
	1.0064	0.0030	55.2	1.0076	0.0087	56.6

Analyzer Calibration Equation:

Weight of $CaCO_3$(g) = [0.0154] X [CO_2 Pressure (kPa)]

Soil Measurement Sample Container No. HYD-10

Test No.	Weight of dry sample (g)	Tare (g)	CO_2 Pressure (kPa)	Computed Weight of $CaCO_3$ (g)	Percentage of $CaCO_3$
1	4.0023	0.0038	5.8	0.08926148	2.23
2	8.0025	0.0064	11.3	0.17392144	2.17
				Average Percentage =	2.2

Note: Sample is pulverized with a mortar and pestle to pass all particles through a No. 40 (0.42 mm) sieve.

File: Cal_Car_MW_sites_1to4_30to40cm_cc1.wpd

UNM Geoenvironmental Laboratory
Hydraulic Conductivity Test with Double Ring Compaction Mold Permeameter (Decreasing Head-Water and Increasing Tail-Water Method)

Sample No. MW Borrow-Mix-SHC-1 Project No. SNL Mixed Waste Landfill Cover

Location MW Borrow - West (mixed 1.2.3 and 4) Boring No. _____

Depth of Sample 15 to 45 cm Date of Test 5/9/99

Tested By C. Anderson

Description of Soil _____

Sample Notes Sample directly from Bucket #2. No water added. Mixed in mixer

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[A] **Unit Weight Determination**

(1) Weight of permeameter (mold) ~~with base plate and gasket attached~~ + soil 3746.81 g

(2) Weight of empty permeameter (mold) ~~with base plate and gasket attached~~ 2032.22 g

(3) Weight of soil specimen [(1) - (2)] 1714.59 g

(4) Diameter of soil specimen, D [i.e., inside diameter of permeameter (mold)] 10.12 cm

(5) Cross-sectional area of soil specimen (i.e., $\pi D^2/4$) 80.436 cm²

(6) Length of Soil Specimen in permeameter, L 11.66 cm

(7) Volume of soil specimen [(5) X (6)] 937.884 cm³

(8) Unit weight of Soil specimen (air-dried) [(3) / (7)] 1.828 g/cm³

(9) Water content of soil specimen (air dried)[$(g_1 + g_2) / 2$] 8.545 %

(a)	Can no.	MW-1	MW-2
(b)	Weight of air dried soil + can	83.23 g	77.36 g
(c)	Weight of oven dried soil + can	78.38 g	72.93 g
(d)	Weight of can	21.23 g	21.40 g
(e)	Weight of water	4.85 g	4.43 g
(f)	Weight of oven dried soil	57.15 g	51.53 g
(g)	Water content [(e)/(f) X 100]	g_1 8.49 %	g_2 8.60 %

(10) Dry unit weight of soil specimen [((8) / ((9) + 100)) X 100] 1.684 g/cm³

(11) Specific gravity of soil 2.685

(12) Volume of solids [(7) X (10) / (11)] 588.230 cm³

(13) Volume of voids [(7) - (12)] 349.654 cm³

(14) Void ratio, e, of soil specimen [(13)/(12)] 0.594

(15) Porosity, n [(13) / (7)] 0.373

[B] **Permeameter Dimensions**

(16) Cross-sectional area of headwater standpipe, a $(6.96)^2 \pi/4 = 38.046$ cm²

(17) Cross-sectional area of tailwater pipettes, (Δvolume / Δlength) 9.0cc / 17.95 cm = 0.501 cm²

(18) Cross-sectional area of inner ring, A_i $(7.12)^2 \pi/4 = 39.815$ cm²

(19) Cross-sectional area of outer ring, A_o [(5) - (18)] 40.621 cm

UNM Geoenvironmental Laboratory
Hydraulic Conductivity Test with Double Ring Compaction Mold Permeameter
(Decreasing Head-Water and Increasing Tail-Water Method)

[C] **Permeability Test** Sample No. MW-Borrow-Mix-SHC-1 Length of soil specimen in permeameter, L = 11.66 cm

Trial No.	Initial Time t_1 (hr : min : s)	Final Time t_2 (hr : min : s)	Δ time Δt ($t_2 - t_1$) (s)	Temp. T (°C)	Initial Head-Water Elev. (HW_1) (cm)	Final Head-Water Elev. (HW_2) (cm)	Area of Sect. (Inner and outer) (A_i and A_o) (cm^2)	Initial Tail-Water Elev. (TW_1) (cm)	Final Tail-Water Elev. (TW_2) (cm)	Initial Pipette Vol. (Vol_1) (ml)	Final Pipette Vol. (Vol_2) (ml)
5/10/99 1	6:01 PM 0:00:00	0:07:30	450	22.2	69.9	69.3	i= 39.815	i= 14.7	i= 28.9	i= 9.0	i= 1.81
							o= 40.621	o= 15.5	o= 32.5	o= 8.54	o= 0.0
5/11/99 2	2:04 PM 0:00:00	0:06:10	370	22.0	69.6	69.1	i= 39.815	i= 14.7	i= 28.6	i= 9.0	i= 1.99
							o= 40.621	o= 16.1	o= 32.6	o= 8.25	o= 0.0
5/13/99 3	12:58 AM 0:00:00	0:05:13	313	22.8	69.6	69.0	i= 39.815	i= 14.7	i= 28.2	i= 9.0	i= 2.28
							o= 40.621	o= 16.1	o= 32.6	o= 8.22	o= 0.0
5/13/99 4	12:59 PM 0:00:00	0:05:02	302	22.2	69.6	69.0	i= 39.815	i= 14.7	i= 27.5	i= 9.0	i= 2.59
							o= 40.621	o= 16.4	o= 32.8	o= 8.10	o= 0.0
5/13/99 5	6:20 PM 0:00:00	0:04:57	297	23.8	69.6	69.0	i= 39.815	i= 14.6	i= 27.4	i= 9.0	i= 2.62
							o= 40.621	o= 15.8	o= 32.6	o= 8.38	o= 0.0

Trial No. L= 11.66	ΔVol (Vol_1-Vol_2) (ml)	Initial Head Loss, h_1 (HW_1-TW_1) (cm)	Final Head Loss, h_2 (HW_2-TW_2) (cm)	Hydraulic Conductivity @ T °C K_T (cm/s)	Viscosity Correction Factor R_T	Hydraulic Conductivity, K @ 20 °C (cm/s)	Location
5/10/99 1	7.19	55.2	40.4	0.00009868	0.9486	0.00009361	Inside
	8.54	54.4	36.8	0.00012098		0.00011476	Outside
5/11/99 2	7.01	54.9	40.5	0.00011721	0.9530	0.00011171	Inside
	8.25	53.5	36.5	0.00014396		0.00013719	Outside
5/13/99 3	6.72	54.9	40.8	0.00013236	0.9354	0.00012381	Inside
	8.22	53.5	36.4	0.00016977		0.00015881	Outside
5/13/99 4	6.41	54.9	41.5	0.00012980	0.9486	0.00012313	Inside
	8.10	53.2	36.4	0.00017391		0.00016497	Outside
5/13/99 5	6.38	55.0	41.6	0.00013109	0.9142	0.00011984	Inside
	8.38	53.8	36.4	0.00018186		0.00016626	Outside

Hydraulic Conductivity (cm/s)	Recommended Maximum Hydraulic Gradient
1×10^{-7} to 1×10^{-8}	2
1×10^{-8} to 1×10^{-9}	5
1×10^{-9} to 1×10^{-10}	10
1×10^{-10} to 1×10^{-11}	20
less than 1×10^{-11}	30

Correction Factor, R_T, for Viscosity of Water at Various Temperatures

Temp. (°C)	R_T	Temp. (°C)	R_T
16	1.106	24	0.910
17	1.077	25	0.889
18	1.051	26	0.869
19	1.025	27	0.850
20	1.000	28	0.832
21	0.976	29	0.814
22	0.953	30	0.797
23	0.931	31	0.780

$K_T = [(\Delta Vol) \times (L) / ((A) \times (\Delta t) \times (h_1 - h_2))] \times \ln (h_1 / h_2)$

Ave. Inner K = See Page 3 (cm/s)

Ave. Outer K = See Page 3 (cm/s)

Where: $A = A_i$ or A_o, $\Delta Vol = \Delta Vol_i$ or ΔVol_o, $\Delta t = \Delta$ time $= t_2 - t_1$
h_1 = Head loss across specimen at $t_1 = HW_1 - TW_1$
h_2 = Head loss across specimen at $t_2 = HW_2 - TW_2$

UNM Geoenvironmental Laboratory
Hydraulic Conductivity Test with Double Ring Compaction Mold Permeameter
(Decreasing Head-Water and Increasing Tail-Water Method)

[C] Permeability Test Sample No. MW-Borrow-Mix-SHC-1 Length of soil specimen in permeameter, L = 11.66 cm

Trial No.	Initial Time t_1 (hr : min : s)	Final Time t_2 (hr : min : s)	Δ time Δ t ($t_2 - t_1$) (s)	Temp. T (°C)	Initial Head-Water Elev. (HW_1) (cm)	Final Head-Water Elev. (HW_2) (cm)	Area of Sect. (inner and outer) (A_i and A_o) (cm^2)	Initial Tail-Water Elev. (TW_1) (cm)	Final Tail-Water Elev. (TW_2) (cm)	Initial Pipette Vol. (Vol_1) (ml)	Final Pipette Vol. (Vol_2) (ml)
5/14/99 6	9:35 AM 0:00:00	0:04.41	281	23.2	69.6	69.0	i= 39.815	i= 14.7	i= 26.9	i= 9.0	i= 2.88
							o= 40.621	o= 15.3	o= 32.5	o= 8.65	o= -0.01
5/14/99 7	3:43 PM 0:00:00	0:04.41	281	23.0	69.6	69.0	i= 39.815	i= 14.7	i= 27.0	i= 9.0	i= 2.83
							o= 40.621	o= 15.8	o= 32.5	o= 8.40	o= -0.01
							i=	i=	i=	i=	i=
							o=	o=	o=	o=	o=
							i=	i=	i=	i=	i=
							o=	o=	o=	o=	o=
							i=	i=	i=	i=	i=
							o=	o=	o=	o=	o=

Trial No. L= 11.66	ΔVol (Vol_1-Vol_2) (ml)	Initial Head Loss, h_1 (HW_1-TW_1) (cm)	Final Head Loss, h_2 (HW_2-TW_2) (cm)	Hydraulic Conductivity @ T °C K_T (cm/s)	Viscosity Correction Factor R_T	Hydraulic Conductivity, K @ 20 °C (cm/s)	Location
5/14/99 6	6.12	54.9	42.1	0.00013228	0.9268	0.00012260	Inside
	8.66	54.3	36.5	0.00019741		0.00018296	Outside
5/14/99 7	6.17	54.9	42.0	0.00013351	0.9310	0.00012430	Inside
	8.41	53.8	36.5	0.00019265		0.00017936	Outside
	i=	i=	i=	i=		i=	Inside
	o=	o=	o=	o=		o=	Outside
	i=	i=	i=	i=		i=	Inside
	o=	o=	o=	o=		o=	Outside
	i=	i=	i=	i=		i=	Inside
	o=	o=	o=	o=		o=	Outside

Hydraulic Conductivity (cm/s)	Recommended Maximum Hydraulic Gradient
1×10^{-7} to 1×10^{-8}	2
1×10^{-8} to 1×10^{-9}	5
1×10^{-9} to 1×10^{-10}	10
1×10^{-10} to 1×10^{-11}	20
less than 1×10^{-11}	30

Correction Factor, R_T, for Viscosity of Water at Various Temperatures

Temp. (°C)	R_T	Temp. (°C)	R_T
16	1.106	24	0.910
17	1.077	25	0.889
18	1.051	26	0.869
19	1.025	27	0.850
20	1.000	28	0.832
21	0.976	29	0.814
22	0.953	30	0.797
23	0.931	31	0.780

$K_T = [(\Delta Vol) \times (L) / ((A) \times (\Delta t) \times (h_1 - h_2))] \times \ln (h_1 / h_2)$

Ave. Inner K (#4-7) = 0.0001218 (cm/s)

Ave. Outer K (#4-7) = 0.0001725 (cm/s)

Where: $A = A_i$ or A_o, $\Delta Vol = \Delta Vol_i$ or ΔVol_o, $\Delta t = \Delta$ time $= t_2 - t_1$
h_1 = Head loss across specimen at $t_1 = HW_1 - TW_1$
h_2 = Head loss across specimen at $t_2 = HW_2 - TW_2$

UNM Geoenvironmental Laboratory
Hydraulic Conductivity Test with Double Ring Compaction Mold Permeameter (Decreasing Head-Water and Increasing Tail-Water Method)

Sample No. MW Borrow-Mix-SHC-2 Project No. SNL Mixed Waste Landfill Cover

Location MW Borrow - West (mixed 1, 2, 3 and 4) Boring No. _____

Depth of Sample 15 to 45 cm Date of Test 5/9/99

Tested By C. Anderson

Description of Soil _____

Sample Notes Sample from Bucket #2. Half of soil oven dried, then blended with half of Soil directly from Bucket #2. Water added to bring sample to 5% (approximate) grav. moisture.

[A] Unit Weight Determination

(1) Weight of permeameter (mold) ~~with base plate and gasket attached~~ + soil 3514.33 g

(2) Weight of empty permeameter (mold) ~~with base plate and gasket attached~~ 1994.23 g

(3) Weight of soil specimen [(1) - (2)] 1520.10 g

(4) Diameter of soil specimen, D [i.e., inside diameter of permeameter (mold)] 10.14 cm

(5) Cross-sectional area of soil specimen (i.e., $\pi D^2/4$) 80.754 cm^2

(6) Length of Soil Specimen in permeameter, L 11.59 cm

(7) Volume of soil specimen [(5) X (6)] 935.94 cm^3

(8) Unit weight of Soil specimen (air-dried) [(3) / (7)] 1.624 g/cm^3

(9) Water content of soil specimen (air dried)[$(g_1 + g_2) / 2$] 4.89 %

(a)		Can no. MW-3	Can no. MW-4
(b)	Weight of air dried soil + can	109.31 g	98.49 g
(c)	Weight of oven dried soil + can	105.23 g	94.88 g
(d)	Weight of can	20.99 g	21.63 g
(e)	Weight of water	4.08 g	3.61 g
(f)	Weight of oven dried soil	84.24 g	73.25 g
(g)	Water content [(e)/(f) X 100]	g_1 4.84 %	g_2 4.93 %

(10) Dry unit weight of soil specimen [((8) / ((9) + 100)) X 100] 1.548 g/cm^3

(11) Specific gravity of soil 2.685

(12) Volume of solids [(7) X (10) / (11)] 539.603 cm^3

(13) Volume of voids [(7) - (12)] 396.337 cm^3

(14) Void ratio, e, of soil specimen [(13)/(12)] 0.734

(15) Porosity, n [(13) / (7)] 0.423

[B] Permeameter Dimensions

(16) Cross-sectional area of headwater standpipe, a $(6.96)^2 \pi/4 = 38.046$ cm^2

(17) Cross-sectional area of tailwater pipettes, (Δvolume / Δlength) 9.0cc / 17.95 cm = 0.501 cm^2

(18) Cross-sectional area of inner ring, A_i $(7.12)^2 \pi/4 = 39.815$ cm^2

(19) Cross-sectional area of outer ring, A_o [(5) - (18)] 40.939 cm

UNM Geoenvironmental Laboratory
Hydraulic Conductivity Test with Double Ring Compaction Mold Permeameter
(Decreasing Head-Water and Increasing Tail-Water Method)

[C] Permeability Test Sample No. MW-Borrow-Mix-SHC-2 Length of soil specimen in permeameter, L = 11.59 cm

Trial No.	Initial Time t_1 (hr : min : s)	Final Time t_2 (hr : min : s)	Δ time Δt ($t_2 - t_1$) (s)	Temp. T (°C)	Initial Head-Water Elev. (HW_1) (cm)	Final Head-Water Elev. (HW_2) (cm)	Area of Sect. (inner and outer) (A_i and A_o) (cm²)	Initial Tail-Water Elev. (TW_1) (cm)	Final Tail-Water Elev. (TW_2) (cm)	Initial Pipette Vol. (Vol_1) (ml)	Final Pipette Vol. (Vol_2) (ml)
5/10/99 1	6:28 PM 0:00:00	0:03:51	231	21.9	69.7	69.1	i= 39.815	i= 14.8	i= 31.4	i= 9.0	i= 0.65
							o= 40.939	o= 15.5	o= 32.5	o= 8.56	o= 0.0
5/11/99 2	2:15 PM 0:00:00	0:03:25	205	21.9	69.7	69.1	i= 39.815	i= 14.8	i= 31.9	i= 9.0	i= 0.38
							o= 40.939	o= 15.0	o= 32.5	o= 8.60	o= 0.01
5/13/99 3	1:14 AM 0:00:00	0:02:36	156	22.8	69.8	69.2	i= 39.815	i= 14.8	i= 31.7	i= 9.0	i= 0.46
							o= 40.939	o= 15.0	o= 32.6	o= 8.60	o= 0.0
5/13/99 4	1:16 PM 0:00:00	0:02:15	135	22.3	69.7	69.1	i= 39.815	i= 14.8	i= 30.6	i= 9.0	i= 1.03
							o= 40.939	o= 15.5	o= 32.5	o= 8.50	o= 0.0
5/13/99 5	6:36 PM 0:00:00	0:02:03	123	23.6	69.7	69.1	i= 39.815	i= 14.8	i= 29.7	i= 9.0	i= 1.50
							o= 40.939	o= 16.1	o= 32.6	o= 8.25	o= -0.01

Trial No. L= 11.59	ΔVol (Vol_1-Vol_2) (ml)	Initial Head Loss, h_1 (HW_1-TW_1) (cm)	Final Head Loss, h_2 (HW_2-TW_2) (cm)	Hydraulic Conductivity @ T °C K_T (cm/s)	Viscosity Correction Factor R_T	Hydraulic Conductivity, K @ 20 °C (cm/s)	Location
5/10/99 1	8.35	54.9	37.7	0.00022993	0.9553	0.00021965	Inside
	8.56	54.2	36.6	0.00023404		0.00022357	Outside
5/11/99 2	8.62	54.9	37.2	0.00026915	0.9553	0.00025712	Inside
	8.79	54.7	36.6	0.00026948		0.00025744	Outside
5/13/99 3	8.54	55.0	37.5	0.00034876	0.9354	0.00032623	Inside
	8.80	54.8	36.6	0.00035418		0.00033130	Outside
5/13/99 4	7.97	54.9	38.5	0.00037165	0.9464	0.00035192	Inside
	8.50	54.2	36.6	0.00039765		0.00037634	Outside
5/13/99 5	7.50	54.9	39.4	0.00037990	0.9184	0.00034890	Inside
	8.26	53.6	36.5	0.00042719		0.00039233	Outside

Hydraulic Conductivity (cm/s)	Recommended Maximum Hydraulic Gradient
1×10^{-7} to 1×10^{-8}	2
1×10^{-8} to 1×10^{-9}	5
1×10^{-9} to 1×10^{-10}	10
1×10^{-10} to 1×10^{-11}	20
less than 1×10^{-11}	30

Correction Factor, R_T, for Viscosity of Water at Various Temperatures

Temp. (°C)	R_T	Temp. (°C)	R_T
16	1.106	24	0.910
17	1.077	25	0.889
18	1.051	26	0.869
19	1.025	27	0.850
20	1.000	28	0.832
21	0.976	29	0.814
22	0.953	30	0.797
23	0.931	31	0.780

$K_T = [(\Delta Vol) \times (L) / ((A) \times (\Delta t) \times (h_1 - h_2))] \times \ln (h_1 / h_2)$

Where: $A = A_i$ or A_o, $\Delta Vol = \Delta Vol_i$ or ΔVol_o, $\Delta t = \Delta$ time $= t_2 - t_1$
h_1 = Head loss across specimen at $t_1 = HW_1 - TW_1$
h_2 = Head loss across specimen at $t_2 = HW_2 - TW_2$

Ave. Inner K = See Page 5 (cm/s)

Ave. Outer K = See Page 5 (cm/s)

UNM Geoenvironmental Laboratory
Hydraulic Conductivity Test with Double Ring Compaction Mold Permeameter
(Decreasing Head-Water and Increasing Tail-Water Method)

[C] Permeability Test Sample No. MW-Borrow-Mix-SHC-2 Length of soil specimen in permeameter, L = 11.59 cm

Trial No.	Initial Time t_1 (hr : min : s)	Final Time t_2 (hr : min : s)	Δ time Δ t ($t_2 - t_1$) (s)	Temp. T (°C)	Initial Head-Water Elev. (HW_1) (cm)	Final Head-Water Elev. (HW_2) (cm)	Area of Sect. (Inner and outer) (A_i and A_o) (cm^2)	Initial Tail-Water Elev. (TW_1) (cm)	Final Tail-Water Elev. (TW_2) (cm)	Initial Pipette Vol. (Vol_1) (ml)	Final Pipette Vol. (Vol_2) (ml)
5/14/99 6	9:50 AM 0:00:00	0:01:47	107	23.0	69.7	69.2	i= 39.815	i= 14.9	i= 28.9	i= 9.0	i= 1.95
							o= 40.939	o= 15.6	o= 32.7	o= 8.5	o= -0.01
5/14/99 7	3:58 PM 0:00:00	0:01:47	107	23.2	69.7	69.1	i= 39.815	i= 14.8	i= 29.5	i= 9.0	i= 1.60
							o= 40.939	o= 15.5	o= 32.6	o= 8.55	o= -0.02
5/15/99 8	11:65 AM 0:00:00	0:01:32	92	21.9	69.6	69.0	i= 39.815	i= 14.8	i= 28.4	i= 9.0	i= 2.15
							o= 40.939	o= 15.1	o= 32.7	o= 8.70	o= -0.08
5/15/99 9	6:25 PM 0:00:00	0:01:18	78	25.0	69.7	69.2	i= 39.815	i= 14.8	i= 28.2	i= 9.0	i= 2.30
							o= 40.939	o= 15.2	o= 33.1	o= 8.70	o= -0.31
5/16/99 10	8:44 AM 0:00:00	0:01:06	66	23.8	69.7	69.1	i= 39.815	i= 14.7	i= 27.1	i= 9.0	i= 2.74
							o= 40.939	o= 16.2	o= 32.8	o= 8.20	o= -0.03

Trial No. L= 11.59	ΔVol (Vol_1-Vol_2) (ml)	Initial Head Loss, h_1 (HW_1-TW_1) (cm)	Final Head Loss, h_2 (HW_2-TW_2) (cm)	Hydraulic Conductivity @ T °C K_T (cm/s)	Viscosity Correction Factor R_T	Hydraulic Conductivity, K @ 20 °C (cm/s)	Location
5/14/99 6	7.05	54.8	40.3	0.00040653	0.9310	0.00037848	Inside
	8.51	54.1	36.5	0.00050344		0.00046870	Outside
5/14/99 7	7.40	54.9	39.6	0.00042985	0.9248	0.00039753	Inside
	8.57	54.2	36.5	0.00050649		0.00046840	Outside
5/15/99 8	6.85	54.8	40.6	0.00046778	0.9553	0.00043732	Inside
	8.78	54.5	36.3	0.00060328		0.00057631	Outside
5/15/99 9	6.70	54.9	41.0	0.00052517	0.8890	0.00046687	Inside
	9.01	54.5	36.1	0.00073208		0.00065082	Outside
5/16/99 10	6.26	55.0	42.0	0.00057272	0.9142	0.00052359	Inside
	8.23	53.5	36.5	0.00079403		0.00072590	Outside

Hydraulic Conductivity (cm/s)	Recommended Maximum Hydraulic Gradient
1×10^{-7} to 1×10^{-9}	2
1×10^{-8} to 1×10^{-9}	5
1×10^{-9} to 1×10^{-10}	10
1×10^{-10} to 1×10^{-11}	20
less than 1×10^{-11}	30

Correction Factor, R_T, for Viscosity of Water at Various Temperatures

Temp. (°C)	R_T	Temp. (°C)	R_T
16	1.106	24	0.910
17	1.077	25	0.889
18	1.051	26	0.869
19	1.025	27	0.850
20	1.000	28	0.832
21	0.978	29	0.814
22	0.953	30	0.797
23	0.931	31	0.780

$K_T = [(\Delta Vol) \times (L) / ((A) \times (\Delta t) \times (h_1 - h_2))] \times \ln (h_1 / h_2)$

Where: $A = A_i$ or A_o, $\Delta Vol = \Delta Vol_i$ or ΔVol_o, $\Delta t = \Delta$ time $= t_2 - t_1$
h_1 = Head loss across specimen at $t_1 = HW_1 - TW_1$
h_2 = Head loss across specimen at $t_2 = HW_2 - TW_2$

Ave. Inner K = See Page 5 (cm/s)

Ave. Outer K = See Page 5 (cm/s)

UNM Geoenvironmental Laboratory
Hydraulic Conductivity Test with Double Ring Compaction Mold Permeameter
(Decreasing Head-Water and Increasing Tail-Water Method)

C] Permeability Test Sample No. MW-Borrow-Mix-SHC-2 Length of soil specimen in permeameter, L = 11.59 cm

Trial No. L= 11.59	Initial Time t_1 (hr : min : s)	Final Time t_2 (hr : min : s)	Δ time Δ t ($t_2 - t_1$) (s)	Temp. T (°C)	Initial Head-Water Elev. (HW_1) (cm)	Final Head-Water Elev. (HW_2) (cm)	Area of Sect. (inner and outer) (A_i and A_o) (cm^2)	Initial Tail-Water Elev. (TW_1) (cm)	Final Tail-Water Elev. (TW_2) (cm)	Initial Pipette Vol. (Vol_1) (ml)	Final Pipette Vol. (Vol_2) (ml)
5/16/99 11	12:47 PM 0:00:00	0:01:08	68	23.0	69.8	69.3	i= 39.815	i= 14.8	i= 27.1	i= 9.0	i= 2.82
							o= 40.939	o= 15.8	o= 32.6	o= 8.35	o= -0.03
5/16/99 12	5:11 PM 0:00:00	0:01:07	67	23.3	69.9	69.3	i= 39.815	i= 14.8	i= 27.5	i= 9.0	i= 2.61
							o= 40.939	o= 15.3	o= 32.8	o= 8.60	o= -0.04
5/16/99 13	9:48 PM 0:00:00	0:01:07	67	24.1	69.7	69.1	i= 39.815	i= 14.8	i= 27.8	i= 9.0	i= 2.48
							o= 40.939	o= 15.5	o= 32.7	o= 8.50	o= -0.03
5/17/99 14	11:53 AM 0:00:00	0:03:56	236	23.6	44.8	44.0	i= 39.815	i= 14.8	i= 31.3	i= 9.0	i= 0.62
							o= 40.939	o= 15.3	o= 32.6	o= 8.65	o= 0.00
5/17/99 15	2:24 PM 0:00:00	0:04:05	245	23.2	44.6	44.1	i= 39.815	i= 14.7	i= 31.5	i= 9.0	i= 0.69
							o= 40.939	o= 15.8	o= 32.5	o= 8.40	o= 0.00

Trial No. L= 11.59	ΔVol (Vol_1-Vol_2) (ml)	Initial Head Loss, h_1 (HW_1-TW_1) (cm)	Final Head Loss, h_2 (HW_2-TW_2) (cm)	Hydraulic Conductivity @ T °C K_T (cm/s)	Viscosity Correction Factor R_T	Hydraulic Conductivity, K @ 20 °C (cm/s)	Location
5/16/99 11	6.18	55.0	42.2	0.00056412	0.9310	0.00052520	Inside
	8.38	54.0	36.7	0.00080245		0.00074709	Outside
5/16/99 12	6.39	55.1	41.8	0.00057866	0.9247	0.00053324	Inside
	8.64	54.6	36.7	0.00081022		0.00074921	Outside
5/16/99 13	6.52	54.9	41.3	0.00059290	0.9079	0.00053830	Inside
	8.53	54.2	36.4	0.00080613		0.00073189	Outside
5/17/99 14	8.38	29.8	12.7	0.00051555	0.9184	0.00047348	Inside
	8.65	29.3	11.5	0.00054520		0.00050071	Outside
5/17/99 15	8.41	29.9	12.6	0.00049913	0.9266	0.00046260	Inside
	8.40	28.8	11.6	0.00051318		0.00047562	Outside

Hydraulic Conductivity (cm/s)	Recommended Maximum Hydraulic Gradient
1×10^{-7} to 1×10^{-8}	2
1×10^{-8} to 1×10^{-9}	5
1×10^{-9} to 1×10^{-10}	10
1×10^{-10} to 1×10^{-11}	20
less than 1×10^{-11}	30

Correction Factor, R_T, for Viscosity of Water at Various Temperatures

Temp. (°C)	R_T	Temp. (°C)	R_T
16	1.106	24	0.910
17	1.077	25	0.889
18	1.051	26	0.869
19	1.025	27	0.850
20	1.000	28	0.832
21	0.976	29	0.814
22	0.953	30	0.797
23	0.931	31	0.780

$K_T = [(\Delta Vol) \times (L) / ((A) \times (\Delta t) \times (h_1 - h_2))] \times \ln (h_1 / h_2)$

Ave. Inner K = See Page 5 (cm/s)

Ave. Outer K = See Page 5 (cm/s)

Where: $A = A_i$ or A_o, $\Delta Vol = \Delta Vol_i$ or ΔVol_o, $\Delta t = \Delta$ time $= t_2 - t_1$
h_1 = Head loss across specimen at $t_1 = HW_1 - TW_1$
h_2 = Head loss across specimen at $t_2 = HW_2 - TW_2$

UNM Geoenvironmental Laboratory
Hydraulic Conductivity Test with Double Ring Compaction Mold Permeameter
(Decreasing Head-Water and Increasing Tail-Water Method)

C) Permeability Test Sample No. MW-Borrow-Mix-SHC-2 Length of soil specimen in permeameter, L = 11.59 cm

Trial No. L= 11.59	Initial Time t_1 (hr : min : s)	Final Time t_2 (hr : min : s)	Δ time Δ t (t_2 - t_1) (s)	Temp. T (°C)	Initial Head-Water Elev. (HW_1) (cm)	Final Head-Water Elev. (HW_2) (cm)	Area of Sect. (inner and outer) (A_i and A_o) (cm²)	Initial Tail-Water Elev. (TW_1) (cm)	Final Tail-Water Elev. (TW_2) (cm)	Initial Pipette Vol. (Vol_1) (ml)	Final Pipette Vol. (Vol_2) (ml)
5/17/99 16	4:39 PM 0:00:00	0:04:16	256	23.2	44.4	43.8	i= 39.815	i= 14.7	i= 31.4	i= 9.0	i= 0.62
							o= 40.939	o= 15.6	o= 32.6	o= 8.5	o= 0.0
5/17/99 17	6:41 PM 0:00:00	0:04:16	256	23.3	44.6	44.0	i= 39.815	i= 14.7	i= 31.6	i= 9.0	i= 0.53
							o= 40.939	o= 15.6	o= 32.6	o= 8.45	o= 0.0
5/18/99 18	10:22 AM 0:00:00	0:03:35	215	22.0	44.5	43.9	i= 39.815	i= 14.8	i= 32.2	i= 9.0	i= 0.20
							o= 40.939	o= 14.8	o= 32.5	o= 8.90	o= 0.00

Trial No. L= 11.59	ΔVol (Vol_1-Vol_2) (ml)	Initial Head Loss, h_1 (HW_1-TW_1) (cm)	Final Head Loss, h_2 (HW_2-TW_2) (cm)	Hydraulic Conductivity @ T °C K_T (cm/s)	Viscosity Correction Factor R_T	Hydraulic Conductivity, K @ 20 °C (cm/s)	Location
5/17/99 16	8.38	29.7	12.4	0.00048110	0.9268	0.00044588	Inside
	8.50	28.8	11.2	0.00050443		0.00046750	Outside
5/17/99 17	8.47	29.9	12.4	0.00048440	0.9247	0.00044793	Inside
	8.45	29.0	11.4	0.00049573		0.00045841	Outside
5/18/99 18	8.80	29.7	11.7	0.00061662	0.9530	0.00058764	Inside
	8.90	29.7	11.4	0.00061320		0.00058438	Outside
							Inside
							Outside
							Inside
							Outside

Hydraulic Conductivity (cm/s)	Recommended Maximum Hydraulic Gradient
1×10^{-7} to 1×10^{-8}	2
1×10^{-8} to 1×10^{-9}	5
1×10^{-9} to 1×10^{-10}	10
1×10^{-10} to 1×10^{-11}	20
less than 1×10^{-11}	30

Correction Factor, R_T, for Viscosity of Water at Various Temperatures

Temp. (°C)	R_T	Temp. (°C)	R_T
16	1.106	24	0.910
17	1.077	25	0.889
18	1.051	26	0.869
19	1.025	27	0.850
20	1.000	28	0.832
21	0.976	29	0.814
22	0.953	30	0.797
23	0.931	31	0.780

$K_T = [(\Delta Vol) \times (L) / ((A) \times (\Delta t) \times (h_1 - h_2))] \times \ln (h_1 / h_2)$

Ave. Inner K (#14-17) = 0.000445 (cm/s)

Ave. Outer K (#14-17)= 0.000462 (cm/s)

Where: $A = A_i$ or A_o, $\Delta Vol = \Delta Vol_i$ or ΔVol_o, $\Delta t = \Delta$ time $= t_2 - t_1$
h_1 = Head loss across specimen at $t_1 = HW_1 - TW_1$
h_2 = Head loss across specimen at $t_2 = HW_2 - TW_2$

UNM Geoenvironmental Laboratory
Hydraulic Conductivity Test with Double Ring Compaction Mold Permeameter (Decreasing Head-Water and Increasing Tail-Water Method)

Sample No. MW Borrow-Mix-SHC-3 Project No. SNL Mixed Waste Landfill Cover

Location MW Borrow - West (mixed 1, 2, 3 and 4) Boring No. _____

Depth of Sample 15 to 45 cm Date of Test 5/18/99

Tested By C. Anderson

Description of Soil Mixed Sample from Sites 1, 2, 3, & 4

Sample Notes Soil from Bucket #4. 25% of soil oven dried, then blended with 75% of soil directly from Bucket #4 to obtain 6.7% (approximate) grav. moisture - screened 3/8" sieve.

[A] **Unit Weight Determination**

(1) Weight of permeameter (mold) ~~with base plate and gasket attached~~ + soil 3633.98 g

(2) Weight of empty permeameter (mold) ~~with base plate and gasket attached~~ 1993.93 g

(3) Weight of soil specimen [(1) - (2)] 1640.05 g

(4) Diameter of soil specimen, D [i.e., inside diameter of permeameter (mold)] 10.13 cm

(5) Cross-sectional area of soil specimen (i.e., $\pi D^2/4$) 80.595 cm^2

(6) Length of Soil Specimen in permeameter, L 11.60 cm

(7) Volume of soil specimen [(5) X (6)] 934.90 cm^3

(8) Unit weight of Soil specimen (air-dried) [(3) / (7)] 1.754 g/cm^3

(9) Water content of soil specimen (air dried)[$(g_1 + g_2)$ / 2] 6.08 %

(a)		Can no. MW-3	Can no. MW-4
(b)	Weight of air dried soil + can	96.22 g	93.19 g
(c)	Weight of oven dried soil + can	91.96 g	89.04 g
(d)	Weight of can	20.99 g	21.64 g
(e)	Weight of water	4.26 g	4.15 g
(f)	Weight of oven dried soil	70.97 g	67.40 g
(g)	Water content [(e)/(f) X 100]	g_1 6.003 %	g_2 6.157 %

(10) Dry unit weight of soil specimen [((8) / ((9) + 100)) X 100] 1.654 g/cm^3

(11) Specific gravity of soil 2.685

(12) Volume of solids [(7) X (10) / (11)] 575.912 cm^3

(13) Volume of voids [(7) - (12)] 358.988 cm^3

(14) Void ratio, e, of soil specimen [(13)/(12)] 0.623

(15) Porosity, n [(13) / (7)] 0.384

[B] **Permeameter Dimensions**

(16) Cross-sectional area of headwater standpipe, a $(6.96)^2 \pi/4 = 38.046$ cm^2

(17) Cross-sectional area of tailwater pipettes, (Δvolume / Δlength) 9.0cc / 17.95 cm = 0.501 cm^2

(18) Cross-sectional area of inner ring, A_i $(7.12)^2 \pi/4 = 39.815$ cm^2

(19) Cross-sectional area of outer ring, A_o [(5) - (18)] 40.780 cm

UNM Geoenvironmental Laboratory
Hydraulic Conductivity Test with Double Ring Compaction Mold Permeameter
(Decreasing Head-Water and Increasing Tail-Water Method)

C) Permeability Test Sample No. MW Borrow-Mix-SHC-3 Length of soil specimen in permeameter, L = 11.60 cm

Trial No.	Initial Time t_1 (hr : min : s)	Final Time t_2 (hr : min : s)	Δ time Δ t (t_2 - t_1) (s)	Temp. T (°C)	Initial Head-Water Elev. (HW_1) (cm)	Final Head-Water Elev. (HW_2) (cm)	Area of Secl. (Inner and outer) (A_i and A_o) (cm^2)	Initial Tail-Water Elev. (TW_1) (cm)	Final Tail-Water Elev. (TW_2) (cm)	Initial Pipette Vol. (Vol_1) (ml)	Final Pipette Vol. (Vol_2) (ml)
5/23/99 1	1:49 PM 0:00:00	0:05:20	320	22.7	69.6	68.9	i= 39.815	i= 14.8	i= 31.5	i= 9.0	i= 0.60
							o= 40.780	o= 14.6	o= 32.5	o=9.0	o= 0.0
5/23/99 2	9:43 PM 0:00:00	0:04:57	297	23.0	69.8	69.2	i= 39.815	i= 14.7	i= 32.4	i= 9.0	i= 0.11
							o= 40.780	o= 14.8	o= 32.6	o= 8.9	o= 0.0
5/24/99 3	1:45 AM 0:00:00	0:04:49	289	23.0	69.8	69.3	i= 39.815	i= 14.7	i= 32.2	i= 9.0	i= 0.20
							o= 40.780	o= 14.8	o= 32.5	o= 8.9	o= 0.02
5/24/99 4	6:48 PM 0:00:00	0:04:45	285	22.6	69.7	69.2	i= 39.815	i= 14.8	i= 32.6	i= 8.95	i= 0.04
							o= 40.780	o= 14.7	o= 32.6	o= 9.0	o= -0.02
5/25/99 5	7:48 PM 0:00:00	0:04:33	273	22.8	68.3	67.7	i= 39.815	i= 14.7	i= 32.4	i= 9.0	i= 0.08
							o= 40.780	o= 14.7	o= 32.4	o= 8.9	o= 0.02

Trial No. L= 11.60	ΔVol (Vol_1-Vol_2) (ml)	Initial Head Loss, h_1 (HW_1-TW_1) (cm)	Final Head Loss, h_2 (HW_2-TW_2) (cm)	Hydraulic Conductivity @ T °C K_T (cm/s)	Viscosity Correction Factor R_T	Hydraulic Conductivity, K @ 20 °C (cm/s)	Location
5/10/99 1	8.40	54.8	37.4	0.00016791	0.9376	0.00015743	Inside
	9.00	55.0	36.4	0.00017754		0.00016646	Outside
5/11/99 2	8.89	55.1	36.8	0.00019236	0.9310	0.00017909	Inside
	8.90	55.0	36.6	0.00018868		0.00017566	Outside
5/13/99 3	8.80	55.1	37.1	0.00019494	0.9310	0.00018149	Inside
	8.88	55.0	36.8	0.00019298		0.00017966	Outside
5/13/99 4	8.91	54.9	36.7	0.00020156	0.9398	0.00018942	Inside
	9.02	55.0	36.6	0.00019928		0.00018728	Outside
5/13/99 5	8.92	53.6	35.3	0.00021727	0.9398	0.00020419	Inside
	8.88	53.6	35.3	0.00021117		0.00019846	Outside

Hydraulic Conductivity (cm/s)	Recommended Maximum Hydraulic Gradient
1×10^{-7} to 1×10^{-8}	2
1×10^{-8} to 1×10^{-9}	5
1×10^{-9} to 1×10^{-10}	10
1×10^{-10} to 1×10^{-11}	20
less than 1×10^{-11}	30

Correction Factor, R_T, for Viscosity of Water at Various Temperatures

Temp. (°C)	R_T	Temp. (°C)	R_T
16	1.106	24	0.910
17	1.077	25	0.889
18	1.051	26	0.869
19	1.025	27	0.850
20	1.000	28	0.832
21	0.976	29	0.814
22	0.953	30	0.797
23	0.931	31	0.780

$K_T = [(\Delta Vol) \times (L) / ((A) \times (\Delta t) \times (h_1 - h_2))] \times \ln (h_1 / h_2)$

Ave. Inner K = See Page 3 (cm/s)

Ave. Outer K = See Page 3 (cm/s)

Where: $A = A_i$ or A_o, $\Delta Vol = \Delta Vol_i$ or ΔVol_o, $\Delta t = \Delta$ time $= t_2 - t_1$
h_1 = Head loss across specimen at $t_1 = HW_1 - TW_1$
h_2 = Head loss across specimen at $t_2 = HW_2 - TW_2$

UNM Geoenvironmental Laboratory
Hydraulic Conductivity Test with Double Ring Compaction Mold Permeameter
(Decreasing Head-Water and Increasing Tail-Water Method)

C] Permeability Test Sample No. MW Borrow-Mix-SHC-3 Length of soil specimen in permeameter, L = 11.60 cm

Trial No.	Initial Time t_1 (hr : min : s)	Final Time t_2 (hr : min : s)	Δ time Δ t ($t_2 - t_1$) (s)	Temp. T (°C)	Initial Head-Water Elev. (HW_1) (cm)	Final Head-Water Elev. (HW_2) (cm)	Area of Sect. (Inner and outer) (A_i and A_o) (cm^2)	Initial Tail-Water Elev. (TW_1) (cm)	Final Tail-Water Elev. (TW_2) (cm)	Initial Pipette Vol. (Vol_1) (ml)	Final Pipette Vol. (Vol_2) (ml)
5/26/99 6	1:23 PM 0:00:00	0:04:30	270	22.2	69.7	69.1	i= 39.815	i= 14.7	i= 31.9	i= 9.0	i= 0.30
							o= 40.780	o= 14.9	o= 32.5	o= 8.85	o= -0.02
5/26/99 7	7:13 PM 0:00:00	0:04:35	275	21.8	69.7	69.1	i= 39.815	i= 14.7	i= 31.8	i= 9.0	i= 0.40
							o= 40.780	o= 14.9	o= 32.6	o= 8.85	o= 0.00
5/27/99 8	12:55 AM 0:00:00	0:04:28	268	22.0	69.7	69.1	i= 39.815	i= 14.8	i= 31.7	i= 9.0	i= 0.48
							o= 40.780	o= 15.3	o= 32.6	o= 8.88	o= -0.02
5/27/99 9	10:00 AM 0:00:00	0:03:54	234	22.2	69.7	69.1	i= 39.815	i= 14.7	i= 31.3	i= 9.0	i= 0.73
							o= 40.780	o= 15.4	o= 32.6	o= 8.60	o= -0.31
							i=	i=	i=	i=	i=
							o=	o=	o=	o=	o=

Trial No. L= 11.60	ΔVol (Vol_1-Vol_2) (ml)	Initial Head Loss, h_1 (HW_1-TW_1) (cm)	Final Head Loss, h_2 (HW_2-TW_2) (cm)	Hydraulic Conductivity @ T °C K_T (cm/s)	Viscosity Correction Factor R_T	Hydraulic Conductivity, K @ 20 °C (cm/s)	Location
5/26/99 6	8.70	55.0	37.2	0.00020623	0.9486	0.00019563	Inside
	8.87	54.8	36.6	0.00020725		0.00019660	Outside
5/26/99 7	8.60	55.0	37.3	0.00019990	0.9576	0.00019143	Inside
	8.85	54.8	36.5	0.00020328		0.00019466	Outside
5/27/99 8	8.52	54.9	37.4	0.00020316	0.9530	0.00019361	Inside
	8.70	54.4	36.5	0.00020586		0.00019618	Outside
5/27/99 9	8.27	55.0	37.8	0.00022451	0.9486	0.00021297	Inside
	8.91	54.3	36.5	0.00024170		0.00022928	Outside
							Inside
							Outside

Hydraulic Conductivity (cm/s)	Recommended Maximum Hydraulic Gradient
1×10^{-7} to 1×10^{-8}	2
1×10^{-8} to 1×10^{-9}	5
1×10^{-9} to 1×10^{-10}	10
1×10^{-10} to 1×10^{-11}	20
less than 1×10^{-11}	30

Correction Factor, R_T, for Viscosity of Water at Various Temperatures

Temp. (°C)	R_T	Temp. (°C)	R_T
16	1.106	24	0.910
17	1.077	25	0.889
18	1.051	26	0.869
19	1.025	27	0.850
20	1.000	28	0.832
21	0.978	29	0.814
22	0.953	30	0.797
23	0.931	31	0.780

$K_T = [(\Delta Vol) \times (L) / ((A) \times (\Delta t) \times (h_1 - h_2))] \times \ln (h_1 / h_2)$

Ave. Inner K (#6-9) = 0.000198 (cm/s)

Ave. Outer K (#6-9) = 0.000204 (cm/s)

Where: $A = A_i$ or A_o, $\Delta Vol = \Delta Vol_i$ or ΔVol_o, $\Delta t = \Delta$ time $= t_2 - t_1$
h_1 = Head loss across specimen at $t_1 = HW_1 - TW_1$
h_2 = Head loss across specimen at $t_2 = HW_2 - TW_2$

UNM Geoenvironmental Laboratory
Hydraulic Conductivity Test with Double Ring Compaction Mold Permeameter (Decreasing Head-Water and Increasing Tail-Water Method)

Sample No. MW CAMU - Unscreened-SHC-1 Project No. SNL Mixed Waste Landfill Cover

Location CAMU Borrow Pit Boring No. _____

Depth of Sample Borrow Pile Date of Test 5/18/99

Tested By C. Anderson

Description of Soil CAMU Unscreened

Sample Notes Soil from Bucket #4. 25% of soil oven dried, then blended with 75% of soil directly from Bucket (approximate 8% grav. moisture) - screened 3/8" sieve.

[A] Unit Weight Determination

(1) Weight of permeameter (mold) ~~with base plate and gasket attached~~ + soil 3659.06 g

(2) Weight of empty permeameter (mold) ~~with base plate and gasket attached~~ 2032.52 g

(3) Weight of soil specimen [(1) - (2)] 1624.54 g

(4) Diameter of soil specimen, D [i.e., inside diameter of permeameter (mold)] 10.12 cm

(5) Cross-sectional area of soil specimen (i.e., $\pi D^2/4$) 80.436 cm^2

(6) Length of Soil Specimen in permeameter, L 11.66 cm

(7) Volume of soil specimen [(5) X (6)] 937.88 cm^3

(8) Unit weight of Soil specimen (air-dried) [(3) / (7)] 1.732 g/cm^3

(9) Water content of soil specimen (air dried)[$(g_1 + g_2) / 2$] 4.17 %

(a)		Can no. MW-1	Can no. MW-2
(b)	Weight of air dried soil + can	116.16 g	110.15 g
(c)	Weight of oven dried soil + can	112.42 g	106.54 g
(d)	Weight of can	21.23 g	21.38 g
(e)	Weight of water	3.74 g	3.61 g
(f)	Weight of oven dried soil	91.19 g	85.16 g
(g)	Water content [(e)/(f) X 100]	g_1 4.10 %	g_2 4.239 %

(10) Dry unit weight of soil specimen [((8) / ((9) + 100)) X 100] 1.663 g/cm^3

(11) Specific gravity of soil 2.69

(12) Volume of solids [(7) X (10) / (11)] 579.81 cm^3

(13) Volume of voids [(7) - (12)] 358.07 cm^3

(14) Void ratio, e, of soil specimen [(13)/(12)] 0.618

(15) Porosity, n [(13) / (7)] 0.382

[B] Permeameter Dimensions

(16) Cross-sectional area of headwater standpipe, a $(6.96)^2 \pi/4 = 38.046$ cm^2

(17) Cross-sectional area of tailwater pipettes, (Δvolume / Δlength) 9.0cc / 17.95 cm = 0.501 cm^2

(18) Cross-sectional area of inner ring, A_i $(7.12)^2 \pi/4 = 39.815$ cm^2

(19) Cross-sectional area of outer ring, A_o [(5) - (18)] 40.621 cm

UNM Geoenvironmental Laboratory
Hydraulic Conductivity Test with Double Ring Compaction Mold Permeameter
(Decreasing Head-Water and Increasing Tail-Water Method)

[C] Permeability Test Sample No. MW CAMU - Unscreened-SHC-1 Length of soil specimen in permeameter, L = 11.66 cm

Trial No.	Initial Time t_1 (hr : min : s)	Final Time t_2 (hr : min : s)	Δ time Δt ($t_2 - t_1$) (s)	Temp. T (°C)	Initial Head-Water Elev. (HW_1) (cm)	Final Head-Water Elev. (HW_2) (cm)	Area of Secl. (Inner and outer) (A_i and A_o) (cm^2)	Initial Tail-Water Elev. (TW_1) (cm)	Final Tail-Water Elev. (TW_2) (cm)	Initial Pipette Vol. (Vol_1) (ml)	Final Pipette Vol. (Vol_2) (ml)
5/23/99 1	1:31 PM 0:00:00	0:06:16	376	22.2	69.6	69.1	i= 39.815	i= 14.8	i= 28.0	i= 9.0	i= 2.28
							o= 40.621	o= 14.7	o= 32.6	o=9.0	o= -0.02
5/23/99 2	9:26 PM 0:00:00	0:05:34	334	23.2	69.6	69.0	i= 39.815	i= 14.7	i= 27.8	i= 9.0	i= 2.40
							o= 40.621	o= 15.7	o= 32.6	o= 8.7	o= -0.01
5/24/99 3	1:31 AM 0:00:00	0:05:17	317	22.8	69.7	69.2	i= 39.815	i= 14.7	i= 27.3	i= 9.0	i= 2.70
							o= 40.621	o= 15.1	o= 32.6	o= 8.8	o= 0.00
5/24/99 4	8:37 PM 0:00:00	0:04:26	266	22.7	69.0	68.4	i= 39.815	i= 14.7	i= 25.1	i= 9.0	i= 3.80
							o= 40.621	o= 15.2	o= 32.6	o= 8.8	o= -0.02
5/25/99 5	7:35 PM 0:00:00	0:03:11	191	22.6	69.7	69.3	i= 39.815	i= 14.7	i= 21.5	i= 9.0	i= 5.60
							o= 40.621	o= 16.0	o= 32.6	o= 8.4	o= -0.02

Trial No. t_m 11.66	ΔVol (Vol_1-Vol_2) (ml)	Initial Head Loss, h_1 (HW_1-TW_1) (cm)	Final Head Loss, h_2 (HW_2-TW_2) (cm)	Hydraulic Conductivity @ T °C K_T (cm/s)	Viscosity Correction Factor R_T	Hydraulic Conductivity, K @ 20 °C (cm/s)	Location
5/10/99 1	6.72	54.8	41.1	0.00010991	0.9466	0.00010426	Inside
	9.02	54.9	36.5	0.00015276		0.00014491	Outside
5/11/99 2	8.60	54.9	41.2	0.00012126	0.9288	0.00011239	Inside
	8.71	53.9	36.4	0.00016792		0.00015562	Outside
5/13/99 3	6.30	55.0	41.9	0.00012087	0.9354	0.00011306	Inside
	8.80	54.6	36.6	0.00017707		0.00016563	Outside
5/13/99 4	5.20	54.3	43.3	0.00011782	0.9376	0.00011046	Inside
	8.82	53.8	35.8	0.00021538		0.00020194	Outside
5/13/99 5	3.40	55.0	47.8	0.00010159	0.9398	0.00009547	Inside
	8.42	53.7	36.7	0.00028333		0.00026627	Outside

Hydraulic Conductivity (cm/s)	Recommended Maximum Hydraulic Gradient
1×10^{-7} to 1×10^{-8}	2
1×10^{-8} to 1×10^{-9}	5
1×10^{-9} to 1×10^{-10}	10
1×10^{-10} to 1×10^{-11}	20
less than 1×10^{-11}	30

Correction Factor, R_T, for Viscosity of Water at Various Temperatures

Temp. (°C)	R_T	Temp. (°C)	R_T
16	1.106	24	0.910
17	1.077	25	0.889
18	1.051	26	0.869
19	1.025	27	0.850
20	1.000	28	0.832
21	0.976	29	0.814
22	0.953	30	0.797
23	0.931	31	0.780

$K_T = [(\Delta Vol) \times (L) / ((A) \times (\Delta t) \times (h_1 - h_2))] \times \ln (h_1 / h_2)$

Where: $A = A_i$ or A_o, $\Delta Vol = \Delta Vol_i$ or ΔVol_o, $\Delta t = \Delta$ time $= t_2 - t_1$
h_1 = Head loss across specimen at $t_1 = HW_1 - TW_1$
h_2 = Head loss across specimen at $t_2 = HW_2 - TW_2$

Ave. Inner K = See Page 3 (cm/s)

Ave. Outer K = See Page 3 (cm/s)

UNM Geoenvironmental Laboratory
Hydraulic Conductivity Test with Double Ring Compaction Mold Permeameter
(Decreasing Head-Water and Increasing Tail-Water Method)

C] Permeability Test Sample No. MW CAMU - Unscreened-SHC-1 Length of soil specimen in permeameter, L = 11.66 cm

Trial No.	Initial Time t_1 (hr : min : s)	Final Time t_2 (hr : min : s)	Δ time Δ t (t_2 - t_1) (s)	Temp. T (°C)	Initial Head-Water Elev. (HW_1) (cm)	Final Head-Water Elev. (HW_2) (cm)	Area of Sect. (inner and outer) (A_i and A_o) (cm²)	Initial Tail-Water Elev. (TW_1). (cm)	Final Tail-Water Elev. (TW_2) (cm)	Initial Pipette Vol. (Vol_1) (ml)	Final Pipette Vol. (Vol_2) (ml)
5/26/99 6	1:06 PM 0:00:00	0:08:53	533	21.9	44.8	44.3	i= 39.815	i= 14.7	i= 26.8	i= 9.0	i= 2.69
							o= 40.621	o= 14.9	o= 32.6	o= 8.88	o= -0.02
5/26/99 7	6:58 PM 0:00:00	0:10:23	623	21.4	44.8	44.3	i= 39.815	i= 14.7	i= 32.3	i= 9.0	i= 0.15
							o= 40.621	o= 14.9	o= 32.6	o= 8.88	o= 0.00
5/27/99 8	12:40 AM 0:00:00	0:10:09	609	21.6	44.8	44.2	i= 39.815	i= 14.8	i= 32.5	i= 9.0	i= 0.16
							o= 40.621	o= 14.9	o= 32.6	o= 8.90	o= -0.01
5/2799 9	9:41 AM 0:00:00	0:09:44	584	22.2	44.8	44.1	i= 39.815	i= 14.8	i= 32.4	i= 9.0	i= 0.13
							o= 40.621	o= 15.1	o= 32.7	o= 8.80	o= 0.00
5/28/99 10	4:52 PM 0:00:00	0:09:23	563	20.4	44.7	44.1	i= 39.815	i= 14.7	i= 32.2	i= 9.0	i= 0.22
							o= 40.621	o= 15.5	o= 32.5	o= 8.50	o= 0.00

Trial No. L= 11.66	ΔVol (Vol_1-Vol_2) (ml)	Initial Head Loss, h_1 (HW_1-TW_1) (cm)	Final Head Loss, h_2 (HW_2-TW_2) (cm)	Hydraulic Conductivity @ T °C K_T (cm/s)	Viscosity Correction Factor R_T	Hydraulic Conductivity, K @ 20 °C (cm/s)	Location
5/26/99 6	8.11	30.1	17.5	0.00014450	0.9553	0.00013804	Inside
	8.90	29.9	11.7	0.00024710		0.00023605	Outside
5/26/99 7	8.85	30.1	12.0	0.00021137	0.9668	0.00020435	Inside
	8.88	29.9	11.7	0.00021093		0.00020392	Outside
5/27/99 8	8.84	30.0	11.7	0.00021873	0.9622	0.00021046	Inside
	8.91	29.9	11.6	0.00021729		0.00020908	Outside
5/27/99 9	8.87	30.0	11.7	0.00022887	0.9486	0.00021710	Inside
	8.80	29.7	11.4	0.00022632		0.00021469	Outside
5/28/99 10	8.78	30.0	11.9	0.00023331	0.9904	0.00023107	Inside
	8.50	29.2	11.6	0.00022731		0.00022513	Outside

Hydraulic Conductivity (cm/s)	Recommended Maximum Hydraulic Gradient
1×10^{-7} to 1×10^{-8}	2
1×10^{-8} to 1×10^{-9}	5
1×10^{-9} to 1×10^{-10}	10
1×10^{-10} to 1×10^{-11}	20
less than 1×10^{-11}	30

Correction Factor, R_T, for Viscosity of Water at Various Temperatures

Temp. (°C)	R_T	Temp. (°C)	R_T
16	1.106	24	0.910
17	1.077	25	0.889
18	1.051	26	0.869
19	1.025	27	0.850
20	1.000	28	0.832
21	0.976	29	0.814
22	0.953	30	0.797
23	0.931	31	0.780

$K_T = [(\Delta Vol) \times (L) / ((A) \times (\Delta t) \times (h_1 - h_2))] \times \ln (h_1 / h_2)$

Where: $A = A_i$ or A_o, $\Delta Vol = \Delta Vol_i$ or ΔVol_o, $\Delta t = \Delta$ time $= t_2 - t_1$
h_1 = Head loss across specimen at $t_1 = HW_1 - TW_1$
h_2 = Head loss across specimen at $t_2 = HW_2 - TW_2$

Ave. Inner K (#7-10) = 0.000216 (cm/s)

Ave. Outer K (#7-10) = 0.000213 (cm/s)

University of New Mexico
Department of Civil Engineering
Geoenvironmental Laboratory

Hanging Column Test

Sample No. MW-B-Mix-HC-1

Project SNL Mixed Waste Landfill Cover

Container Identification MW-HC-1

Date at Start of Test 5/05/99

Tested by C. Anderson

Date at End of Test 5/26/99

Description of Sample Mixes from Bucket #2. Mixed Sites 1. 2. 3 & 4 - passing # 4 sieve

Sample Preparation

Initial Soil Moisture Content	
Wt. Pan (g)	21.48
Wt. Pan + Wet Soil (g)	86.86
Wt. Pan + Dry Soil (g)	81.62
Wt. Water (g)	5.24
Wt. Dry Soil (g)	60.14
Grav. Moisture (%)	8.71

Expected Test Density (g/cm³)	1.54
Sample Height (cm)	2.425
Sample Diameter (cm)	6.00
Sample Volume (cm³)	68.565
Packing Grav. Moisture (%)	8.7 (est.)
Wt. Dry Soil Required (g)	105.59
Wt. Water Required (g)	9.19
Sample Weight Required (g)	114.78

Sample Construction

Sample Moisture Content	
Wt. Pan (g)	21.40
Wt. Pan + Wet Soil (g)	74.22
Wt. Pan + Dry Soil (g)	70.02
Wt. Water (g)	4.2
Wt. Dry Soil (g)	48.62
Grav. Moisture (%)	8.64

Wt. Wet Sample + Apparatus (g)	162.40
Wt. Apparatus (g)	47.83
Wt. Wet sample (g)	114.57
Sample Wet Density (g/cm³)	1.671
Sample Dry Density (g/cm³)	1.538
Computed Wt. Dry Soil (g)	105.46

Sample Initial Saturation or Drying

Initial Saturation	
Wt. Sat. Sample + Apparatus (g)	179.78
Wt. Dry Soil (g)	105.46
Wt. Apparatus (g)	47.83
Wt. Water in Sat. Sample (g)	26.49
Grav. Moisture at Saturation (%)	25.12
Volumetric Moisture at Sat. (%)	38.63

Initial Air or Pressure Plate Dry	
Wt. Air/PP Sample + Apparatus (g)	N. A.
Wt. Dry Soil (g)	
Wt. Apparatus (g)	
Wt. Water in Air/PP Sample (g)	
Initial Gravimetric Moisture (%)	
Initial Volumetric Moisture (%)	

Sample Testing

Start of Test: Date 5/06/99 , Time 12:08 PM Sample No. MW-B-Mix-HC-1

Initial Measurements		Final Measurements				
Elev. Initial Water Surf. (cm)	Elev. Sample at Bottom (cm)	Date (MM/DD/YY)	Time (HH/MM)	Elev. Final Water Surf. (cm)	Wt. Sample + Apparatus (g)	Suction Head (cm)
136	135	5/7/99	12:04 PM	136	181.80	1
138	135	5/8/99	2:40 PM	138	182.14	3
141	135	5/9/99	2:25 PM	141	182.02	6
145	135	5/10/99	4:02 PM	145	181.82	10
155	135	5/11/99	3:40 PM	155	181.46	20
165	135	5/12/99	11:50 PM	165	181.39	30
175	135	5/14/99	8:20 AM	175	181.35	40
185	135	5/15/99	12:18 PM	185	178.69	50
195	135	5/16/99	4:30 PM	195	175.39	60
205	135	5/18/99	12:45 PM	205	173.58	70
180	90	5/20/99	10:49 AM	180	171.53	90
200	90	5/22/99	4:21 PM	200	170.19	110
220	90	5/24/99	6:20 PM	220	169.32	130
240	90	5/26/99	6:50 PM	240	168.67	150
240	90					

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Geoenvironmental Laboratory

Hanging Column Test

Sample No. MW-B-Mix-HC-2

Project SNL Mixed Waste Landfill Cover

Container Identification MW-HC-2

Date at Start of Test 5/05/99

Tested by C. Anderson

Date at End of Test 5/26/99

Description of Sample Mixes from Bucket #2, Mixed Sites 1, 2, 3 & 4 - passing # 4 sieve

Sample Preparation

Initial Soil Moisture Content	
Wt. Pan (g)	21.48
Wt. Pan + Wet Soil (g)	86.86
Wt. Pan + Dry Soil (g)	81.62
Wt. Water (g)	5.24
Wt. Dry Soil (g)	60.14
Grav. Moisture (%)	8.71

Expected Test Density (g/cm³)	1.54
Sample Height (cm)	2.50
Sample Diameter (cm)	5.99
Sample Volume (cm³)	70.450
Packing Grav. Moisture (%)	8.7 (est.)
Wt. Dry Soil Required (g)	108.49
Wt. Water Required (g)	9.44
Sample Weight Required (g)	117.93

Sample Construction

Sample Moisture Content	
Wt. Pan (g)	21.60
Wt. Pan + Wet Soil (g)	68.46
Wt. Pan + Dry Soil (g)	64.66
Wt. Water (g)	3.8
Wt. Dry Soil (g)	43.06
Grav. Moisture (%)	8.82

Wt. Wet Sample + Apparatus (g)	165.19
Wt. Apparatus (g)	46.83
Wt. Wet sample (g)	118.36
Sample Wet Density (g/cm³)	1.680
Sample Dry Density (g/cm³)	1.544
Computed Wt. Dry Soil (g)	108.76

Sample Initial Saturation or Drying

Initial Saturation	
Wt. Sat. Sample + Apparatus (g)	182.57
Wt. Dry Soil (g)	108.76
Wt. Apparatus (g)	46.83
Wt. Water in Sat. Sample (g)	26.978
Grav. Moisture at Saturation (%)	24.80
Volumetric Moisture at Sat. (%)	38.29

Initial Air or Pressure Plate Dry	
Wt. Air/PP Sample + Apparatus (g)	N. A.
Wt. Dry Soil (g)	
Wt. Apparatus (g)	
Wt. Water in Air/PP Sample (g)	
Initial Gravimetric Moisture (%)	
Initial Volumetric Moisture (%)	

Sample Testing

Start of Test: Date 5/06/99 , Time 12:04 PM Sample No. MW-B-Mix-HC-2

Initial Measurements		Final Measurements				
Elev. Initial Water Surf. (cm)	Elev. Sample at Bottom (cm)	Date (MM/DD/YY)	Time (HH/MM)	Elev. Final Water Surf. (cm)	Wt. Sample + Apparatus (g)	Suction Head (cm)
136	135	5/7/99	12:06 PM	136	184.07	1
138	135	5/8/99	2:42 PM	138	184.21	3
141	135	5/9/99	2:26 PM	141	183.66	6
145	135	5/10/99	4:04 PM	145	183.12	10
155	135	5/11/99	3:42 PM	155	182.66	20
165	135	5/12/99	11:51 PM	165	182.45	30
175	135	5/14/99	8:21 AM	175	182.33	40
185	135	5/15/99	12:19 PM	185	181.85	50
195	135	5/16/99	4:31 PM	195	180.73	60
205	135	5/18/99	12:46 PM	205	179.23	70
180	90	5/20/99	10:51 AM	180	176.95	90
200	90	5/22/99	4:22 PM	200	175.55	110
220	90	5/24/99	6:22 PM	220	174.56	130
240	90	5/26/99	6:51 PM	240	173.87	150
240	90					

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Geoenvironmental Laboratory

Hanging Column Test

Sample No. MW-B-Mix-HC-3

Project SNL Mixed Waste Landfill Cover

Container Identification MW-HC-3

Date at Start of Test 5/05/99

Tested by C. Anderson

Date at End of Test 5/26/99

Description of Sample Mixes from Bucket #2, Mixed Sites 1, 2, 3 & 4 - passing # 4 sieve

Sample Preparation

Initial Soil Moisture Content	
Wt. Pan (g)	21.48
Wt. Pan + Wet Soil (g)	86.86
Wt. Pan + Dry Soil (g)	81.62
Wt. Water (g)	5.24
Wt. Dry Soil (g)	60.14
Grav. Moisture (%)	8.71

Expected Test Density (g/cm³)	1.60
Sample Height (cm)	2.48
Sample Diameter (cm)	5.99
Sample Volume (cm³)	69.887
Packing Grav. Moisture (%)	8.7 (est.)
Wt. Dry Soil Required (g)	111.82
Wt. Water Required (g)	9.73
Sample Weight Required (g)	121.55

Sample Construction

Sample Moisture Content	
Wt. Pan (g)	21.10
Wt. Pan + Wet Soil (g)	63.94
Wt. Pan + Dry Soil (g)	60.52
Wt. Water (g)	3.42
Wt. Dry Soil (g)	39.42
Grav. Moisture (%)	8.68

Wt. Wet Sample + Apparatus (g)	169.48
Wt. Apparatus (g)	48.43
Wt. Wet sample (g)	121.05
Sample Wet Density (g/cm³)	1.732
Sample Dry Density (g/cm³)	1.594
Computed Wt. Dry Soil (g)	111.39

Sample Initial Saturation or Drying

Initial Saturation	
Wt. Sat. Sample + Apparatus (g)	187.07
Wt. Dry Soil (g)	111.39
Wt. Apparatus (g)	48.43
Wt. Water in Sat. Sample (g)	27.254
Grav. Moisture at Saturation (%)	24.47
Volumetric Moisture at Sat. (%)	39.00

Initial Air or Pressure Plate Dry	
Wt. Air/PP Sample + Apparatus (g)	N. A.
Wt. Dry Soil (g)	
Wt. Apparatus (g)	
Wt. Water in Air/PP Sample (g)	
Initial Gravimetric Moisture (%)	
Initial Volumetric Moisture (%)	

Sample Testing

Start of Test: Date 5/06/99 , Time 12:14 PM Sample No. MW-B-Mix-HC-3

Initial Measurements		Final Measurements				
Elev. Initial Water Surf. (cm)	Elev. Sample at Bottom (cm)	Date (MM/DD/YY)	Time (HH/MM)	Elev. Final Water Surf. (cm)	Wt. Sample + Apparatus (g)	Suction Head (cm)
136	135	5/7/99	12:08 PM	136	188.20	1
138	135	5/8/99	2:45 PM	138	188.33	3
141	135	5/9/99	2:28 PM	141	188.07	6
145	135	5/10/99	4:05 PM	145	187.80	10
155	135	5/11/99	3:43 PM	155	187.26	20
165	135	5/12/99	11:52 PM	165	187.08	30
175	135	5/14/99	8:22 AM	175	186.91	40
185	135	5/15/99	12:20 PM	185	185.84	50
195	135	5/16/99	4:32 PM	195	183.57	60
205	135	5/18/99	12:48 PM	205	181.44	70
180	90	5/20/99	10:52 AM	180	179.18	90
200	90	5/22/99	4:23 PM	200	177.94	110
220	90	5/24/99	6:23 PM	220	177.00	130
240	90	5/26/99	6:52 PM	240	176.34	150
240	90					

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Hanging Column Test

Sample No. MW-B-Mix-HC-4

Project SNL Mixed Waste Landfill Cover

Container Identification MW-HC-4

Date at Start of Test 5/05/99

Tested by C. Anderson

Date at End of Test 5/26/99

Description of Sample Mixes from Bucket #2. Mixed Sites 1, 2, 3 & 4 - passing # 4 sieve

Sample Preparation

Initial Soil Moisture Content	
Wt. Pan (g)	21.48
Wt. Pan + Wet Soil (g)	86.86
Wt. Pan + Dry Soil (g)	81.62
Wt. Water (g)	5.24
Wt. Dry Soil (g)	60.14
Grav. Moisture (%)	8.71

Expected Test Density (g/cm³)	1.60
Sample Height (cm)	2.48
Sample Diameter (cm)	6.005
Sample Volume (cm³)	70.237
Packing Grav. Moisture (%)	8.7 (est.)
Wt. Dry Soil Required (g)	112.38
Wt. Water Required (g)	9.78
Sample Weight Required (g)	122.16

Sample Construction

Sample Moisture Content	
Wt. Pan (g)	20.97
Wt. Pan + Wet Soil (g)	66.34
Wt. Pan + Dry Soil (g)	62.77
Wt. Water (g)	3.57
Wt. Dry Soil (g)	41.8
Grav. Moisture (%)	8.54

Wt. Wet Sample + Apparatus (g)	170.31
Wt. Apparatus (g)	48.26
Wt. Wet sample (g)	122.05
Sample Wet Density (g/cm³)	1.738
Sample Dry Density (g/cm³)	1.601
Computed Wt. Dry Soil (g)	112.45

Sample Initial Saturation or Drying

Initial Saturation	
Wt. Sat. Sample + Apparatus (g)	187.42
Wt. Dry Soil (g)	112.45
Wt. Apparatus (g)	48.26
Wt. Water in Sat. Sample (g)	26.714
Grav. Moisture at Saturation (%)	23.76
Volumetric Moisture at Sat. (%)	38.03

Initial Air or Pressure Plate Dry	
Wt. Air/PP Sample + Apparatus (g)	N. A.
Wt. Dry Soil (g)	
Wt. Apparatus (g)	
Wt. Water in Air/PP Sample (g)	
Initial Gravimetric Moisture (%)	
Initial Volumetric Moisture (%)	

Sample Testing

Start of Test: Date 5/06/99 , Time 12:17 PM Sample No. MW-B-Mix-HC-4

Initial Measurements		Final Measurements				
Elev. Initial Water Surf. (cm)	Elev. Sample at Bottom (cm)	Date (MM/DD/YY)	Time (HH/MM)	Elev. Final Water Surf. (cm)	Wt. Sample + Apparatus (g)	Suction Head (cm)
136	135	5/7/99	12:10 PM	136	188.98	1
138	135	5/8/99	2:48 PM	138	188.86	3
141	135	5/9/99	2:29 PM	141	188.33	6
145	135	5/10/99	4:06 PM	145	187.94	10
155	135	5/11/99	3:45 PM	155	187.48	20
165	135	5/12/99	11:53 PM	165	187.30	30
175	135	5/14/99	8:23 AM	175	187.16	40
185	135	5/15/99	12:21 PM	185	186.70	50
195	135	5/16/99	4:33 PM	195	185.14	60
205	135	5/18/99	12:49 PM	205	182.90	70
180	90	5/20/99	10:53 AM	180	180.91	90
200	90	5/22/99	4:24 PM	200	179.76	110
220	90	5/24/99	6:24 PM	220	178.89	130
240	90	5/26/99	6:53 PM	240	178.27	150
240	90					

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Hanging Column Test

Sample No. MW-B-Mix-HC-5

Project SNL Mixed Waste Landfill Cover

Container Identification MW-HC-5

Date at Start of Test 5/06/99

Tested by C. Anderson

Date at End of Test 5/27/99

Description of Sample Mixes from Bucket #2, Mixed Sites 1, 2, 3 & 4 - passing # 4 sieve

Sample Preparation

Initial Soil Moisture Content	
Wt. Pan (g)	21.48
Wt. Pan + Wet Soil (g)	86.86
Wt. Pan + Dry Soil (g)	81.62
Wt. Water (g)	5.24
Wt. Dry Soil (g)	60.14
Grav. Moisture (%)	8.71

Expected Test Density (g/cm³)	1.66
Sample Height (cm)	2.51
Sample Diameter (cm)	6.00
Sample Volume (cm³)	70.969
Packing Grav. Moisture (%)	8.7 (est.)
Wt. Dry Soil Required (g)	117.81
Wt. Water Required (g)	10.25
Sample Weight Required (g)	128.06

Sample Construction

Sample Moisture Content	
Wt. Pan (g)	20.94
Wt. Pan + Wet Soil (g)	71.57
Wt. Pan + Dry Soil (g)	67.54
Wt. Water (g)	4.03
Wt. Dry Soil (g)	46.6
Grav. Moisture (%)	8.65

Wt. Wet Sample + Apparatus (g)	172.12
Wt. Apparatus (g)	44.87
Wt. Wet sample (g)	127.25
Sample Wet Density (g/cm³)	1.793
Sample Dry Density (g/cm³)	1.650
Computed Wt. Dry Soil (g)	117.12

Sample Initial Saturation or Drying

Initial Saturation	
Wt. Sat. Sample + Apparatus (g)	187.61
Wt. Dry Soil (g)	117.12
Wt. Apparatus (g)	44.87
Wt. Water in Sat. Sample (g)	25.619
Grav. Moisture at Saturation (%)	21.87
Volumetric Moisture at Sat. (%)	36.10

Initial Air or Pressure Plate Dry	
Wt. Air/PP Sample + Apparatus (g)	N. A.
Wt. Dry Soil (g)	
Wt. Apparatus (g)	
Wt. Water in Air/PP Sample (g)	
Initial Gravimetric Moisture (%)	
Initial Volumetric Moisture (%)	

Sample Testing

Start of Test: Date 5/07/99 , Time 12:25 PM Sample No. MW-B-Mix-HC-5

Initial Measurements		Final Measurements				
Elev. Initial Water Surf. (cm)	Elev. Sample at Bottom (cm)	Date (MM/DD/YY)	Time (HH/MM)	Elev. Final Water Surf. (cm)	Wt. Sample + Apparatus (g)	Suction Head (cm)
46	45	5/8/99	2:50 PM	46	189.22	1
48	45	5/9/99	2:30 PM	48	189.26	3
51	45	5/10/99	4:08 PM	51	188.90	6
55	45	5/11/99	3:50 PM	55	188.82	10
65	45	5/12/99	11:55 PM	65	188.82	20
75	45	5/14/99	8:26 AM	75	188.79	30
85	45	5/15/99	12:23 PM	85	188.55	40
95	45	5/16/99	4:35 PM	95	188.35	50
105	45	5/17/99	5:44 PM	105	187.71	60
115	45	5/19/99	5:20 PM	115	185.91	70
135	45	5/21/99	2:30 PM	135	182.82	90
155	45	5/23/99	4:00 PM	155	181.40	110
175	45	5/25/99	5:03 PM	175	180.45	130
195	45	5/27/99	5:56 PM	195	179.80	150

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Hanging Column Test

Sample No. MW-B-Mix-HC-6

Project SNL Mixed Waste Landfill Cover

Container Identification MW-HC-6

Date at Start of Test 5/06/99

Tested by C. Anderson

Date at End of Test 5/27/99

Description of Sample Mixes from Bucket #2. Mixed Sites 1, 2, 3 & 4 - passing # 4 sieve

Sample Preparation

Initial Soil Moisture Content	
Wt. Pan (g)	21.48
Wt. Pan + Wet Soil (g)	86.86
Wt. Pan + Dry Soil (g)	81.62
Wt. Water (g)	5.24
Wt. Dry Soil (g)	60.14
Grav. Moisture (%)	8.71

Expected Test Density (g/cm³)	1.66
Sample Height (cm)	2.435
Sample Diameter (cm)	6.00
Sample Volume (cm³)	68.848
Packing Grav. Moisture (%)	8.7 (est.)
Wt. Dry Soil Required (g)	114.29
Wt. Water Required (g)	9.94
Sample Weight Required (g)	124.23

Sample Construction

Sample Moisture Content	
Wt. Pan (g)	21.59
Wt. Pan + Wet Soil (g)	79.71
Wt. Pan + Dry Soil (g)	75.15
Wt. Water (g)	4.56
Wt. Dry Soil (g)	53.56
Grav. Moisture (%)	8.51

Wt. Wet Sample + Apparatus (g)	171.80
Wt. Apparatus (g)	48.03
Wt. Wet sample (g)	123.77
Sample Wet Density (g/cm³)	1.798
Sample Dry Density (g/cm³)	1.657
Computed Wt. Dry Soil (g)	114.06

Sample Initial Saturation or Drying

Initial Saturation	
Wt. Sat. Sample + Apparatus (g)	186.66
Wt. Dry Soil (g)	114.06
Wt. Apparatus (g)	48.03
Wt. Water in Sat. Sample (g)	24.571
Grav. Moisture at Saturation (%)	21.54
Volumetric Moisture at Sat. (%)	35.69

Initial Air or Pressure Plate Dry	
Wt. Air/PP Sample + Apparatus (g)	N. A.
Wt. Dry Soil (g)	
Wt. Apparatus (g)	
Wt. Water in Air/PP Sample (g)	
Initial Gravimetric Moisture (%)	
Initial Volumetric Moisture (%)	

Sample Testing

Start of Test: Date 5/07/99 , Time 12:25 PM Sample No. MW-B-Mix-HC-6

Initial Measurements		Final Measurements				
Elev. Initial Water Surf. (cm)	Elev. Sample at Bottom (cm)	Date (MM/DD/YY)	Time (HH/MM)	Elev. Final Water Surf. (cm)	Wt. Sample + Apparatus (g)	Suction Head (cm)
46	45	5/8/99	2:52 PM	46	188.71	1
48	45	5/9/99	2:31 PM	48	188.52	3
51	45	5/10/99	4:10 PM	51	188.28	6
55	45	5/11/99	3:52 PM	55	188.06	10
65	45	5/12/99	11:56 PM	65	187.95	20
75	45	5/14/99	8:27 AM	75	187.90	30
85	45	5/15/99	12:24 PM	85	187.67	40
95	45	5/16/99	4:36 PM	95	187.38	50
105	45	5/17/99	5:45 PM	105	186.92	60
115	45	5/19/99	5:09 PM	115	184.79	70
135	45	5/21/99	2:32 PM	135	181.91	90
155	45	5/23/99	4:02 PM	155	180.63	110
175	45	5/25/99	5:05 PM	175	179.71	130
195	45	5/27/99	5:57 PM	195	179.06	150

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Hanging Column Test

Sample No. MW-B-Mix-HC-7

Project SNL Mixed Waste Landfill Cover

Container Identification MW-HC-7

Date at Start of Test 5/06/99

Tested by C. Anderson

Date at End of Test 5/27/99

Description of Sample Mixes from Bucket #2. Mixed Sites 1, 2, 3 & 4 - passing # 4 sieve

Sample Preparation

Initial Soil Moisture Content	
Wt. Pan (g)	21.48
Wt. Pan + Wet Soil (g)	86.86
Wt. Pan + Dry Soil (g)	81.62
Wt. Water (g)	5.24
Wt. Dry Soil (g)	60.14
Grav. Moisture (%)	8.71

Expected Test Density (g/cm³)	1.60
Sample Height (cm)	2.485
Sample Diameter (cm)	6.01
Sample Volume (cm³)	70.496
Packing Grav. Moisture (%)	8.7 (est.)
Wt. Dry Soil Required (g)	112.79
Wt. Water Required (g)	9.81
Sample Weight Required (g)	122.61

Sample Construction

Sample Moisture Content	
Wt. Pan (g)	21.41
Wt. Pan + Wet Soil (g)	66.80
Wt. Pan + Dry Soil (g)	63.18
Wt. Water (g)	3.62
Wt. Dry Soil (g)	41.77
Grav. Moisture (%)	8.67

Wt. Wet Sample + Apparatus (g)	170.92
Wt. Apparatus (g)	48.57
Wt. Wet sample (g)	122.35
Sample Wet Density (g/cm³)	1.736
Sample Dry Density (g/cm³)	1.597
Computed Wt. Dry Soil (g)	112.59

Sample Initial Saturation or Drying

Initial Saturation	
Wt. Sat. Sample + Apparatus (g)	N. A.
Wt. Dry Soil (g)	
Wt. Apparatus (g)	
Wt. Water in Sat. Sample (g)	
Grav. Moisture at Saturation (%)	-
Volumetric Moisture at Sat. (%)	-

Initial Air ~~or Pressure Plate~~ Dry (5/10/99)	
Wt. Air/PP Sample + Apparatus (g)	163.59
Wt. Dry Soil (g)	112.59
Wt. Apparatus (g)	48.57
Wt. Water in Air/PP Sample (g)	2.42781
Initial Gravimetric Moisture (%)	2.16
Initial Volumetric Moisture (%)	3.44

Sample Testing

Start of Test: Date 5/10/99 , Time 4:50 PM Sample No. MW-B-Mix-HC-7

Initial Measurements		Final Measurements				
Elev. Initial Water Surf. (cm)	Elev. Sample at Bottom (cm)	Date (MM/DD/YY)	Time (HH/MM)	Elev. Final Water Surf. (cm)	Wt. Sample + Apparatus (g)	Suction Head (cm)
204	4	5/11/99	6:24 PM	204	167.10	200
204	4	5/13/99	12:08 AM	204	168.15	200
204	4	5/14/99	8:49 AM	204	168.68	200
204	4	5/15/99	12:33 PM	204	169.10	200
204	4	5/16/99	4:48 PM	204	169.37	200
204	4	5/17/99	5:48 PM	204	169.57	200
204	4	5/18/99	1:03 PM	204	169.45	200
204	64	5/19/99	5:24 PM	204	169.62	140
204	64	5/21/99	2:36 PM	204	169.74	140
204	64	5/23/99	4:07 PM	204	170.09	140
204	64	5/25/99	5:10 PM	204	170.31	140
204	64	5/27/99	5:58 PM	204	170.46	140
	At 5/18/99 volumetric moisture (%) =				11.76	
	At 5/27/99 volumetric moisture (%) =				13.19	

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Hanging Column Test

Sample No. MW-B-Mix-HC-8

Project SNL Mixed Waste Landfill Cover

Container Identification MW-HC-8

Date at Start of Test 5/06/99

Tested by C. Anderson

Date at End of Test 5/27/99

Description of Sample Mixes from Bucket #2, Mixed Sites 1, 2, 3 & 4 - passing # 4 sieve

Sample Preparation

Initial Soil Moisture Content	
Wt. Pan (g)	21.48
Wt. Pan + Wet Soil (g)	86.86
Wt. Pan + Dry Soil (g)	81.62
Wt. Water (g)	5.24
Wt. Dry Soil (g)	60.14
Grav. Moisture (%)	8.71

Expected Test Density (g/cm³)	1.60
Sample Height (cm)	2.49
Sample Diameter (cm)	6.01
Sample Volume (cm³)	70.638
Packing Grav. Moisture (%)	8.7 (est.)
Wt. Dry Soil Required (g)	113.02
Wt. Water Required (g)	9.83
Sample Weight Required (g)	122.85

Sample Construction

Sample Moisture Content	
Wt. Pan (g)	21.66
Wt. Pan + Wet Soil (g)	68.80
Wt. Pan + Dry Soil (g)	65.07
Wt. Water (g)	3.73
Wt. Dry Soil (g)	43.41
Grav. Moisture (%)	8.59

Wt. Wet Sample + Apparatus (g)	170.94
Wt. Apparatus (g)	48.38
Wt. Wet sample (g)	122.56
Sample Wet Density (g/cm³)	1.735
Sample Dry Density (g/cm³)	1.598
Computed Wt. Dry Soil (g)	112.86

Sample Initial Saturation or Drying

Initial Saturation	
Wt. Sat. Sample + Apparatus (g)	N. A.
Wt. Dry Soil (g)	
Wt. Apparatus (g)	
Wt. Water in Sat. Sample (g)	
Grav. Moisture at Saturation (%)	
Volumetric Moisture at Sat. (%)	

Initial Air ~~or Pressure Plate~~ Dry (5/10/99)	
Wt. Air/PP Sample + Apparatus (g)	163.63
Wt. Dry Soil (g)	112.8623
Wt. Apparatus (g)	48.38
Wt. Water in Air/PP Sample (g)	2.387684
Initial Gravimetric Moisture (%)	2.12
Initial Volumetric Moisture (%)	3.38

Sample Testing

Start of Test: Date 5/10/99 , Time 4:51 PM Sample No. MW-B-Mix-HC-8

Initial Measurements		Final Measurements				
Elev. Initial Water Surf. (cm)	Elev. Sample at Bottom (cm)	Date (MM/DD/YY)	Time (HH/MM)	Elev. Final Water Surf. (cm)	Wt. Sample + Apparatus (g)	Suction Head (cm)
196	-4	5/11/99	6:28 PM	196	167.17	200
196	-4	5/13/99	12:10 AM	196	168.27	200
196	-4	5/14/99	8:50 AM	196	168.77	200
196	-4	5/15/99	12:35 PM	196	169.17	200
196	-4	5/16/99	4:52 PM	196	169.43	200
196	-4	5/17/99	5:51 PM	196	169.62	200
196	-4	5/18/99	1:05 PM	196	169.40	200
196	56	5/19/99	5:26 PM	196	169.52	140
196	56	5/21/99	2:39 PM	196	169.68	140
196	56	5/23/99	4:08 PM	196	170.08	140
196	56	5/25/99	5:11 PM	196	170.26	140
196	56	5/27/99	6:00 PM	196	170.48	140
	At 5/18/99 volumetric moisture (%) =				11.55	
	At 5/27/99 volumetric moisture (%) =				13.08	

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Pressure Plate Test

Sample No. MW-B-Mix-PP-1

Project SNL Mixed Waste Landfill Cover

Container Identification MW-PP-1

Date at Start of Test 5/10/99

Tested by C. Anderson

Date at End of Test 5/27/99

Description of Sample Mixes from Bucket #2, Mixed Sites 1, 2, 3 & 4 - passing # 4 sieve

Sample Preparation

Initial Soil Moisture Content	
Wt. Pan (g)	21.48
Wt. Pan + Wet Soil (g)	86.86
Wt. Pan + Dry Soil (g)	81.62
Wt. Water (g)	5.24
Wt. Dry Soil (g)	60.14
Grav. Moisture (%)	8.71

Expected Test Density (g/cm³)	1.60
Sample Height (cm)	2.50
Sample Diameter (cm)	6.01
Sample Volume (cm³)	70.922
Packing Grav. Moisture (%)	8.7 (est.)
Wt. Dry Soil Required (g)	113.47
Wt. Water Required (g)	9.87
Sample Weight Required (g)	123.35

Sample Construction

Sample Moisture Content	
Wt. Pan (g)	21.60
Wt. Pan + Wet Soil (g)	66.77
Wt. Pan + Dry Soil (g)	63.27
Wt. Water (g)	3.5
Wt. Dry Soil (g)	41.67
Grav. Moisture (%)	8.40

Wt. Wet Sample + Apparatus (g)	168.24
Wt. Apparatus (g)	45.00
Wt. Wet sample (g)	123.24
Sample Wet Density (g/cm³)	1.738
Sample Dry Density (g/cm³)	1.603
Computed Wt. Dry Soil (g)	113.69

Sample Initial Saturation or Drying

Initial Saturation	
Wt. Sat. Sample + Apparatus (g)	187.81
Wt. Dry Soil (g)	113.69
Wt. Apparatus (g)	45.00
Wt. Water in Sat. Sample (g)	29.119
Grav. Moisture at Saturation (%)	25.61
Volumetric Moisture at Sat. (%)	41.06

Initial Air or Pressure Plate Dry	
Wt. Air/PP Sample + Apparatus (g)	N. A.
Wt. Dry Soil (g)	
Wt. Apparatus (g)	
Wt. Water in Air/PP Sample (g)	
Initial Gravimetric Moisture (%)	
Initial Volumetric Moisture (%)	

Sample Testing

Start of Test: Date 5/10/99, Time 5:25 PM Sample No. MW-B-Mix-PP-1

Initial Measurements		Final Measurements					
Pressure Gage (bars)	Burette Reading (cm^3)	Date (MM/DD/YY)	Time (HH/MM)	Pressure Gage (bars)	Burette Reading (cm^3)	Wt. Sample + Apparatus (g)	Suction Head (cm)
0.33	36.8	5/14/99	9:05 AM	0.35	25	172.27	357
0.33	25.5	5/15/99	12:36 PM	0.35	29.8	172.21	357
0.33	29.8	5/16/99	4:53 PM	0.45	30.0	172.01	459
0.33	30.5	5/17/99	6:20 PM	0.52	39.5	171.81	531
11.3	32.0	5/21/99	2:40 PM	11.00	1.4	170.31	11228
11.5	3.0	5/25/99	5:14 PM	10.70	-2.2	169.18	10922
11.5	16.3						
		At 5/17/99 volumetric moisture (%) =				18.50	
		At 5/25/99 volumetric moisture (%) =				14.79	

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Pressure Plate Test

Sample No. MW-B-Mix-PP-2

Project SNL Mixed Waste Landfill Cover

Container Identification MW-PP-2

Date at Start of Test 5/10/99

Tested by C. Anderson

Date at End of Test 5/25/99

Description of Sample Mixes from Bucket #2, Mixed Sites 1, 2, 3 & 4 - passing # 4 sieve

Sample Preparation

Initial Soil Moisture Content	
Wt. Pan (g)	21.48
Wt. Pan + Wet Soil (g)	86.86
Wt. Pan + Dry Soil (g)	81.62
Wt. Water (g)	5.24
Wt. Dry Soil (g)	60.14
Grav. Moisture (%)	8.71

Expected Test Density (g/cm³)	1.60
Sample Height (cm)	2.44
Sample Diameter (cm)	6.01
Sample Volume (cm³)	69.220
Packing Grav. Moisture (%)	8.7 (est.)
Wt. Dry Soil Required (g)	110.75
Wt. Water Required (g)	9.64
Sample Weight Required (g)	120.39

Sample Construction

Sample Moisture Content	
Wt. Pan (g)	21.59
Wt. Pan + Wet Soil (g)	59.34
Wt. Pan + Dry Soil (g)	56.42
Wt. Water (g)	2.92
Wt. Dry Soil (g)	34.83
Grav. Moisture (%)	8.38

Wt. Wet Sample + Apparatus (g)	168.21
Wt. Apparatus (g)	47.96
Wt. Wet sample (g)	120.25
Sample Wet Density (g/cm³)	1.737
Sample Dry Density (g/cm³)	1.603
Computed Wt. Dry Soil (g)	110.95

Sample Initial Saturation or Drying

Initial Saturation	
Wt. Sat. Sample + Apparatus (g)	184.79
Wt. Dry Soil (g)	110.95
Wt. Apparatus (g)	47.96
Wt. Water in Sat. Sample (g)	25.881
Grav. Moisture at Saturation (%)	23.33
Volumetric Moisture at Sat. (%)	37.39

Initial Air or Pressure Plate Dry	
Wt. Air/PP Sample + Apparatus (g)	N. A.
Wt. Dry Soil (g)	
Wt. Apparatus (g)	
Wt. Water in Air/PP Sample (g)	
Initial Gravimetric Moisture (%)	
Initial Volumetric Moisture (%)	

Sample Testing

Start of Test: Date 5/10/99, Time 5:25 PM Sample No. MW-B-Mix-PP-2

Initial Measurements		Final Measurements					
Pressure Gage (bars)	Burette Reading (cm^3)	Date (MM/DD/YY)	Time (HH/MM)	Pressure Gage (bars)	Burette Reading (cm^3)	Wt. Sample + Apparatus (g)	Suction Head (cm)
0.33	36.8	5/14/99	9:05 AM	0.35	25	171.79	357
0.33	25.5	5/15/99	12:36 PM	0.35	29.8	171.69	357
0.33	29.8	5/16/99	4:53 PM	0.45	30.0	171.59	459
0.33	30.5	5/17/99	6:20 PM	0.52	39.5	171.43	531
11.3	32.0	5/21/99	2:40 PM	11.00	1.4	170.12	11228
11.5	3.0	5/25/99	5:14 PM	10.70	-2.2	169.00	10922
11.5	16.3						
		At 5/17/99 volumetric moisture (%) =				18.09	
		At 5/25/99 volumetric moisture (%) =				14.58	

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Pressure Plate Test

Sample No. MW-B-Mix-PP-3

Project SNL Mixed Waste Landfill Cover

Container Identification MW-PP-3

Date at Start of Test 5/10/99

Tested by C. Anderson

Date at End of Test 5/25/99

Description of Sample Mixes from Bucket #2, Mixed Sites 1, 2, 3 & 4 - passing # 4 sieve

Sample Preparation

Initial Soil Moisture Content	
Wt. Pan (g)	21.48
Wt. Pan + Wet Soil (g)	86.86
Wt. Pan + Dry Soil (g)	81.62
Wt. Water (g)	5.24
Wt. Dry Soil (g)	60.14
Grav. Moisture (%)	8.71

Expected Test Density (g/cm³)	1.54
Sample Height (cm)	2.50
Sample Diameter (cm)	6.005
Sample Volume (cm³)	70.804
Packing Grav. Moisture (%)	8.7 (est.)
Wt. Dry Soil Required (g)	109.04
Wt. Water Required (g)	9.49
Sample Weight Required (g)	118.52

Sample Construction

Sample Moisture Content	
Wt. Pan (g)	20.93
Wt. Pan + Wet Soil (g)	62.80
Wt. Pan + Dry Soil (g)	59.49
Wt. Water (g)	3.31
Wt. Dry Soil (g)	38.56
Grav. Moisture (%)	8.58

Wt. Wet Sample + Apparatus (g)	167.35
Wt. Apparatus (g)	48.74
Wt. Wet sample (g)	118.61
Sample Wet Density (g/cm³)	1.675
Sample Dry Density (g/cm³)	1.543
Computed Wt. Dry Soil (g)	109.23

Sample Initial Saturation or Drying

Initial Saturation	
Wt. Sat. Sample + Apparatus (g)	186.61
Wt. Dry Soil (g)	109.23
Wt. Apparatus (g)	48.74
Wt. Water in Sat. Sample (g)	28.637
Grav. Moisture at Saturation (%)	26.22
Volumetric Moisture at Sat. (%)	40.45

Initial Air or Pressure Plate Dry	
Wt. Air/PP Sample + Apparatus (g)	N. A.
Wt. Dry Soil (g)	
Wt. Apparatus (g)	
Wt. Water in Air/PP Sample (g)	
Initial Gravimetric Moisture (%)	
Initial Volumetric Moisture (%)	

Sample Testing

Start of Test: Date 5/10/99, Time 5:25 PM Sample No. MW-B-Mix-PP-3

Initial Measurements		Final Measurements					
Pressure Gage (bars)	Burette Reading (cm^3)	Date (MM/DD/YY)	Time (HH/MM)	Pressure Gage (bars)	Burette Reading (cm^3)	Wt. Sample + Apparatus (g)	Suction Head (cm)
0.33	36.8	5/14/99	9:05 AM	0.35	25	170.84	357
0.33	25.5	5/15/99	12:36 PM	0.35	29.8	170.74	357
0.33	29.8	5/16/99	4:53 PM	0.45	30.0	170.60	459
0.33	30.5	5/17/99	6:20 PM	0.52	39.5	170.43	531
11.3	32.0	5/21/99	2:40 PM	11.00	1.4	169.09	11228
11.5	3.0	5/25/99	5:14 PM	10.70	-2.2	168.07	10922
11.5	16.3						
		At 5/17/99 volumetric moisture (%) =				17.59	
		At 5/25/99 volumetric moisture (%) =				14.26	

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Pressure Plate Test

Sample No. MW-B-Mix-PP-4

Project SNL Mixed Waste Landfill Cover

Container Identification MW-PP-4

Date at Start of Test 5/10/99

Tested by C. Anderson

Date at End of Test 5/25/99

Description of Sample Mixes from Bucket #2. Mixed Sites 1, 2, 3 & 4 - passing # 4 sieve

Sample Preparation

Initial Soil Moisture Content	
Wt. Pan (g)	21.48
Wt. Pan + Wet Soil (g)	86.86
Wt. Pan + Dry Soil (g)	81.62
Wt. Water (g)	5.24
Wt. Dry Soil (g)	60.14
Grav. Moisture (%)	8.71

Expected Test Density (g/cm³)	1.54
Sample Height (cm)	2.43
Sample Diameter (cm)	6.005
Sample Volume (cm³)	68.821
Packing Grav. Moisture (%)	8.7 (est.)
Wt. Dry Soil Required (g)	105.98
Wt. Water Required (g)	9.22
Sample Weight Required (g)	115.21

Sample Construction

Sample Moisture Content	
Wt. Pan (g)	21.02
Wt. Pan + Wet Soil (g)	67.74
Wt. Pan + Dry Soil (g)	64.07
Wt. Water (g)	3.67
Wt. Dry Soil (g)	43.05
Grav. Moisture (%)	8.53

Wt. Wet Sample + Apparatus (g)	163.48
Wt. Apparatus (g)	48.04
Wt. Wet sample (g)	115.44
Sample Wet Density (g/cm³)	1.677
Sample Dry Density (g/cm³)	1.546
Computed Wt. Dry Soil (g)	106.37

Sample Initial Saturation or Drying

Initial Saturation	
Wt. Sat. Sample + Apparatus (g)	183.62
Wt. Dry Soil (g)	106.37
Wt. Apparatus (g)	48.04
Wt. Water in Sat. Sample (g)	29.208
Grav. Moisture at Saturation (%)	27.46
Volumetric Moisture at Sat. (%)	42.44

Initial Air or Pressure Plate Dry	
Wt. Air/PP Sample + Apparatus (g)	N. A.
Wt. Dry Soil (g)	
Wt. Apparatus (g)	
Wt. Water in Air/PP Sample (g)	
Initial Gravimetric Moisture (%)	
Initial Volumetric Moisture (%)	

Sample Testing

Start of Test: Date 5/10/99, Time 5:25 PM Sample No. MW-B-Mix-PP-4

Initial Measurements		Final Measurements					
Pressure Gage (bars)	Burette Reading (cm^3)	Date (MM/DD/YY)	Time (HH/MM)	Pressure Gage (bars)	Burette Reading (cm^3)	Wt. Sample + Apparatus (g)	Suction Head (cm)
0.33	36.8	5/14/99	9:05 AM	0.35	25	167.05	357
0.33	25.5	5/15/99	12:36 PM	0.35	29.8	166.95	357
0.33	29.8	5/16/99	4:53 PM	0.45	30.0	166.82	459
0.33	30.5	5/17/99	6:20 PM	0.52	39.5	166.67	531
11.3	32.0	5/21/99	2:40 PM	11.00	1.4	164.90	11228
11.5	3.0	5/25/99	5:14 PM	10.70	-2.2	163.95	10922
11.5	16.3						
		At 5/17/99 volumetric moisture (%) =				17.81	
		At 5/25/99 volumetric moisture (%) =				13.86	

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Geoenvironmental Laboratory

Pressure Plate Test

Sample No. MW-B-Mix-PP-5

Project SNL Mixed Waste Landfill Cover

Container Identification MW-PP-5

Date at Start of Test 5/10/99

Tested by C. Anderson

Date at End of Test 5/25/99

Description of Sample Mixes from Bucket #2, Mixed Sites 1, 2, 3 & 4 - passing # 4 sieve

Sample Preparation

Initial Soil Moisture Content	
Wt. Pan (g)	21.48
Wt. Pan + Wet Soil (g)	86.86
Wt. Pan + Dry Soil (g)	81.62
Wt. Water (g)	5.24
Wt. Dry Soil (g)	60.14
Grav. Moisture (%)	8.71

Expected Test Density (g/cm³)	1.66
Sample Height (cm)	2.43
Sample Diameter (cm)	6.005
Sample Volume (cm³)	68.821
Packing Grav. Moisture (%)	8.7 (est.)
Wt. Dry Soil Required (g)	114.24
Wt. Water Required (g)	9.94
Sample Weight Required (g)	124.18

Sample Construction

Sample Moisture Content	
Wt. Pan (g)	21.13
Wt. Pan + Wet Soil (g)	67.44
Wt. Pan + Dry Soil (g)	63.64
Wt. Water (g)	3.8
Wt. Dry Soil (g)	42.51
Grav. Moisture (%)	8.94

Wt. Wet Sample + Apparatus (g)	168.43
Wt. Apparatus (g)	44.40
Wt. Wet sample (g)	124.03
Sample Wet Density (g/cm³)	1.802
Sample Dry Density (g/cm³)	1.654
Computed Wt. Dry Soil (g)	113.85

Sample Initial Saturation or Drying

Initial Saturation	
Wt. Sat. Sample + Apparatus (g)	183.22
Wt. Dry Soil (g)	113.85
Wt. Apparatus (g)	44.40
Wt. Water in Sat. Sample (g)	24.967
Grav. Moisture at Saturation (%)	21.93
Volumetric Moisture at Sat. (%)	36.28

Initial Air or Pressure Plate Dry	
Wt. Air/PP Sample + Apparatus (g)	N. A.
Wt. Dry Soil (g)	
Wt. Apparatus (g)	
Wt. Water in Air/PP Sample (g)	
Initial Gravimetric Moisture (%)	-
Initial Volumetric Moisture (%)	-

Sample Testing

Start of Test: Date 5/10/99, Time 5:25 PM Sample No. MW-B-Mix-PP-5

Initial Measurements		Final Measurements					
Pressure Gage (bars)	Burette Reading (cm^3)	Date (MM/DD/YY)	Time (HH/MM)	Pressure Gage (bars)	Burette Reading (cm^3)	Wt. Sample + Apparatus (g)	Suction Head (cm)
0.33	36.8	5/14/99	9:05 AM	0.35	25	172.15	357
0.33	25.5	5/15/99	12:36 PM	0.35	29.8	172.07	357
0.33	29.8	5/16/99	4:53 PM	0.45	30.0	171.89	459
0.33	30.5	5/17/99	6:20 PM	0.52	39.5	171.74	531
11.3	32.0	5/21/99	2:40 PM	11.00	1.4	170.07	11228
11.5	3.0	5/25/99	5:14 PM	10.70	-2.2	168.92	10922
11.5	16.3						
		At 5/17/99 volumetric moisture (%) =				19.60	
		At 5/25/99 volumetric moisture (%) =				15.50	

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Geoenvironmental Laboratory

Pressure Plate Test

Sample No. MW-B-Mix-PP-6

Project SNL Mixed Waste Landfill Cover

Container Identification MW-PP-6

Date at Start of Test 5/10/99

Tested by C. Anderson

Date at End of Test 5/25/99

Description of Sample Mixes from Bucket #2, Mixed Sites 1, 2, 3 & 4 - passing # 4 sieve

Sample Preparation

Initial Soil Moisture Content	
Wt. Pan (g)	21.48
Wt. Pan + Wet Soil (g)	86.86
Wt. Pan + Dry Soil (g)	81.62
Wt. Water (g)	5.24
Wt. Dry Soil (g)	60.14
Grav. Moisture (%)	8.71

Expected Test Density (g/cm³)	1.66
Sample Height (cm)	2.50
Sample Diameter (cm)	6.01
Sample Volume (cm³)	70.922
Packing Grav. Moisture (%)	8.7 (est.)
Wt. Dry Soil Required (g)	117.73
Wt. Water Required (g)	10.24
Sample Weight Required (g)	127.97

Sample Construction

Sample Moisture Content	
Wt. Pan (g)	21.68
Wt. Pan + Wet Soil (g)	69.58
Wt. Pan + Dry Soil (g)	65.78
Wt. Water (g)	3.8
Wt. Dry Soil (g)	44.1
Grav. Moisture (%)	8.62

Wt. Wet Sample + Apparatus (g)	176.50
Wt. Apparatus (g)	48.29
Wt. Wet sample (g)	128.21
Sample Wet Density (g/cm³)	1.808
Sample Dry Density (g/cm³)	1.664
Computed Wt. Dry Soil (g)	118.04

Sample Initial Saturation or Drying

Initial Saturation	
Wt. Sat. Sample + Apparatus (g)	190.89
Wt. Dry Soil (g)	118.04
Wt. Apparatus (g)	48.29
Wt. Water in Sat. Sample (g)	24.561
Grav. Moisture at Saturation (%)	20.81
Volumetric Moisture at Sat. (%)	34.63

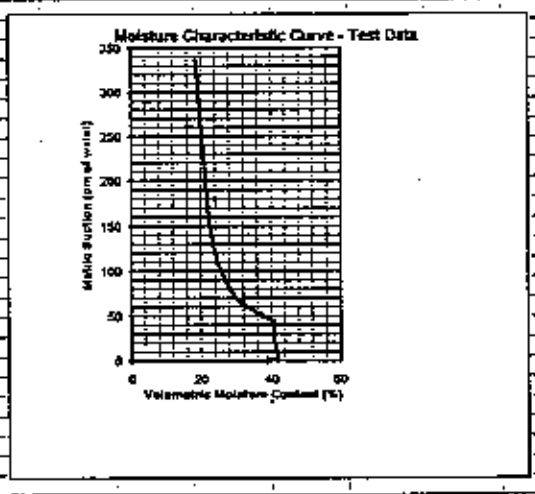
Initial Air or Pressure Plate Dry	
Wt. Air/PP Sample + Apparatus (g)	N. A.
Wt. Dry Soil (g)	
Wt. Apparatus (g)	
Wt. Water in Air/PP Sample (g)	
Initial Gravimetric Moisture (%)	
Initial Volumetric Moisture (%)	

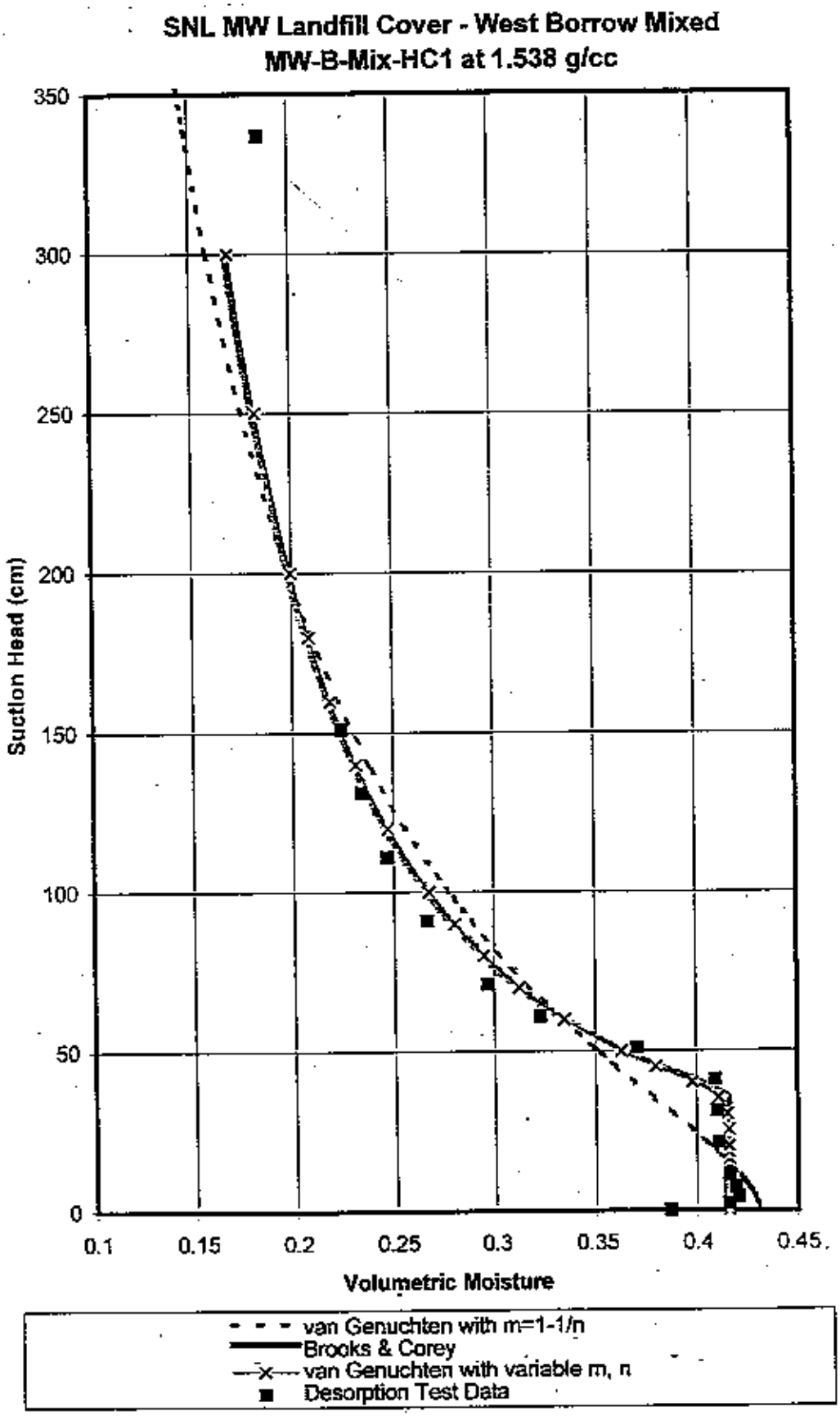
Sample Testing

Start of Test: Date 5/10/99, Time 5:25 PM Sample No. MW-B-Mix-PP-6

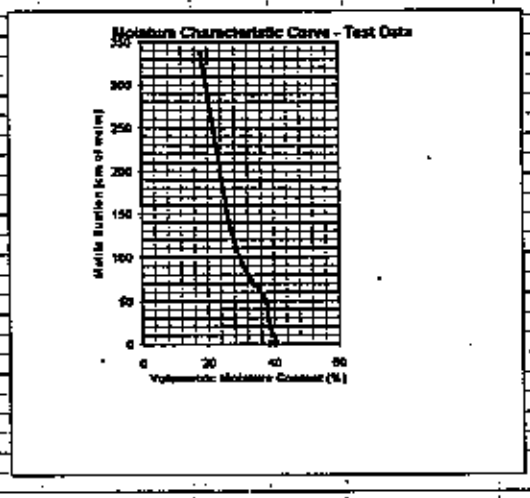
Initial Measurements		Final Measurements					
Pressure Gage (bars)	Burette Reading (cm^3)	Date (MM/DD/YY)	Time (HH/MM)	Pressure Gage (bars)	Burette Reading (cm^3)	Wt. Sample + Apparatus (g)	Suction Head (cm)
0.33	36.8	5/14/99	9:05 AM	0.35	25	180.19	357
0.33	25.5	5/15/99	12:36 PM	0.35	29.8	180.09	357
0.33	29.8	5/16/99	4:53 PM	0.45	30.0	179.99	459
0.33	30.5	5/17/99	6:20 PM	0.52	39.5	179.80	531
11.3	32.0	5/21/99	2:40 PM	11.00	1.4	178.72	11228
11.5	3.0	5/25/99	5:14 PM	10.70	-2.2	177.96	10922
11.5	16.3						
		At 5/17/99 volumetric moisture (%) =				18.99	
		At 5/25/99 volumetric moisture (%) =				16.40	

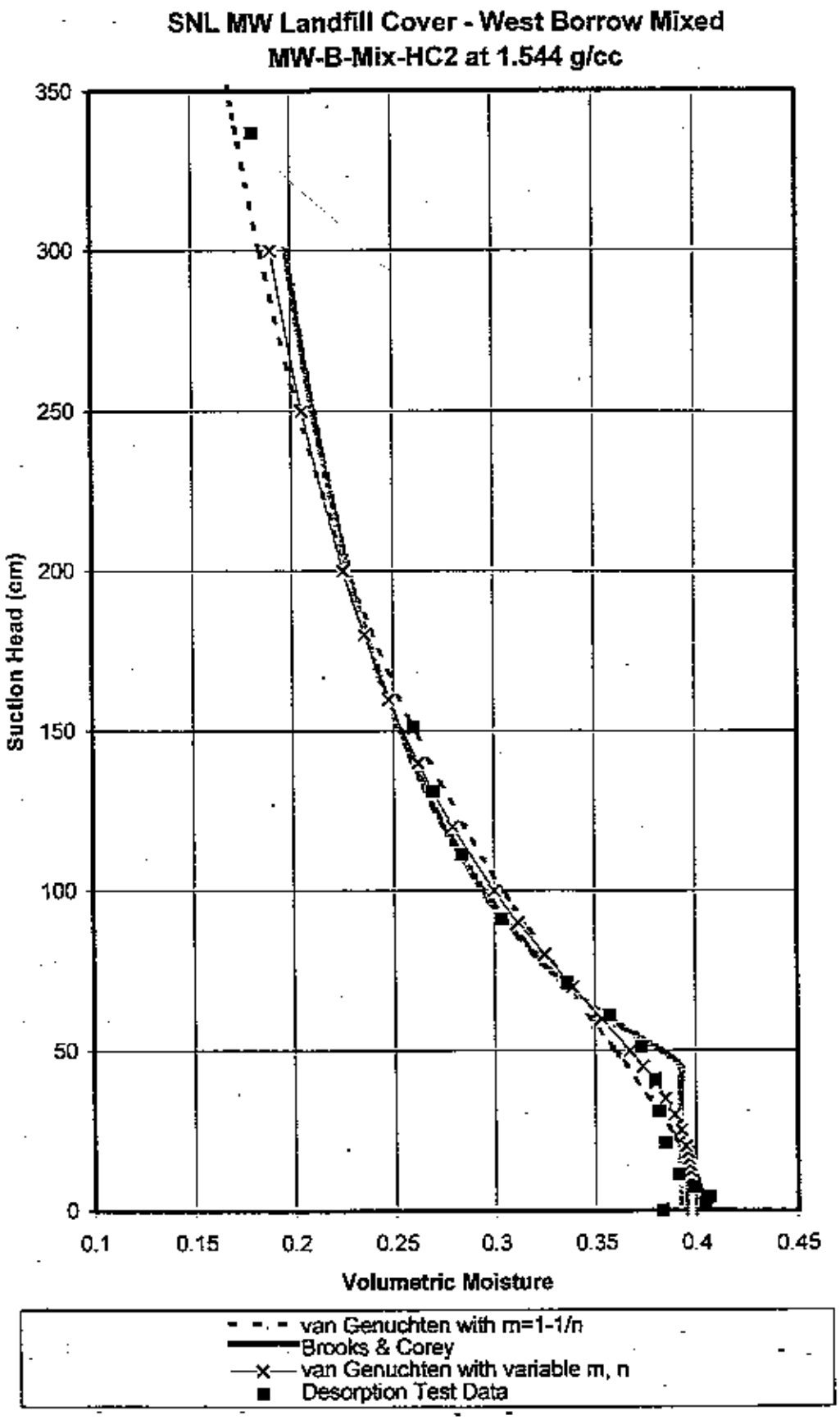
	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q
1	Hanging Column Analysis - SNL Mixed Waste Landfill Cover										Brooks & Corey Par.			van Genuchten Param. (drying)			
2											drying				m=1-1/n	Var. m, n	
3											WCr =	0.0352		WCr =	0.0000	0.0352	
4	Sample identification		MW-8-Mix-HC-1		sample dry density		1.536 g/cc				alpha =	0.02678	(1/cm)	alpha =	0.01627	0.02706	(1/cm)
5	salt weight (same-app)		179.78 (g)		Sample height (cm)		2.425				n =	0.50633		n =	1.61314	13.96401	
6	weight of dry solids		105.45 (g)								Theta-s =	0.41537		Theta-s	0.43119	0.41618	
7	salt weight of water		26.49 (g)		spreadsheet assumes 1 g of water = 1 ml of water									m=	1-1/n	0.03582	
8	grav. W at sat		25.11853 %														
9	vol. W at sat		38.6323 %						calculation		data to plot				Fitted Data to Plot		
10	app weight-dry solids		153.29 (g)			raw			based on						vanGenuc	vanGenuc	Brooks&C
11			sample	water loss	cum.	calculation	weight of		grav. moist					Pressure	m=1-1/n	Var. m, n	
12		pressure	weight	from sam.	water loss	vol mois.	water	grav mois.	vol mois.		pressure	vol mois.					
13		(cm wat.)	(g)	(g)	(g)	%	(g)	%	%		(cm wat.)	%					
14	0	0	179.78	0	0	38.6323	26.49	25.11853	38.6323		0	38.6323	0.386323	0	0.431191	0.41618	0.41537
15	1	2.2125	181.80	-2.02	-2.02	41.57821	28.51	27.03395	41.57821		2.2125	41.57821	0.415782	1	0.430977	0.41618	0.41537
16	3	4.2125	182.14	-0.34	-2.36	42.07408	28.85	27.35634	42.07408		4.2125	42.07408	0.420741	2	0.430539	0.41618	0.41537
17	6	7.2125	182.02	0.12	-2.24	41.89905	28.73	27.24256	41.89905		7.2125	41.89905	0.418991	3	0.429941	0.41618	0.41537
18	10	11.2125	181.82	0.2	-2.04	41.60738	28.53	27.05291	41.60738		11.2125	41.60738	0.416074	4	0.429209	0.41618	0.41537
19	20	21.2125	181.46	0.36	-1.68	41.08236	28.17	26.71155	41.08236		21.2125	41.08236	0.410824	5	0.428361	0.41618	0.41537
20	30	31.2125	181.39	0.07	-1.61	40.98028	28.1	26.64517	40.98028		31.2125	40.98028	0.409803	6	0.427409	0.41618	0.41537
21	40	41.2125	181.35	0.04	-1.57	40.92194	28.06	26.60724	40.92194		41.2125	40.92194	0.409219	7	0.426363	0.41618	0.41537
22	50	51.2125	178.69	2.66	1.09	37.04267	25.4	24.08496	37.04267		51.2125	37.04267	0.370427	8	0.425252	0.41618	0.41537
23	60	61.2125	175.39	3.3	4.39	32.23004	22.1	20.95581	32.23004		61.2125	32.23004	0.3223	9	0.424023	0.41618	0.41537
24	70	71.2125	173.58	1.81	6.2	29.59038	20.29	19.23952	29.59038		71.2125	29.59038	0.295904	10	0.422742	0.41618	0.41537
25	90	91.2125	171.53	2.05	8.25	26.60072	18.24	17.28566	26.60072		91.2125	26.60072	0.266007	11	0.419867	0.41618	0.41537
26	110	111.2125	170.19	1.34	9.59	24.5465	16.9	16.02503	24.5465		111.2125	24.5465	0.245465	12	0.417011	0.41618	0.41537
27	130	131.2125	169.32	0.87	10.46	23.37772	16.03	15.20008	23.37772		131.2125	23.37772	0.233777	14	0.411846	0.41618	0.41537
28	150	151.2125	168.67	0.65	11.11	22.42977	15.38	14.58373	22.42977		151.2125	22.42977	0.224298	16	0.406526	0.41617	0.41537
29		337				18.5			18.5		337	18.5	0.185	18	0.401075	0.41617	0.41537
30														20	0.398033	0.41622	0.41537
31														25	0.386531	0.41462	0.41537
32														30	0.379097	0.41004	0.41537
33														35	0.369595	0.397753	0.402384
34														40	0.360242	0.379864	0.381167
35														45	0.351119	0.362819	0.363229
36														50	0.333753	0.334559	0.334357
37														60	0.317707	0.312474	0.311938
38														70	0.303006	0.294657	0.293881
39														80	0.28959	0.279694	0.278833
40														90	0.277356	0.267401	0.266296
41														100	0.255987	0.24727	0.245856
42														120	0.238043	0.231617	0.230152
43														140	0.222812	0.218995	0.21744
44														160	0.209741	0.209537	0.20691
45														180	0.198403	0.199687	0.198007
46														200	0.175684	0.182407	0.180648
47														250	0.15856	0.166545	0.167844
48														300	0.148344	0.152069	0.160273
49														337	0.145138	0.149722	0.157904
50														350	0.134294	0.15172	0.149897
51														400	0.125322	0.14509	0.14327
52														450	0.117753	0.139479	0.137666
53														500	0.105636	0.130438	0.128649
54														600	0.095309	0.123409	0.121545
55														700	0.088865	0.117741	0.116004
56														800	0.082759	0.113044	0.111338
57														900	0.077642	0.109069	0.107388
58														1000	0.069504	0.102568	0.101034
59														1200	0.063279	0.097686	0.0961
60														1400	0.058332	0.09367	0.092126
61														1600	0.054286	0.090343	0.088837
62														1800	0.050903	0.087528	0.086056
63														2000	0.045535	0.082991	0.08158
64														2400	0.041438	0.079464	0.078104
65														2800	0.038187	0.076619	0.075305
66														3200	0.035533	0.074263	0.072987
67														3600	0.03331	0.072288	0.071029
68														4000	0.030942	0.070139	0.068858
69														4500	0.028055	0.068374	0.067208
70														5000	0.027407	0.066838	0.065702
71														5500	0.025984	0.065496	0.06439
72														6000	0.02474	0.064315	0.063233
73														6500	0.023642	0.063263	0.062203
74														7000	0.021784	0.061459	0.060441
75														8000	0.020267	0.059954	0.058962
76														9000	0.018896	0.0587	0.057749
77														10000	0.01699	0.056863	0.055765
78														12000	0.015458	0.055078	0.054223
79														14000	0.014639	0.05422	0.053389
80														15000	0.014243	0.053801	0.052982
81														16000	0.013251	0.052743	0.051955
82														18000	0.012422	0.051847	0.051086
83														20000	0.010834	0.050098	0.049392
84														25000	0.009688	0.048807	0.048143
85														30000	0.008814	0.047802	0.047173
86														35000	0.008121	0.046982	0.046392
87														40000	0.007556	0.046321	0.045745
88														45000	0.007083	0.045754	0.045198
89														50000	0.006334	0.044839	0.044318
90														60000	0.005789	0.044127	0.043635
91														70000	0.00531	0.043554	0.043084
92														80000	0.00494	0.043078	0.042629
93														90000	0.004631	0.042678	0.042244
94														100000	0.003811	0.041311	0.040939
95														150000	0.003027	0.040496	0.040162
96														200000	0.00264	0.03994	0.039633
97														250000	0.002361	0.039529	0.039243
														300000	0.001979	0.038952	0.038696
														400000	0.001726	0.038557	0.038323
														500000			



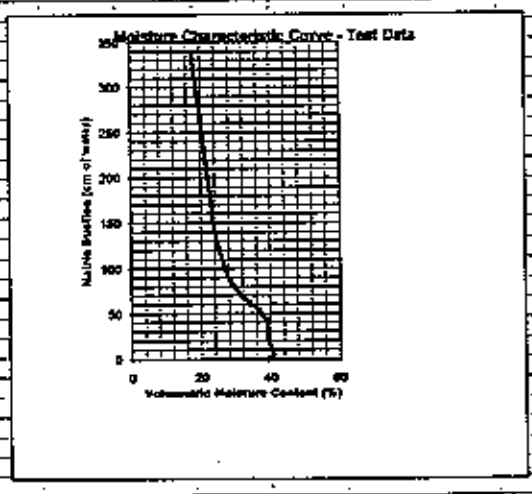

SNL MW Landfill Cover - West Borrow Mixed
MW-B-Mix-HC1 at 1.538 g/cc
Suction Head (cm)
350
300
250
200
150
100
50
0
0.1
0.15
0.2
0.25
0.3
0.35
0.4
0.45
Volumetric Moisture
van Genuchten with m=1-1/n
Brooks & Corey
van Genuchten with variable m, n
Desorption Test Data

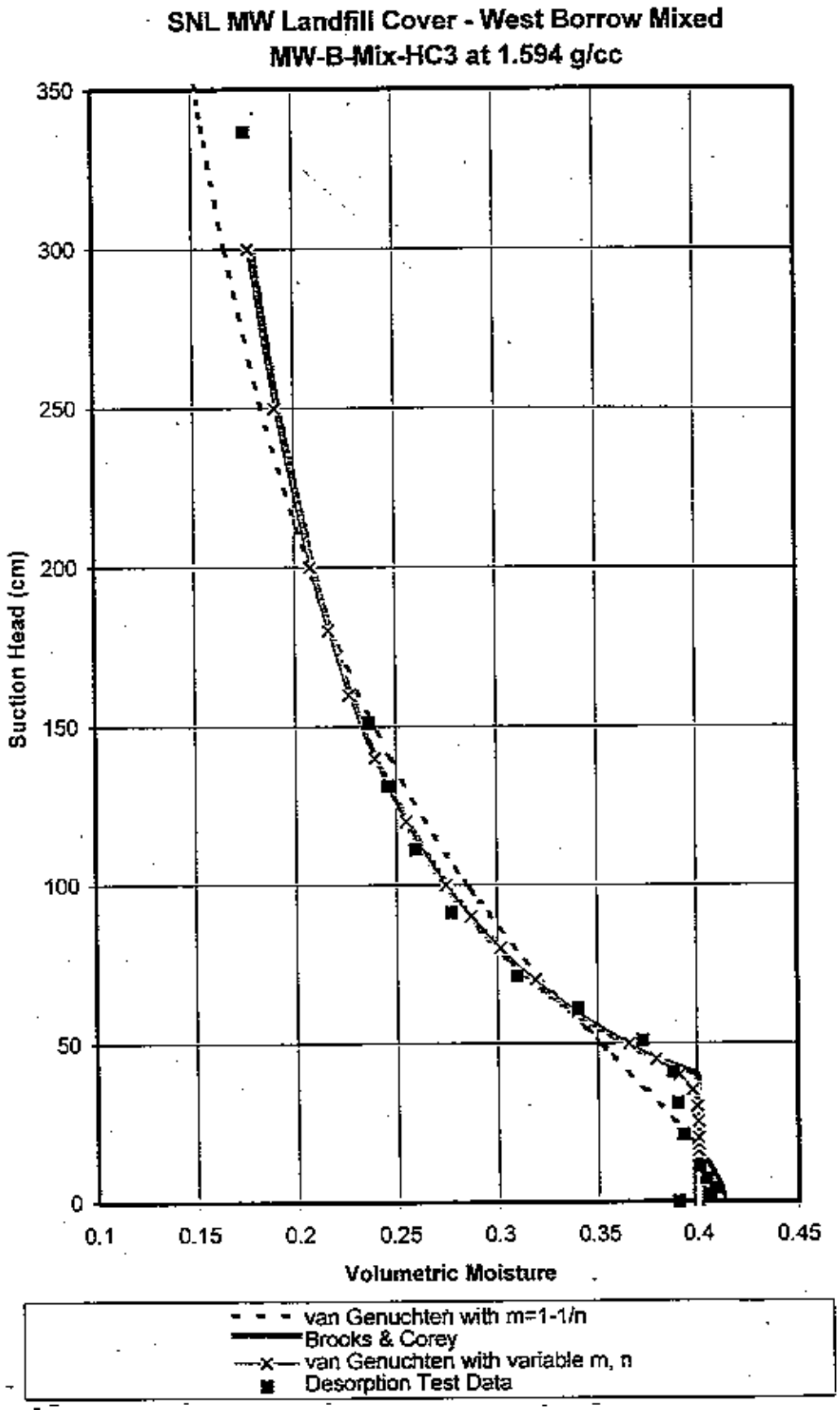
	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q
1	Hanging Column Analysis - Sill, Mixed Waste Landfill Cover										Brooks & Corey Par.			van Genuchten Param. (drying)			
2											drying				m=1-1/n	Var. m, n	
3											WCr =	0.0352		WCr =	0.0000	0.0352	
4	Sample Identification	MW-B-Mix-HC-2		sample dry density		1.544 g/cc					alpha =	0.02133	(1/cm)	alpha =	0.01048	0.01735	(1/cm)
5	sat weight (sam+app)	182.57 (g)		Sample height (cm)		2.5					n =	0.42384		n =	1.63634	2.95253	
6	weight of dry solids	108.76 (g)									Theta-s =	0.39217		Theta-s	0.40408	0.3977	
7	sat weight of water	28.98 (g)		spreadsheet assumes 1 g of water = 1 ml of water										m=	1-1/n	0.17405	
8	grav. W at sat	24.80691%															
9	vol. W at sat	38.30188%							calculation		data to plot				Fitted Data to Plot		
10	app weight+dry solids	155.58 (g)							based on						vanGenuch	vanGenuc	Brooks&C
11			sample	water loss	cum.	calculation	weight of		grav. mois					Pressure	m=1-1/n	Var. m, n	
12		pressure	weight	from sam.	water loss	vol mois.	water	grav mois.	vol mois		pressure	vol mois.					
13		(cm wat.)	(g)	(g)	(g)	%	(g)	%	%		(cm wat.)	%					
14	0	0	182.57	0	0	38.30188	28.98	24.80691	38.30188		0	38.30188	0.383019	0	0.40408	0.3977	0.39217
15	1	2.25	184.07	-1.5	-1.5	40.43134	28.48	26.1861	40.43134		2.25	40.43134	0.404313	1	0.40399	0.3977	0.39217
16	3	4.25	184.21	-0.14	-1.64	40.63008	28.62	26.31482	40.63008		4.25	40.63008	0.406301	2	0.4038	0.397769	0.39217
17	6	7.25	183.66	0.55	-1.09	39.84928	28.07	25.80912	39.84928		7.25	39.84928	0.398493	3	0.403536	0.397678	0.39217
18	10	11.25	183.12	0.54	-0.55	39.08269	27.53	25.31261	39.08269		11.25	39.08269	0.390827	4	0.403211	0.397654	0.39217
19	20	21.25	182.66	0.46	-0.09	38.42964	27.07	24.88967	38.42964		21.25	38.42964	0.384296	5	0.40283	0.397575	0.39217
20	30	31.25	182.45	0.21	0.12	38.13152	26.86	24.696581	38.13152		31.25	38.13152	0.381315	6	0.402399	0.397521	0.39217
21	40	41.25	182.33	0.12	0.24	37.96116	26.74	24.586241	37.96116		41.25	37.96116	0.379612	7	0.401821	0.397575	0.39217
22	50	51.25	181.85	0.48	0.72	37.27974	26.26	24.144911	37.27974		51.25	37.27974	0.372797	8	0.4014	0.397515	0.39217
23	60	61.25	180.73	1.12	1.84	35.68974	25.14	23.11512	35.68974		61.25	35.68974	0.356897	9	0.400538	0.397438	0.39217
24	70	71.25	179.23	1.5	3.34	33.56028	23.64	21.73583	33.56028		71.25	33.56028	0.335603	10	0.400239	0.397343	0.39217
25	90	91.25	176.95	2.28	5.62	30.3235	21.36	19.63957	30.3235		91.25	30.3235	0.303235	11	0.399933	0.397089	0.39217
26	110	111.25	175.55	1.4	7.02	28.33601	19.96	18.35234	28.33601		111.25	28.33601	0.28336	14	0.3975	0.39674	0.39217
27	130	131.25	174.56	0.99	8.01	26.93056	18.97	17.44207	26.93056		131.25	26.93056	0.269305	16	0.39696	0.396283	0.39217
28	150	151.25	173.67	0.89	8.71	25.95101	18.28	16.80765	25.95101		151.25	25.95101	0.25951	18	0.396295	0.395704	0.39217
29		337				18.09			18.09		337	18.09	0.1809	20	0.392547	0.394994	0.39217
30														25	0.387823	0.392588	0.39217
31														30	0.382682	0.389221	0.39217
32														35	0.377261	0.384889	0.39217
33														40	0.371515	0.379868	0.39217
34														45	0.365828	0.373696	0.39217
35														50	0.35996	0.367149	0.382559
36														60	0.348171	0.353052	0.356721
37														70	0.336543	0.338537	0.336382
38														80	0.325253	0.32473	0.319606
39														90	0.314442	0.311746	0.305943
40														100	0.30414	0.299832	0.294116
41														120	0.285162	0.279144	0.274858
42														140	0.268287	0.262089	0.259697
43														160	0.253324	0.247844	0.247341
44														180	0.240038	0.235835	0.237008
45														200	0.228203	0.225556	0.228193
46														250	0.209594	0.205265	0.210773
47														300	0.184507	0.180214	0.187713
48														337	0.173004	0.161276	0.169895
49														350	0.169335	0.178476	0.167432
50														400	0.156827	0.169009	0.179054
51														450	0.146382	0.161169	0.172047
52														500	0.137514	0.154542	0.165069
53														600	0.123228	0.14388	0.156335
54														700	0.112174	0.135607	0.148672
55														800	0.103329	0.128951	0.142427
56														900	0.095054	0.123445	0.137204
57														1000	0.089731	0.118785	0.132748
58														1200	0.080287	0.111318	0.125492
59														1400	0.072684	0.10552	0.11978
60														1600	0.06701	0.100858	0.115125
61														1800	0.062213	0.097	0.111232
62														2000	0.058208	0.093742	0.107911
63														2400	0.051867	0.088505	0.102503
64														2800	0.047042	0.084445	0.098245
65														3200	0.043223	0.081178	0.094775
66														3600	0.04011	0.078478	0.091874
67														4000	0.037515	0.076196	0.089398
68														4500	0.034812	0.073788	0.086756
69														5000	0.032558	0.071754	0.084506
70														5500	0.030645	0.070006	0.082553
71														6000	0.028995	0.068484	0.080838
72														6500	0.027558	0.067142	0.079316
73														7000	0.026289	0.065949	0.077951
74														8000	0.024149	0.063909	0.075598
75														9000	0.022407	0.062223	0.073531
76														10000	0.020954	0.060798	0.071952
77														12000	0.01866	0.058506	0.069218
78														14000	0.016917	0.056733	0.067066
79														15000	0.015988	0.055772	0.065889
80														16000	0.015139	0.055005	0.065312
81														18000	0.014417	0.054124	0.063846
82														20000	0.013483	0.053126	0.062594
83														25000	0.011895	0.051184	0.060122
84														30000	0.010417	0.049754	0.058288
85														35000	0.009444	0.048545	0.056809
86														40000	0.008674	0.047753	0.055619
87														45000	0.008048	0.047018	0.054625
88														50000	0.007526	0.045393	0.053776
89														60000	0.006702	0.045392	0.052395
90														70000	0.006078	0.044615	0.051307
91														80000	0.005581	0.043991	0.05042
92														90000	0.005178	0.043474	0.049679
93														100000	0.004842	0.043038	0.049048
94														150000	0.003741	0.041564	0.04686
95														200000	0.003115	0.040688	0.045521
96														250000	0.002703	0.040094	0.044589
97														300000	0.002407	0.039656	0.043891
														400000	0.002004	0.039044	0.042893
														500000	0.001738	0.038627	0.042199



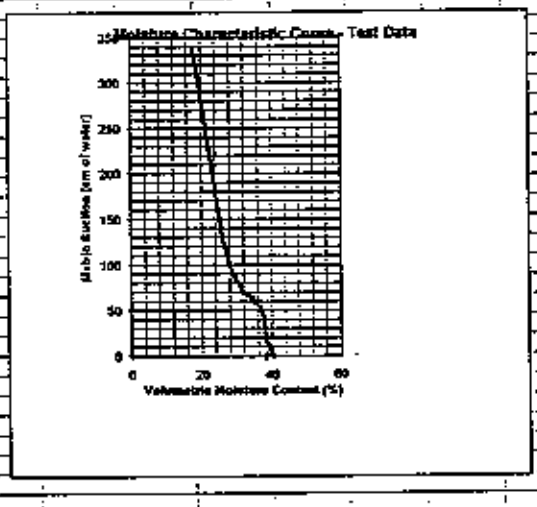

SNL MW Landfill Cover - West Borrow Mixed
MW-B-Mix-HC2 at 1.544 g/cc
Suction Head (cm)
350
300
250
200
150
100
50
0
0.1
0.15
0.2
0.25
0.3
0.35
0.4
0.45
Volumetric Moisture
van Genuchten with m=1-1/n
Brooks & Corey
van Genuchten with variable m, n
Desorption Test Data

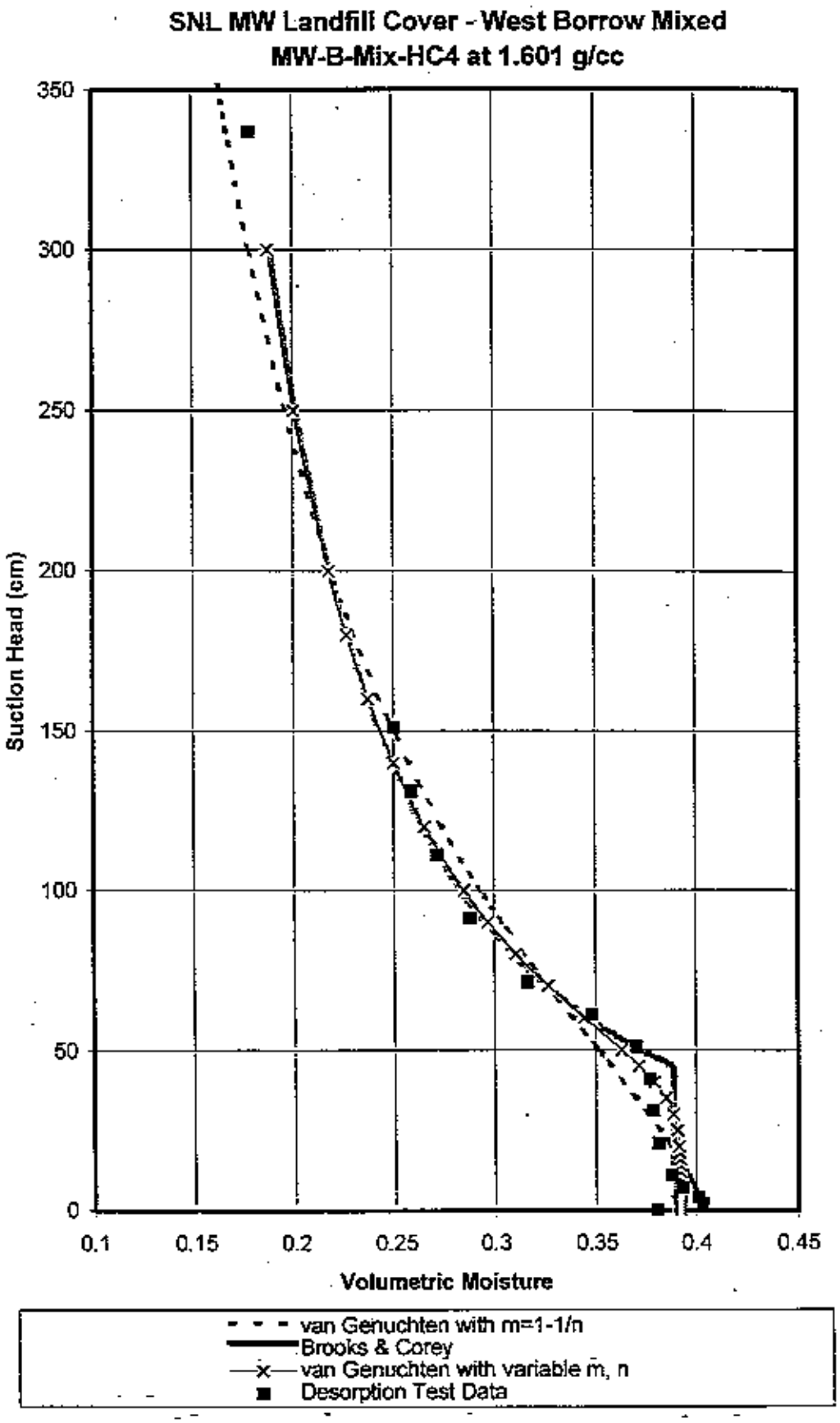
	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q
1	Hanging Column Analysis - SML Mixed Waste Landfill Cover										Brooks & Corey Par. -			van Genuchten Param. (drying)			
2											drying				m=1-1/n	Var. m, n	
3											WCr =	0.0352		WCr =	0.0000	0.0352	
4	Sample identification	MW-B-Mix-HC-3			sample dry density	1.594 g/cc					alpha =	0.02517	(1/cm)	alpha = 1	0.0135	0.02444	(1/cm)
5	sat weight (sam+app)	187.07	(g)		Sample height (cm)	2.48					n =	0.45779		n =	1.82408	10.291961	
6	weight of dry solids	111.39	(g)								Theta-r =	0.40025		Theta-s	0.41344	0.40059	
7	sat weight of water	27.25	(g)		spreadsheet assumes 1 g of water = 1 ml of water									m=	1-1/n	0.04587	
8	grav. W at sat	24.4636	%														
9	vol. W at sat	38.99497	%					calculation			data to plot				Fitted Data to Plot		
10	app weight+dry solids	158.82	(g)			ratio		based on							vanGenuc	vanGenuc	Brooks&C
11			sample	water loss	cum.	calculation	weight of 1	grav. mois.						Pressure	m=1-1/n	Var. m, n	
12		pressure	weight	from sam.	water loss	vol mois.	water	grav mois.	vol mois.		pressure	vol mois.		0	0.41344	0.40059	0.40025
13		(cm wat.)	(g)	(g)	(g)	%	(g)	%	%		(cm wat.)	%		1	0.413294	0.40059	0.40025
14	0	0	187.07	0	0	38.99497	27.25	24.4636	38.99497		0	38.99497	0.38995	2	0.412991	0.40059	0.40025
15	1	2.24	186.20	-1.13	-1.13	40.612011	26.38	25.47805	40.612011		2.24	40.612011	0.40612	3	0.412573	0.40059	0.40025
16	3	4.24	186.33	-0.13	-1.26	40.79804	26.51	25.59476	40.79804		4.24	40.79804	0.40798	4	0.41205	0.40059	0.40025
17	6	7.24	186.07	0.26	-1	40.42596	26.25	25.36134	40.42596		7.24	40.42596	0.40426	5	0.411483	0.40059	0.40025
18	10	11.24	187.60	0.27	-0.73	40.03961	27.98	25.11695	40.03961		11.24	40.03961	0.400396	6	0.41079	0.40059	0.40025
19	20	21.24	187.26	0.54	-0.19	39.26886	27.44	24.63417	39.26886		21.24	39.26886	0.392689	7	0.410047	0.40059	0.40025
20	30	31.24	187.08	0.18	-0.01	39.00928	27.26	24.47257	39.00928		31.24	39.00928	0.390093	8	0.409246	0.40059	0.40025
21	40	41.24	186.91	0.17	0.16	38.76601	27.09	24.31095	38.76601		41.24	38.76601	0.38765	9	0.408374	0.40059	0.40025
22	50	51.24	185.84	1.07	1.23	37.23483	26.02	23.35637	37.23483		51.24	37.23483	0.372348	10	0.407459	0.40059	0.40025
23	60	61.24	183.57	2.27	3.5	33.98644	23.75	21.32148	33.98644		61.24	33.98644	0.339864	12	0.405461	0.40059	0.40025
24	70	71.24	181.44	2.13	5.63	30.9384	21.62	19.40328	30.9384		71.24	30.9384	0.309384	14	0.40329	0.40059	0.40025
25	90	91.24	179.19	2.26	7.89	27.70432	19.36	17.38038	27.70432		91.24	27.70432	0.277043	16	0.400964	0.40059	0.40025
26	110	111.24	177.94	1.24	9.13	25.92967	18.12	16.267171	25.92967		111.24	25.92967	0.259299	18	0.398502	0.40059	0.40025
27	130	131.24	177.00	0.94	10.07	24.58472	17.18	15.42329	24.58472		131.24	24.58472	0.245847	20	0.395922	0.40059	0.40025
28	150	151.24	176.34	0.66	10.73	23.64025	16.52	14.83077	23.64025		151.24	23.64025	0.236403	25	0.389052	0.40059	0.40025
29		337				17.59			17.59		337	17.59	0.1759	30	0.381778	0.39991	0.40025
30														35	0.37424	0.39754	0.40025
31														40	0.366578	0.39094	0.399119
32														45	0.358896	0.37947	0.380016
33														50	0.35127	0.36774	0.36378
34														60	0.336404	0.33991	0.337468
35														70	0.322279	0.31872	0.316873
36														80	0.309016	0.301436	0.30017
37														90	0.296566	0.287045	0.286261
38														100	0.285207	0.274827	0.274439
39														120	0.26477	0.255065	0.255282
40														140	0.247229	0.239633	0.240286
41														160	0.232097	0.227144	0.228125
42														180	0.218949	0.216762	0.217996
43														200	0.207435	0.207952	0.20939
44														250	0.1841	0.190579	0.192475
45														300	0.165314	0.177857	0.179881
46														337	0.155638	0.170235	0.172379
47														350	0.15228	0.167844	0.170023
48														400	0.140892	0.15974	0.162028
49														450	0.131443	0.153004	0.155371
50														500	0.123457	0.147288	0.149712
51														600	0.11085	0.138044	0.140542
52														700	0.100779	0.130625	0.133385
53														800	0.092899	0.124683	0.127544
54														900	0.086434	0.120127	0.122696
55														1000	0.081017	0.116005	0.118576
56														1200	0.072406	0.109342	0.1119
57														1400	0.065825	0.104138	0.108674
58														1600	0.0606	0.099926	0.102435
59														1800	0.056331	0.096426	0.098906
60														2000	0.052764	0.093455	0.095806
61														2400	0.047111	0.08865	0.091045
62														2800	0.042803	0.084899	0.08724
63														3200	0.039389	0.081862	0.084154
64														3600	0.036603	0.079339	0.081584
65														4000	0.034277	0.077197	0.0794
66														4500	0.031651	0.074925	0.07708
67														5000	0.029626	0.072898	0.075108
68														5500	0.028108	0.071335	0.073404
69														6000	0.026521	0.069891	0.071912
70														6500	0.025325	0.068594	0.070591
71														7000	0.024181	0.067446	0.069411
72														8000	0.022249	0.065478	0.067382
73														9000	0.020673	0.063839	0.065693
74														10000	0.019356	0.062449	0.064257
75														12000	0.017276	0.060202	0.06193
76														14000	0.015892	0.058447	0.060109
77														15000	0.014846	0.057493	0.059117
78														16000	0.014438	0.057027	0.058632
79														18000	0.013415	0.055846	0.057402
80														20000	0.012561	0.054844	0.056356
81														25000	0.010628	0.05288	0.054302
82														30000	0.009753	0.051422	0.052772
83														35000	0.008859	0.050284	0.051575
84														40000	0.00815	0.049352	0.050604
85														45000	0.007573	0.048596	0.049795
86														50000	0.007091	0.047946	0.049106
87														60000	0.006328	0.046895	0.047994
88														70000	0.005748	0.046074	0.047125
89														80000	0.005288	0.04541	0.046416
90														90000	0.004913	0.044857	0.045827
91														100000	0.004601	0.044369	0.045327
92														150000	0.003572	0.042788	0.043611
93														200000	0.002985	0.041824	0.042573
94														250000	0.002597	0.041152	0.041857
95														300000	0.002318	0.04067	0.041324
96														400000	0.001937	0.039976	0.040566
97														500000	0.001685	0.039498	0.040047



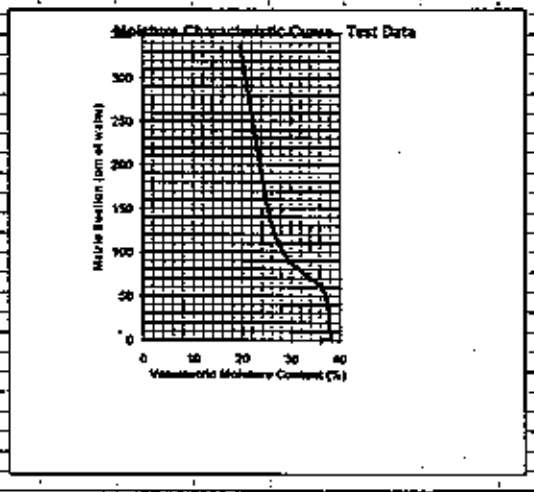

SNL MW Landfill Cover - West Borrow Mixed
MW-B-Mix-HC3 at 1.594 g/cc
Suction Head (cm)
350
300
250
200
150
100
50
0
0.1
0.15
0.2
0.25
0.3
0.35
0.4
0.45
Volumetric Moisture
van Genuchten with m=1-1/n
Brooks & Corey
van Genuchten with variable m, n
Desorption Test Data

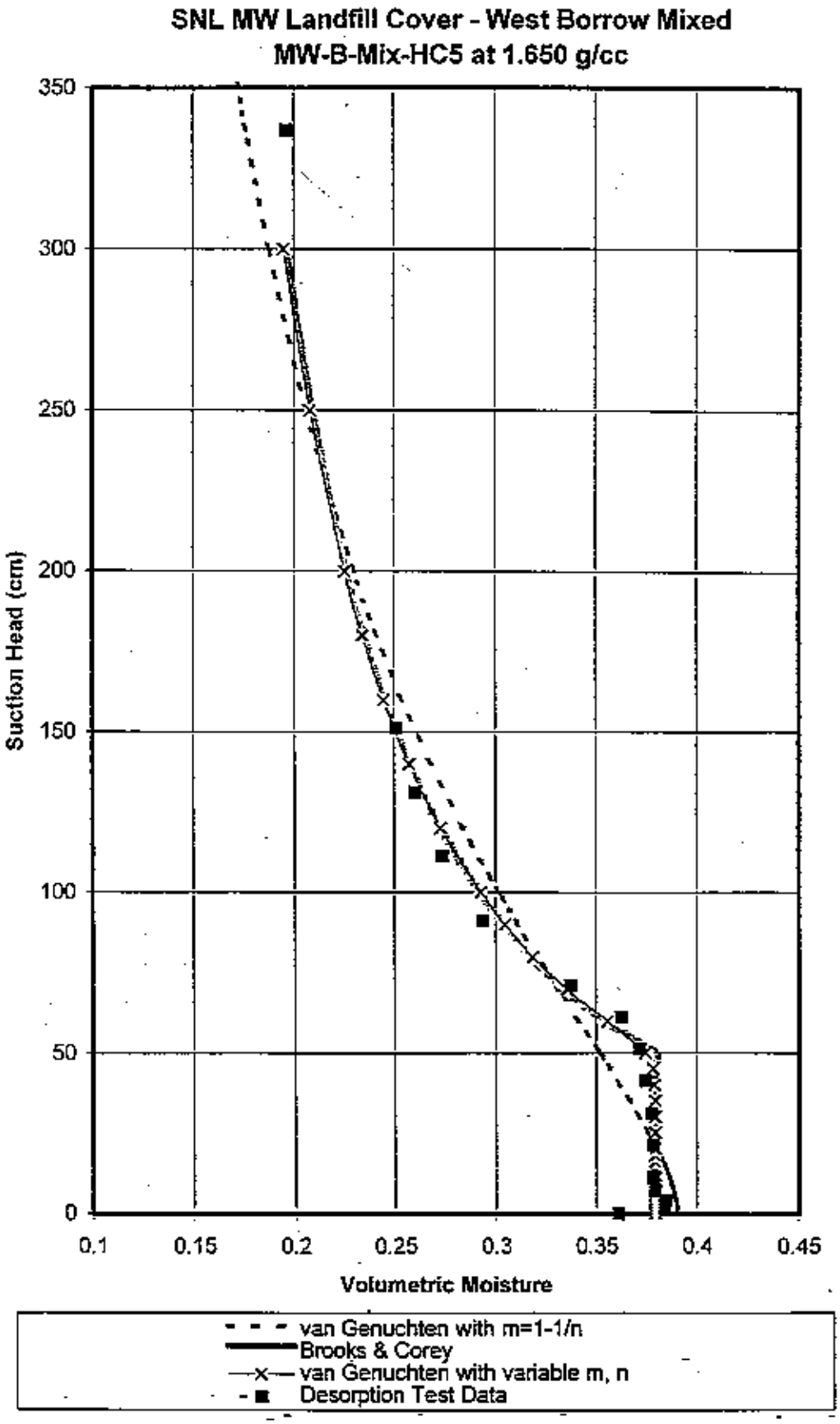
	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q
1	Hanging Column Analysis - SNL Mixed Waste Landfill Cover										Brooks & Corey Par.			van Genuchten Param. (drying)			
2											drying				m=1-1/n	Var. m, n	
3											WCr =	0.0352		WCr =	0.0000	0.0352	
4	Sample Identification		MW-B-Mix-HC-4		sample dry density		1.601 g/cc				alpha =	0.02235 (1/cm)		alpha =	0.01185	0.0221 (1/cm)	
5	sat weight (sam+app)		187.42 (g)		Sample height (cm)		2.48				n =	0.43805		n =	1.60831	5.12033	
6	weight of dry solids		112.45 (g)								Theta-s =	0.38864		Theta-s	0.40204	0.39215	
7	sat weight of water		26.71 (g)		spreadsheet assumes 1 g of water = 1 ml of water									mF	1-1/n	0.0681	
8	grav. W at sat		23.75278 %												1		
9	vol. W at sat		38.0282 %						calculation		data to plot				Fitted Data to Plot		
10	app weight+dry solids		150.71 (g)			ratio			based on						vanGenuc	vanGenuc	Brooks&C
11			sample	water loss	cum.	calculation	weight of		grav. mois.					Pressure	m=1-1/n	Var. m, n	
12		pressure	weight	from sam.	water loss	vol mois.	water	grav mois.	vol mois		pressure	vol mois.					
13		(cm wat.)	(g)	(g)	(g)	%	(g)	%	%		(cm wat.)	%					
14	0	0	187.42	0	0	38.0282	26.71	23.75278	38.0282		0	38.0282	0.380282	0	0.40204	0.39215	0.38864
15	1	2.24	188.98	-1.56	-1.56	40.24924	28.27	25.14008	40.24924		2.24	40.24924	0.402492	1	0.401917	0.39215	0.38864
16	3	4.24	188.86	0.12	-1.44	40.07839	28.15	25.03336	40.07839		4.24	40.07839	0.400784	2	0.401668	0.39215	0.38864
17	5	7.24	188.33	0.53	-0.91	39.32381	27.62	24.56203	39.32381		7.24	39.32381	0.393238	3	0.401327	0.39215	0.38864
18	10	11.24	187.94	0.39	-0.52	38.76855	27.23	24.21521	38.76855		11.24	38.76855	0.387685	4	0.400911	0.39215	0.38864
19	20	21.24	187.48	0.45	-0.06	38.11362	26.77	23.80614	38.11362		21.24	38.11362	0.381136	5	0.400428	0.39215	0.38864
20	30	31.24	187.30	0.18	0.12	37.85735	26.59	23.64926	37.85735		31.24	37.85735	0.378573	6	0.399885	0.392149	0.38864
21	40	41.24	187.16	0.14	0.26	37.65803	26.45	23.52157	37.65803		41.24	37.65803	0.37658	7	0.399281	0.392148	0.38864
22	50	51.24	186.70	0.46	0.72	37.0031	25.99	23.11249	37.0031		51.24	37.0031	0.370031	8	0.398645	0.392142	0.38864
23	60	61.24	185.14	1.56	2.28	34.78206	24.43	21.72521	34.78206		61.24	34.78206	0.347821	9	0.397205	0.392136	0.38864
24	70	71.24	182.90	2.24	4.52	31.59288	22.19	19.73321	31.59288		71.24	31.59288	0.315929	10	0.395613	0.392116	0.38864
25	90	91.24	180.91	1.99	6.51	28.75963	20.2	17.96354	28.75963		91.24	28.75963	0.287596	14	0.393876	0.392074	0.38864
26	110	111.24	179.76	1.15	7.66	27.12232	19.05	16.94066	27.12232		111.24	27.12232	0.271223	16	0.392201	0.392001	0.38864
27	130	131.24	178.89	0.87	8.53	25.88366	18.18	16.15719	25.88366		131.24	25.88366	0.258837	18	0.390035	0.391677	0.38864
28	150	151.24	178.27	0.62	9.15	25.00094	17.56	15.81583	25.00094		151.24	25.00094	0.250009	20	0.387961	0.391584	0.38864
29		337				17.81			17.81		337	17.81	0.1781	25	0.382425	0.390714	0.38864
30														30	0.376605	0.389628	0.38864
31														35	0.370328	0.3849	0.38864
32														40	0.363995	0.379229	0.38864
33														45	0.357586	0.371757	0.387546
34														50	0.351166	0.36301	0.371653
35														60	0.338479	0.34419	0.345625
36														70	0.326209	0.326297	0.325541
37														80	0.314508	0.310494	0.308044
38														90	0.303445	0.296802	0.294273
39														100	0.293045	0.28499	0.283541
40														120	0.274177	0.265427	0.264477
41														140	0.257689	0.250053	0.249506
42														160	0.243203	0.237502	0.237329
43														180	0.230472	0.227045	0.227164
44														200	0.219206	0.218147	0.218505
45														250	0.196052	0.200533	0.201434
46														300	0.178135	0.187573	0.188673
47														337	0.167274	0.179785	0.181049
48														350	0.163841	0.177338	0.178651
49														400	0.152149	0.169029	0.1705
50														450	0.142385	0.162104	0.163696
51														500	0.134091	0.156214	0.1579
52														600	0.12071	0.145659	0.148481
53														700	0.110333	0.138172	0.141084
54														800	0.102007	0.133094	0.135067
55														900	0.09515	0.128029	0.130045
56														1000	0.089386	0.12372	0.125767
57														1200	0.080169	0.115731	0.118814
58														1400	0.073129	0.111254	0.113354
59														1600	0.067504	0.108808	0.108914
60														1800	0.062895	0.103102	0.105207
61														2000	0.059035	0.099951	0.102049
62														2400	0.052897	0.094838	0.096917
63														2800	0.048203	0.090532	0.092587
64														3200	0.044472	0.08758	0.089609
65														3600	0.04142	0.08487	0.086873
66														4000	0.038866	0.082564	0.084542
67														4500	0.036196	0.080113	0.082061
68														5000	0.033963	0.078029	0.079947
69														5500	0.032082	0.076226	0.078117
70														6000	0.030419	0.074647	0.076512
71														6500	0.028961	0.073249	0.075089
72														7000	0.027711	0.071997	0.073814
73														8000	0.025561	0.069848	0.07162
74														9000	0.023903	0.068053	0.069789
75														10000	0.022333	0.066528	0.068229
76														12000	0.02	0.064055	0.065693
77														14000	0.018219	0.062117	0.063702
78														15000	0.017266	0.06106	0.062614
79														16000	0.016505	0.060543	0.062062
80														18000	0.015649	0.059232	0.06073
81														20000	0.014882	0.058116	0.059579
82														25000	0.012827	0.055922	0.057309
83														30000	0.011487	0.054286	0.055611
84														35000	0.010464	0.053004	0.054278
85														40000	0.009651	0.051963	0.053194
86														45000	0.008967	0.051085	0.05229
87														50000	0.008432	0.050358	0.051519
88														60000	0.007551	0.049151	0.050258
89														70000	0.006878	0.048223	0.049262
90														80000	0.006344	0.047462	0.048482
91														90000	0.005906	0.046827	0.047814
92														100000	0.005543	0.046298	0.047245
93														150000	0.004335	0.044434	0.045285
94														200000	0.003643	0.04331	0.044091
95														250000	0.003183	0.042534	0.043263
96														300000	0.00285	0.041895	0.042644
97														400000	-0.002395	0.041133	0.041762
														500000	0.002092	0.040565	0.041151



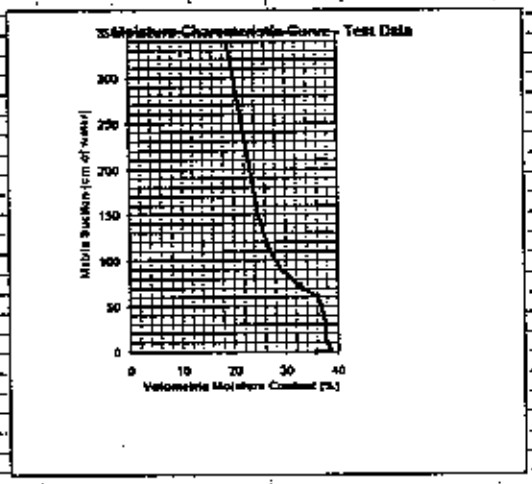

SNL MW Landfill Cover - West Borrow Mixed
MW-B-Mix-HC4 at 1.601 g/cc
Suction Head (cm)
350
300
250
200
150
100
50
0
0.1
0.15
0.2
0.25
0.3
0.35
0.4
0.45
Volumetric Moisture
van Genuchten with m=1-1/n
Brooks & Corey
van Genuchten with variable m, n
Desorption Test Data

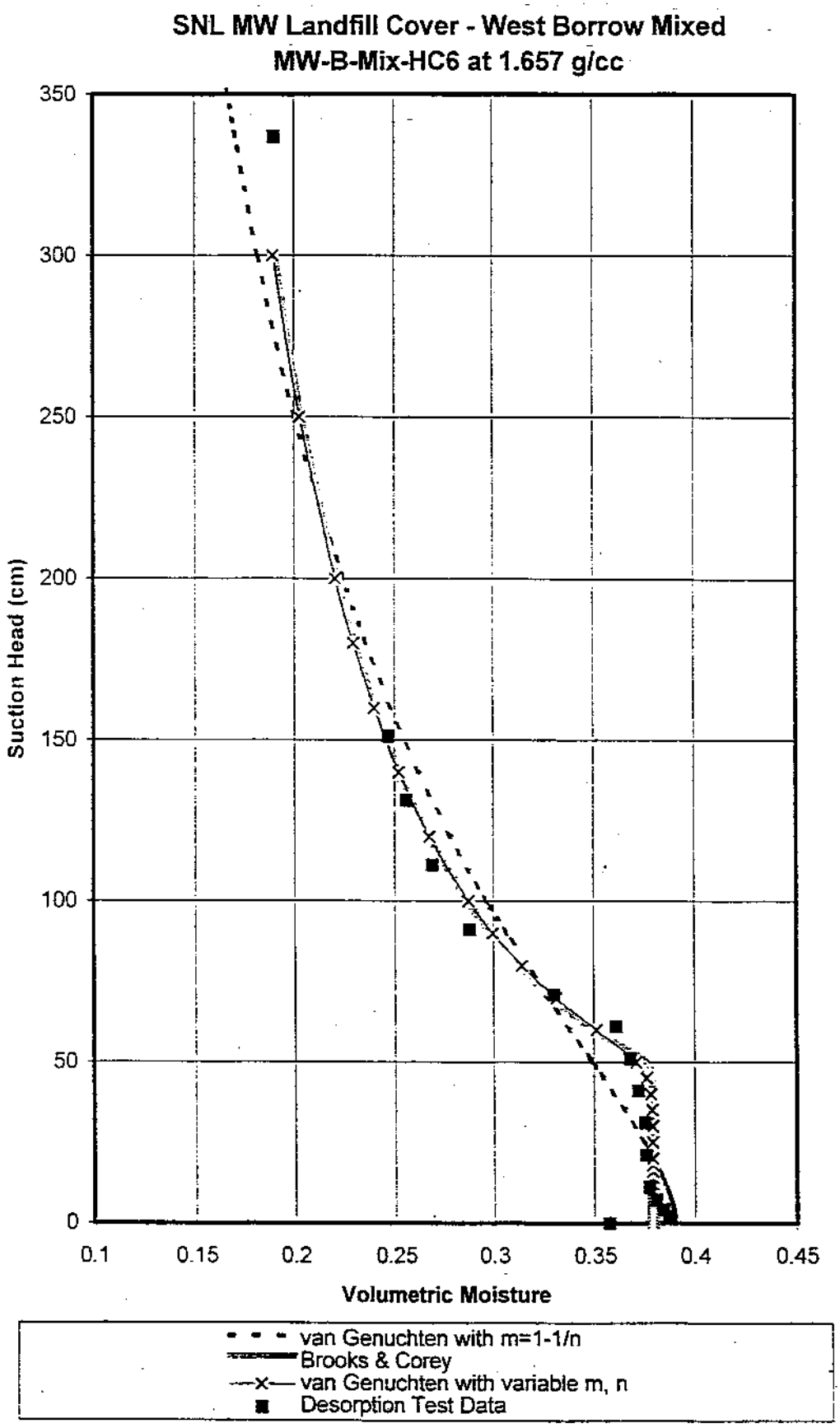
	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q
1	Hanging Column Analysis - SW, Mixed Waste Landfill Cover										Brooks & Corey Par.			van Genuchten Param. (drying)			
2											drying				m=1-1/n	Var. m, n	
3											WCr =	0.0352		WCr =	0.0000	0.0352	
4	Sample identification	MW-B-Mix-HC-5			sample dry density		1.65	g/cc			alpha =	0.01865	(1/cm)	alpha =	0.00989	0.01853	(1/cm)
5	sat weight (sam+app)		187.61	(g)	Sample height (cm)		2.51				n =	0.42449		n =	1.62792	16.60282	
6	weight of dry solids		117.12	(g)							Theta-s =	0.37923		Theta-s	0.39015	0.37923	
7	sat weight of water		25.62	(g)	spreadsheet assumes 1 g of water = 1 ml of water									m=	1-1/n	0.02515	
8	grav. W at sat		21.875	%													
9	vol. W at sat		36.09375	%					calculation		data to plot				Fitted Data to Plot		
10	app weight+dry solids		161.99	(g)		ratio			based on						vanGenuc	vanGenuc	Brooks&C
11			sample	water loss	cum.	calculation	weight of		grav. moist.					Pressure	m=1-1/n	Var. m, n	
12		pressure	weight	from sam.	water loss	vol mois.	water	grav moist.	vol mois		pressure	vol mois.					
13		(cm wat.)	(g)	(g)	(g)	%	(g)	%	%		(cm wat.)	%					
14	0	0	187.61	0	0	36.09375	25.62	21.875	36.09375		0	36.09375	0.360938	0	0.39015	0.37923	0.37923
15	1	2.255	189.22	-1.61	-1.61	38.36194	27.23	23.24968	38.36194		2.255	38.36194	0.383619	1	0.390071	0.37923	0.37923
16	3	4.255	189.26	-0.04	-1.65	38.41829	27.27	23.28381	38.41829		4.255	38.41829	0.384183	2	0.389654	0.37923	0.37923
17	5	7.255	188.90	0.36	-1.29	37.91112	26.91	22.97643	37.91112		7.255	37.91112	0.379111	3	0.389677	0.37923	0.37923
18	10	11.255	188.82	0.08	-1.21	37.79841	26.83	22.90613	37.79841		11.255	37.79841	0.377984	4	0.389395	0.37923	0.37923
19	20	21.255	188.82	0	-1.21	37.79841	26.83	22.90613	37.79841		21.255	37.79841	0.377984	5	0.389068	0.37923	0.37923
20	30	31.255	188.79	0.03	-1.18	37.75615	26.8	22.88251	37.75615		31.255	37.75615	0.377561	6	0.388894	0.37923	0.37923
21	40	41.255	188.55	0.24	-0.94	37.41803	26.56	22.6776	37.41803		41.255	37.41803	0.374180	7	0.388282	0.37923	0.37923
22	50	51.255	188.35	0.2	-0.74	37.13627	26.36	22.50983	37.13627		51.255	37.13627	0.371363	8	0.387833	0.37923	0.37923
23	60	61.255	187.71	0.64	-0.1	36.23463	25.72	21.88038	36.23463		61.255	36.23463	0.362346	9	0.38735	0.37923	0.37923
24	70	71.255	185.91	1.8	1.7	33.69677	23.92	20.4235	33.69677		71.255	33.69677	0.336968	10	0.386834	0.37923	0.37923
25	90	91.255	182.82	3.09	4.79	29.34554	20.83	17.78518	29.34554		91.255	29.34554	0.293455	12	0.385711	0.37923	0.37923
26	110	111.255	181.40	1.42	6.21	27.34503	19.41	16.67275	27.34503		111.255	27.34503	0.27345	14	0.384478	0.37923	0.37923
27	130	131.255	180.45	0.95	7.16	26.00666	18.46	15.76161	26.00666		131.255	26.00666	0.260067	16	0.383144	0.37923	0.37923
28	150	151.255	179.80	0.65	7.81	25.09093	17.81	15.20653	25.09093		151.255	25.09093	0.250909	18	0.381721	0.37923	0.37923
29		337				19.6			19.6		337	19.6	0.196	20	0.380215	0.37923	0.37923
30														25	0.376139	0.37923	0.37923
31														30	0.3717	0.378229	0.37923
32														35	0.368983	0.379214	0.37923
33														40	0.36206	0.379062	0.37923
34														45	0.355992	0.378234	0.37923
35														50	0.35183	0.374629	0.37923
36														60	0.341387	0.355755	0.353947
37														70	0.330994	0.335497	0.333757
38														80	0.320623	0.318613	0.317305
39														90	0.310985	0.304483	0.303547
40														100	0.301549	0.292438	0.29181
41														120	0.283964	0.272854	0.272689
42														140	0.268179	0.257483	0.257656
43														160	0.254024	0.24494	0.245397
44														180	0.241352	0.23445	0.235146
45														200	0.229984	0.225566	0.226401
46														250	0.208223	0.207982	0.209121
47														300	0.187528	0.194827	0.196168
48														337	0.178089	0.185665	0.185415
49														350	0.17245	0.184449	0.185972
50														400	0.160052	0.178078	0.177664
51														450	0.149847	0.169052	0.170716
52														500	0.140784	0.163065	0.164789
53														600	0.126452	0.15333	0.155136
54														700	0.115319	0.14568	0.147541
55														800	0.105385	0.139455	0.14135
56														900	0.099031	0.134256	0.136173
57														1000	0.092853	0.129629	0.131757
58														1200	0.083008	0.122621	0.124568
59														1400	0.075467	0.116959	0.118905
60														1600	0.069472	0.112353	0.114283
61														1800	0.064569	0.108505	0.110436
62														2000	0.060471	0.105226	0.107145
63														2400	0.053971	0.099895	0.101787
64														2800	0.049017	0.095705	0.097569
65														3200	0.04509	0.092296	0.094132
66														3600	0.041886	0.089448	0.091258
67														4000	0.039212	0.087022	0.088806
68														4500	0.036423	0.084436	0.086192
69														5000	0.034096	0.082235	0.083962
70														5500	0.032118	0.080328	0.082028
71														6000	0.030413	0.078554	0.08033
72														6500	0.028924	0.077169	0.078822
73														7000	0.02761	0.07584	0.077472
74														8000	0.025392	0.073551	0.075142
75														9000	0.023583	0.071638	0.073194
76														10000	0.022074	0.070008	0.071532
77														12000	0.019687	0.067358	0.068827
78														14000	0.017872	0.065275	0.066697
79														15000	0.016803	0.064137	0.065532
80														16000	0.016435	0.063581	0.064961
81														18000	0.015263	0.062168	0.06351
82														20000	0.014286	0.060959	0.062271
83														25000	0.012419	0.05858	0.059825
84														30000	0.011076	0.0568	0.057991
85														35000	0.010054	0.055401	0.056547
86														40000	0.009245	0.054253	0.055371
87														45000	0.008586	0.053312	0.054387
88														50000	0.008037	0.052502	0.053548
89														60000	0.007167	0.051185	0.052182
90														70000	0.006506	0.050149	0.051106
91														80000	0.005983	0.049307	0.050229
92														90000	0.005556	0.048604	0.049496
93														100000	0.005201	0.048004	0.048871
94														150000	0.004032	0.045937	0.046709
95														200000	0.003365	0.044675	0.045386
96														250000	0.002925	0.0438	0.044456
97														300000	0.002609	0.043145	0.043776
														400000	0.002178	0.042212	0.04279
														500000	0.001893	0.041564	0.042104




SNL MW Landfill Cover - West Borrow Mixed
MW-B-Mix-HC5 at 1.650 g/cc
Suction Head (cm)
350
300
250
200
150
100
50
0
0.1
0.15
0.2
0.25
0.3
0.35
0.4
0.45
Volumetric Moisture
van Genuchten with m=1-1/n
Brooks & Corey
van Genuchten with variable m, n
Desorption Test Data

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q
1	Hanging Column Analysis - SNL Mixed Waste Landfill Cover										Brooks & Corey Par.			van Genuchten Param. (drying)			
2															m=1-1/n	Var. m, n	
3												drying					
4	Sample identification	MW-B-Mix-HC-5			sample dry density		1.657	g/cc			WCr =	0.0352		WCr =	0.0000	0.0352	
5	sat weight (sam+app)	186.66	(g)		Sample height (cm)		2.435				alpha =	0.020036	(1/cm)	alpha =	0.0102	0.01958	(1/cm)
6	weight of dry solids	114.05	(g)								n =	0.43709		n =	1.630271	12.86025	
7	sat weight of water	24.57	(g)		spreadsheet assumes 1 g of water = 1 ml of water						Theta-s =	0.37867		Theta-s	0.39021	0.37889	
8	grav. W at sat	21.54129	%											m=	1-1/n	0.03475	
9	vol. W at sat	35.69392	%						calculation		data to plot						
10	app weight+dry solids	162.08	(g)			ratio			based on							Fitted Data to Plot	
11			sample	water loss	cum.	calculation	weight of		grav. mois							VanGenuc	VanGenuc. Brooks&C
12		pressure	weight	from sam.	water loss	vol mois.	water	grav mois.	vol mois		pressure	vol mois.		Pressure	m=1-1/n	Var. m, n	
13		(cm wat.)	(g)	(g)	(g)	%	(g)	%	%		(cm wat.)	%					
14	0	0	186.66	0	0	35.69392	24.57	21.54129	35.69392		0	35.69392	0.3569391	0	0.39021	0.37889	0.37867
15	1	2.2175	188.71	-2.05	-2.05	38.67205	26.62	23.33859	38.67205		2.2175	38.67205	0.38672	3	0.3896986	0.37889	0.37867
16	3	4.2175	188.52	0.19	-1.86	38.39603	26.43	23.17201	38.39603		4.2175	38.39603	0.38395	4	0.3893941	0.37889	0.37867
17	6	7.2175	188.28	0.24	-1.62	38.04737	26.19	22.9616	38.04737		7.2175	38.04737	0.380474	5	0.3890037	0.37889	0.37867
18	10	11.2175	188.06	0.22	-1.4	37.72777	26.97	22.76872	37.72777		11.2175	37.72777	0.377278	6	0.3886341	0.37889	0.37867
19	20	21.2175	187.85	0.11	-1.29	37.56796	25.86	22.67228	37.56796		21.2175	37.56796	0.37568	7	0.3881881	0.37889	0.37867
20	30	31.2175	187.90	0.05	-1.24	37.49533	25.81	22.628441	37.49533		31.2175	37.49533	0.374953	8	0.3877021	0.37889	0.37867
21	40	41.2175	187.67	0.23	-1.01	37.1612	25.58	22.42679	37.1612		41.2175	37.1612	0.371612	9	0.3871791	0.37889	0.37867
22	50	51.2175	187.38	0.29	-0.72	36.7399	25.29	22.172541	36.7399		51.2175	36.7399	0.367399	10	0.38662	0.37889	0.37867
23	60	61.2175	186.92	0.46	-0.26	36.07164	24.83	21.76924	36.07164		61.2175	36.07164	0.360716	12	0.3854051	0.37889	0.37867
24	70	71.2175	184.79	2.13	1.87	32.97729	22.7	19.90161	32.97729		71.2175	32.97729	0.329773	14	0.38407	0.37889	0.37867
25	90	91.2175	181.91	2.88	4.75	28.79339	19.82	17.37682	28.79339		91.2175	28.79339	0.287934	16	0.3826281	0.37889	0.37867
26	110	111.2175	180.63	1.28	6.03	26.93388	18.54	16.2546	26.93388		111.2175	26.93388	0.269339	18	0.381091	0.37889	0.37867
27	130	131.2175	179.71	0.92	6.95	25.59735	17.62	15.44801	25.59735		131.2175	25.59735	0.255974	20	0.3794541	0.37889	0.37867
28	150	151.2175	179.06	0.65	7.6	24.65307	16.97	14.87813	24.65307		151.2175	24.65307	0.246531	25	0.3750711	0.37889	0.37867
29		337				18.99			18.99		337	18.99	0.1899	30	0.3703	0.37874	0.37867
30														35	0.3652441	0.37877	0.37867
31														40	0.3599841	0.37824	0.37867
32														45	0.3545871	0.37622	0.37867
33														50	0.3491081	0.37086	0.37602
34														60	0.338078	0.3512491	0.349897
35														70	0.327169	0.331034	0.328392
36														80	0.316557	0.314004	0.312713
37														90	0.306352	0.299726	0.298798
38														100	0.296511	0.287563	0.286924
39														120	0.278604	0.267817	0.267643
40														140	0.262528	0.252332	0.252497
41														160	0.248223	0.239754	0.240179
42														180	0.235484	0.228265	0.228892
43														200	0.224167	0.220339	0.221129
44														250	0.200466	0.202768	0.203851
45														300	0.181962	0.189556	0.190903
46														337	0.170716	0.181633	0.183214
47														350	0.167148	0.179374	0.180786
48														400	0.154974	0.171022	0.172532
49														450	0.144768	0.164058	0.165641
50														500	0.136127	0.158131	0.15977
51														600	0.122115	0.148512	0.150228
52														700	0.111317	0.140969	0.142733
53														800	0.102636	0.134842	0.136839
54														900	0.095496	0.129733	0.131546
55														1000	0.089504	0.125385	0.12721
56														1200	0.079964	0.118328	0.120182
57														1400	0.072664	0.112794	0.114625
58														1600	0.066865	0.108299	0.110123
59														1800	0.062124	0.104551	0.106364
60														2000	0.058164	0.101361	0.103161
61														2400	0.051867	0.096184	0.097955
62														2800	0.047105	0.092125	0.093866
63														3200	0.043317	0.088827	0.09054
64														3600	0.040227	0.085977	0.087763
65														4000	0.037649	0.083737	0.085397
66														4500	0.034961	0.081249	0.082878
67														5000	0.032718	0.079131	0.080733
68														5500	0.030814	0.077298	0.078875
69														6000	0.029171	0.075693	0.077245
70														6500	0.027738	0.07427	0.075799
71														7000	0.026473	0.072998	0.074509
72														8000	0.024338	0.070808	0.072277
73														9000	0.022598	0.068982	0.070416
74														10000	0.021147	0.067428	0.068831
75														12000	0.018852	0.064907	0.066255
76														14000	0.017107	0.062929	0.064232
77														15300	0.016177	0.061885	0.063127
78														16000	0.015727	0.061323	0.062566
79														18000	0.014602	0.059963	0.061212
80														20000	0.013664	0.058843	0.060041
81														25000	0.011872	0.056599	0.057733
82														30000	0.010583	0.054925	0.056007
83														35000	0.009603	0.053612	0.054651
84														40000	0.008828	0.052545	0.053548
85														45000	0.008197	0.051656	0.052627
86														50000	0.00787	0.050899	0.051843
87														60000	0.006837	0.049671	0.050568
88														70000	0.006204	0.048707	0.049567
89														80000	0.005704	0.047925	0.048752
90														90000	0.005295	0.047272	0.048072
91														100000	0.004955	0.046717	0.047493
92														150000	0.003838	0.044806	0.045496
93														200000	0.003201	0.043649	0.04428
94														250000	0.002781	0.042847	0.043436
95														300000	0.002479	0.042249	0.042805
96														400000	0.002088	0.041399	0.041907
97														500000	0.001797	0.04081	0.041283




SNL MW Landfill Cover - West Borrow Mixed
MW-B-Mix-HC6 at 1.657 g/cc
Suction Head (cm)
350
300
250
200
150
100
50
0
0.1
0.15
0.2
0.25
0.3
0.35
0.4
0.45
Volumetric Moisture
van Genuchten with m=1-1/n
Brooks & Corey
van Genuchten with variable m, n
Desorption Test Data

Appendix B

Photos of Laboratory Apparatus

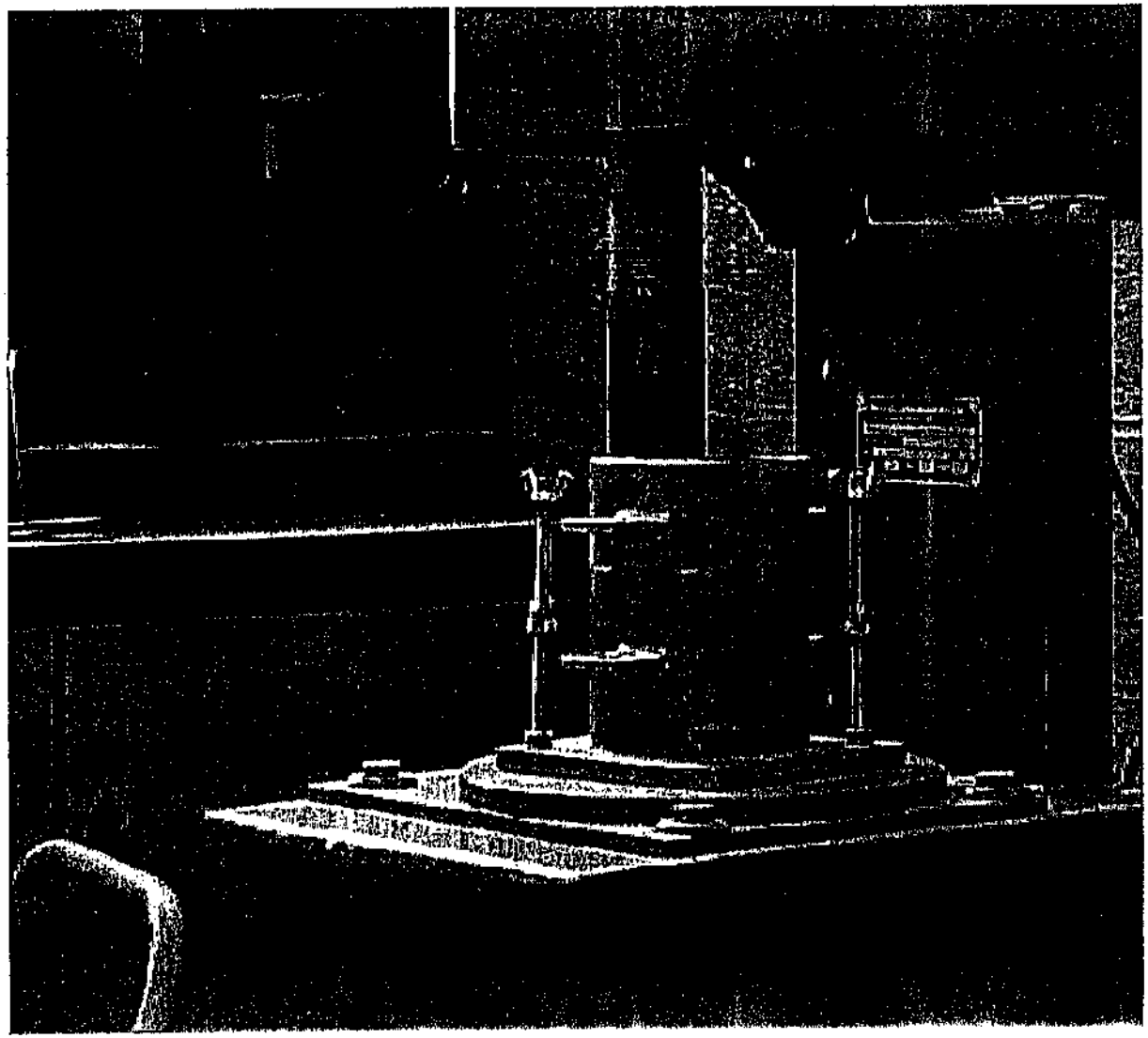


Photo 1 - Mechanical Proctor Hammer Used for Compaction Tests

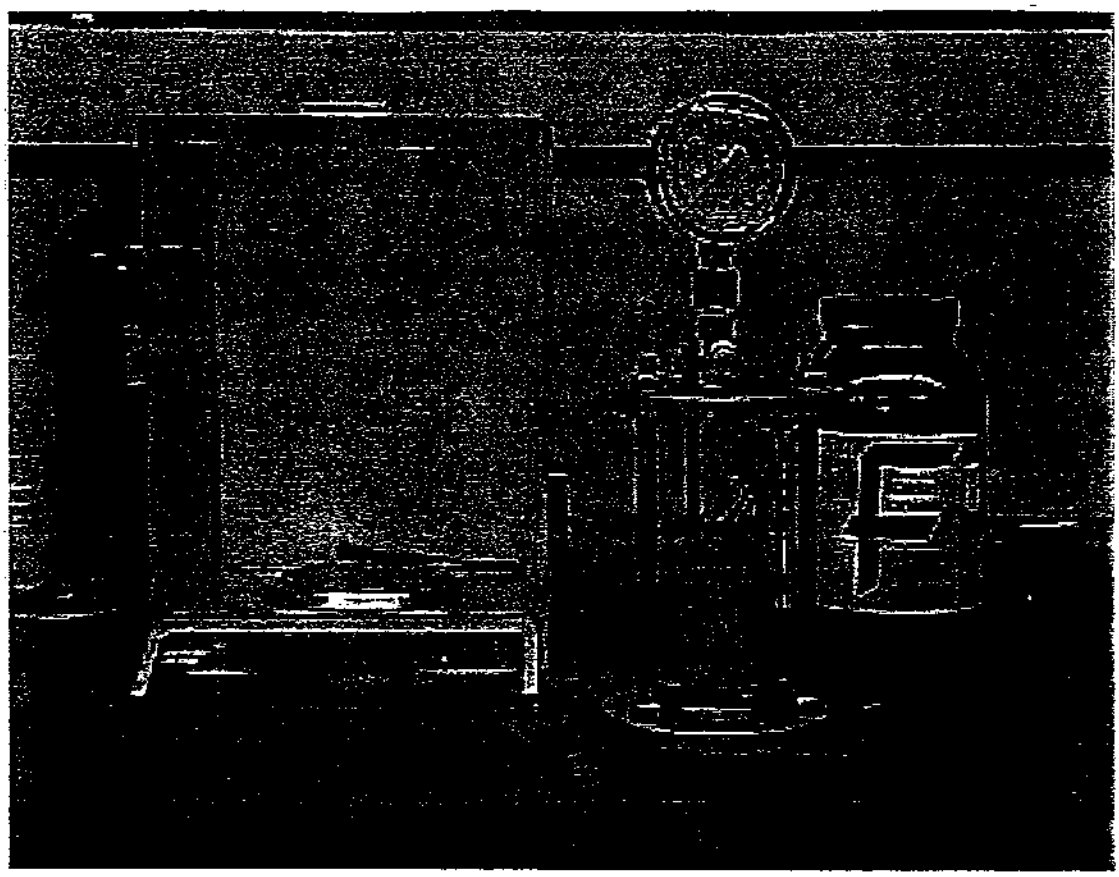


Photo 2 - Rapid Calcium Carbonate Analyzer and Analytical Balance

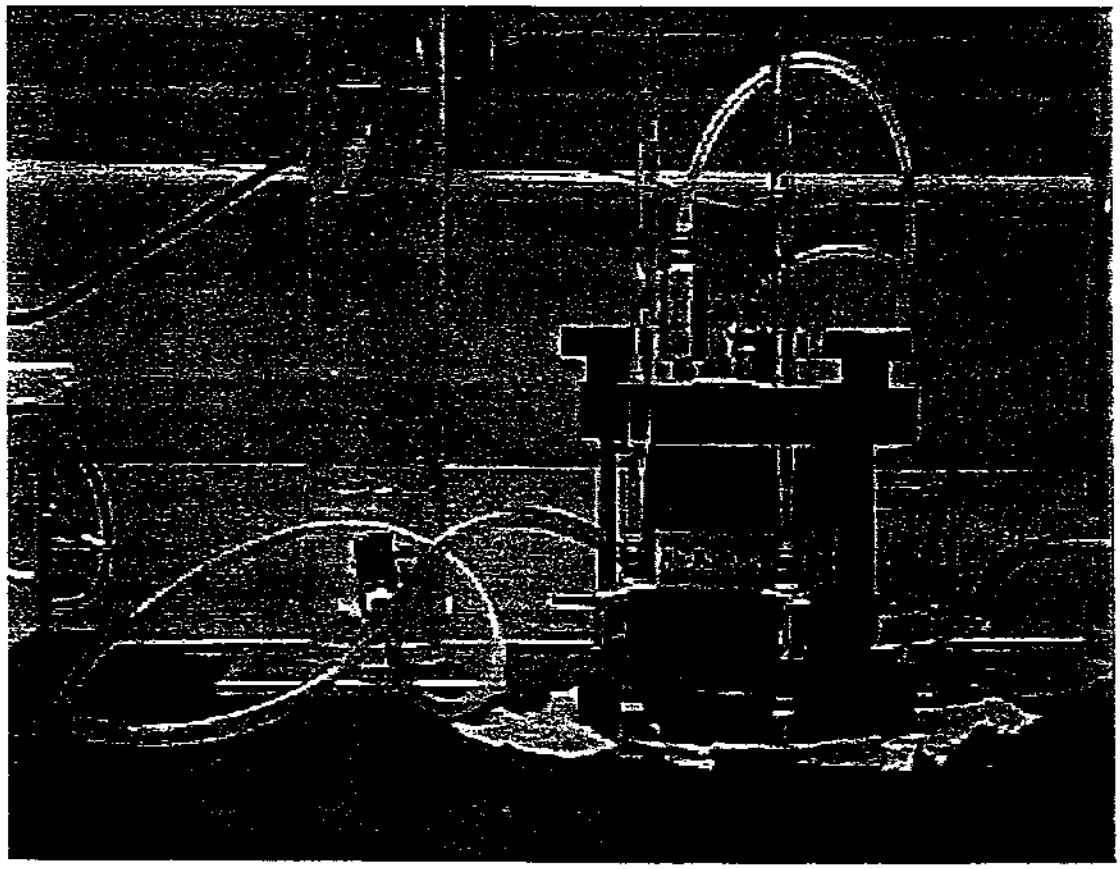


Photo 3 - Double Ring Compaction Mold Permeameter

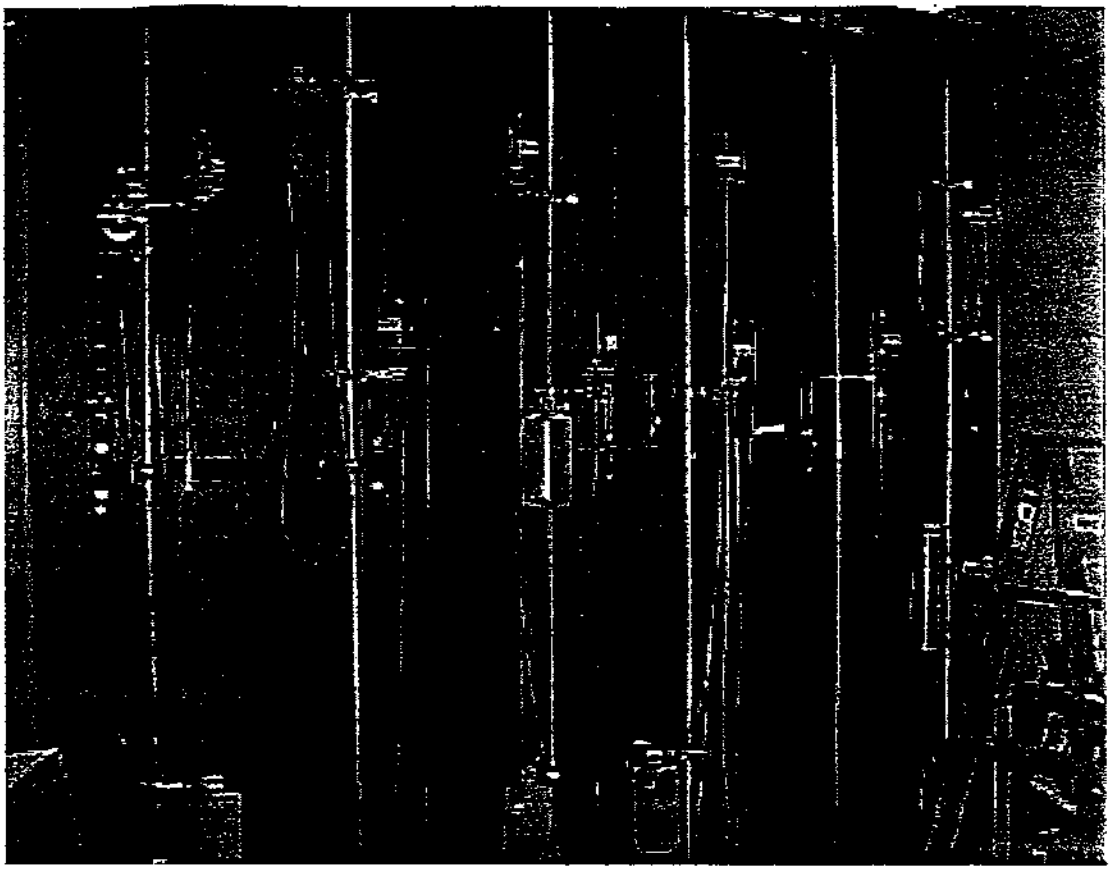


Photo 4 - Hanging Column Test Area

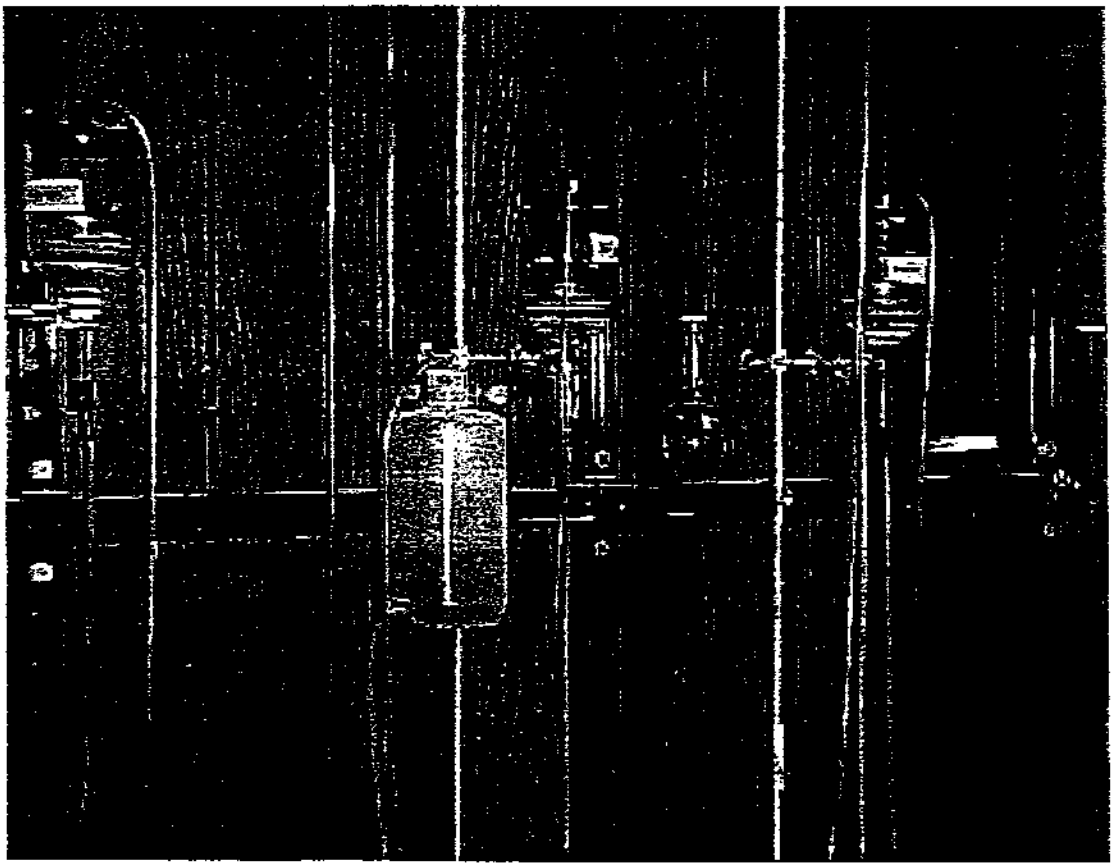


Photo 5 - Hanging Column Funnel and Supply Bottle

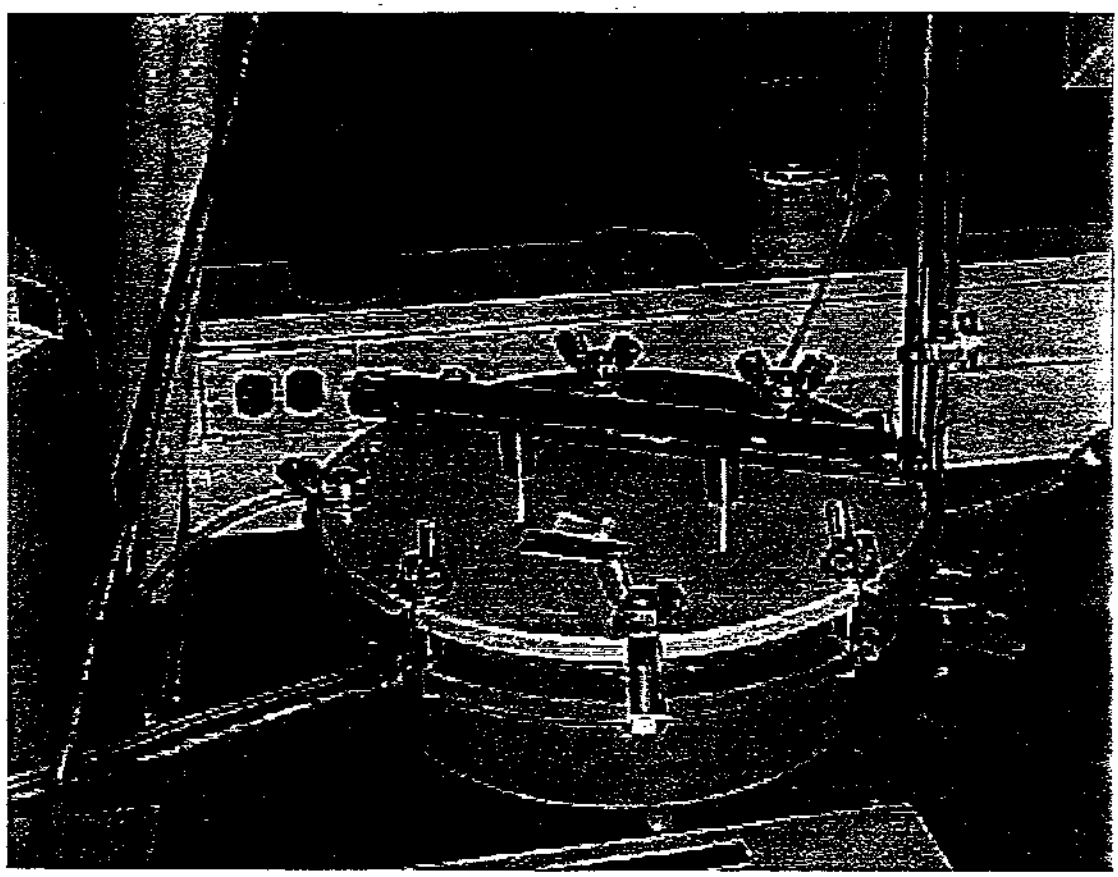


Photo 6 - Pressure Plate Apparatus Under Pressure

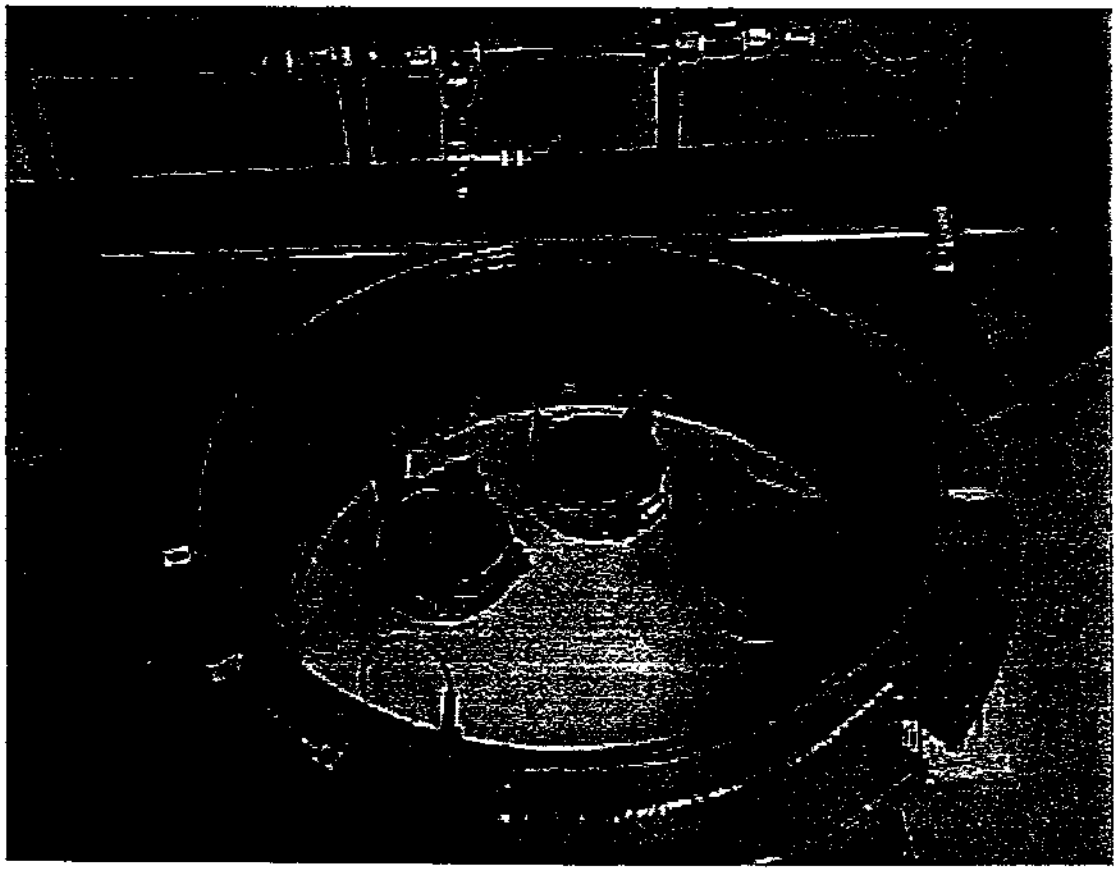


Photo 7 - Pressure Plate Apparatus Opened for Sample Weighing

Appendix J

Erosion Protection Analysis for Gravel Admixture Layer

This report is undergoing review for publication as a SAND Document.
09/03/99

August 13, 1999

Sandia National Laboratories, Mixed Waste Landfill Cover Erosion Protection Analysis for Gravel Admixture Layer

by
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Geoenvironmental Laboratory
Department of Civil Engineering
University of New Mexico
Albuquerque, NM 87131

The following document presents an analysis of measures to provide surface erosion protection for the Mixed Waste Landfill at Sandia National Laboratories, Albuquerque, New Mexico. This analysis presents design recommendations for the gravel admixture surface layer. The analysis evaluated the landfill for a 100-year storm event and performed computations to select a proposed surface treatment to minimize expected erosion. The analysis is based on a single 100-year rainfall, but the treatment proposed would remain stable for a series of events provided that the peak runoff intensity does not exceed the intensity for a 100-year event.

The following physical parameters were used in the analysis:

- Cover surface area: (300 ft X 425 ft) − (100 ft X 220 ft) with a surface area of 2.422 acres = 0.980 Ha.
- Cover top area : (350 ft X 475 ft) − (100 ft X 220 ft) with a surface area of 3.312 acres = 1.340 Ha.
- Site Location: Latitude: 34° 59.5' north, Longitude: 106° 32.8' west.
- NM State Plane Coordinates at center: Y = 1,452,396, X = 411,604
- Bernalillo County Atlas location: R-20
- Elevation: 5380 feet
- Slope of landfill cover top surface: 0.03 foot per foot. Slope of landfill edge treatment: 0.05 foot per foot.
- Cover soils are silty clayey sand with D_{50}=0.13 mm.

The following hydrologic assumptions were made for this analysis:

- 24-Hour and 6-Hour rainfall quantities (based on National Oceanic and Atmospheric Administration Atlas 2, Volume IV-New Mexico, 1973):
  100-year 24-hour=4.04 inches
  100-year 6-hour=2.50 inches
  2-year 24-hour=1.40 inch

2-year 6-hour=1.20 inch

- Peak hour rainfall (based on U.S.D.I. Bureau of Reclamation, *Personal Computer Programs; Estimating Probable Maximum Precipitation and Precipitation Frequency-Duration in the Western United States*, 1989,"User manual for Program PREFRE"):

  100-year 5-minute=0.65 inches
  100-year 15-minute=1.27 inches
  100-year 30 minute=1.66 inches
  100-year 1-hour=2.05 inches
  100-year 2-hour=2.20 inches
  100-year 3 hour=2.30 inches
  Primary zone=7
  Short Duration zone=6

- Rainfall distribution:

  Peak hour of rainfall occurs in second hour of a 6-hour storm.
  Peak 5-minutes occurs at 25 minutes after start of second hour.
  Superimposed rainfall with the peak 5 minutes within the peak 15 minutes, within the peak 30 minutes, within the peak hour.

- Minimum time to unit hydrograph peak=5 minutes.
- Unit hydrograph: AHYMO's three segment gamma function with parameters calibrated to New Mexico rainfall-runoff conditions.
- Landfill surface is revegetated with native grasses.
- Soil losses based on initial abstraction of 0.5 inches and uniform infiltration of 0.17 inches per hour.
- Overland flow slope length = 350 feet.
- Sheet flow erosion based on Modified Universal Soil Loss Equation (MUSLE)(J. Williams, 1975) with:

  Crop Factor (C)=0.35
  Erosion Practice (P)=1.0
  Length-Slope factor (LS) = 0.42 at top surface (3% slope)
  0.66 at side slopes (5% slope)
  Soil Factor (K)=0.10 for 67% soil - 33% gravel cover.
  Wash Load Factor=3.0 (Ref: Mussetter, et al., for AMAFCA, *Sediment and Erosion Design Guide*, 1994)

- Rill geometry based on average annual flow rate and soil grain size relation from "Engineering Analysis of Fluvial Systems", (1982), Simons, Li and Associates, equation 5.7:

$$b = 37\,(Q_m^{0.38} / M^{0.39})$$

Where: b = width of flow (ft)
Q_m = mean annual flow (cfs) ≈ dominant discharge.
M = percentage of silts and clays (<200 sieve).

For arid alluvial channels use Q_m at 10 to 20 percent of the peak flow (Q).
For shallow sections:

$b = 0.5\ F^{0.6}\ F_r^{-0.4}\ Q^{0.4}$

Where: F = width to depth ratio = b / d_h
F_r = Froude number
≈ 1.0 for steep slope natural channels
Q = peak flow in cfs
d_h = hydraulic depth

From these equations the following relations can be derived:

$F = 363.6\ M^{-0.6288}\ d_h^{-0.0812}$

$d_h = (1 / 12.03)\ M^{0.2597}\ Q_m^{0.4136}$

Basin width for rill formation at 25% of basin length.
For MW landfill with 33% gravel cover:

M = 21 percent
At Q_m = 0.05 cfs then d_h = 0.053 ft and b = 3.61 ft
At Q_m = 0.20 cfs then d_h = 0.094 ft and b = 6.11 ft
At Q_m = 0.80 cfs then d_h = 0.167 ft and b = 10.36 ft

- Rill or channelized erosion based on Meyer-Peter, Muller-Woo (MPM-Woo) Method (Mussetter, et al. 1994) using Mussetter's regression equation and the following flow parameters:
  Manning's roughness coefficient: 0.035
  Channel slopes: 0.03 foot per foot at top surface
  0.05 foot per foot at side slopes.
- Channelized flow stability and critical particle size given by the Shield's relation.

The hydrologic/hydraulic analysis of the MW Cover using the AHYMO-97 Program (C.E. Anderson, 1997) produced the following results:

Top surface runoff (3% top slope)
- Peak flow = 5.89 cfs per acre
- Runoff volume = 5669 cubic feet per acre
- Maximum channelized velocity: 2.52 feet per second
- Hydraulic depth of channelized flow (at bottom slope): 0.163 feet.

Side slope with runoff from top surface (5% slope)
- Maximum channelized velocity: 3.07 feet per second
- Hydraulic depth of channelized flow (at bottom slope): 0.147 feet.

Side slope with no runoff from top surface (5% slope)
- Peak flow = 5.92 cfs per acre
- Runoff volume = 5667 cubic feet per acre
- Maximum channelized velocity: 2.125 feet per second
- Hydraulic depth of channelized flow (at bottom slope): 0.085 feet.

The hydrologic/hydraulic analysis was used to compute sediment transport quantities using the SED WASH LOAD and SED TRANS functions of the AHYMO_97 program. The following sediment quantities were computed for the 100-year storm:

For the silty clayey sand borrow soils with gravel surface treatment (33% gravel by weight - 2 parts soil to 1 part gravel), and with revegetation.

Total sediment load: 3.46 tons per acre = 69.2 cu ft per acre (bulked)
Maximum sediment concentration: 19191 PPM-weight
Peak sediment bulking factor: 1.0074

The hydraulic analysis was used to compute the critical particle size that will remain stable for the maximum expected flow velocity and depth during the peak of a 100-year storm event. This is the particle size required to maintain an armored or stable channel configuration for a sequence of flow events. The Shields equation for incipient particle motion was used to compute the critical particle size as follows:

$D_c = \tau_o / (F^* (\gamma_s - \gamma))$

Where:
- D_c = Critical particle diameter
- τ_o = bed shear stress = γ R S
- F^* = Shield's dimensionless shear stress (0.047 used)
- γ_s and γ = specific weights of sediment and water
- R = hydraulic radius $\approx d_h$
- S = channel slope (ft per ft)

The analysis indicates that the borrow soils are very erosive and that a gravel admixture is required to prevent major erosion damage from a 100-year storm event. A gravel admixture to provide 33% gravel by weight has been proposed. A higher density of gravel surface would not increase erosion, but could inhibit the growth of plants. Based on the percentage of stable particles, the maximum depth of rill erosion and the thickness of the total soil-gravel admixture layer can be determined. For any rill erosion that occurs, the gravel that remains in place should provide protection for underlying soil layers with a thickness of 3 to 4 times the diameter of the stable gravel particle. A thickness of 4 times the stable particle diameter is recommended below the bottom of rills for landfill covers. The depth of rills is computed using the US Bureau of Reclamation formula (Pemberton and Lara, 1984, "Computing Degradation and Local Scour"):

$Y_s = y_a ((1/P_c) - 1)$

Where:
- Y_s = Scour depth
- y_a = thickness of armor layer
- P_c = decimal fraction of material coarser than the armoring size

The following gravel admixture layer properties were computed for the Mixed Waste Landfill using gravel at 33% by weight (1 part gravel to 2 parts borrow soil):

Top surface (3% top slope)

- Bed shear stress (τ_o) = 0.305 psf
- Critical particle diameter (D_c) = 0.063 ft = 0.756 inch = 19 mm
- Required thickness of armor layer (y_a) = 3.0 inches
- Scour depth (Y_s) = 6.0 inches
- Thickness of gravel/soil admixture layer = 9 inches = 23 cm
- Recommended gravel gradation = ¾ to 1½ inch

Side slope with runoff from top surface (5% slope)

- Bed shear stress (τ_o) = 0.459 psf
- Critical particle diameter (D_c) = 0.095 ft = 1.14 inch = 29 mm
- Required thickness of armor layer (y_a) = 4.5 inches
- Scour depth (Y_s) = 9.0 inches
- Thickness of gravel/soil admixture layer = 13.5 inches = 35 cm
- Recommended gravel gradation = 1¼ to 2½ inch (or 1½ to 3 inch)

Side slope with no runoff from top surface (5% slope)

- Bed shear stress (τ_o) = 0.265 psf
- Critical particle diameter (D_c) = 0.055 ft = 0.66 inch = 17 mm
- Required thickness of armor layer (y_a) = 3.0 inches
- Scour depth (Y_s) = 6.0 inches
- Thickness of gravel/soil admixture layer = 9.0 inches = 23 cm
- Recommended gravel gradation = ¾ to 1½ inch

Rounded "river run" gravel may be used for the gravel admixture. Crushed base coarse gravel may also be used.

** P R E F R E O U T P U T D A T A **
REVISED JUNE 1988 TO UPDATE COMPUTATION OF SHORT-DURATION VALUES

PRECIPITATION FREQUENCY VALUES FOR SNL Mixed Waste Landfill Cover
PRIMARY ZONE NUMBER= 7
SHORT-DURATION ZONE NUMBER= 6

LATITUDE 34.99N LONGITUDE 106.55W ELEVATION 5380 FEET

POINT VALUES

DURATION	RETURN PERIOD 2-YR	5-YR	10-YR	25-YR	50-YR	100-YR	500-YR	
5-MIN	.34	.41	.46	.54	.60	.65	.79	5-MIN
10-MIN	.52	.63	.72	.84	.93	1.02	1.24	10-MIN
15-MIN	.62	.77	.88	1.03	1.15	1.27	1.54	15-MIN
30-MIN	.80	1.00	1.14	1.34	1.50	1.66	2.02	30-MIN
1-HR	.96	1.22	1.39	1.65	1.85	2.05	2.50	1-HR
2-HR	1.04	1.31	1.51	1.78	1.99	2.20	2.69	2-HR
3-HR	1.10	1.38	1.58	1.86	2.08	2.30	2.81	3-HR
6-HR	1.20	1.50	1.72	2.02	2.26	2.50	3.05	6-HR
12-HR	1.30	1.65	1.89	2.23	2.50	2.77	3.39	12-HR
24-HR	1.40	1.79	2.06	2.44	2.74	3.04	3.73	24-HR

* IF YOUR SITE IS IN ARIZONA OR W. NEW MEXICO, PLEASE CONSULT THE FOLLOWING PAPER FOR REVISED DEPTH-AREA VALUES:
"DEPTH-AREA RATIOS IN THE SEMI-ARID SOUTHWEST UNITED STATES"
NOAA TECHNICAL MEMORANDUM NWS HYDRO-40
ZEHR AND MYERS
AUGUST 1984

FOR MANY HYDROLOGIC PURPOSES, PRECIPITATION FALLING AS RAIN MUST BE TREATED DIFFERENTLY THAN THAT FALLING AS SNOW. PLEASE REFER TO THE ATLAS VOLUME FOR THE STATE OF INTEREST FOR SEASONAL ADJUSTMENTS.

PREPARED AUG 10, 1999

INPUT DATA

PROJECT NAME=SNL Mixed Waste Landfill Cover
ZONE= 7 SHORT-DURATION ZONE= 6
LATITUDE= 34.99 LONGITUDE= 106.55 ELEVATION= 5380
2-YR, 6-HR PCPN= 1.20 100-YR, 6-HR PCPN= 2.50
2-YR, 24-HR PCPN= 1.40 100-YR, 24-HR PCPN= 3.04

* * * * E N D O F R U N * * * *

```
   AHYMO PROGRAM (AHYMO_97) -                          - Version:  1997.02c
        RUN DATE (MON/DAY/YR) = 08/12/1998
        START TIME (HR:MIN:SEC) = 17:55:24      USER NO.= AHYMO-G-9702a01UNM1CE-AH
        INPUT FILE = D:\PCHYMO\SNLMRS3.DAT

* FILE:  SNLMW_s3.DAT
*S RAINFALL/SEDIMENT FOR SNL MIXED WASTE LANDFILL, ALBUQUERQUE, NM
* TOP COVER - 3% SLOPE      AND SIDE TRANSITION = 5% SLOPE
*S 350 FT X 475 FT - 100 FT X 220 FT TOP AREA = 3.312 ACRES = 0.005175 SQ MI
*
* FOR ANALYSIS OF RUNOFF WITH MAX. LENGTH OF RUNOFF = 350 FT, USE A BASIN
* LENGTH - WIDTH RATIO OF 4 TO 1.  THEREFORE EACH RUNOFF SEGMENT WILL
* HAVE A WIDTH OF 87.5 FT AND AN AREA OF 0.703 ACRES = 0.001099 SQ MI.
*
START               TIME=0.0  PUNCH CODE=0  PRINT LINES=-6
*
*
* Set land factors IA to values commonly used by the Corps of Engineers
* Set the INF for treatment C to 0.17 to match saturated hydraulic
* conductivity of the gravel - soil mix (1 part gravel to 2 parts soil)
LAND FACTORS        TYPE=1
                    TREATMENT A  IA=0.50    INF=1.00
                    TREATMENT B  IA=0.50    INF=0.60
                    TREATMENT C  IA=0.50    INF=0.17
                    TREATMENT D  IA=0.0001  INF=0.0001
*   6-hour rainfall distribution - 100 year storm
RAINFALL            TYPE=I  RAIN QUARTER=0.0
                    RAIN ONE=2.05    RAIN SIX=2.50    RAIN DAY=3.04
                    DT=.083333

              COMPUTED 6-HOUR RAINFALL DISTRIBUTION BASED ON NOAA ATLAS 2 - PEAK AT 1.40 HR.
              DT =     .083333 HOURS        END TIME =     5.999977 HOURS
                 .0000   .0069   .0142   .0220   .0302   .0389   .0482
                 .0583   .0692   .0812   .0944   .1091   .1259   .1408
                 .1892   .3495   .6808  1.2533  1.5080  1.6705  1.8037
                1.9170  2.0151  2.1007  2.1759  2.1931  2.2085  2.2224
                2.2352  2.2471  2.2581  2.2685  2.2784  2.2877  2.2966
                2.3051  2.3132  2.3210  2.3286  2.3359  2.3429  2.3497
                2.3563  2.3627  2.3689  2.3750  2.3809  2.3867  2.3923
                2.3978  2.4032  2.4085  2.4136  2.4187  2.4237  2.4285
                2.4333  2.4380  2.4426  2.4471  2.4515  2.4559  2.4602
                2.4645  2.4686  2.4728  2.4768  2.4808  2.4848  2.4886
                2.4925  2.4963  2.5000

RAINFALL            TYPE=1  RAIN QUARTER=0.0
                    RAIN ONE=2.05    RAIN SIX=2.50    RAIN DAY=3.04
                    DT=.05

              COMPUTED 6-HOUR RAINFALL DISTRIBUTION BASED ON NOAA ATLAS 2 - PEAK AT 1.40 HR.
              DT =     .050000 HOURS        END TIME =     6.000000 HOURS
                 .0000   .0041   .0084   .0127   .0173   .0220   .0268
                 .0319   .0371   .0426   .0482   .0542   .0604   .0670
                 .0739   .0812   .0889   .0972   .1060   .1155   .1259
                 .1345   .1441   .1717   .2371   .3495   .5234   .7737
                1.1161  1.3860  1.5080  1.6089  1.6891  1.7788  1.8511
                1.9170  1.9775  2.0331  2.0845  2.1319  2.1759  2.1865
                2.1963  2.2056  2.2142  2.2224  2.2302  2.2377  2.2448
                2.2516  2.2581  2.2644  2.2705  2.2764  2.2822  2.2877
                2.2931  2.2983  2.3034  2.3084  2.3132  2.3179  2.3226
                2.3271  2.3315  2.3359  2.3401  2.3443  2.3483  2.3524
                2.3563  2.3602  2.3640  2.3677  2.3714  2.3750  2.3786
                2.3821  2.3856  2.3890  2.3923  2.3957  2.3989  2.4022
                2.4053  2.4085  2.4116  2.4147  2.4177  2.4207  2.4237
                2.4266  2.4295  2.4323  2.4352  2.4380  2.4407  2.4435
                2.4462  2.4489  2.4515  2.4542  2.4568  2.4594  2.4619
                2.4645  2.4670  2.4695  2.4719  2.4744  2.4768  2.4792
                2.4816  2.4840  2.4863  2.4886  2.4909  2.4932  2.4955
                2.4978  2.5000

COMPUTE NM HYD      ID=1  HYD NO=101    AA=0.001099  PER A=0.0
                    PER B=0.0 PER C=100.0 PER D=0.0 TP=-0.133333  RAIN=-1
```

K = .072666HR TP = .1333333HR K/TP RATIO = .545000 SHAPE CONSTANT, N = 7.106420
UNIT PEAK = 4.3378 CFS UNIT VOLUME = .9966 B = 526.28 P60 = 2.0500
AREA = .001099 SQ MI IA = .50000 INCHES INF = .17000 INCHES PER HOUR
RUNOFF COMPUTED BY INITIAL ABSTRACTION/INFILTRATION NUMBER METHOD - DT = .050000

PRINT HYD ID=1 CODE=0

PARTIAL HYDROGRAPH 101.00

TIME HRS	FLOW CFS	TIME HRS	FLOW CFS	TIME HRS	FLOW CFS	TIME HRS	FLOW CFS	TIME HRS	FLOW CFS
.000	.0	.650	.0	1.300	.0	1.950	.8	2.600	.0
.050	.0	.700	.0	1.350	.2	2.000	.7	2.650	.0
.100	.0	.750	.0	1.400	1.1	2.050	.6	2.700	.0
.150	.0	.800	.0	1.450	2.3	2.100	.5	2.750	.0
.200	.0	.850	.0	1.500	3.0	2.150	.3	2.800	.0
.250	.0	.900	.0	1.550	2.7	2.200	.2	2.850	.0
.300	.0	.950	.0	1.600	2.0	2.250	.1	2.900	.0
.350	.0	1.000	.0	1.650	1.6	2.300	.1	2.950	.0
.400	.0	1.050	.0	1.700	1.3	2.350	.1	3.000	.0
.450	.0	1.100	.0	1.750	1.2	2.400	.1		
.500	.0	1.150	.0	1.800	1.1	2.450	.1		
.550	.0	1.200	.0	1.850	1.0	2.500	.0		
.600	.0	1.250	.0	1.900	.9	2.550	.0		

RUNOFF VOLUME = 1.56006 INCHES = .0014 ACRE-FEET
PEAK DISCHARGE RATE = 2.87 CFS AT 1.500 HOURS BASIN AREA = .0011 SQ. MI.

COMPUTE RATING CURVE CID=1 VS NO=1 NO SEG=6 MIN ELEV=0.00 MAX ELEV=0.3252
CH SLP=0.03 FP SLP=0.03
FIRST SEGMENT N=0.035 DIST=2.13
SECOND SEGMENT N=0.035 DIST=3.38
THIRD SEGMENT N=0.035 DIST=5.19
FOURTH SEGMENT N=0.035 DIST=6.99
FIFTH SEGMENT N=0.035 DIST=8.24
SIXTH SEGMENT N=0.035 DIST=10.38

DIST	ELEV	DIST	ELEV	DIST	ELEV
0	0.3252	0.01	0.3252	2.13	0.1848
3.38	0.1060	5.19	0.0000	6.99	0.1060
8.24	0.1848	10.37	0.3252	10.38	0.3252

RATING CURVE VALLEY SECTION 1.0

WATER SURFACE ELEV	FLOW AREA SQ FT	FLOW RATE CFS	TOP WIDTH FT
.00	.00	.00	.00
.02	.00	.00	.58
.03	.02	.01	1.17
.05	.04	.03	1.75
.07	.08	.06	2.33
.09	.12	.11	2.91
.10	.18	.18	3.50
.12	.24	.29	4.05
.14	.32	.43	4.59
.15	.40	.60	5.13
.17	.49	.80	5.68
.19	.60	1.04	6.22
.21	.71	1.32	6.73
.22	.83	1.64	7.25
.24	.95	2.00	7.77
.26	1.09	2.41	8.29
.27	1.24	2.85	8.81
.29	1.39	3.34	9.32
.31	1.56	3.87	9.84
.33	1.73	4.46	10.36

SED WASH LOAD ID=1 SOIL K=0.10 CROP C=0.35 EROSION PRACTICE=1.0
LS=0.42 PER IMP=0 WASH LOAD FACTOR=3
SEDIMENT YIELD (Wash Mat.) = 2.0 (TONS) WASH LOAD CONCENTRATION = 15895 (ppm-w)
PERCENTAGE IMPERVIOUS AREA = .000 WASH LOAD FACTOR = 3.00000

SEDIMENT TRANS ID=1 IRS=2 CODE=10 A FACT=0.0000016 B FACT=1.65
C FACT=0.88 D EXP=-1.0 NUMBER WASH=-1 CID=-1
Use wash load from SED WASH LOAD command - Concentration = 15995 (PPM-w)
Use channel data from COMPUTE RATING CURVE command - CID = 1

- - - - - - - - - - - - - - - - - - - -

TIME (HRS)	WATER FLOW (CFS)	VELOCITY (FT/SEC)	HYD. DEPTH (FT)	WIDTH (FT)	WASHLOAD CONC. (PPM-w)	BED MAT. TRANSPORT (CFS)	BED CONC. (PPM-w)	TOTAL CONC. (PPM-w)	BULKING FACTOR	ACCUM. SEDIMENT (TONS)
.000	.00	.000	.000	.00	15995.	.00	0.	15995.	1.0000	.00
.500	.00	.000	.000	.00	15995.	.00	0.	15995.	1.0000	.00
1.000	.00	.000	.000	.00	15995.	.00	0.	15995.	1.0000	.00
1.500	2.97	2.327	.143	8.94	15995.	.00	9.	16004.	1.0061	.60
2.000	.72	1.583	.084	5.46	15995.	.00	8.	16003.	1.0061	1.82
2.500	.04	.698	.029	1.94	15995.	.00	5.	16000.	1.0061	2.01
3.000	.00	.305	.008	.57	15995.	.00	4.	15998.	1.0061	2.02

AT PEAK FLOW OF 2.973 WITH TIME AT 1.50 HOURS: BEDMAT = .00 (TONS) = .0000 (AC-FT bulked)
TOTAL SED = .60 (TONS) = .0003 (AC-FT bulked)
PEAK BULKING FACTOR = 1.006137 = 16004. (PPM-w)

	WEIGHT (TONS)	UNBULKED VOLUME (AC-FT)	BULKED VOLUME (AC-FT)	CONCENTRATION BY WEIGHT (PPM)	AVERAGE BULKING FACTOR
WASHMAT =	2.02	.0006	.0009	15994.	
BEDMAT =	.00	.0000	.0000	9.	
TOTAL SEDIMENT =	2.02	.0006	.0009	16002.	1.006137

SEDIMENT TRANSPORT CAPACITY: .84433 AC-FT/SQ MI (bulked) = 2.8734 TONS/ACRE (at Porosity=0.395)

* COMPUTE WITH 5 MIN TP
COMPUTE NM HYD ID=1 HYD NO=101 DA=0.001099 PER A=0.0
PER B=0.0 PER C=100.0 PER D=0.0 TP=-0.083333 RAIN=-1

K = .045416HR TP = .083333HR K/TP RATIO = .545000 SHAPE CONSTANT, N = 7.106420
UNIT PEAK = 6.9405 CFS UNIT VOLUME = 1.006 K = 526.28 PEO = 2.0500
AREA = .001099 SQ MI IA = .50000 INCHES INF = .17000 INCHES PER HOUR
RUNOFF COMPUTED BY INITIAL ABSTRACTION/INFILTRATION NUMBER METHOD - DT = .050000

PRINT HYD ID=1 CODE=0

PARTIAL HYDROGRAPH 101.00

TIME HRS	FLOW CFS	TIME HRS	FLOW CFS	TIME HRS	FLOW CFS	TIME HRS	FLOW CFS	TIME HRS	FLOW CFS
.000	.0	.550	.0	1.100	.0	1.650	1.3	2.200	.1
.050	.0	.600	.0	1.150	.0	1.700	1.2	2.250	.1
.100	.0	.650	.0	1.200	.0	1.750	1.0	2.300	.0
.150	.0	.700	.0	1.250	.0	1.800	.9	2.350	.0
.200	.0	.750	.0	1.300	.1	1.850	.8	2.400	.0
.250	.0	.800	.0	1.350	1.0	1.900	.7	2.450	.0
.300	.0	.850	.0	1.400	2.7	1.950	.7	2.500	.0
.350	.0	.900	.0	1.450	3.5	2.000	.6	2.550	.0
.400	.0	.950	.0	1.500	3.0	2.050	.4	2.600	.0
.450	.0	1.000	.0	1.550	2.0	2.100	.2	2.650	.0
.500	.0	1.050	.0	1.600	1.5	2.150	.1		

RUNOFF VOLUME = 1.58006 INCHES = .0914 ACRE-FEET
PEAK DISCHARGE RATE = 3.55 CFS AT 1.450 HOURS BASIN AREA = .0011 SQ. MI.

COMPUTE RATING CURVE CID=1 VS NO=1 NO SEG=6 MIN ELEV=0.00 MAX ELEV=0.3252
CH SLP=0.03 FP SLP=0.03
FIRST SEGMENT N=0.035 DIST=2.13
SECOND SEGMENT N=0.035 DIST=3.38
THIRD SEGMENT N=0.035 DIST=5.19

```
FOURTH SEGMENT  N=0.035  DIST=6.89
FIFTH SEGMENT   N=0.035  DIST=8.24
SIXTH SEGMENT   N=0.035  DIST=10.38
 DIST  ELEV     DIST  ELEV     DIST  ELEV
    0  0.8252   0.01  0.3252   2.13  0.1848
 3.38  0.1060   5.19  0.0000   6.99  0.1060
 8.24  0.1848  10.37  0.3252  10.38  0.8252
```

RATING CURVE VALLEY SECTION 1.0

WATER SURFACE ELEV	FLOW AREA SQ FT	FLOW RATE CFS	TOP WIDTH FT
.00	.00	.00	.00
.02	.00	.00	.58
.03	.02	.01	1.17
.05	.04	.03	1.75
.07	.08	.06	2.33
.09	.12	.11	2.91
.10	.16	.18	3.50
.12	.24	.29	4.05
.14	.32	.43	4.59
.15	.40	.60	5.13
.17	.49	.80	5.68
.19	.60	1.04	6.22
.21	.71	1.32	6.73
.22	.83	1.64	7.25
.24	.95	2.00	7.77
.26	1.09	2.41	8.29
.27	1.24	2.85	8.81
.29	1.39	3.34	9.32
.31	1.56	3.87	9.84
.33	1.73	4.46	10.36

```
SED WASH LOAD       ID=1  SOIL K=0.10  CROP C=0.35  EROSION PRACTICE=1.0
                    LS=0.42  PER IMP=0   WASH LOAD FACTOR=3
        SEDIMENT YIELD (Wash Mat.) =        2.2 (TONS)   WASH LOAD CONCENTRATION =      17626 (ppm-w)
        PERCENTAGE IMPERVIOUS AREA =        .000          WASH LOAD FACTOR =    3.00000

SEDIMENT TRANS      ID=1  IBS=2  CONE=10  A FACT=0.0000016  B FACT=1.65
                    C FACT=0.88  D EXP=-1.0  NUMBER WASH=-1  CID=-1
            Use wash load from SED WASH LOAD command - Concentration =      17626 (PPM-w)
            Use channel data from COMPUTE RATING CURVE command - CID =     1

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TIME (HRS)	WATER FLOW (CFS)	VELOCITY (FT/SEC)	HYD. DEPTH (FT)	WIDTH (FT)	WASHLOAD CONC. (PPM-w)	SED MAT. TRANSPORT (CFS)	SED CONC. (PPM-w)	TOTAL CONC. (PPM-w)	BULKING FACTOR	ACCUM. SEDIMENT (TONS)
.000	.00	.000	.000	.00	17626.	.00	0.	17626.	1.0000	.00
.500	.00	.000	.000	.00	17626.	.00	0.	17626.	1.0000	.00
1.000	.00	.000	.000	.00	17626.	.00	0.	17626.	1.0000	.00
1.500	2.96	2.324	.143	8.92	17626.	.00	9.	17635.	1.0068	1.04
2.000	.61	1.507	.078	5.15	17626.	.00	8.	17633.	1.0068	2.13
2.500	.01	.454	.015	.94	17626.	.00	4.	17630.	1.0068	2.23

```
        AT PEAK FLOW OF       3.546 WITH TIME AT     1.45 HOURS:  SEDMAT =        .00 (TONS) =      .0000 (AC-FT bulked)
                                                                 TOTAL SED =       .74 (TONS) =      .0003 (AC-FT bulked)
        PEAK BULKING FACTOR =   1.006774 =     17635. (PPM-w)
```

	WEIGHT (TONS)	UNBULKED VOLUME (AC-FT)	BULKED VOLUME (AC-FT)	CONCENTRATION BY WEIGHT (PPM)	AVERAGE BULKING FACTOR
WASHMAT =	2.23	.0006	.0010	17625.	
SEDMAT =	.00	.0000	.0000	9.	
TOTAL SEDIMENT =	2.23	.0006	.0010	17633.	1.006774

```
        SEDIMENT TRANSPORT CAPACITY:      .93194 AC-FT/SQ MI (bulked) =     3.1715 TONS/ACRE (at Porosity=0.395)

*s ADJUST RAINFALL TO MATCH PREFREE OUTPUT =0.65 IN @ 5 MIN, 1.27 IN @ 15 MIN
```

```
RAINFALL            TYPE=0  DT=0.083333
                      .0000   .0069   .0142   .0220   .0302   .0389   .0482
                      .0583   .0692   .0812   .0844   .1091   .1259   .1408
                      .1892   .2937   .6420  1.2920  1.5637  1.6705  1.8037
                     1.9170  2.0151  2.1007  2.1759  2.1931  2.2085  2.2224
                     2.2352  2.2471  2.2581  2.2685  2.2784  2.2877  2.2966
                     2.3051  2.3132  2.3210  2.3288  2.3359  2.3429  2.3497
                     2.3563  2.3627  2.3689  2.3750  2.3809  2.3867  2.3923
                     2.3978  2.4032  2.4085  2.4136  2.4187  2.4237  2.4285
                     2.4333  2.4380  2.4426  2.4471  2.4515  2.4559  2.4602
                     2.4645  2.4686  2.4728  2.4768  2.4808  2.4848  2.4886
                     2.4925  2.4963  2.5000
              INPUT OF MASS RAINFALL WITH DT =     .083333 HR.
COMPUTE NM HYD      ID=1  HYD NO=101    DA=0.001099  PER A=0.0
                    PER B=0.0 PER C=100.0 PER D=0.0 TP=-0.133333  RAIN=-1

    K =   .072666HR    TP =   .133333HR    K/TP RATIO =   .545000     SHAPE CONSTANT, N =  7.106420
    UNIT PEAK =   4.3378    CFS   UNIT VOLUME =    1.006       B =   526.28      P60 = 2.0523
    AREA =      .001099 SQ MI    IA =    .50000 INCHES    INF =    .17000 INCHES PER HOUR
    RUNOFF COMPUTED BY INITIAL ABSTRACTION/INFILTRATION NUMBER METHOD - DT =   .083333

PRINT HYD           ID=1 CODE=0
```

PARTIAL HYDROGRAPH 101.00

TIME HRS	FLOW CFS	TIME HRS	FLOW CFS	TIME HRS	FLOW CFS	TIME HRS	FLOW CFS	TIME HRS	FLOW CFS
.000	.0	.667	.0	1.333	.3	2.000	.7	2.667	.0
.083	.0	.750	.0	1.417	2.0	2.083	.5	2.750	.0
.167	.0	.833	.0	1.500	3.1	2.167	.2	2.833	.0
.250	.0	.917	.0	1.583	2.0	2.250	.1	2.917	.0
.333	.0	1.000	.0	1.667	1.2	2.333	.1	3.000	.0
.417	.0	1.083	.0	1.750	1.1	2.417	.1		
.500	.0	1.167	.0	1.833	.9	2.500	.0		
.583	.0	1.250	.0	1.917	.8	2.583	.0		

```
   RUNOFF VOLUME =      1.56106 INCHES      =        .0915 ACRE-FEET
   PEAK DISCHARGE RATE =       3.12 CFS  AT   1.500 HOURS   BASIN AREA =   .0011 SQ. MI.


COMPUTE RATING CURVE CID=1  VS NO=1  NO SEG=6  MIN ELEV=0.00  MAX ELEV=0.3252
                    CH SLP=0.03  FP SLP=0.03
                    FIRST SEGMENT   N=0.035  DIST=2.13
                    SECOND SEGMENT  N=0.035  DIST=3.38
                    THIRD SEGMENT   N=0.035  DIST=5.19
                    FOURTH SEGMENT  N=0.035  DIST=6.89
                    FIFTH SEGMENT   N=0.035  DIST=8.24
                    SIXTH SEGMENT   N=0.035  DIST=10.38
                     DIST  ELEV     DIST  ELEV     DIST  ELEV
                        0  0.8252   0.01  0.3252   2.13  0.1848
                     3.38  0.1060   5.19  0.0000   6.89  0.1060
                     8.24  0.1848  10.37  0.3252  10.38  0.8252
```

RATING CURVE VALLEY SECTION 1.0

WATER SURFACE ELEV	FLOW AREA SQ FT	FLOW RATE CFS	TOP WIDTH FT
.00	.00	.00	.00
.02	.00	.00	.58
.03	.02	.01	1.17
.05	.04	.03	1.75
.07	.08	.06	2.33
.09	.12	.11	2.91
.10	.18	.18	3.50
.12	.24	.28	4.05
.14	.32	.43	4.58
.15	.40	.60	5.13
.17	.49	.80	5.68
.19	.60	1.04	6.22
.21	.71	1.32	6.73
.22	.83	1.64	7.25

.24	.95	2.80	7.77
.26	1.09	2.41	8.29
.27	1.24	2.85	8.81
.29	1.39	3.34	9.32
.31	1.56	3.87	9.84
.33	1.73	4.46	10.36

```
SED WASH LOAD        ID=1  SOIL K=0.10  CROP C=0.35  EROSION PRACTICE=1.0
                     LS=0.42  PER IMP=0   WASH LOAD FACTOR=3
        SEDIMENT YIELD (Wash Mat.) =        2.1 (TONS)   WASH LOAD CONCENTRATION =      16408 (ppm-w)
        PERCENTAGE IMPERVIOUS AREA =        .000         WASH LOAD FACTOR =    3.00000

SEDIMENT TRANS       ID=1  IDS=2  CODE=10  A FACT=0.0000016  B FACT=1.65
                     C FACT=0.88  D EXP=-1.0  NUMBER WASH=-1  CID=-1
              Use wash load from SED WASH LOAD command - Concentration =      16408 (PPM-w)
              Use channel data from COMPUTE RATING CURVE command - CID =      1

  * * * * * * * * * * * * * * * * *
```

TIME (HRS)	WATER FLOW (CFS)	VELOCITY (FT/SEC)	HYD. DEPTH (FT)	WIDTH (FT)	WASHLOAD CONC. (PPM-w)	SED MAT. TRANSPORT (CFS)	SED CONC. (PPM-w)	TOTAL CONC. (PPM-w)	BULKING FACTOR	ACCUM. SEDIMENT (TONS)
.000	.00	.000	.000	.00	16408.	.00	0.	16408.	1.0000	.00
.833	.00	.000	.000	.00	16408.	.00	0.	16408.	1.0000	.00
1.667	1.23	1.834	.102	6.55	16408.	.00	8.	16416.	1.0063	1.36
2.500	.04	.685	.028	1.89	16408.	.00	5.	16413.	1.0063	2.07

```
        AT PEAK FLOW OF       3.115 WITH TIME AT     1.50 HOURS:  BEDMAT =        .00 (TONS) =      .0000 (AC-FT bulked)
                                                                TOTAL SED =       .86 (TONS) =      .0004 (AC-FT bulked)
        PEAK BULKING FACTOR =   1.006299 =     16417. (PPM-w)
```

	WEIGHT (TONS)	UNBULKED VOLUME (AC-FT)	BULKED VOLUME (AC-FT)	CONCENTRATION BY WEIGHT (PPM)	AVERAGE BULKING FACTOR
WASHMAT =	2.07	.0006	.0010	16407.	
BEDMAT =	.00	.0000	.0000	9.	
TOTAL SEDIMENT =	2.08	.0006	.0010	16416.	1.006298

```
        SEDIMENT TRANSPORT CAPACITY:      .86705 AC-FT/SQ MI (bulked) =     2.9507 TONS/ACRE (at Porosity=0.395)

* COMPUTE WITH 5 MIN TP
COMPUTE NM HYD       ID=1  HYD NO=101    DA=0.001099  PER A=0.0
                     PER B=0.0 PER C=100.0 PER D=0.0 TP=-0.083333  RAIN=-1

    K =   .045416HR    TP =   .083333HR    K/TP RATIO =    .545000     SHAPE CONSTANT, N =  7.106420
    UNIT PEAK =   6.9405    CFS   UNIT VOLUME =    1.118       B =   526.28       P60 = 2.0523
    AREA =       .001099 SQ MI    IA =    .50000 INCHES    INF =    .17000 INCHES PER HOUR
    RUNOFF COMPUTED BY INITIAL ABSTRACTION/INFILTRATION NUMBER METHOD - DT =   .083333

PRINT HYD            ID=1 CODE=0
```

PARTIAL HYDROGRAPH 101.00

TIME HRS	FLOW CFS	TIME HRS	FLOW CFS	TIME HRS	FLOW CFS	TIME HRS	FLOW CFS	TIME HRS	FLOW CFS
.000	.0	.583	.0	1.167	.0	1.750	1.0	2.333	.0
.083	.0	.667	.0	1.250	.0	1.833	.6	2.417	.0
.167	.0	.750	.0	1.333	.8	1.917	.7	2.500	.0
.250	.0	.833	.0	1.417	4.1	2.000	.6	2.583	.0
.333	.0	.917	.0	1.500	2.5	2.083	.2	2.667	.0
.417	.0	1.000	.0	1.583	1.2	2.167	.1		
.500	.0	1.083	.0	1.667	1.1	2.250	.0		

```
    RUNOFF VOLUME =     1.56106 INCHES     =        .0015 ACRE-FEET
    PEAK DISCHARGE RATE =       4.14 CFS  AT   1.417 HOURS   BASIN AREA =   .0011 SQ. MI.

COMPUTE RATING CURVE CID=1  VS NO=1  NO SEG=6  MIN ELEV=0.00  MAX ELEV=0.3252
```

```
CH SLP=0.03  FP SLP=0.03
FIRST SEGMENT   N=0.035  DIST=2.13
SECOND SEGMENT  N=0.035  DIST=3.38
THIRD SEGMENT   N=0.035  DIST=5.19
FOURTH SEGMENT  N=0.035  DIST=6.99
FIFTH SEGMENT   N=0.035  DIST=8.24
SIXTH SEGMENT   N=0.035  DIST=10.38
 DIST  ELEV     DIST  ELEV     DIST  ELEV
    0  0.8252   0.01  0.3252   2.13  0.1848
 3.38  0.1060   5.19  0.0000   6.98  0.1060
 8.24  0.1848  10.37  0.3252  10.38  0.8252
```

RATING CURVE VALLEY SECTION 1.0

WATER SURFACE ELEV	FLOW AREA SQ FT	FLOW RATE CFS	TOP WIDTH FT
.00	.00	.00	.00
.02	.00	.00	.58
.03	.02	.01	1.17
.05	.04	.03	1.75
.07	.08	.06	2.33
.09	.12	.11	2.91
.10	.18	.18	3.50
.12	.24	.29	4.05
.14	.32	.43	4.59
.15	.40	.60	5.13
.17	.49	.80	5.68
.19	.60	1.04	6.22
.21	.71	1.32	6.73
.22	.83	1.64	7.25
.24	.95	2.00	7.77
.26	1.09	2.41	8.29
.27	1.24	2.85	8.81
.29	1.39	3.34	9.32
.31	1.56	3.87	9.84
.33	1.73	4.46	10.36

```
SED WASH LOAD       ID=1  SOIL K=0.10  CROP C=0.35  EROSION PRACTICE=1.0
                    LS=0.42  PER IMP=0   WASH LOAD FACTOR=3
        SEDIMENT YIELD (Wash Mat.) =        2.4 (TONS)   WASH LOAD CONCENTRATION =      19183 (ppm-w)
        PERCENTAGE IMPERVIOUS AREA =        .000         WASH LOAD FACTOR =    3.00000

SEDIMENT TRANS      ID=1  IDS=2  CODE=10  A FACT=0.0000016  B FACT=1.65
                    C FACT=0.88  D EXP=-1.0  NUMBER WASH=-1  CID=-1
              Use wash load from SED WASH LOAD command - Concentration =      19183 (PPM-w)
              Use channel data from COMPUTE RATING CURVE command - CID =     1

 * * * * * * * * * * * * * * * * * *
```

TIME (HRS)	WATER FLOW (CFS)	VELOCITY (FT/SEC)	HYD. DEPTH (FT)	WIDTH (FT)	WASHLOAD CONC. (PPM-w)	BED MAT. TRANSPORT (CFS)	BED CONC. (PPM-w)	TOTAL CONC. (PPM-w)	BULKING FACTOR	ACCUM. SEDIMENT (TONS)
.000	.00	.000	.000	.00	19183.	.00	0.	19183.	1.0000	.00
.833	.00	.000	.000	.00	19183.	.00	0.	19183.	1.0000	.00
1.667	1.14	1.794	.099	6.39	19183.	.00	8.	19191.	1.0074	1.81
2.500	.01	.436	.014	.86	19183.	.00	4.	19187.	1.0074	2.43

```
AT PEAK FLOW OF       4.139 WITH TIME AT     1.42 HOURS:  BEDMAT =        .00 (TONS) =      .0000 (AC-FT bulked)
                                                          TOTAL SED =      .91 (TONS) =      .0004 (AC-FT bulked)
PEAK BULKING FACTOR =  1.007384 =     19192. (PPM-w)
```

	WEIGHT (TONS)	UNBULKED VOLUME (AC-FT)	BULKED VOLUME (AC-FT)	CONCENTRATION BY WEIGHT (PPM)	AVERAGE BULKING FACTOR
WASHMAT =	2.43	.0007	.0011	19182.	
BEDMAT =	.00	.0000	.0000	9.	
TOTAL SEDIMENT =	2.43	.0007	.0011	19191.	1.007383

```
SEDIMENT TRANSPORT CAPACITY:     1.01651 AC-FT/SQ MI (bulked) =     3.4593 TONS/ACRE (at Porosity=0.395)
```

```
*S Rating curve and sediment yield for edge slope of 5 % with top runoff
COMPUTE RATING CURVE CID=1  VS NO=1  NO SEG=6  MIN ELEV=0.00  MAX ELEV=0.3252
                    CH SLP=0.05   FP SLP=0.05
                    FIRST SEGMENT   N=0.035  DIST=2.13
                    SECOND SEGMENT  N=0.035  DIST=3.38
                    THIRD SEGMENT   N=0.035  DIST=5.19
                    FOURTH SEGMENT  N=0.035  DIST=6.99
                    FIFTH SEGMENT   N=0.035  DIST=8.24
                    SIXTH SEGMENT   N=0.035  DIST=10.38
                     DIST  ELEV     DIST  ELEV     DIST  ELEV
                        0  0.8252   0.01  0.3252   2.13  0.1848
                     3.38  0.1060   5.19  0.0000   6.99  0.1060
                     8.24  0.1848  10.37  0.3252  10.38  0.8252

                                RATING CURVE VALLEY SECTION  1.0
                                   WATER        FLOW        FLOW        TOP
                                  SURFACE       AREA        RATE        WIDTH
                                   ELEV        SQ FT       CFS          FT
                                    .00          .00         .00         .00
                                    .02          .00         .00         .58
                                    .03          .02         .01        1.17
                                    .05          .04         .04        1.75
                                    .07          .08         .08        2.33
                                    .09          .12         .14        2.91
                                    .10          .18         .24        3.50
                                    .12          .24         .38        4.05
                                    .14          .32         .56        4.59
                                    .15          .40         .78        5.13
                                    .17          .49        1.04        5.68
                                    .19          .60        1.34        6.22
                                    .21          .71        1.71        6.73
                                    .22          .83        2.12        7.25
                                    .24          .95        2.59        7.77
                                    .26         1.09        3.11        8.29
                                    .27         1.24        3.68        8.81
                                    .29         1.39        4.31        9.32
                                    .31         1.56        5.00        9.84
                                    .33         1.73        5.75       10.36
SED WASH LOAD        ID=1  SOIL K=0.10  CROP C=0.35  EROSION PRACTICE=1.0
                     LS=0.66  PER IMP=0   WASH LOAD FACTOR=3
        SEDIMENT YIELD (Wash Mat.) =        3.8 (TONS)   WASH LOAD CONCENTRATION =      29818 (ppm-w)
        PERCENTAGE IMPERVIOUS AREA =        .000         WASH LOAD FACTOR =    3.00000

SEDIMENT TRANS       ID=1  IRS=2  CODE=10  A FACT=0.0000016  B FACT=1.65
                     C FACT=0.88  D EXP=-1.0  NUMBER WASH=-1  CID=-1
            Use wash load from SED WASH LOAD command - Concentration =      29818 (PPM-w)
            Use channel data from COMPUTE RATING CURVE command - CID =     1

 . . . . . . . . . . . . . . . . . .

   TIME    WATER FLOW   VELOCITY   HYD. DEPTH   WIDTH   WASHLOAD CONC.   BED MAT. TRANSPORT   BED CONC.   TOTAL CONC.   BULKING FACTOR   ACCUM. SEDIMENT
   (HRS)   (CFS)        (FT/SEC)   (FT)         (FT)    (PPM-w)          (CFS)                (PPM-w)     (PPM-w)                        (TONS)

   .000     .00         .000       .000         .00     29818.           .00                  0.          29818.        1.0000           .00
   .833     .00         .000       .000         .00     29818.           .00                  0.          29818.        1.0000           .00
  1.667    1.14         2.157      .090         5.85    29818.           .00                 10.          29827.        1.0116          2.85
  2.500     .01         .530       .013         .77     29818.           .00                  5.          29823.        1.0116          3.82

        AT PEAK FLOW OF        4.139 WITH TIME AT      1.42 HOURS:  BEDMAT =        .00 (TONS) =      .0000 (AC-FT bulked)
                                                                    TOTAL SED =     1.43 (TONS) =      .0007 (AC-FT bulked)
        PEAK BULKING FACTOR =   1.011602 =      29829. (PPM-w)

                                   WEIGHT      UNBULKED VOLUME   BULKED VOLUME   CONCENTRATION BY WEIGHT   AVERAGE BULKING FACTOR
                                   (TONS)      (AC-FT)           (AC-FT)         (PPM)

        WASHMAT =                   3.82       .0011             .0018           29817.
        BEDMAT  =                    .00       .0000             .0000              10.
        TOTAL SEDIMENT =            3.82       .0011             .0018           29827.          1.011601
```

SEDIMENT TRANSPORT CAPACITY: 1.59719 AC-FT/SQ MI (bulked) = 5.4354 TONS/ACRE (at Porosity=0.395)

```
* COMPUTE EDGE SLOPE RUNOFF WITH 5 MIN TP WITH 50 FT BY 150 FT CONTRIB. AREA
COMPUTE NM HYD      ID=1  HYD NO=101    DA=0.000269  PER A=0.0
                    PER B=0.0 PER C=100.0 PER D=0.0 TP=-0.083333  RAIN=-1

    K =   .045416HR    TP =   .083333HR    K/TP RATIO =   .545000     SHAPE CONSTANT, N =  7.106420
    UNIT PEAK =   1.6988    CFS   UNIT VOLUME =    1.113       B =   526.28      P60 = 2.0523
    AREA =      .000269 SQ MI    IA =    .50000 INCHES    INF =    .17000 INCHES PER HOUR
    RUNOFF COMPUTED BY INITIAL ABSTRACTION/INFILTRATION NUMBER METHOD - DT =   .083333

PRINT HYD           ID=1 CODE=6
```

PARTIAL HYDROGRAPH 101.00

TIME HRS	FLOW CFS	TIME HRS	FLOW CFS	TIME HRS	FLOW CFS	TIME HRS	FLOW CFS	TIME HRS	FLOW CFS
.000	.0	.500	.0	1.000	.0	1.500	.6	2.000	.1
.083	.0	.583	.0	1.083	.0	1.583	.3	2.083	.0
.167	.0	.667	.0	1.167	.0	1.667	.3	2.167	.0
.250	.0	.750	.0	1.250	.0	1.750	.2	2.250	.0
.333	.0	.833	.0	1.333	.2	1.833	.2	2.333	.0
.417	.0	.917	.0	1.417	1.0	1.917	.2	2.417	.0

RUNOFF VOLUME = 1.56106 INCHES = .0224 ACRE-FEET
PEAK DISCHARGE RATE = 1.02 CFS AT 1.417 HOURS BASIN AREA = .0003 SQ. MI.

```
*S Rating curve and sediment yield for edge slope of 5 % and no top runoff
COMPUTE RATING CURVE CID=1  VS NO=1  NO SEG=6  MIN ELEV=0.00  MAX ELEV=0.3252
                    CH SLP=0.05  FP SLP=0.05
                    FIRST SEGMENT   N=0.035  DIST=2.13
                    SECOND SEGMENT  N=0.035  DIST=3.38
                    THIRD SEGMENT   N=0.035  DIST=5.19
                    FOURTH SEGMENT  N=0.035  DIST=6.99
                    FIFTH SEGMENT   N=0.035  DIST=8.24
                    SIXTH SEGMENT   N=0.035  DIST=10.38
                     DIST  ELEV     DIST  ELEV     DIST  ELEV
                        0  0.8252   0.01  0.3252   2.13  0.1848
                     3.38  0.1060   5.19  0.0000   6.99  0.1060
                     8.24  0.1848  10.37  0.3252  10.38  0.8252
```

RATING CURVE VALLEY SECTION 1.0

WATER SURFACE ELEV	FLOW AREA SQ FT	FLOW RATE CFS	TOP WIDTH FT
.00	.00	.00	.00
.02	.00	.00	.58
.03	.02	.01	1.17
.05	.04	.04	1.75
.07	.08	.08	2.33
.09	.12	.14	2.91
.10	.18	.24	3.50
.12	.24	.38	4.08
.14	.32	.56	4.59
.15	.40	.78	5.13
.17	.49	1.04	5.68
.19	.60	1.34	6.22
.21	.71	1.71	6.73
.22	.83	2.12	7.25
.24	.95	2.59	7.77
.26	1.09	3.11	8.29
.27	1.24	3.68	8.81
.29	1.38	4.31	9.32
.31	1.56	5.00	9.84
.33	1.73	5.75	10.38

```
SED WASH LOAD       ID=1  SOIL K=0.10  CROP C=0.35  EROSION PRACTICE=1.0
                    LS=0.66  PER IMP=0   WASH LOAD FACTOR=3
```

SEDIMENT YIELD (Wash Mat.) = .8 (TONS) WASH LOAD CONCENTRATION = 25360 (ppm-w)
PERCENTAGE IMPERVIOUS AREA = .000 WASH LOAD FACTOR = 3.00000

```
SEDIMENT TRANS      ID=1  IDS=2  CODE=10  A FACT=0.0000016  B FACT=1.65
                    C FACT=0.88  D EXP=-1.0  NUMBER WASH=-1  CID=-1
            Use wash load from SED WASH LOAD command - Concentration =      25360 (PPM-w)
            Use channel data from COMPUTE RATING CURVE command - CID =     1

 * * * * * * * * * * * * * * * * *
```

TIME (HRS)	WATER FLOW (CFS)	VELOCITY (FT/SEC)	HYD. DEPTH (FT)	WIDTH (FT)	WASHLOAD CONC. (PPM-w)	BED MAT. TRANSPORT (CFS)	BED CONC. (PPM-w)	TOTAL CONC. (PPM-w)	BULKING FACTOR	ACCUM. SEDIMENT (TONS)
.000	.00	.000	.000	.00	25360.	.00	0.	25360.	1.0000	.00
.833	.00	.000	.000	.00	25360.	.00	0.	25360.	1.0000	.00
1.667	.28	1.396	.055	3.67	25360.	.00	8.	25367.	1.0098	.59

```
AT PEAK FLOW OF       1.017 WITH TIME AT     1.42 HOURS:  BEDMAT =        .00 (TONS) =      .0000 (AC-FT bulked)
                                                          TOTAL SED =      .30 (TONS) =      .0001 (AC-FT bulked)
PEAK BULKING FACTOR =   1.009822 =     25369. (PPM-w)
```

	WEIGHT (TONS)	UNBULKED VOLUME (AC-FT)	BULKED VOLUME (AC-FT)	CONCENTRATION BY WEIGHT (PPM)	AVERAGE BULKING FACTOR
WASHMAT =	.79	.0002	.0004	25355.	
BEDMAT =	.00	.0000	.0000	8.	
TOTAL SEDIMENT =	.79	.0002	.0004	25363.	1.009820

```
SEDIMENT TRANSPORT CAPACITY:     1.35193 AC-FT/SQ MI (bulked) =     4.6008 TONS/ACRE (at Porosity=0.395)

FINISH

   NORMAL PROGRAM FINISH          END TIME (HR:MIN:SEC) = 17:55:25
```

Appendix K

Alternative Landfill Cover Demonstration

Alternative Landfill Cover Demonstration

The Alternative Landfill Cover Demonstration (ALCD) is a large-scale field demonstration project. There are six cover designs being tested in this demonstration project: two baseline cover profiles (municipal solid waste landfill and hazardous waste landfill) and four alternative cover designs. The goal of the ALCD is to field test, compare and document the performance of alternative landfill cover technologies, of various complexities and costs, for interim stabilization and/or final closure of landfills for use in arid and semi-arid environments. Each test covers is 13-m wide by 100 m long. The 100 m dimension was chosen because it is representative of typical hazardous and mixed waste landfills found throughout the DOE complex (approximately 2 acres in surface area). All covers were constructed with a 5% slope in all layers. The slope lengths are 50 m each (100-m length crowned at the middle with half of the length - 50 m - sloping to the east and the other half toward the west). The western slope is monitored under ambient conditions (passive testing). A sprinkler system was installed in the eastern slope of each cover to facilitate stress testing of the covers (active testing).

Figure K-1. Aerial Photo of ALCD

Continuous water balance and meteorological data are currently being obtained. ALCD monitoring began in May 1997 and is currently in its third year. The site will continue to be actively monitored for a minimum five-year post construction period. In addition, periodic measurements of vegetation cover, biomass, leaf area index, and species composition are being taken.

The objectives of the ALCD are to:

- demonstrate the construction and cost of cover design alternatives;
- measure the performance of the design alternatives using water balance and ancillary data as the primary evaluation criteria; and
- document the results through presentations, reports, and peer- reviewed publications.

The ALCD is not intended to showcase any one particular cover system. The focus of this project is to provide the necessary tools, such as cost, construction and performance data, to the public and regulatory agencies so that design engineers will have better, regulatory acceptable alternatives to the conventional cover designs.

The installed test cover designs descriptions are as follows:

Baseline Test Cover 1 is a basic Soil Cover installed to meet minimum requirements for RCRA Subtitle 'D' governed landfills (US DOE 1993). These requirements apply to municipal solid waste landfills to be closed using engineered covers and generally meet the following performance objectives:

- Permeability of the cover to be less than or equal to the permeability of the bottom liner/subsoil or no greater than 10^{-5} cm/sec;
- minimize infiltration with a minimum of 45 cm of soil; and
- minimize erosion with a minimum of 15 cm of soil for plant growth.

The installed test cover is 60 cm thick (Figure K-2). It is constructed of essentially two layers. The bottom layer is a 45-cm thick compacted soil layer. This barrier layer's primary purpose is to minimize the infiltration of water into the underlying waste. Only native soil from on-site cut excavations was used in this layer. The soil was compacted 'wet of optimum' as recommended by the EPA to remold the soil and lower the initial saturated hydraulic conductivity. Standard construction practices and equipment were used throughout the project. Soil density and water content readings were taken to ensure that the soil placed fell within the specified compaction zone. The soil was placed as specified to meet the maximum 1×10^{-5} cm/sec requirement of Subtitle 'D' regulated facilities. Laboratory test results yielded saturated hydraulic conductivity results on the barrier layer soil between 5.5×10^{-6} cm/sec and 5.1×10^{-7} cm/sec. The initial in-situ saturated hydraulic conductivity was determined to be about 4.9×10^{-7} cm/sec with a sealed double-ringed infiltrometer (ASTM D5093).

The top vegetation layer is 15 cm of loosely laid topsoil. The vegetation layer consists of topsoil cut from the site, stockpiled, and replaced. This layer provides for vegetation growth and erosion protection.

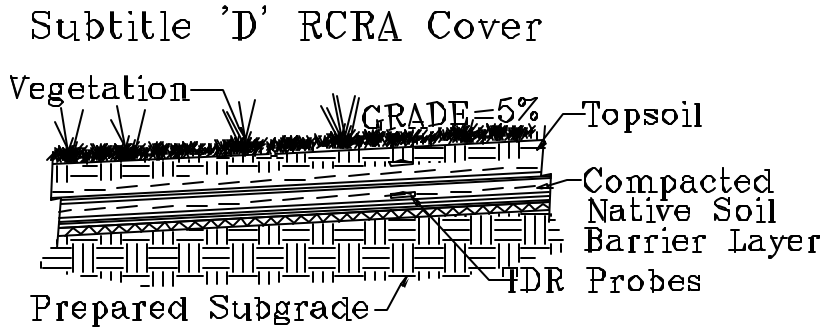

Figure K-2. Baseline Test Cover 1 – Traditional "Municipal Solid Waste Landfill Cover Profile"

Baseline Test Cover 2 is a Compacted Clay Cover designed and constructed in accordance with minimum regulatory requirements for closure of hazardous and mixed waste landfills found in 40 CFR Parts 264 and 265, Subpart N. Under these regulations, owners/operators of landfills are required to perform landfill closures. The primary closure requirements of 264.310 and 265.310 require the owners/operators to design and construct a low-permeability cover over the landfill to minimize migration of liquids into the waste and to provide 30 years of post-closure monitoring and maintenance in order to prevent waste migration into the environment. The cover design must provide for the following:

- minimize liquid migration;
- promote drainage while controlling erosion;
- minimize maintenance;
- have a permeability equal to or less than the permeability of natural subsoil;
- account for freeze/thaw effects; and
- accommodate settling and subsidence so that the cover' s integrity is maintained.

The recommended EPA RCRA Subtitle ' C' final cover design (EPA, 1991) from bottom to top consists of:

1. Low hydraulic conductivity geomembrane/soil layer: a 60 cm layer of compacted natural or amended soil with a maximum saturated hydraulic conductivity of 1 x 10^{-7} cm/sec in intimate contact with a minimum 40 mil geomembrane.
2. Drainage layer: a minimum 30 cm sand layer having a minimum saturated hydraulic conductivity of 1 x 10^{-2} cm/sec, or a layer of geosynthetic material having the same characteristics.
3. Top vegetation/soil layer: a top layer with vegetation (or an armored top surface) and a minimum 60 cm of soil graded at a slope between 3 and 5 percent.

The Baseline Test Cover 2 (Figure K-3) was designed with the following features. It is 1.5 m thick. The bottom layer is a 60 cm thick compacted soil layer. This layer' s primary purpose is as a barrier layer to prevent the downward migration of water into the underlying waste. Laboratory tests revealed that the native soil at the ALCD site required

amendment to meet the saturated hydraulic conductivity requirement (maximum of 1 x 10^{-7} cm/sec). The goal of the laboratory testing was to find a combination of native soil and soil amendment, in this case sodium bentonite, that would yield a saturated hydraulic conductivity maximum of 1 x 10^{-8} cm/sec. Past experience has shown that laboratory testing of hydraulic conductivity yields results at least an order of magnitude better than in-situ soil measurements. Through laboratory testing using a rigid-wall permeameter (Daniels 1985), it was determined that a mixture of 6% by weight of sodium bentonite with the native soil compacted ' wet of optimum' to 98% of maximum dry density per ASTM D698 would be adequate. All permeameter tests in the ' wet of optimum' range yielded results between 10^{-8} to 10^{-9} cm/sec range. The soil was specified to be compacted ' wet of optimum' as recommended by the EPA so as to remold the soil to lower the hydraulic conductivity.

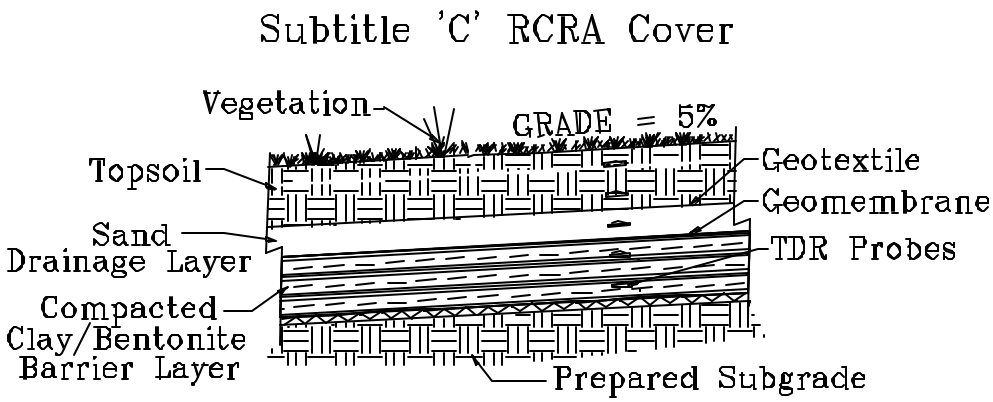

Figure K-3. Baseline Test Cover 2- Traditional "Compacted Clay Cover" for Hazardous Waste Landfills

An acceptable compaction zone was specified similar to that for Baseline Test Cover 1. The combination of the compaction requirements, soil amendment, and placement (' wet of optimum') was done in hopes of yielding a maximum hydraulic conductivity of 1 x 10^{-7} cm/sec. The in-situ saturated hydraulic conductivity was determined to be 7.9 x 10^{-7} cm/sec, 1.8 orders of magnitude better than required. Desiccation cracking is believed to be the cause for the lower than anticipated hydraulic conductivity. The effects of desiccation cracking is not accurately represented in the laboratory.

A 40-mil linear low-density polyethylene geomembrane was placed directly on top of the clay barrier layer. The surface of the clay barrier layer was smooth-roll compacted and prepared to allow for intimate contact between it and the under-surface of the geomembrane to essentially obtain a composite barrier layer. Continuous contact was emphasized in an effort to eliminate gaps between the geomembrane and soil barrier layer where any water that has passed through the geomembrane would have a pathway to run and find a crack in the underlying soil layer. The acceptance of the earth surface was determined prior to placing the geomembrane on it.

A 30-cm thick middle drainage layer constructed of sand was placed directly on the geomembrane. The purpose of the drainage layer is to minimize the time any infiltrated water is in contact with the underlying barrier layer by quickly routing this water that has passed through the vegetation layer laterally to collection drains. The average saturated hydraulic conductivity of the sand installed was 1×10^{-1} cm/sec which is an order of magnitude better than the minimum 1×10^{-2} cm/sec specified. A nonwoven polyester needlepunched geotextile was placed directly on top of the sand drainage layer. This served as a filter between the drainage layer material and top vegetation layer.

The top layer is a 60 cm thick vegetation layer comprised of uncompacted soil. This layer's primary purpose is to provide for vegetation growth, erosion protection, and protect the underlying layers from such things as harmful freeze/thaw cycles. It allows for storage of infiltrated water that can later be evaporated. It is 45 cm of native fill soil covered by 15 cm of topsoil.

Alternative Designs

Design criteria for the alternative covers were very basic. The covers were to be (1) less expensive than Baseline Test Cover 2; (2) more effective than the baseline covers at preventing the infiltration of water into the underlying waste; and (3) easier and more reliable to construct. The native soil came from on-site cut excavations. Other materials to be purchased off-site, such as sand and gravel, must be common and readily available (i.e., no exotic grain-size distributions, etc.).

All compaction of soil required by design in the alternative covers was compacted 'dry of optimum' rather than 'wet of optimum' as currently recommended by the EPA with the traditional covers. Dry-side compaction should result in a compacted barrier soil that is less susceptible to potential desiccation cracking. Dry-side compaction also made construction easier and therefore, less expensive. Dry-side compaction also provides for more initial soil water storage capability than wet-side storage due to the lower initial degree of saturation.

The determination to compact soil 'dry of optimum' for all the alternative covers was confirmed by laboratory testing that showed the saturated hydraulic conductivity of the soil is relatively insensitive to the molding water content. The hydraulic conductivities of three soil test specimens were determined. One of the specimens was compacted 'wet of optimum', one was compacted at the optimum water content, while the third was compacted 'dry of optimum'. The standard Proctor curves revealed the relative insensitivity of the hydraulic conductivity to the water content (Shackleford 1995).

Alternative Test Cover 1 is a Geosynthetic Clay Cover (Figure K-4) identical to Baseline Test Cover 2 with the exception that the problematic clay barrier layer was replaced with a manufactured sheet installed in its place called a geosynthetic clay liner (GCL). The overall thickness of this cover is 90 cm. The cover layers are, from bottom to top: the barrier layer (the GCL membrane covered with a geomembrane comprises the composite barrier layer), sand drainage layer, geotextile filter fabric, and vegetation soil layer,

respectively. The GCL sheet is a composite of two nonwoven fabrics sandwiching a thin layer of bentonite. The saturated hydraulic conductivity of the GCL per the Claymax manufacturer is 5 x 10^{-9} cm/sec.

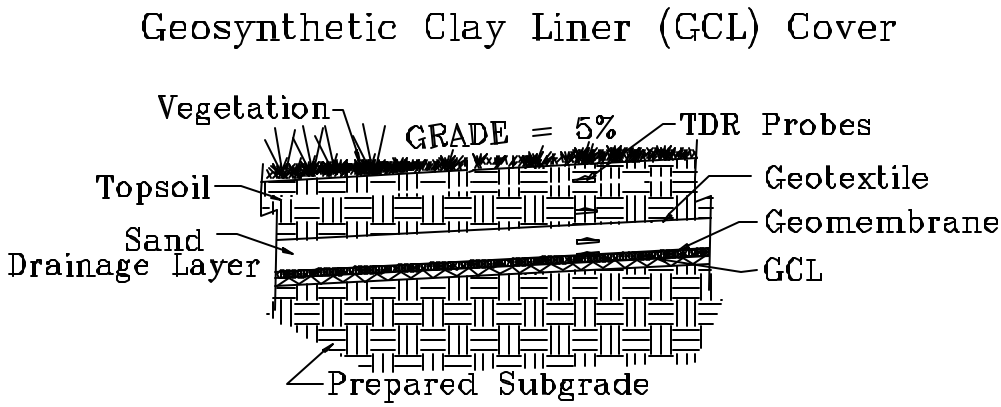

Figure K-4. Alternative Test Cover 1 – GCL Cover

A geomembrane was then installed on the GCL. Its installation, as well as that of the sand drainage layer, geotextile, and topsoil were installed identically to those similar layers in the Compacted Clay Cover.

Alternative Test Cover 2 is a Capillary Barrier (Figure K-5). Differences in pore size distribution and, thus, differences in suction between two soil layers under unsaturated flow conditions cause water to be retained in the upper soil layer as long as the contrast in unsaturated properties (e.g., soil-moisture characteristic curves and unsaturated hydraulic conductivities) of the soils in the two soil layers is sufficiently large. In general, the upper soil layer must consist of a soil with a significantly larger suction than the lower soil layer at the same water content. Thus, a capillary barrier effect results when a relatively fine-grained soil overlies a relatively coarse-grained soil. The capillary pressure head in the fine-grained upper soil layer must approach a value near zero (i.e., saturated conditions) before any appreciable flow occurs into the lower lateral drainage layer.

Design considerations for this cover system included determining the proper soil layer thicknesses and slope to minimize the percolation of water through it. In general, layer thicknesses and slope depend on (1) climatological information for the site at which the cover is to be constructed (e.g., precipitation, temperature, humidity), (2) the characteristics of the soils used in the cover (e.g., hydraulic conductivity, moisture content), and other factors (e.g., slope stability, desiccation considerations). Case studies (e.g., Melchoir *et al.*. 1994, Benson and Khire 1995) were also used to assist with design considerations.

This cover system consists of four primary layers: (1) a surface or topsoil layer; (2) an upper drainage layer; (3) a barrier soil layer; and (4) a lower drainage layer (Figure K-5).

The lower drainage layer was installed in one uncompacted lift. The basic construction requirement for this layer other than thickness and slope was particle size distribution (PSD). A material representative of that tested in the laboratory was warranted. Therefore an allowable PSD was specified. A washed concrete sand, a common construction material, was used and easily met the specified criteria. A 45-cm thick layer of compacted soil was installed on top of the lower sand drainage layer. The barrier soil layer and lower drainage layer comprise the capillary barrier. Care was taken in placing the first lift of soil. It was important to maintain a clean interface between the sand and soil for optimum performance of the capillary break. Native soil taken from on-site cut excavations was compacted within an acceptable compaction zone as specified.

On top of the soil barrier layer, the upper drainage layer consisting of clean pea gravel was installed. The bottom layer of the upper drainage layer was a 22-cm thick lift of gravel meeting a specified allowable PSD. The pea gravel was placed in one uncompacted lift. Above this was a sand layer designed to meet filter criteria between the soil and gravel. Its PSD also met a specified allowable PSD. The sand layer was originally designed to be only 8 cm thick; however, 15 cm was the thinnest practical lift that could be used. This sand layer was also left uncompacted. The sand serves as a graded filter to prevent topsoil from clogging the drainage layer. The gravel allows for lateral drainage of any water that has percolated through the topsoil. The 30-cm thick topsoil layer was then installed on top of the sand. This surface layer is placed to enhance evapotranspiration (ET), protect against desiccation of the barrier soil layer, and provide a medium for growth of vegetation. Vegetation increases ET and protects against surface erosion. The layer was taken from topsoil originally cut from the site that had been stockpiled. It was placed in one uncompacted lift.

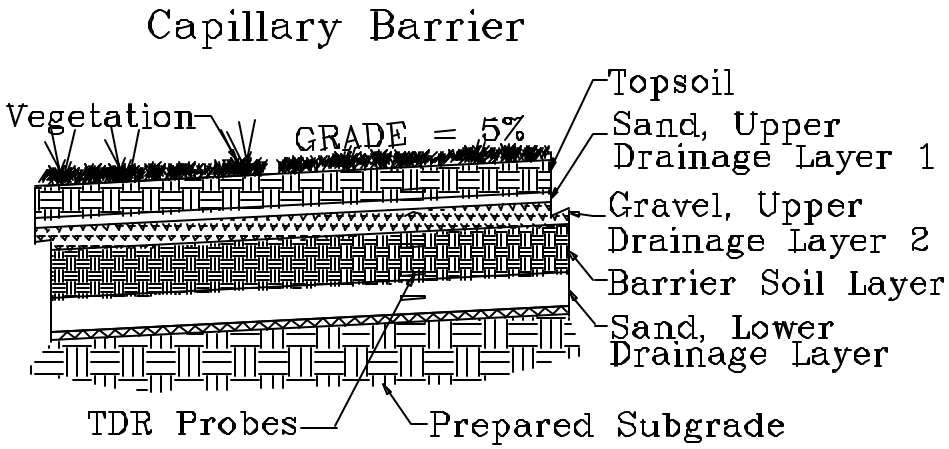

Figure K-5. Alternative Test Cover 2 – Capillary Barrier

Alternative Test Cover 3 referred to as the Anisotropic Barrier (Figure K-6) attempts to limit downward movement of water while encouraging lateral movement of water. This cover is composed of a layering of capillary barriers. The various layers are enhanced by varying soil properties and compaction techniques that lead to the anisotropic properties of the cover.

This cover system consists of 4 layers: (1) a top vegetation layer; (2) a cover soil layer; (3) an interface layer; and (4) a sublayer (Figure K-6). The vegetation layer is 15 cm thick. It is comprised of a mixture of local topsoil and pea-gravel. The gravel to soil mixture by weight is 25%. The gravel and soil were mixed adjacent to the site, then placed on the cover in one uncompacted lift. The gravel was added primarily to assist in minimizing surface erosion to runoff. This layer encourages evapotranspiration, allows for vegetation growth, and reduced surface erosion. Erosion (Ligotke 1994) and water balance studies (Waugh *et al.*. 1994) suggest that moderate amounts of gravel mixed into the cover topsoil will control both water and wind erosion with little effect on vegetation or soil-water balance. As wind and water pass over the surface, some winnowing of fines from the admixture is expected, leaving a vegetated erosion resistant surface sometimes referred to as a "desert pavement". The cover soil layer is 60 cm of native soil. This soil layer required minimal compaction. Its function is to allow for water storage and eventual evapotranspiration and to serve as a rooting medium. The interface layer is 15 cm of fine sand that serves as a filter between the overlying soil and the underlying gravel. It also serves as a drainage layer to laterally divert water that has percolated through the cover soil. The sand was a clean washed concrete sand that met an allowable PSD. Both the sand and pea gravel were placed in uncompacted lifts. The pea gravel sublayer was also 15 cm. The soil over sand layers create one capillary barrier while the sand over gravel creates a second capillary break. The interface layer and sublayer combined also serve a dual purpose as bio-barriers to reduce the penetration or intrusion of roots and burrowing animals into the underlying waste.

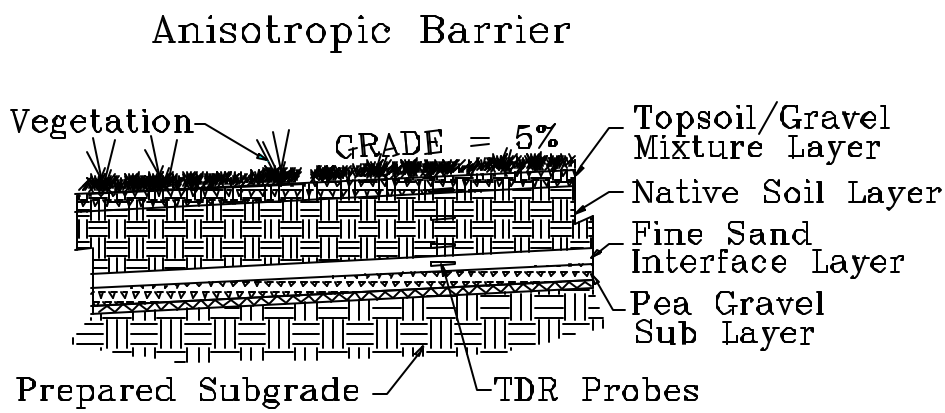

Figure K-6. Alternative Test Cover 3 – Anisotropic Barrier

Alternative Test Cover 4 is referred to as an Evapotranspiration (ET) Cover (Figure K-7). The ET Cover consists of a single, vegetated soil layer constructed to represent an optimum mix of soil texture, soil thickness, and vegetation cover. A cover profile similar to this is the design cover for the MWL. Case studies were used to assist with design considerations (Nyhan *et al.*. 1986, Nyhan *et al.*. 1990). These studies showed that a well designed simple soil cover can be very effective in preventing excessive erosion due to runoff and percolation, particularly in dry environments. The vegetation cover serves as the principal mechanism inhibiting soil moisture movement through the cover and into the waste. However, the texture and depth of soil provide the means of storing soil moisture in the zone where it is available to plants. Many studies have shown that

vegetation in arid and semiarid environments has the potential to remove essentially 100% of the moisture that infiltrates into the soil as long as plant roots can access the moisture. Ideally, the vegetation cover should consist of an optimum mixture of species, including cool season and warm season species. Additionally, species with different growth forms (such as grasses, shrubs, or trees) should be used to revegetate the site in order to spread ET over as much of the growing season as possible. The average annual rainfall in Albuquerque, NM is 20.6 cm/yr.

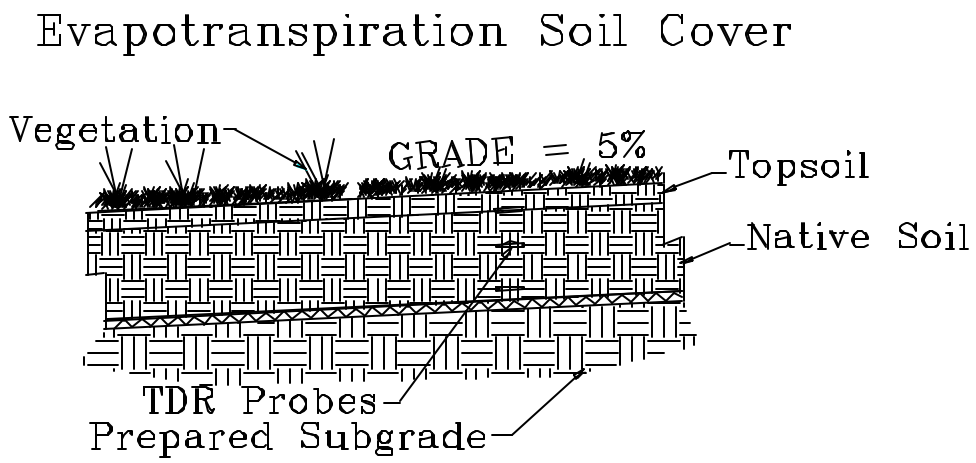

Figure K-7. Alternative Cover 4 – ET Cover

This cover design encourages water storage and enhances ET. The cover is a monolithic soil cover from on-site cut excavations. It is 90 cm thick with the bottom 75 inches compacted and the top 15 cm of topsoil loosely placed.

After completion of earthwork activities, the cover was drill-seeded with a mixture of native seed designed specifically for the area. Many engineers commonly specify seed mixed for landfills from such places as state highway department geographical recommendations. These highway department seed mixes can often be impractical for landfill application. It is generally designed for roadside use where there is actually more precipitation due to runoff from the highways. This is not the case with landfills. The seed mix used was of species native to the immediate area. The mix ensured a good blend of cool and warm weather plants, primarily native grasses.

Performance Monitoring and Instrumentation of the ALCD

Passive testing consists of daily on-site observations to validate system performance and to correct problems. Data is continually obtained for soil moisture status, percolation and interflow, runoff and erosion, precipitation, wind speed and direction, relative humidity, solar radiation, air and soil temperature. Periodic measurements are taken of vegetation cover, biomass, leaf area index, and species composition.

Active testing includes supplemental precipitation added to hydrologically stress the various barriers systems. Water applied using the sprinkler system is tested for rate and

uniformity of application. All water is distributed through electronically controlled flowmeters where quantities discharged are controlled and measured. This system has the flexibility to apply worst case precipitation events. All other measurements under this precipitation regime are the same as described above for passive monitoring.

The water balance equation being used is:

$$E = P - I - R - D - \Delta S;$$

where: precipitation (P), surface runoff (R), lateral drainage (D), evapotranspiration (E), soil water storage (S), and percolation or infiltration (I) are the six water balance variables. With the exception of 'E', quantities of all terms in the water balance equation are being obtained with the monitoring systems. Evapotranspiration is determined by solving the water balance equation for 'E'. All measurements are made with automated monitoring systems to provide continuous data. Manual backup systems are available in case of failure in one or more of the automated measurements systems and/or to verify accuracy of the automated systems.

The first year's data is as follows (Dwyer 1998b):

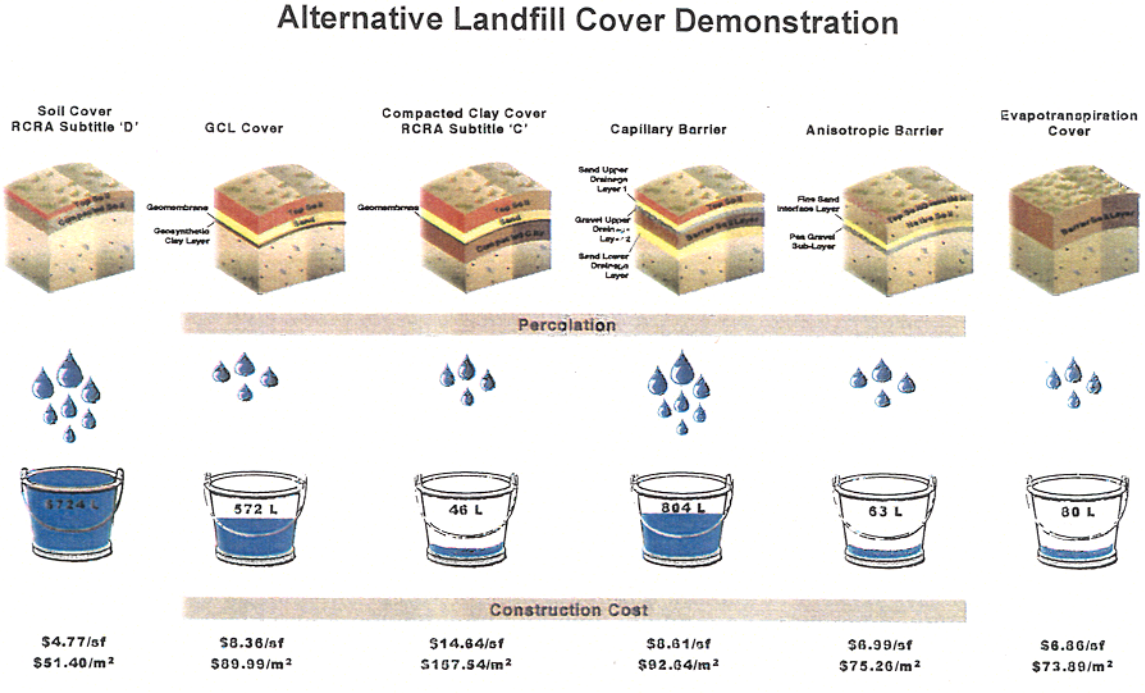

Figure K-8. ALCD First Year Results

These percolation volumes for year 1 put into terms of flux rates and cover efficiency are as follows:

Table K-1. ALCD First Year Flux Rates

Plot	Title	Flux rate (cm/sec)	Flux Rate (cm/yr)	Efficiency
1 – Baseline#1	Subtitle D Cover	2×10^{-8}	0.6	99.98%
2	GCL Cover	2×10^{-9}	0.05	99.998
3 – Baseline#2	Subtitle C Cover	1×10^{-10}	0.004	99.9999
4	Capillary Barrier	2×10^{-9}	0.07	99.998
5	Anisotropic Barrier	2×10^{-10}	0.006	99.9998
6	ET Cover	2×10^{-10}	0.007	99.9998

* Efficiency = (percolation volume ÷ volume of precipitation) x 100%

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