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Lysimeter Study on the Disposal of Paraho Retorted Oil Shale

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LYSIMETER STUDY ON THE DISPOSAL OF PARAHO RETORTED OIL SHALE

by

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FOREWORD

When energy and material resources are extracted, processed, converted, and used, the related pollutional impacts on our environment and even on our health often require that new and increasingly more efficient pollution control methods be used. The Industrial Environmental Research Laboratory-Cincinnati (IERL-Ci) assists in developing and demonstrating new and improved methodologies that will meet these needs both efficiently and economically.

This study used lysimeters to simulate both a low elevation (dry site) and a high elevation (moist site) disposal scheme for Paraho direct heated oil shale. The study investigated the surface vegetative stabilization of retorted shale with and without soil cover and investigated water and salt movement through compacted and uncompacted Paraho retorted shale. The results should be useful to government agencies and private developers involved with developing environmentally acceptable methods for retorted oil shale disposal. For further information, contact the Extraction Technology Branch of the Resource Extraction and Handling Division.

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ABSTRACT

Disposal of large amounts of spent shale will be required if an oil shale industry using surface retorting is developed. This study utilized lysimeters to simulate a low-elevation (dry site) and a high-elevation (moist site) disposal scheme for Paraho (direct-heated) retorted shale. The objectives were to investigate: vegetative stabilization of Paraho retorted shale and retorted shale covered with various soil depths, and water and salt movement in Paraho retorted shale.

The lysimeters were constructed in western Colorado in 1976 and filled in March 1977.

Only a sparse vegetation cover (5% to 15%) was established on retorted shale following fertilization, mulching, and irrigation. In contrast, adequate plant cover (55% to 85%) was established on the soil cover over retorted shale and on soil control treatments.

In the high-elevation (moist) lysimeters, excess irrigation water applied for leaching and plant establishment moved through the retorted shale and out the lower drain under the compacted zone. The electrical conductivity (EC) of the percolate water reached a maximum of 35,000 μmhos/cm, and the pH was 11.4. In contrast, the EC of the percolate from the soil control treatment reached a maximum of 8500 μmhos/cm, and the pH was 8.3.

The low-elevation (dry) lysimeter received less irrigation water than the high-elevation lysimeter, and water did not move through the 150-cm uncompacted zone on unleached treatments.

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ABBREVIATIONS AND SYMBOLS

CSU	Colorado State University
EC	electrical conductivity
mmhos/cm	millimhos per centimeter
μmhos/cm	micromhos per centimeter
ha-m	hectare-meter
SAR	sodium adsorption ratio
SD	standard deviation
TOSCO	The Oil Shale Corporation
USBM	United States Bureau of Mines
$\bar{X}$	mean

ACKNOWLEDGMENTS

We wish to thank the following individuals who worked long and hard on this project: Robert Squires, James Herron, Jeannie Chandler, Robert Foley, and Lori Nukaya.

We also wish to acknowledge the cooperation of the U.S. Environmental Protection Agency for funding the project, Development Engineering, Inc. for providing the retorted shale, U.S. Bureau of Land Management for providing the study site, Battelle Northwest Laboratories for some of the leachate analyses, and the U.S. Department of Energy and the U.S. Navy for the use of the Anvil Points facilities.

SECTION I

INTRODUCTION

Limited domestic oil and natural gas reserves and the increased price of imported oil have renewed interest in developing the nation's western oil shale reserves. These reserves are located within a 65,000 km^2 area of Colorado Utah and Wyoming and are estimated to contain 96 billion m^3 (600 billion barrels) of recoverable shale oil using present-day technology (U.S. Department of Interior, 1973). If an oil shale industry is to develop, many environmental as well as technical problems must be resolved. One of the major environmental problems involves the long-term stabilization of the massive amounts of waste material (spent or retorted shale) that will be produced.

A mature oil shale industry could produce an estimated one million barrels of oil per day (U.S. Department of Interior, 1973). At 1977 use rates, this is about 6% of the U.S. petroleum use. If surface retorting methods are used to produce this quantity of petroleum, approximately 20,000 ha-m of spent shale waste would be generated each year. Part of this spent shale might be disposed of in the mined areas, but a large portion, probably over half, would require surface disposal as canyon fills or as elevated mesas. Thus, from 200 to 400 hectares of land per year would be required for disposal sites.

The retorted shales would have to be managed in such a manner as to avoid pollution from surface erosion (both wind and water) and subsurface leaching of soluble salts. The pollution could be a problem not only in the immediate future (20 to 30 years life expectancy of an individual oil shale plant) but also on a long-term basis.

Stabilization of the exposed surfaces could be attempted by establishing vegetation on retorted shale or soil-covered retorted shale. Leaching of soluble salts might be prevented by: (1) compaction of retorted shale to make it impervious to water, (2) total isolation of retorted shale from water, (3) retorting shale at sufficiently high temperature to produce a pozzolanic (cementing) reaction (Culbertson et al., 1970), or (4) a combination of the above methods. However, on low-elevation sites, leaching of soluble salts through the disposal pile would probably not be a problem because of low precipitation, provided that an adequate plant cover was maintained on the disposal site to transpire subsurface moisture.

The physical and chemical characteristics of the spent shale affect the degree to which the exposed surface can be stabilized with vegetation and the subsurface layers stabilized by compaction or cementation. These characteristics depend on the source of the raw shale, the particle size of the shale after crushing and the retorting parameters such as temperature, flow rate, and carbonate decomposition.

If the materials are finely crushed, such as in the rotating kiln process (TOSCO), then a fine silty spent shale is produced. However, if the raw shale is coarsely crushed, as in the gas combustion processes (Paraho, USBM), then a coarse, gravelly-textured spent shale is produced.

Spent shales retorted at a temperature of about 500 C (TOSCO) have pH's in the 8-9 range, while retorting at combustion zone temperatures of 650-800 C (USBM, Paraho Direct, Union Decarbonized) results in spent shales with pH's of 11-12. The pH of the spent shale produced at high temperatures must be reduced before it can be considered as a plant growth media.

Previous research has shown that the TOSCO spent shale retorted at lower temperatures (< 500 C) was too salty for plant growth and deficient in plant-available nitrogen (N) and phosphorus (P) (Schmehl and McCaslin, 1973). However, good stands of vegetation were established on the TOSCO spent shale, which is fine-textured and highly saline, after leaching, fertilizing with N and P, and sprinkling for seedling establishment (Bloch and Kilburn, 1973; Harbert and Berg, 1978).

In addition to physical and chemical characteristics of the spent shale, the location of the disposal sites would also affect pile stability and deep water percolation. Elevations between 1500 and 2100 m with south to southwest aspects are xeric sites with annual precipitation of 22 to 40 cm. In contrast, elevations above 2100 m, particularly those with north aspects are more mesic with annual precipitation of 40 to 60 cm, here precipitation seasonally exceeds plant growth requirements during the spring snowmelt period (March through May).

Weeks et al. (1974) reported that recharge to the aquifer system in the Piceance Basin occurs principally from spring snowmelt when the evaporative demand is low. Whereas, in the summer months, the precipitation is lost directly to runoff or evapotranspiration. Recharge to the aquifer system is most effective in areas above 2100 m where it is estimated that 65 percent of the total yearly precipitation occurs from November through March (Weeks et al., 1974). Thus, disposal of retorted shale at elevations above 2100 m could pose a major problem with leaching of soluble salts. Water balance calculations for the Piceance Basin region by Wymore (1974) indicates that little opportunity for deep percolation of water occurs at elevations below 2100 m because of low precipitation and high evapotranspiration.

Factors that could affect the leaching of salts within the disposal pile are:

1. texture of the shale
2. total soluble salt concentration of the shale
3. degree of compaction
4. Seasonal precipitation pattern and surface run-in following intense summer storms

5. amount and type of vegetative cover
6. aspect, slope, and elevation of the surface of the disposal pile
7. degree to which cementation occurs in the retorted shale in the disposal pile

Researchers have worked on the problems of leaching and surface stability of TOSCO (Ward et al., 1971; Bloch and Kilburn, 1973; Harbert and Berg, 1978), USBM (Schmehl and McCaslin, 1973; Harbert and Berg, 1978), and Union Oil Company retorted shales (Lipman, 1975). A joint study by Development Engineering, Inc., Woodward-Clyde Consultants of Denver, and U.S. Bureau of Mines involved work on the engineering aspects of compaction and disposal of Paraho retorted shales (Holtz, 1976). Prior to the study reported here, field research had not been done to simultaneously examine the leaching potential and vegetative stabilization of Paraho retorted shale.

Thus, this field research study was designed to model both a low-elevation (dry site) and a high-elevation (moist site) disposal scheme for Paraho retorted shale (direct-heated), in order to investigate:

1. the vegetative stabilization of the surface of Paraho retorted shale and retorted Paraho shale with various depths of soil cover.

2. subsurface water and salt movement through both uncompacted and compacted retorted Paraho shale and retorted Paraho shale with various depths of soil cover.

SECTION II

CONCLUSIONS

1. Analysis of Paraho direct-heated retorted shale shows the material to have a high pH (11.2) and a relatively low soluble salt content (EC 4-5 mmhos/cm on a 1:1 shale to water extract). Initially, the high pH would limit plant establishment directly on Paraho retorted shale.

2. Wetting and drying the shale four times resulted in reduction of the pH from 11.2 to 9.0 in samples collected from the surface. This reduction resulted from recarbonation of retorted shale by atmospheric CO_2. However, after the pH reduction, it appears that nutrient imbalances were inhibiting plant growth on the retorted shale.

3. Four months after placement core samples from the leached uncompacted zone show the pH apparently reduced from 11.2 to 9.0 throughout the 150-cm profile.

4. A sparse vegetative cover (5% to 10%) was established on the retorted shale treatments on both lysimeters. In contrast, a good to excellent cover (55% to 80%) was established on the soil control and soil-covered treatments.

5. The retorted shale at 1 m depth cooled from 232 to 70 C in approximately 10 days but temperatures above 50 C were maintained for an additional 30 days.

6. On the high-elevation lysimeters, water moved rapidly through the retorted shale and soil control treatments. In contrast, on the soil-cover treatments a greater volume of water was held in the soil as the result of the abrupt texture change from a clay loam soil to the gravelly Paraho retorted shale.

7. On the unleached treatments in the low-elevation lysimeters, water did not move below 105 cm in the soil-cover treatments because of the abrupt texture change. In contrast, water moved below 150 cm in the soil control treatments.

8. Ninety-nine percent of the total percolate was from the lower drain under the compacted zone, and only 1% was collected from the upper drain at the interface of the compacted and uncompacted zones. Core samples show that water had penetrated into the compacted zones.

9. The EC of the percolate from the retorted shale treatments reached a maximum of 35 mmhos/cm, but the EC was reduced to 11 mmhos/cm after one pore volume of leachate was collected. In contrast, the EC of the percolate from the soil control did not exceed 8.5 mmhos/cm.

10. The EC and SAR values of the percolate show a high pollution potential if water moves through the retorted shale.

SECTION III

RECOMMENDATIONS

1. An initial attempt to stabilize the surface of Paraho retorted shale with vegetation was not successful, since only 5-15 percent cover was established after intensive treatment. Thus, this retorted shale would require even more intensive management to make it a suitable plant growth medium; it is, therefore, recommended that the shale be covered with soil to insure that an adequate vegetative cover is established.

2. Since the pollution potential from soluble salts is high, water should not be allowed to leach through Paraho retorted oil shale and enter the hydrological system. Possible alternatives to preventing water movement through Paraho retorted shale are compacting the material to make it impervious to water flow and/or covering the material with a depth of soil material sufficient to hold the seasonal precipitation, particularly from spring snowmelt.

3. If a compacted zone is used to prevent water movement through the commercial disposal pile, additional research is needed to insure that the compacted material can be made impervious. This study shows that water has moved into retorted shale compacted to a density of 1.5 to 1.6 g/cm^3.

4. Additional research is needed on the cooling rates of retorted shale under commercial disposal pile conditions. If elevated temperatures are maintained in a disposal pile, a xeric site could result due to warmer surface temperatures and the resulting higher evaporation potential.

SECTION IV

METHODS

Concrete lysimeters were selected to aid in modeling a disposal scheme for Paraho retorted (direct-heated) oil shale. The lysimeters were designed and constructed in such a manner as to provide a solid, waterproof container in which to place and compact the retorted shale obtained directly from the retort.

STUDY DESIGN

A canyon fill retorted-shale disposal site might have the following design features:

1. A fill starting at the lower end of the canyon would probably be constructed of retorted shale and would have a downstream face as steep as 50% or as flat as 25%, depending on the design criteria.

2. Behind the downstream face would be a fill area with a gentle slope (2% to 5%) away from the downstream face.

3. The body of the disposal pile would probably be a highly compacted or cemented zone.

4. The exposed surface of the disposal site would then have an uncompacted zone of either retorted shale alone or soil-covered retorted shale which would be stabilized with vegetation. This zone would have to be sufficiently deep, 150 cm or greater, to provide adequate plant rooting and moisture storage.

Two lysimeters, each 13.4 m wide by 40 m long and 2.4 m deep, were constructed to simulate the disposal system described above. The lysimeters were constructed of reinforced concrete with water stops between the cold seams. Each lysimeter has a 25% slope representing the fill face and a 2% slope representing the fill area. In the lysimeters a 90-cm deep layer of compacted retorted shale (1.5 to 1.6 g/cm^3) was covered with a 150-cm uncompacted zone (1.2 to 1.4 g/cm^3) (Figure 1). The study was designed with two lysimeters to provide replication for mathematical hydrological modeling work during the leaching phase, and then to serve as separate units in which to simulate both a high-elevation (moist) and a low-elevation (dry) disposal site.

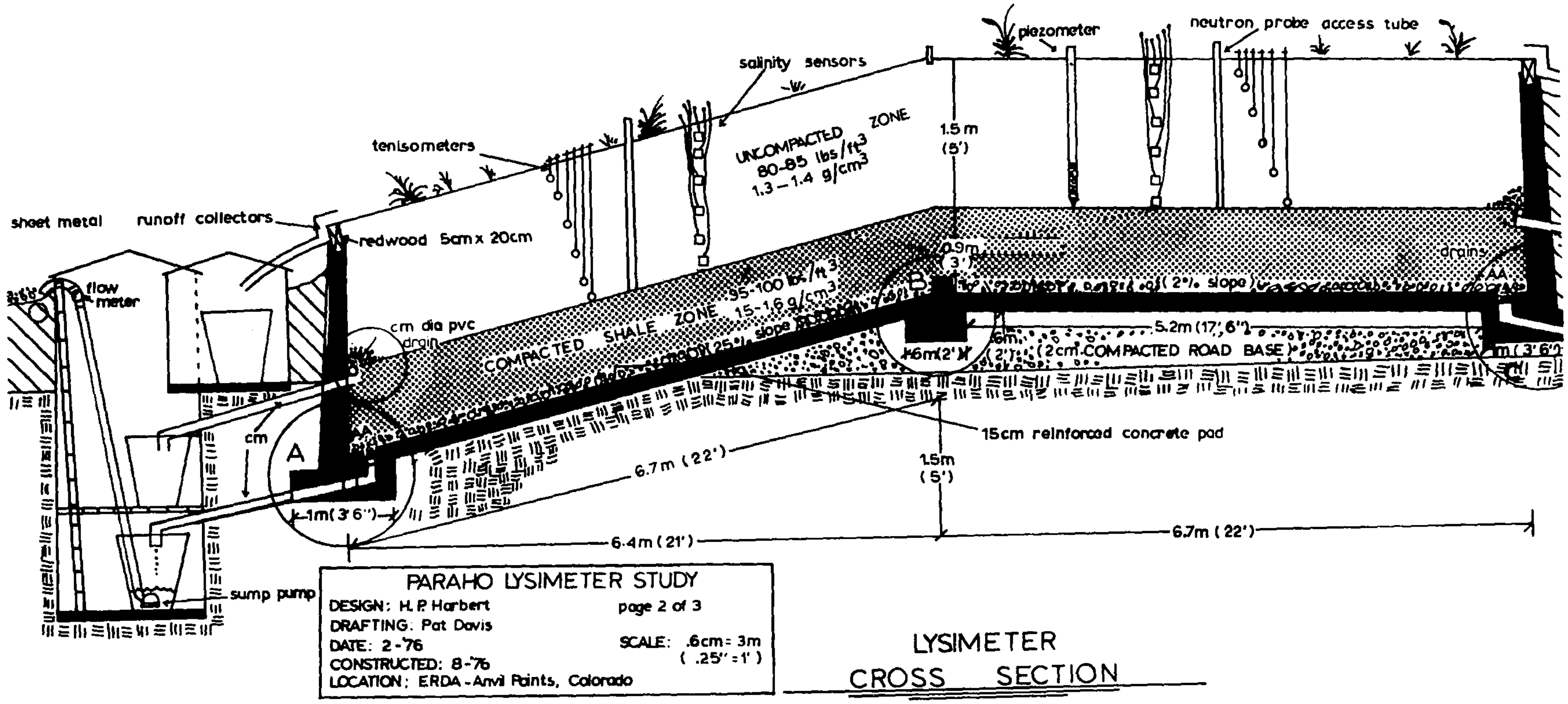

Figure 1. Cross section showing the design of the lysimeters.

The study site is 0.3 km south-southwest of the housing area at the U.S. Department of Energy, Anvil Points Oil Shale Research Facility (Figure 2). The study site, which is on public land managed by the Bureau of Land Management, is characteristic of a low-elevation disposal site with an elevation of 1737 m and a mean annual precipitation of approximately 28 cm. Both lysimeters were built at this site because of its proximity to water, electricity, retorted shale, and concrete construction supplies. Greater precipitation and less evaporation at a high-elevation disposal site was simulated in one of the lysimeters by applying additional irrigation water.

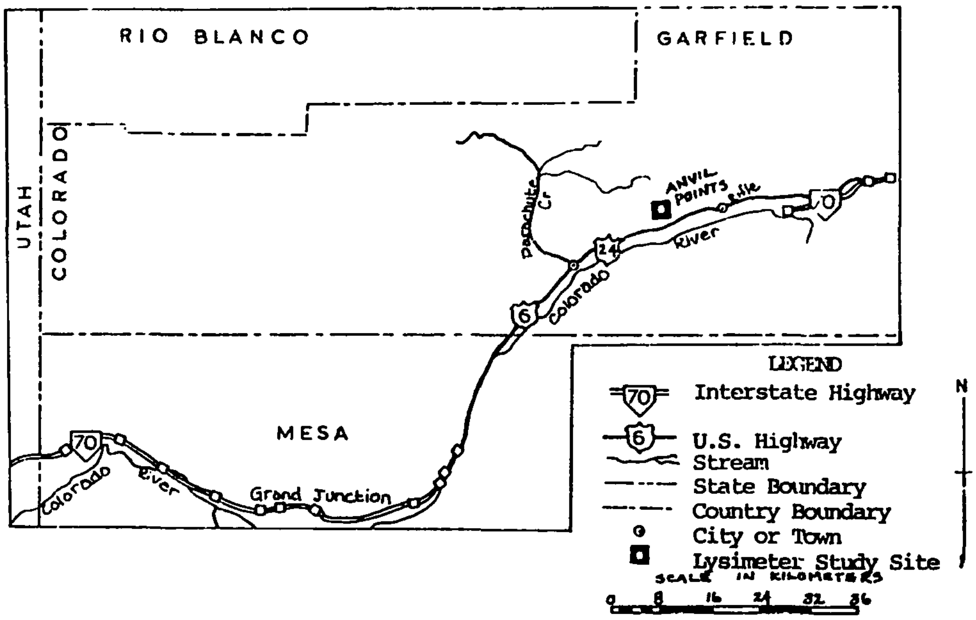

Figure 2. Location of the lysimeter study site.

The following six treatments were tested in each lysimeters on both a 2% and 25% slope:

1. retorted shale to the surface (shale treatment), leached
2. 20-cm soil cover over retorted shale, leached
3. 40-cm soil cover over retorted shale, unleached
4. 60-cm soil cover over retorted shale, unleached
5. 80-cm soil cover over retorted shale, unleached
6. soil control, unleached

Thus within each lysimeter there are 12 treatment areas 6.7 by 6.7 m, six with a 2% north-facing slope and six with a 25% south-facing slope. Each of the 12 treatment areas has an upper drain at the interface of the compacted and uncompacted zones and a lower drain beneath the compacted zone.

Each of the 12 treatment areas are separated into two side by side vegetation and surface runoff replications (3.4 by 6.7 m) divided at the surface with a redwood board. Each 3.4 by 6.7 m replication has a set of instruments to monitor water and salt movement and a surface runoff collector. The location and plot plan for each of the treatments and replications are shown in Figure 3.

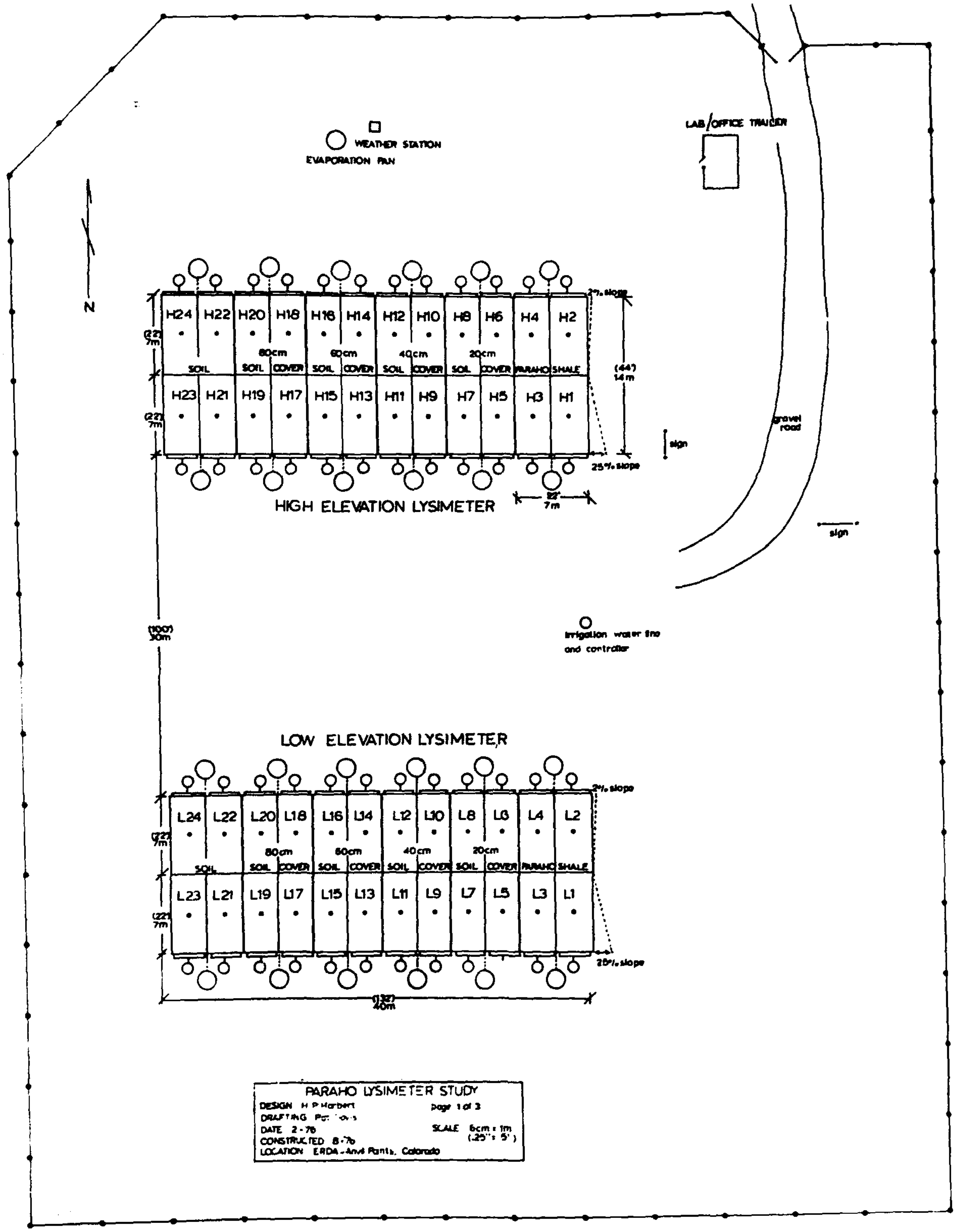

Figure 3. Plot plan of lysimeter study site.

CONSTRUCTION

In April, 1976, the site was cleared of brush and stripped of soil to a depth of 90 cm. The soil was stockpiled for use on soil-covered shale treatments.

The main water line at the housing area was tapped, and a 5-cm PVC plastic water line to the site was buried on the east side of the gravel road constructed from the Anvil Points housing area to the study site. A 220-volt, 100-amp power line to the site was also buried to the east of the road.

Two areas, each 13.4 m wide by 40 m long were staked out 30 m apart in an east-west direction and excavated to a depth of 1.5 m. The south half of each excavation was sloped 25% towards the south. The north side of each area sloped 2% toward the north (Figure 3). In order to provide a stable base on which to construct the concrete floor of the lysimeter both areas were then covered with 40 cm of road base gravel.

Concrete footings were poured along the 40-m length of the toe and crest positions of each slope to provide a base for the concrete walls and pads (Figure 4). A 20-cm rubber water stop was also poured into the footings to provide a water-tight seal between the wall and the footings. The lower drain (5-cm diameter PVC pipe) for each treatment area was inserted as the footer was poured (Figure 5).

Reinforced concrete pads 15-cm thick were poured as 6.7 by 6.7-m square blocks for the floor of each treatment, thus providing a solid unit without cold seams. A 20 by 20-cm concrete curb with a waterstop was poured between each pad to prevent lateral water movement. On the toe of both the 25% and 2% slopes, a 6.7 m wide, 10 cm deep drain was formed in the concrete of each pad (Figure 5).

After the concrete pads were constructed a solid concrete end wall was poured along the entire 13.4 m length of the west end of each lysimeter and along the 25% slope on the east side (Figure 6). The 2% east side was left open for machine access to the lysimeters during the filling operation.

The inside of each lysimeter was then sprayed with a coal-tar-base waterproofing agent (Fabertite) to provide additional sealing and to prevent water within the lysimeter from reacting with the concrete walls and pads, because concrete is chemically similar to retorted shale.

The leachate collection culverts (150 cm in diameter, 3.6 m deep) were installed in front of each treatment (Figure 1) and located 2.4 m from the concrete wall. Holes were cut in the culverts, and the lower and upper drain pipes were installed using 5-cm diameter PVC plastic pipe. The culverts and concrete walls were back-filled and reshaped to the original ground level. Construction of the lysimeters was completed in October 1976.

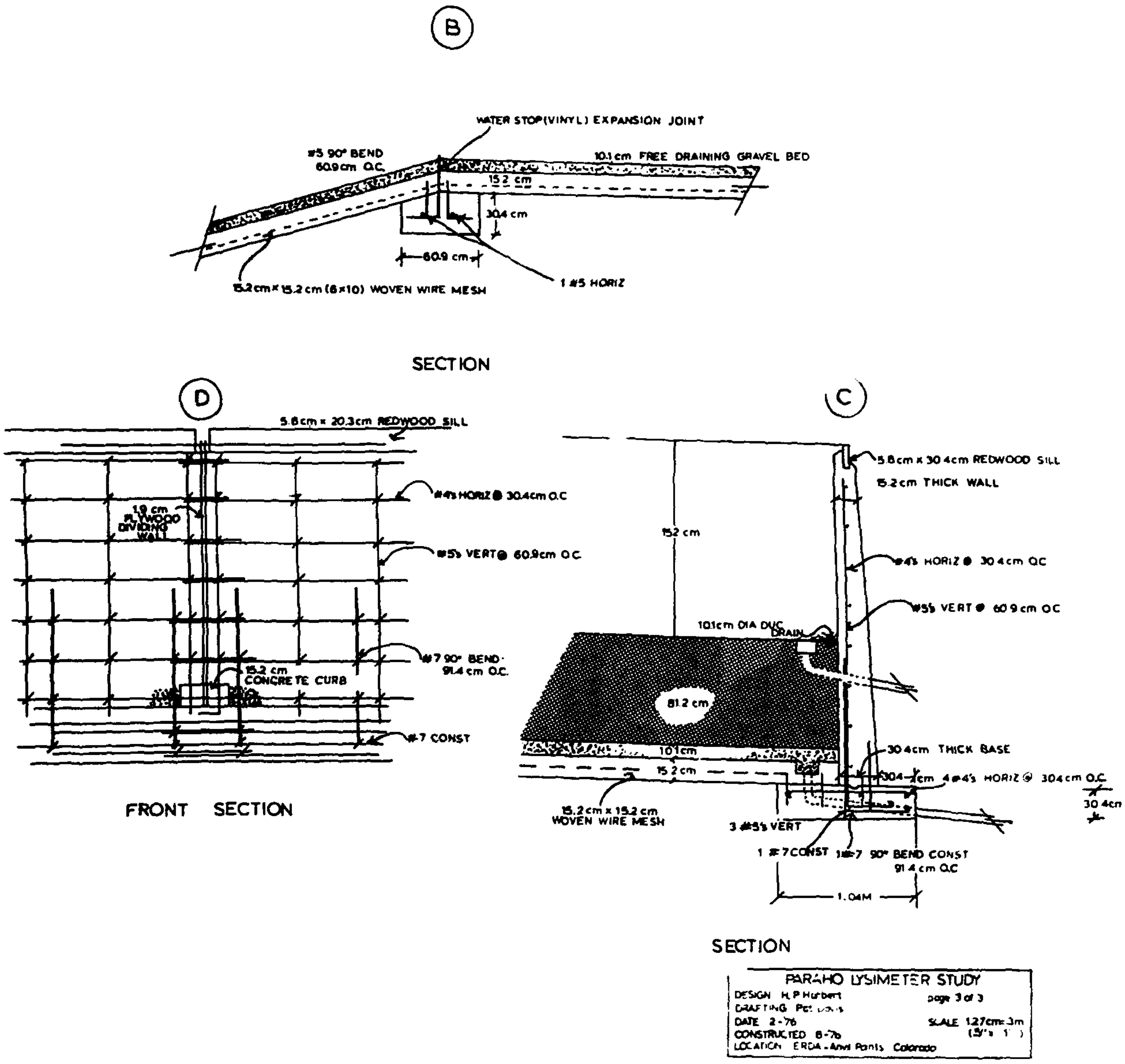

Figure 4. Detailed drawings of the concrete walls, footers, and rebar schedule.

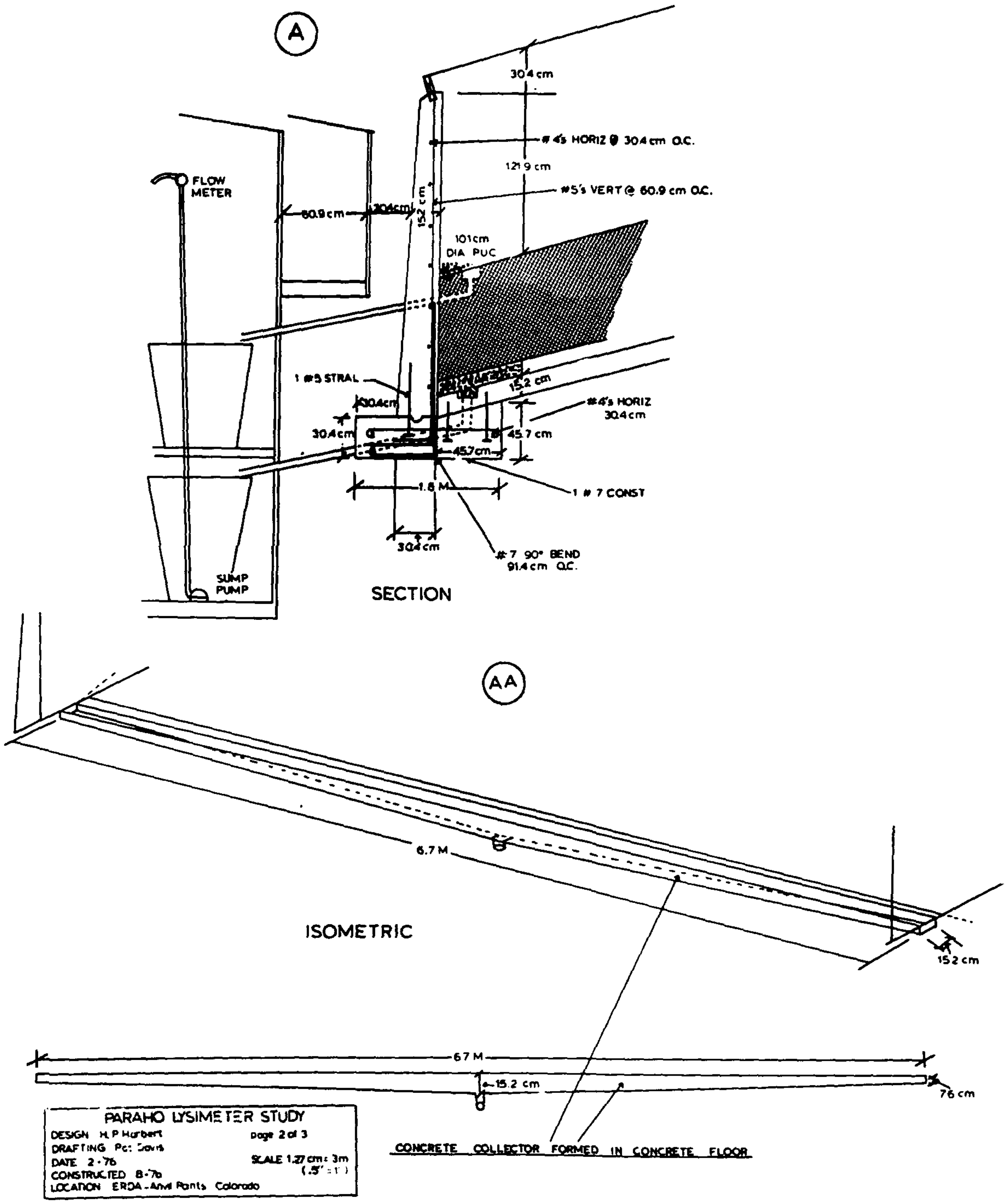

Figure 5. Detailed drawing of the concrete collector and drain system.

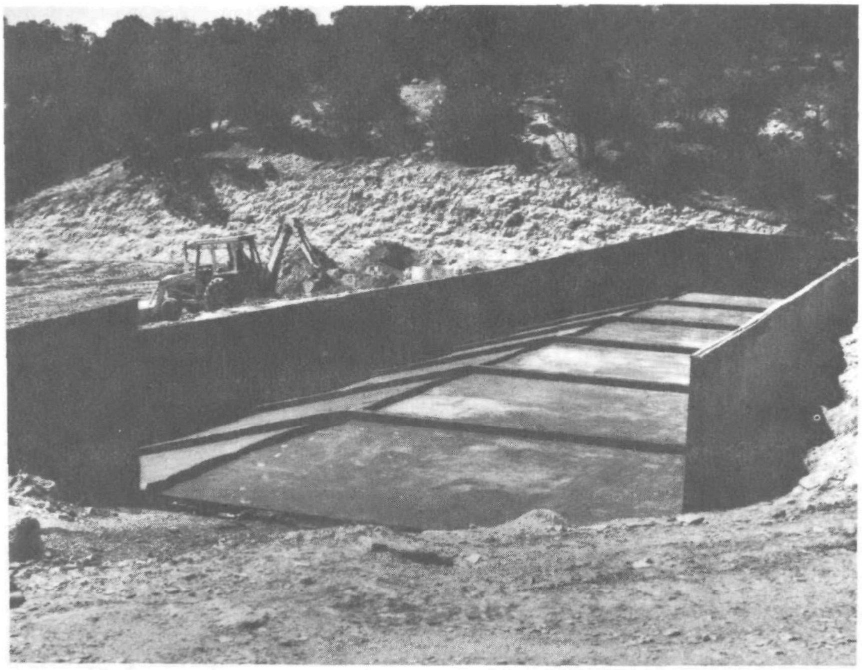

Figure 6. Completed concrete lysimeter and east side entrance. September, 1976.

FILLING OPERATIONS

The bulk of the retorted shale was hauled on a 24 hours per day basis from the retort and placed directly into the lysimeters. However, during some night operations the retorted shale had to be stockpiled before placement. Shale hauling was started on March 21 and completed on April 6. Approximately 4,000 metric tons of retorted shale was used in the study.

The filling operation involved three steps:

1. The inside of the lysimeter was washed and 10 cm of washed 2-cm gravel was placed over the concrete pad to provide a free draining bed (Figure 4).

2. The retorted shale was hauled to the study site in 10-ton dump trucks, dumped over the gravel and then spread in 20-cm thick lifts. The lifts were spread and shaped with either a D4 Caterpillar dozer or small-tracked loader.

3. The 20-cm lifts of retorted shale were compacted with a Vibrostat II vibratory roller (1800 kg, 1500 vpm, 450 kg dynamic load). Fourteen passes were used per lift to obtain the desired density of 1.5 to 1.6 g/cm^3 (Figure 7). A small Raygo Dumont R55 vibratory roller was used next to the concrete walls (weight 300 kg, 4260 vpm, dynamic force 100 kg).

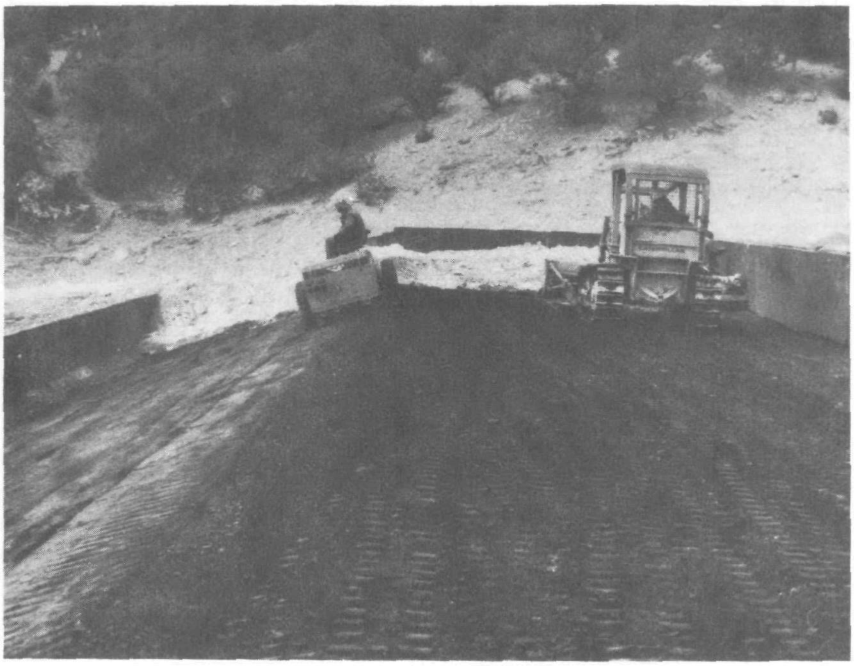

Figure 7. Compacting retorted shale on the 25% slope using a large vibratory compactor chained to a D4 Caterpillar running on the 2% slope.

Density measurements were made on each lift by the nuclear surface density test method, ASTM (D2922-71). The range in density of the compacted zone was from 1.47 to 1.60 g/cm^3 with a mean of 1.53 (Appendix Table 1). Retorted shale was added and compacted until a 90-cm compacted zone was in place above the concrete pad.

Initially, compaction was attempted without water. But, because of the dust created by the hauling and dumping operation it was necessary to apply water at about 7.4% by volume.

The open end of the lysimeters on the east side of the 2% slope was closed and sealed during the compaction operation by placing a 5 cm x 15 cm x 6.7-m board in the opening as each lift was installed. The boards were coated with Farbertite to prevent water seepage from the lysimeter.

Dividing walls made of 2-cm thick plywood were installed every 6.7 m to separate each treatment area and prevent lateral movement of water and salts between treatments. After the walls were set in a 15-cm deep trench dug into the compacted zone, the trench was refilled and compacted as described above. A solid 2.4-m high plywood wall was installed between the compacted shale zone and the soil control treatment area at the far west end. The latter area was filled with 2.4 m of uncompacted soil.

Drains at the interface of the compacted and uncompacted zones were installed using perforated 5-cm diameter PVC plastic pipe. The drains were set in furrows dug 5 cm deep into the upper surface of the compacted zone along the entire 6.7-m length of each treatment. The drain pipes were sloped 2% to the center of each treatment area and connected to the drain pipe in the center of the concrete wall. Drain pipes were then covered with 15 cm of washed, 2-cm diameter gravel to prevent clogging.

After the dividing walls and drains were installed, the retorted shale for the uncompacted zone was dumped directly into the lysimeters from the trucks and shaped as needed with a front-end loader. The same density test described for the compacted zone were used to measure the density of the uncompacted zone which was found to range from 1.2 to 1.4 g/cm^3. A front-end loader was used to place and shape the soil-cover treatments. The east side of the uncompacted zone in each lysimeter was closed with a solid, 2.0-cm thick, waterproofed plywood wall.

Measuring Retorted Shale Temperatures

Temperatures of the retorted shale in the uncompacted zone were measured following the filling operation. Measurements were made periodically with a thermocouple probe and continuously with a thermocouple recorder (Foxboro Model ER 4037, 31-day recorder).

On March 31, immediately after filling, a thermcouple probe was used to measure temperatures at a depth of one m in each treatment area containing retorted shale. Access to this depth was gained by coring a small hole in the shale or soil over shale and then inserting the probe. Additional measurements were taken on April 8 and May 20. The probe was provided by Development Engineering, Inc. and had a temperature range of 0 to 1000 C.

Three thermocouples were used in series to obtain a mean temperature at a depth of one m in the retorted shale treatment area on the high-elevation lysimeter. The thermocouples were connected to the recorder which was operated from April 8 until May 5.

Wet-Dry Cycles

Previous research by Bell and Berg (1977) has shown that the pH could be reduced from 11 to 9 in Paraho direct-heated shale by wetting and drying it a minimum of four times. Thus, in April, the retorted shale treatments on both lysimeters were subjected to 4 wet-dry cycles. A total of 380 liters of water was hand-sprayed over each 6.7 x 6.7-m retorted shale treatment area, and then the shale was allowed to air-dry for 7 days. This cycle was repeated three more times bringing the total water added during the four cycles to 1520 liters. Retorted shale samples were collected before and after the wet-dry cycles and were analyzed for pH and EC on a 1:1 shale to water by weight extract.

INSTRUMENTATION

The lysimeters were instrumented with tensiometers, piezometers, neutron probe access tubes, and salinity sensors to monitor the water and salt movement through the uncompacted retorted shale zone and the soil-covered retorted shale. All instruments were installed using a Giddings hydraulic soil probe.

Each replication was instrumented (Figure 8), except for the soil controls in which only neutron probe access tubes were installed. The compacted zone was not instrumented in either lysimeter as the integrity of the compaction would have been broken by drilling the holes.

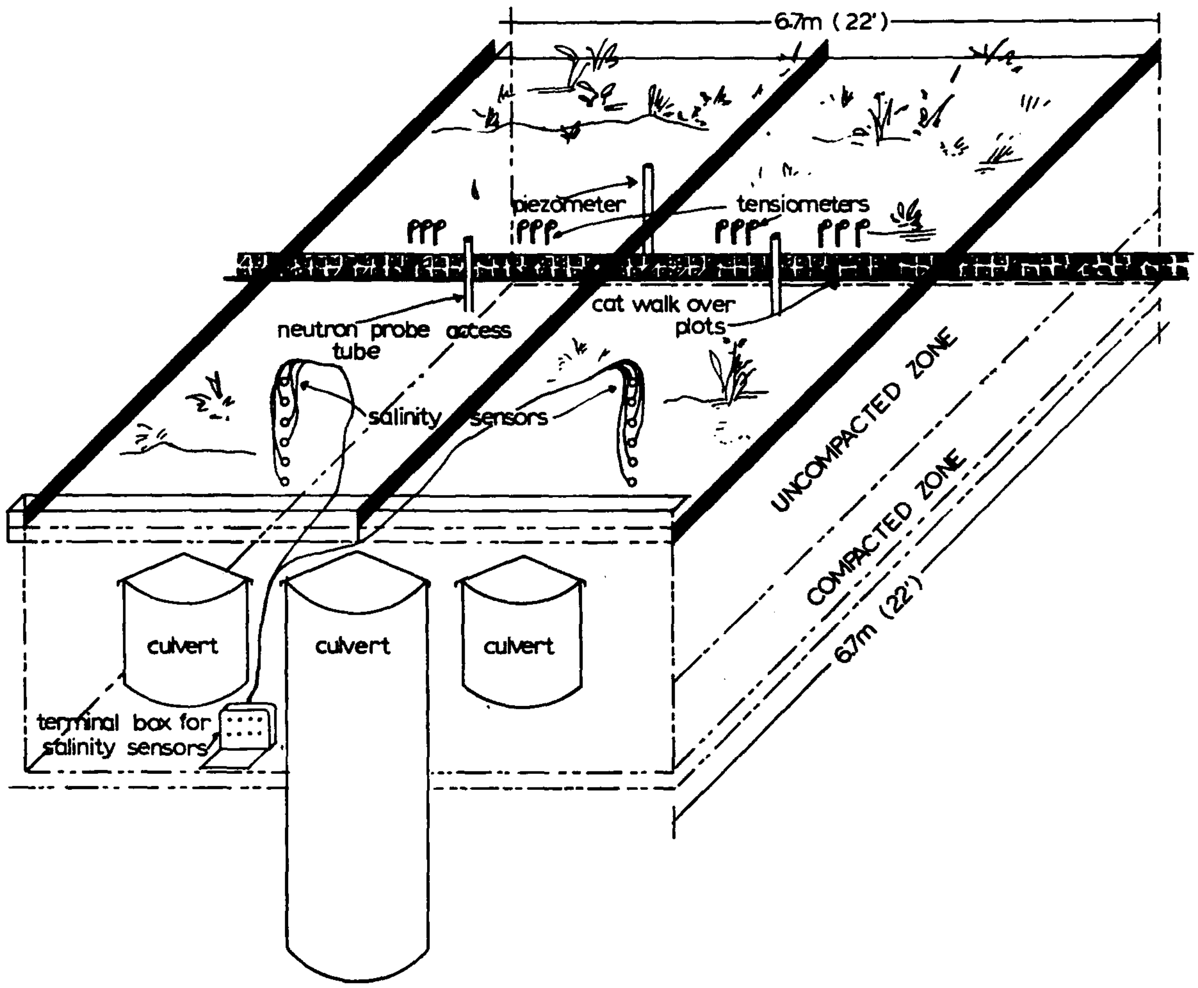

Figure 8. Location of the instruments in each replication.

Tensiometers (Soil Moisture Equipment Co., model 2710) were installed at 15, 30, 60, 90, 120, and 150-cm depths to measure soil and shale water matric potential. The tensiometers were filled with water once the neutron probe measurements indicated that sufficient moisture (>30% by volume) was in the soil or shale for tensiometers to hold suction. Tensiometer readings were made daily during the leaching phase and weeky thereafter. The tensiometers were drained for the winter in late September 1977. The tensiometer data was for the use of Dr. McWhorter in his modeling study and are not included in this report.

Piezometers (3-cm diameter steel pipe with 45-cm 60-mesh screen well points attached to the end) were installed to a depth of 150 cm (the interface between the compacted and uncompacted zone) in each treatment area on both the 25% and 2% slopes. The piezometers were capped to prevent irrigation water from entering and were read daily during the leaching phase and weekly thereafter.

Neutron probe access tubes (3.8-cm EMT electrical conduit) were installed to a depth of 150 cm in each replication. The tubes were not capped on the bottom next to the compacted zone, but were capped at the surface end with a rubber stopper.

Salinity sensors (Soil Moisture Equipment Co., model 5105) with 750-cm leads were installed at 15, 30, 60, 90, 120, and 150-cm depths within each replication. The sensors were stacked in one hole at the appropriate depths. then back-filled with <2-mm size shale fines to insure contact with the retorted shale. The leads were pulled from the center of each replication and inserted into a board in front of each treatment area, thus providing easy access during data collection (Figure 8). The sensors were read daily during the leaching phase and weekly during the establishment phase.

Moisture Measurements

Retorted shale and soil volumetric moisture measurements were taken daily during the leaching phase and weekly during the establishment phase. Measurements were made using a Troxler Model S6A neutron probe and Model 3800 scaler with rate meter. Readings were taken at 15-cm increments starting 15 cm below the surface and continuing to a depth of 150 cm.

To accurately determine the moisture content of the retorted shale, a calibration curve was developed according to the method described by Van Bavel (1958) (Appendix Table 2). The probe manufacturer's calibration curve for a standard soil was used to convert all readings taken in the soil (Appendix Table 3).

Sump Pump System

The subsurface drain system within each treatment area was fitted with a 120-liter plastic container, electric sump pump, and low meter to measure both the rate and total volume of percolate from each lower drain (Figure 1).

Electrical power (110-volts AC) was connected to each 150-cm diameter collection culvert. Within eac culvert, a sump pump (Zoeller model 54) was used. The pump was designed with a float-activated on-off switch, which allowed the system to turn on whenever the container had more than 5 cm of water. If all the sump pumps (24) operated at once, the electrical demand would have exceeded the capacity at the site. Therefore a sump pump controller was designed to turn on the electricity to 6 pumps at 3-minute intervals. The sumped water was measured through a totalizing flow meter (Corad Model CM3) and dumped into a 5-cm diameter PVC plastic drain line outside each culvert.

Water from the upper drains was measured with a meter stick in the plastic containers as the total volume of water collected during several days did not exceed the capacity of the collection container.

Surface Runoff Collectors

A surface runoff collector made of 22-gauge sheet metal was fitted on each 3.3 x 6.7-m replication. The collectors were connected to a 106-cm diameter, 1.2-m deep collection culvert that was sealed with concrete on the floor and then waterproofed. Each collection culvert was then fitted with a 120-liter plastic container to collect the runoff water and sediment. Redwood plot divider boards were installed between each replication and connected to the runoff collectors. The runoff collection system was completed in August 1977, and will be used to collect the spring snowmelt runoff and summer storm runoff (Figure 9).

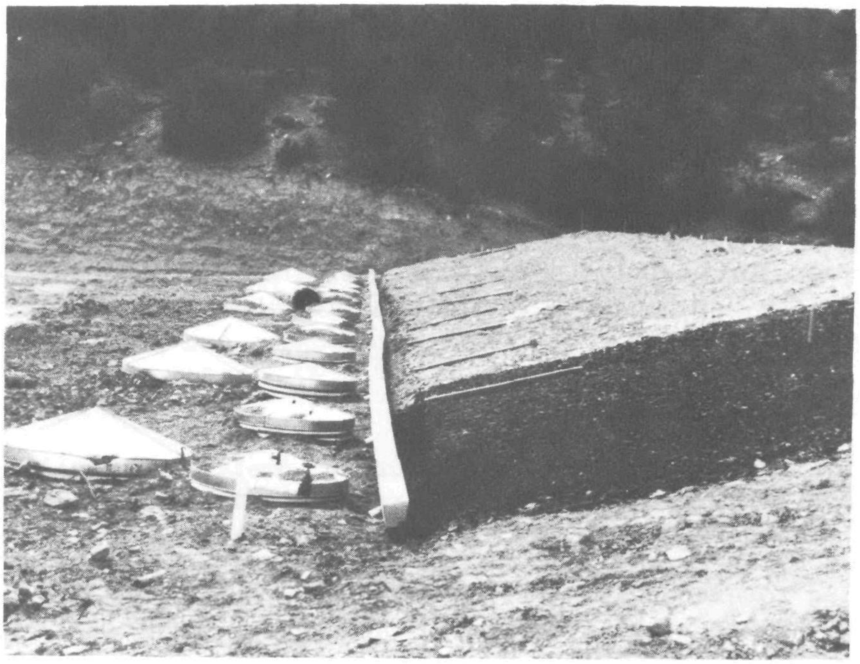

Figure 9. Surface runoff collection system on 25% slope treatments.

Irrigation System and Water Supply

Both lysimeters were fitted with an automated, solid set, square pattern sprinkler system. The 3-cm diameter outside laterals were placed along the 40-m concrete walls just off the lysimeter. The center lateral was placed across the top of the lysimeters at the break between the 25% and 2% slopes. Rainbird #14 VLA TNT sprinkler heads with 0.15-mm, 5° nozzles were placed every 6.7 m along each lateral. The sprinklers along the toe of the 25% slopes were set on 60-cm risers while the others were on 30-cm risers. The system was controlled using a Rainbird Model AG7, 7-station time clock and a 24-volt DC solenoid valve.

Water for sprinkling came from the domestic water supply system at Anvil Points which uses Colorado River water. The pH and EC of the water was determined periodically, typical values were pH 7.8 and conductivity of 1100 µmhos/cm (Appendix Table 4).

Water was delivered from the sprinkler heads at the rate of 0.4 cm/hr (on an area basis), however, water delievered to the lysimeter surface was less than this due to evaporative demand. Overall, irrigation application efficiency was 66% for the continuous sprinkling during leaching over the June 2-15 period. The amount of water actually applied to the lysimeter surface was measured in small plastic rain gauges set on each of the 12 treatment areas on each lysimeter. This later measurement is the measurement used as water applied since there was no surface runoff.

ESTABLISHMENT AND ANALYSIS

Leaching

The retorted shale and 20 cm of soil-cover treatments were leached with approximately 77 cm of water before they were seeded. The other treatments were not leached and were covered with plastic to prevent leaching. During the leaching phase, water was applied 24 hours per day for 13 days. The leach water application for each lysimeter was determined daily by recording the amount of water that accumulated in the plastic rain gauges set at ground level on each treatment (Appendix Tables 5 and 6).

Analysis of Percolate Water

Water samples collected from the subsurface drains were analyzed by both the Colorado State University (CSU) Soil and Water Testing Laboratory, Fort Collins, and the CSU Department of Agricultural and Chemical Engineering Testing Laboratory in Grand Junction, Colorado. All analytical work was performed according to either ASTM (1976) standard procedures or procedures approved by U.S. Environmental Protection Agency for water quality.

The water samples were collected directly from the drain pipes in plastic bottles. The samples were then refrigerated at the study site and transported to Grand Junction or Fort Collins for analysis. Additional samples of the percolate water were collected for Battelle Northwestern Laboratories, Richland, Washington for analyses for trace elements and organic complexes.

The EC and pH of the percolate water and irrigation water were measured periodically at the study site during the leaching and establishment phases. Analysis was with a Fisher Model 7 pH meter and Beckman conductivity bridge according to procedures in USDA Handbook #60 (Richards, 1954).

Fertilization

Before seeding, the plots were fertilized at the rate of 168 kg P/ha with triple superphosphate and then rototilled to a depth of 15 cm to incorporate the P.

Nitrogen was applied at the rate of 67 kg N/ha as NH_4NO_3 to each plot on July 3 following germination and again on August 15.

Seeding and Mulching

Each lysimeter was seeded on June 24 with a mixture of species native to the elevation being modeled (Table 1). In addition, serviceberry and bitterbrush seedlings were transplanted into each replication on the high-elevation lysimeters.

Following seeding, each treatment was mulched with alfalfa hay at the rate of 2200 kg/ha. Prior to placement, the mulch was covered with plastic and treated with methyl bromide at the rate of 9 kg/ton in an attempt to kill any viable seeds. The mulch was then spread on each treatment area and held in place with Conwed plastic mulch netting.

Establishment Irrigation

The vegetative cover was established on both lysimeters using almost daily applications of irrigation water (Appendix Tables 5 and 6). The high-elevation lysimeter was irrigated at the approximate rate of 2.0 cm per day starting on June 28 and running to August 18. This application rate, approximately 100% in excess of the pan evaporation rate, was applied to insure water movement through the lysimeter. Over the establishment period 83.6 cm of water was applied.

The low-elevation lysimeter was irrigated almost daily from June 28 until August 18 at the rate of 1.0 cm per day or approximately the daily pan evaporation rate. Over the establishment period 37.6 cm of water was applied.

Vegetation Analysis

Analysis of the vegetative cover was completed on August 26, 1977, using the quadrat method. Six quadrats, 20 by 40-cm, were placed randomly on each 3.3 by 6.7-m replication, and the total number of individual plants by species was determined. The percent of vegetative ground cover, not including litter and mulch, was estimated visually from each quadrat.

Core Sample Analysis

Core samples were collected from the retorted shale treatment areas on both lysimeters on September 1 using a soil sample tube (Soil Moisture Equipment Co., Model 215). Samples were collected in 15-cm increments, to the depth of 150 cm. Samples were stored in plastic bags and analyzed by the CSU Soil and Water Testing Laboratory. Analyses for common cations (Na, Ca, Mg, K) and anions (HCO_3, Cl, SO_4), pH, and EC were determined on a 1:1 shale to

TABLE 1. SEEDING MIXTURES AND RATES OF PURE LIVE SEEDS APPLIED TO THE LOW- AND HIGH-ELEVATION LYSIMETERS.

Common Name	Scientific Nomenclature	Rate (kg/ha)
HIGH-ELEVATION MIXTURE		
Species Seeded		
Western wheatgrass	*Agropyron smithii*	9.0
Bluebunch wheatgrass	*Agropyron spicatum*	4.5
Utah sweetvetch	*Hedysarum boreale utahensis*	4.5
Palmer penstemon	*Penstemon palmeri*	2.2
Lupine spp.	*Lupines spp.*	2.2
Arrowleaf balsamroot	*Balsamorhiza sagittata*	2.2
	TOTAL	24.6
Species Transplanted		
Serviceberry, Utah	*Amelanchier utahensis*	4/replication
Bitterbrush, antelope	*Purshia tridentata*	2/replication
LOW-ELEVATION MIXTURE		
Species Seeded		
Western wheatgrass	*Agropyron smithii*	4.5
Bluebunch wheatgrass	*Agropyron spicatum*	4.5
Indian ricegrass	*Oryzopsis hymenoides*	4.5
Galleta	*Hilaria jamesii*	4.5
Winterfat	*Ceratoides lanata*	1.1
Fourwing saltbush	*Atriplex canescens*	2.2
Utah sweetvetch	*Hedysarum boreale utahensis*	4.5
Palmer penstemon	*Penstemon palmeri*	2.2
	TOTAL	28.0

water by weight extracts, using the method described by Soltanpour and Schwab (1977). Analyses were made on the air-dried retorted shale, which was ground to <2-mm.

Meteorological Measurements

Ambient air temperature, relative humidity, precipitation, and pan evaporation were measured at the site daily during the summer. Temperature and relative humidity were measured with a 31-day hydrothermograph (Weather Measure Corp., model H331). Precipitation was measured with a tipping bucket gauge (Weather Measure Corp., model P511 with 90-day recorder). Pan evaporation was measured using a standard U.S. Weather Bureau class A pan, steel well, and hook gauge. The meteorological data collected at the study site are listed in Appendix Tables 7 and 8.

SECTION V

RESULTS AND DISCUSSION

CHEMICAL AND PHYSICAL PROPERTIES OF RETORTED SHALE AND SOIL

The retorted shale and soil used in this study were characterized as to their physical and chemical properties that might have the greatest effect on plant growth (i.e. pH, EC, particle size, plant-available N, P and K, and common water soluble cations and anions).

Retorted shale samples were collected from the retort and analyzed daily during the filling operation (March 21 through April 4) by Development Engineering, Inc. personnel at Anvil Points. In addition to routine analysis associated with the retorting operation, the samples were analyzed for pH and EC. Analysis procedures and results are listed in Appendix Tables 9 and 10. A description of the Paraho oil shale retorting process is given by Jones (1976).

The pH of the shale taken directly from the retort was between 11.3 and 11.6, and the EC was between 2.2 and 4.3 mmhos/cm on a 1:1 by weight water to shale extract. Electrical conductivities were not determined on a saturated paste extract because the coarseness of the shale prevented an accurate determination of saturation as described for soils by the U.S. Salinity Laboratory (Richards, 1954). A rough conversion of conductivity of a 1:1 extract to a saturated paste extract can be made by doubling the 1:1 conductivity extract reading. A soil is considered to be saline when the EC of a saturation extract is >4 mmhos/cm. Thus, the shale as it exits the retorted can be characterized as having a high pH and moderate soluble salt content. In terms of plant growth, the high pH would be a limiting factor and salinity would appear to be less of a problem. However, when the shale is exposed to the atmosphere, the pH will decrease and the EC will increase as shown below.

Samples were collected by CSU personnel as the retorted shale was dumped from the truck into the lysimeters, these samples were air-dried and then stored in Ziplock plastic bags. In comparison with the samples collected at the retort, the pH is lower (9.7), and the EC is higher (7.1 mmhos/cm) (Table 2). The pH reduction may have occurred during the hauling but most likely occurred from the time of collection in March and April until analysis in September. The pH reduction is discussed in more detail in the wet-dry results section.

The analyses of the soil used in both the soil controls and soil-cover treatments are given in Table 2. The soil, a mixture of A and C horizons, was non-saline and calcareous.

TABLE 2. CHEMICAL CHARACTERISTICS OF PARAHO RETORTED SHALE AND SOIL USED IN THE LYSIMETER STUDY.*

Measurement	Retorted Shale, Uncompacted	Soil Cover
EC, mmhos/cm @ 25 C †	7.1	1.7
pH†	9.7	8.2
SAR†	19.0	4.7
Cations, meq/l †		
Ca	21.6	5.2
Mg	24.3	5.8
Na	91.5	11.0
K	7.1	0.1
Anions, meq/l †		
HCO_3	1.7	2.1
Cl	3.6	2.0
SO_4	131.3	13.1
CO_3	0.5	0.4
P, ppm	2	3
K, ppm	383	74
NO_3-N, ppm	2	6

* Values given are the means of four replications.

† Shale analyses were on a 1:1 extract; soil analyses were on a saturaion extract.

The SAR (sodium adsorption ratio) is a measure of the ratio of sodium to calcium and magnesium in either soils or water and is an estimate of the dispersion potential posed by exchangeable sodium in a soil when excess soluble salts are leached out (Richards, 1954). With SAR values of 15 and greater a potential problem with sodium dispersion exists. The SAR values in the retorted shale were much higher than in the soil (Table 2).

In comparing the fertility characteristics of the retorted shale with the soil, plant-available P ($NaHCO_3$ extraction) is low in both materials, K (1 N ammonium acetate extraction) is adequate, and nitrate-N is low. Physically, the soil is fine-textured (clay loam) and the shale is very coarse (gravelly sandy loam). Although the retorted shale is coarse, the particles are porous and contain soluble salts. The ramifications of these textural and chemical differences will be discussed in the sections on moisture and percolation.

The retorted shale was sampled to determine the amount of fines before and after compaction. About 90% of the uncompacted shale is >2 mm (gravel-size). After compaction, the percent gravel was reduced to 47.8% (Table 3). A reduction in particle size of Paraho retorted shale with compaction was reported by Holtz (1976).

TABLE 3. PARTICLE SIZE ANALYSIS OF RETORTED SHALE, RETORTED SHALE AFTER COMPACTION AND SOIL.*

Particle Size	Retorted Shale, Uncompacted	Retorted Shale, Compacted	Soil
Gravel % >2 mm	90.5	47.8	38.9
Sand % 0.05-2 mm	5.2	27.6	22.5
Silt % 0.002-0.05 mm	2.9	17.2	20.8
Clay % <0.002 mm	1.4	7.4	17.8

* Values given are the means of four replications, analysis of <2 mm particles was by the hydrometer method.

WET-DRY CYCLES

The principle behind the wet and dry cycles for pH reduction is recarbonation of the retorted shale. The process is best explained by the following simplified equations:

$$(1) \quad \underset{\text{retorted shale}}{CaO} + \underset{\text{irrigation}}{H_2O} \rightarrow Ca(OH)_2$$

$$(2) \quad Ca(OH)_2 + \underset{\text{atmosphere}}{CO_2} \rightarrow CaCO_3 + H_2O$$

As a result of the four wet-dry cycles (also handling and exposure in general), the pH was reduced from 11.4 to 9.2 but the EC increased from 4 to 6.1 (Appendix Tables 11 and 12). The increase in the EC is probably a reflection of the increased solubility of Ca and Mg salts as the pH is decreased.

The pH of the retorted shale would probably drop by allowing the shale to weather and recarbonate naturally from the CO_2 in the atmosphere. Apparently, the amount of carbonate decomposition is minimal in the Paraho direct retorting mode and this fact allowed for rapid recarbonation of the retorted shale. The amount of carbonate decomposition has both advantages and disadvantages in terms of disposal. If the carbonate decomposition is low, the pH will drop rapidly. But if more carbonates are converted to oxides, the pH will not drop as rapidly and the retorted shale should have a greater cementing quality. The cementing should provide greater pile stability and reduced water movement through the shale, but highly cemented shales would require deep soil covers to insure adequate moisture storage for perennial plants.

RETORTED SHALE TEMPERATURES

Although a sharp drop in the temperature from 230 to 64-80 C occurred within 10 days after placement, an additional 30 days was required for the shale to drop below 60 C at the 1 m recording depth. The average daily ambient air temperature during the measurement period ranged from -1.9 C to 15.4 C. Retorted shale temperature measurements (Appendix Tables 13 and 14) are illustrated in Figure 10.

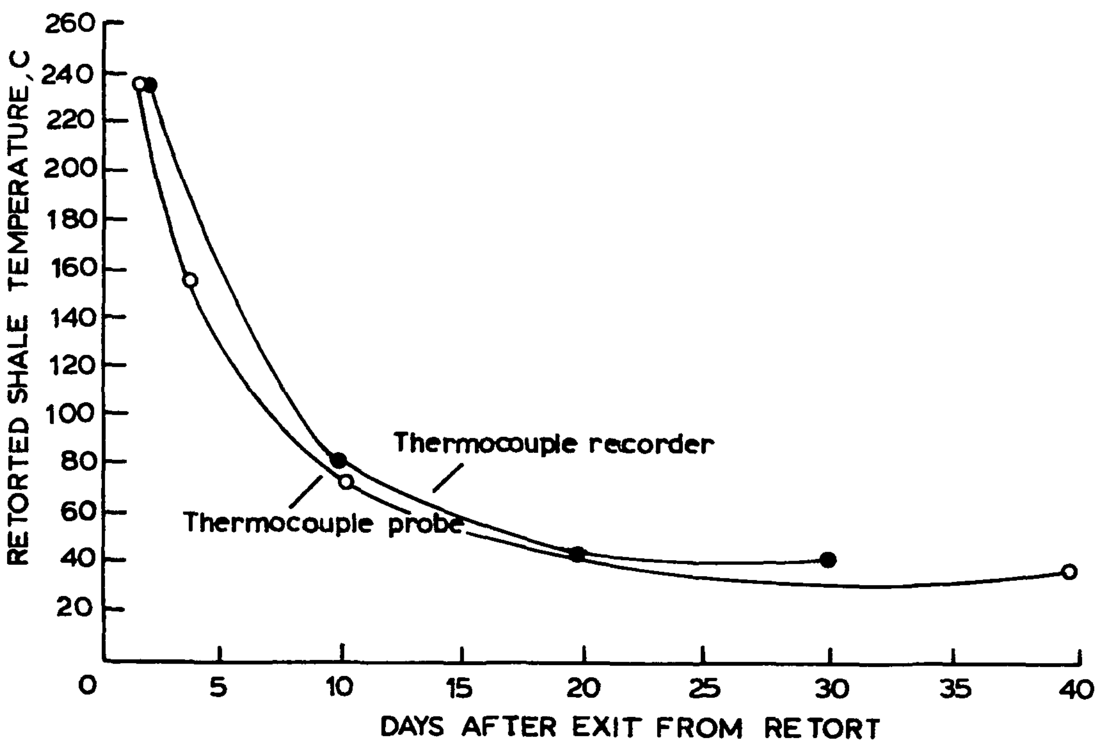

Figure 10. Cooling rates for retorted shale, temperatures were measured at 1 m depth with either a thermocouple recorder or probe, April 5 through May 5, 1977.

During a snow storm on April 5, it was observed that 10 cm of snow accumulated on the soil control and the area surrounding the lysimeters. But snow on the treatments with retorted shale and soil-covered shale melted. The melting occurred even on the treatment with 80 cm of soil over retorted shale.

In summary, it appears that a droughty site could develop if retorted shale is dumped hot and covered with soil before being allowed to cool. Additional research is needed to document the rate of cooling and predict surface temperatures of the disposal pile under commercial scale operations.

VEGETATION

A good to excellent (55% to 85%) vegetative cover was established on all the soil-cover treatments in both lysimeters. By contrast, the vegetative cover established on the retorted shale treatments was sparse (5% to 15%) and individual plants were small on both lysimeters after one growing season (Table 4). The sparse vegetative cover on the shale is probably a reflection of higher pH's (9-9.5), plant nutrient imbalances (Na:Ca:Mg), and higher surface temperatures. The alfalfa mulch used in this study decayed rather rapidly exposing some of the black retorted shale, this may have resulted in higher surface temperatures than on the soil covers. Surface temperatures were not measured this first year but should be in the future. The vegetative cover on the retorted shale treatments for the high-elevation lysimeter is twice as abundant as that on the low-elevation lysimeter (Table 4), this is probably because more irrigation water was applied to the former during establishment.

TABLE 4. PERCENT VEGETATIVE COVER FOR EACH TREATMENT ON THE HIGH- AND LOW-ELEVATION LYSIMETERS, AUGUST 1977.

Treatments	High-Elevation Lysimeter		Low-Elevation Lysimeter	
	2% Slope	25% Slope	2% Slope	25% Slope
Paraho retorted shale	15*	10	5	5
20 cm soil cover	65	65	70	85
40 cm soil cover	65	75	70	80
60 cm soil cover	80	65	85	80
80 cm soil cover	80	75	80	80
Soil control	60	55	80	75

* Values are means for six quadrats in each of two replications.

In contrast to this limited plant growth on retorted shale, Harbert and Berg (1978) reported good vegetative growth directly on weathered USBM spent shale that was produced by a process similar to the Paraho direct-heated shale. This suggests that if the Paraho material were allowed to weather that a more suitable plant growth medium might be obtained.

The vegetative cover on the soil-cover treatments for the low-elevation lysimeters was greater than for the high-elevation lysimeters (Table 4).

This difference was due to the use of galleta, a warm season grass, that was seeded only on the low-elevation lysimeter. This grass grew vigorously during the hot months of July and August.

The vegetation on the high-elevation lysimeters was dominated by the wheatgrasses, alfalfa, and plantain (Appendix Tables 15-20). The latter two species were brought in with the hay mulch. Galleta plus the species mentioned above dominated the vegetation growing on the low-elevation lysimeters (Appendix Tables 21-26). It will take several years for the species and plant densities to begin to come into equilibrium with the various edaphic and moisture regimes, for this reason no further discussion on the vegetation is in this publication.

Alfalfa plants were clipped from all treatments on both lysimeters in early September for selected trace element analysis. The results will be presented in a separate report.

The vegetation will be an important component of the study in the future, both in terms of soil moisure depletion and trace element uptake.

MOISTURE

Moisture measurements were made daily during the leaching phase (June 2-15) and weekly during the establishment phase (June 21 to August 17). The moisture readings for the above periods are given in Appendix Tables 27 through 50 for both the high and low-elevation lysimeters. The large volume of soil moisture data (Appendix Tables 27-50) is summarized in this report by plotting soil or spent shale moisture curves for June 5, June 14, and September 1 for the retorted shale and 20 cm of soil-cover treatments, which were leached and then irrigated for plant establishment (Figures 11 and 12). On the unleached treatments (40, 60, and 80 cm of soil-cover and soil control), readings were plotted for June 21, July 15, and September 1.

A review of the moisture data (Appendix Tables 27-50) reveals that several July readings show unusually high moisture values (>60% by volume). These high readings occurred just prior to having the neutron probe repaired. Review of the data collected from other studies in 1977 on which the same probe was used also indicates that higher than normal readings were obtained during several dates in July. However, the July 15 readings dates graphed in Figures 11 and 12 appear to be accurate.

<u>Moisture Profiles for Leached Treatments, High- and Low-Elevation Lysimeters</u>

To ameliorate the retorted shale as a plant growth medium, 76 to 78 cm of leach water was applied to both the retorted shale and 20-cm soil-cover treatments during the period of June 2 through 15.

The June 5 readings show that the wetting front had moved to a depth of 75 cm in each of the leached treatments (Figures 11 and 12). By June 5, a total of 13.6 and 16.9 cm of water had been applied to the high- and low-elevation lysimeters, respectively.

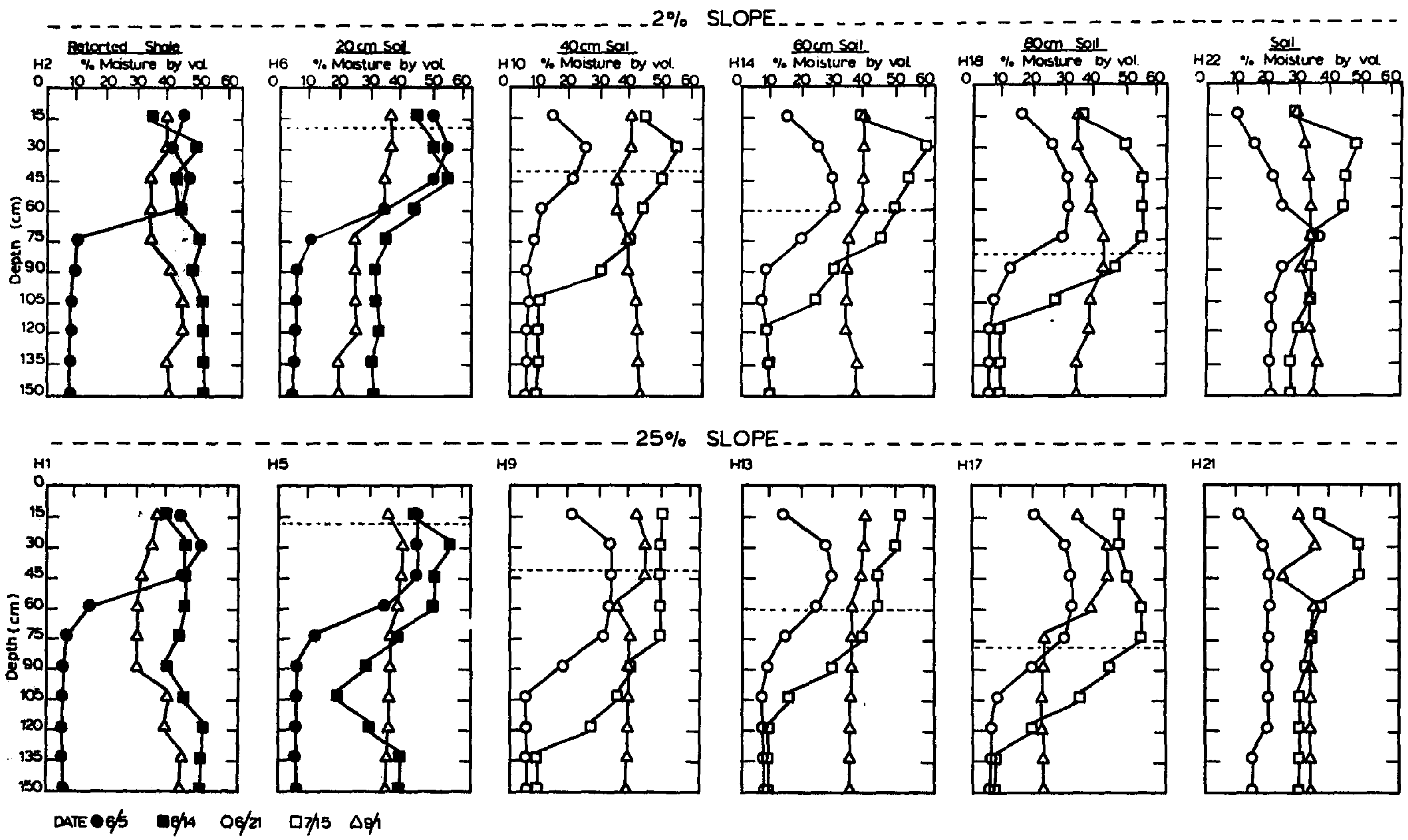

Figure 11. Moisture profiles for the high-elevation lysimeter treatments.

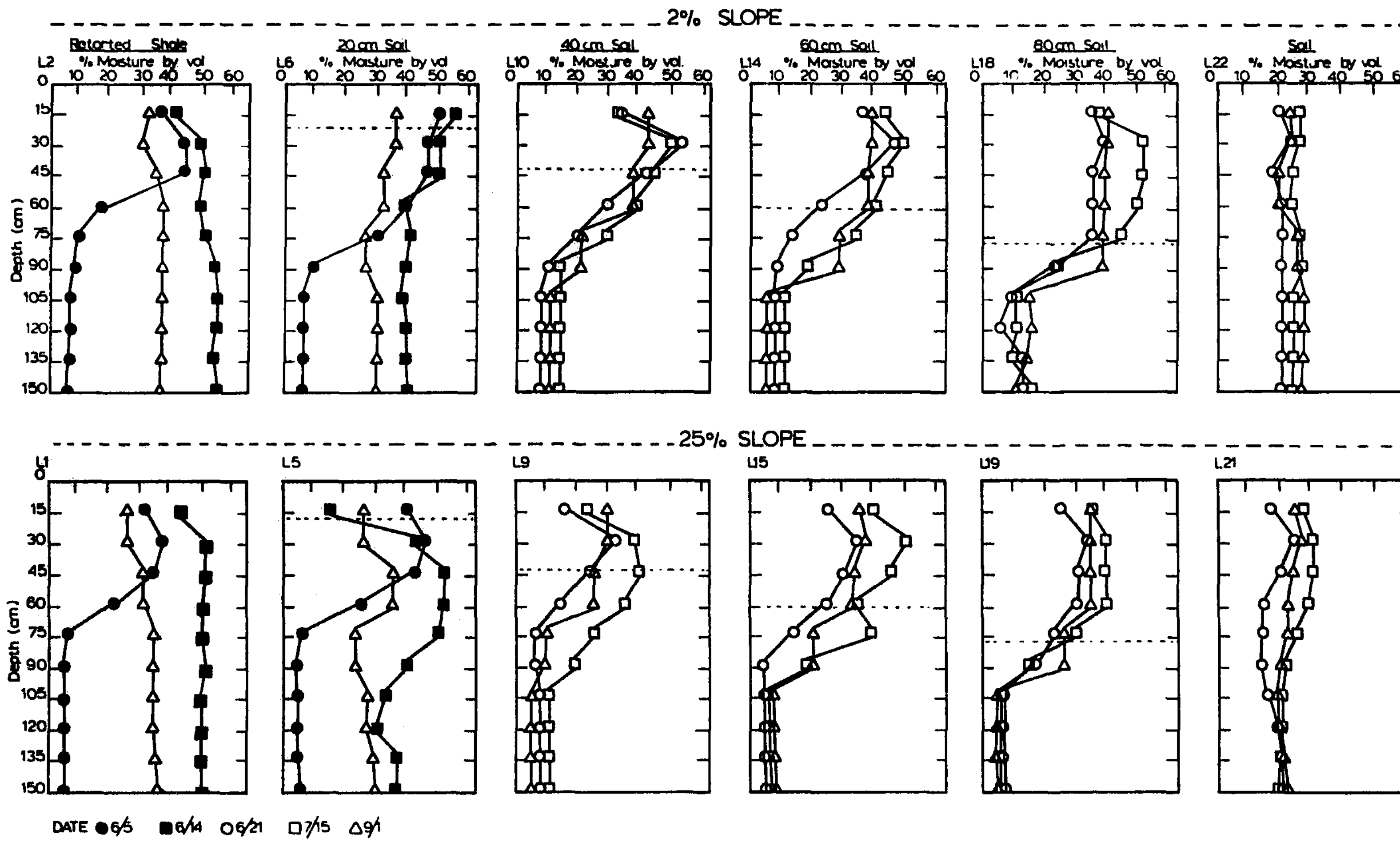

Figure 12. Moisture profiles for the low-elevation lysimeter treatments.

Water was starting to drip from the lower drain of each leached treatment by June 9. On June 14, after the addition of approximately 77 cm of water to both lysimeters, the uncompacted zone (150 cm profile) of each treatment was filled to approximately 48% by volume (Figures 11 and 12), and water was flowing from the drain below the compacted zone of each treatment.

The moisture data do not show the development of a water table at the interface of the compacted and uncompacted zones in either lysimeter (Figures 11 and 12). Likewise, the piezometers gave no indication that a water table ever developed at the interface of either the 2% or 25% slopes. The lack of a water table and the presence of little or no percolate from the upper drains suggests that water was moving through the compacted zone.

The September 1 moisture readings for the leached treatments show a decrease in total moisture content (to less than 40%) in the high-elevation lysimeter and approximately 30% in the low-elevation lysimeter (Figures 11 and 12). The difference in moisture contents of the two lysimeters reflects the smaller amount of irrigation water applied for plant establishment to the low-elevation lysimeter. The overall reduction in moisture content between June 14 and September 1 in both lysimeters is the result of drainage and evapotranspiration.

Moisture Profiles During Plant Establishment Irrigation on High-Elevation Lysimeter

Irrigation for plant establishment over the period of June 19 through August 17 was applied to the high-elevation lysimeter in amounts approximately 100% greater than the daily pan evaporation rate. The purpose of this excess irrigation was to simulate a 50 to 60 cm annual precipitation area in which seasonal precipitation exceeds evapotranspiration. Thus this treatment was designed to move water through the 150-cm uncompacted soil and shale zone and out the drain system to produce data on the quality of percolate.

The July 15 readings, after the addition of 40 cm of water to the 40, 60, and 80-cm soil-cover treatments, show the wetting front had moved to a depth of 105 cm on the 2% slope soil-cover treatments and 135 cm on the 25% slope soil-cover treatments. In contrast, water had already moved through the 150-cm depth on the soil control and was starting to drip from the lower drain.

For each of the soil-cover treatments the July 15 readings indicate that the moisture content of the soil is at near saturation (approximately 50%). The ability of the soil over shale to hold such a large volume of water is the result of the great textural difference between the soil and underlying retorted shale. Miller (1973) reports that any textural discontinuity that affects pore size distribution will result in decreased water movement. Since the shale layer is considerably coarser than the soil above it, the soil will not conduct significant amounts of water until the pores are filled. Once these pores are filled, a positive hydraulic pressure results, and water moves into the underlying shale as shown by the September 1 moisture readings (Figure 11).

To simulate a 40 to 60-cm annual precipitation zone, the high-elevation lysimeters will be irrigated in the spring for a number of years to represent the snowmelt recharge.

Moisture Profiles During Plant Establishment Irrigation on Low-Elevation Lysimeter

Irrigation for plant establishment was applied to the low-elevation lysimeter at approximately the daily pan evaporation rate. The purpose of this irrigation schedule was to supply sufficient moisture for plant establishment but not enough to move water through the 150-cm profile. On low-elevation disposal sites supporting an adequate plant cover, it is probable that moisture will never percolate through the entire uncompacted profile. In the future, no irrigation water will be applied to the low-elevation lysimeter.

By July 15 the soil-cover on the 60-cm and 80-cm soil-cover treatments was near saturation (approximately 50%) but the underlying shale was still dry (Figure 12). However, in the 40-cm of soil-cover treatments (both 2% and 25% slopes) moisture had penetrated into the spent shale. Apparently, the 20 cm of water applied by July 15 exceeded the water-holding capacity of the 40 cm of soil, and some deep percolation occurred.

The September 1 readings for the unleached soil-cover treatments show moisture depletion in the soil cover and water penetration to only 105 cm (Figure 12). Apparently, before establishment of a substantial vegetative cover in July, water moved deeper into the profile because irrigation was in excess of evapotranspiration. By August, water was being depleted from the profile because of greater evapotranspiration resulting from greater vegetation cover (Figure 12).

In the soil control, moisture was distributed evenly throughout the 150-cm profile on both the 2% and 25% slopes. In contrast, the moisture in the soil-cover treatments did not penetrate below 105 cm (Figure 13). The difference in depth of moisture penetration between the soil control and soil-cover treatments resulted from the abrupt textural boundary in the soil-covered treatments as discussed earlier.

Moisture Content of Compacted Zone

Core samples were taken from the compacted zone on 3 May 1978. The compacted zone was very difficult to drive the sampling tube into, as a result, some depth increments were combined and only one core reached the bottom of the compacted zone. The core samples were placed into soil moisture cans immediately after sampling, weighed, dried for 48 hours at 100 C and reweighed. Note that the results are reported in percent moisture by weight rather than in percent moisture by volume. After sampling the core holes were filled with concrete.

In the high-elevation treatments where excess irrigation had been applied, the moisture in the compacted zone averaged 21.8%, this was comparable to the 20.4% moisture in the overlying uncompacted zone (Table 5). On the low-elevation treatment receiving limited irrigation the water had penetrated to a depth of 105 cm and the shale in the compacted zone contained 3-4% water.

The above data shows water moved through the uncompacted zone into the compacted zone when excess water was applied.

TABLE 5. PERCENT MOISTURE BY WEIGHT IN CORE SAMPLES TAKEN FROM THE LYSIMETERS, 3 MAY 1978.

Depth (cm)	Treatment Sampled			
	High Elevation			Low Elevation
	Shale *Plot 2*	Shale *Plot 4*	40 cm Soil Cover *Plot 12*	60 cm Soil Cover *Plot 13*
0- 15	24.4	20.8	12.7	10.3
15- 30	22.9	17.9	13.5	10.3
30- 45	21.1	21.4	14.2	11.8
45- 60	25.6	19.9	15.7	15.4
60- 75	17.9	21.8	21.4	13.3
75- 90	26.3	18.1	15.3	14.8
90-105	21.8	17.5	18.4	9.9
105-120	22.8	16.8	22.7	}
120-135	18.7	18.9	23.7	} 2.1
135-150	19.7	17.6	22.7	}
- - - - -	- - - - -	- - - - -	- - - - -	- - - - - *
150-165	23.1	20.1	20.5	3.4
165-180	22.0	20.8	22.5	4.2
180-195	}		} 22.9	
195-210	} 20.6		}	
210-225	}			
225-240	23.4			

* Dashed line indicates the interface of the uncompacted and the compacted zones.

In the future, moisture will be monitored to determine if sufficient moisture is depleted each growing season from the profile of the soil-cover treatments to hold the following years snowmelt recharge. If sufficient depletion does occur, it may be possible to hold the seasonal recharge in the soil cover and thus prevent water from entering the shale. If water does penetrate the retorted shale, the plant roots probably will not grow into the high pH shale and the water will not be extracted. This process could eventually lead to percolation of water through the disposal pile.

In summary, the moisture data for the two lysimeters show that:

1. Excess water moved readily through the uncompacted zones and out of the lower drain below the compacted zone in the retorted shale treatments in the high-elevation lysimeters.

2. Under the conditions in 1 above the core samples show that water moved through the uncompacted zone into the compacted zone.

3. On treatments with soil cover a larger volume of water was held in the soil because of the abrupt textural change between the fine soil and the underlying coarse shale.

4. On the unleached soil-cover treatments in the low-elevation lysimeters water penetrated only to a depth of 105 cm.

PERCOLATE

The percolate data has been summarized by graphing EC values against total liters of percolate from the lysimeters (Figures 13 and 14). The daily flow rates, pH, EC, and total liters of percolate for each treatment are given in Appendix Tables 51 through 98.

The EC of the Colorado River irrigation water used during leaching and plant establishment averaged about 1 mmhos/cm (Appendix Table 4), a sample of the irrigation water was collected on June 3 for additional analysis (Appendix Table 99).

The percolate data are discussed separately for the various treatments within each lysimeters. Only the data from the lower drains (below the compacted zone) are presented since 99% of the total volume of percolate was from these drains. In the following discussion, the amount of percolate is presented in terms of volume in liters and as a depth over the treatment area. One cm of percolate from a 6.7 x 6.7 m treatment area equals 450 liters.

Note again that only the retorted shale and 20-cm soil-cover plots were leached. Leaching was continuous, with a total of 76 to 78 cm of water applied from June 2 through June 15. The high-elevation lysimeter received 83.6 cm of irrigation water for plant establishment during the period of June 19 through August 17; and the low-elevation lysimeter received 37.6 cm of water over the same period.

High Elevation Lysimeter

Retorted Shale --

Percolate was beginning to flow from the lower drain of the 25% slope by June 8, following the application of 31 cm of leach water. This initial percolate had an EC of 18.7 mmhos/cm and a pH of 8.2. By June 16, when leaching was stopped, the EC had increased to a maximum of 31 mmhos/cm (Figure 13) and the pH to 10.7. At this point a total of 8900 liters of percolate (19.7 cm) or 26% of the total leach water applied had been collected.

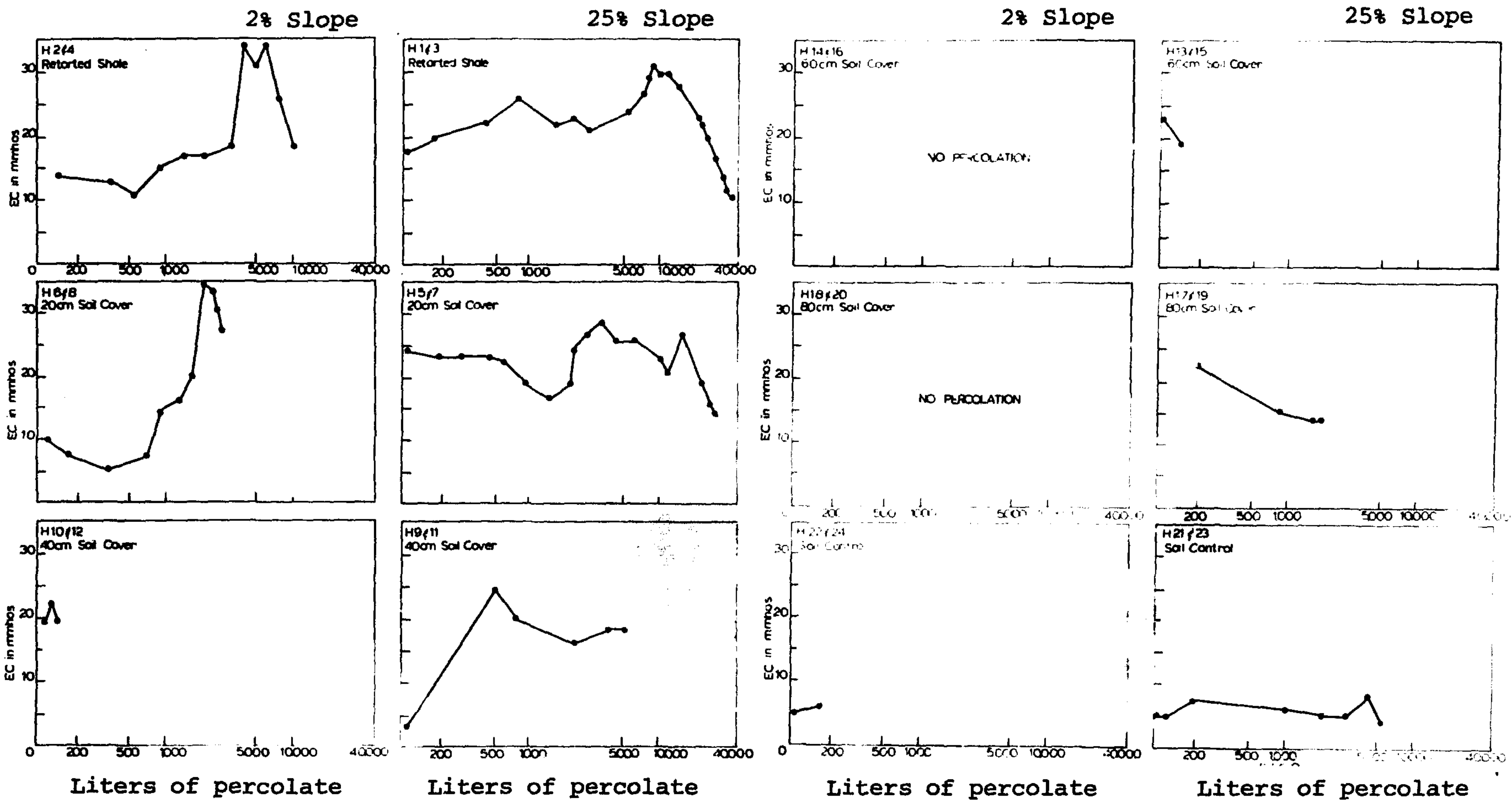

Figure 13. Electrical conductivity and amount of percolate from lower drains of the high-elevation lysimeter.

The lower drain of the 2% slope did not start flowing until June 10, after 46 cm of water had been applied. The EC of the percolate reached a maximum of 34.5 mmhos/cm on June 16. By the end of the leaching, 4790 liters (10.6 cm) of percolate had been collected.

During plant establishment, water was applied in almost daily increments of about 2 cm/day. The EC of the percolate decreased from 31 mmhos/cm (pH 10.7) on June 15 to 11 mmhos/cm (pH 8.6) on September 2 when a calculated one pore volume of water had passed through the uncompacted zone of the 25% slope (Appendix Table 51). One pore volume was calculated to be approximately 32,400 liters (72 cm) per 6.7 x 6.7-m plot with a depth of 150 cm. The porosity in the uncompacted zone was calculated to be 47.5% assuming a bulk density of 1.36 g/cm^3 and a particle density of 2.60 g/cm^3.

Although one pore volume of water did not pass through the 2% slope, the EC decreased from a maximum of 34.5 mmhos/cm on June 16 to 17.3 mmhos/cm on September 1 (Figure 13).

By September 1, a total of 9513 liters (21.1 cm) of percolate had been collected from the 2% slope, and 34,110 liters (75.8 cm) had been collected from the adjacent 25% slope treatment. This percolate represents 13% of the total water applied on the 2% slope and 48% of the water applied on the 25% slope.

The difference in the total amount of percolate between the two slopes could be caused by one or more of the following factors: (1) The difference in slope steepness may concentrate percolate faster at the lower drain on the 25% slope; (2) A possible greater compaction of the 2% slope (although the compaction data do not show a difference in the density values between slopes, see Appendix Table 1; and (3) A larger area is being drained by the 25% slope drain, because there is no dividing wall to separate the two slopes.

20-cm of Soil Cover --

During the leaching phase, the EC of the percolate from the 25% slope reached a maximum of 28.4 mmhos/cm with a pH of 11 after 4715 liters (10.4 cm) of percolate had been collected on June 17. On the 2% slope, the maximum EC was 35.1 mmhos/cm (pH 11.2) on June 16 after 1651 liters (1.4 cm) of percolate had been collected.

During the plant establishment irrigation percolate from the 25% slope treatment decreased in EC from 26.5 mmhos/cm (pH 10.7) on July 29 to 14.7 mmhos/cm (pH 9.6) on September 1 after a total of 24,637 liters (54.7 cm) of percolate had been collected. By contrast, flow from the 2% slope treatment practically stopped after the leaching phase; and only 254 liters of percolate were collected between June 29 and September 1. Total percolate collected from the 2% slope was 2179 liters (4.8 cm) by September 1.

40-cm of Soil Cover --

This treatment and the following high-elevation treatments were irrigated (83.6 cm) during plant establishment, no water was applied for leaching during the period between June 2-15.

On August 1, after the application of 64.8 cm of water, the percolate from the 25% slope had an EC of 24.4 mmhos/cm and a pH of 10.4. By September 1, a total of 3863 liters (8.6 cm) of percolate had been collected and the EC of the percolate had decreased to 19.1 mmhos/cm with a pH of 10.6 (Appendix Table 53).

On the 2% slope, only 94.7 liters (0.21 cm) of percolate were collected between June 29 and September 1. The highest EC was 22.3 mmhos/cm with a pH of 11.2 (Figure 13, Appendix Table 59).

60-cm of Soil Cover --

On the 25% slope, a total of 55.9 liters (0.12 cm) of percolate was collected by September 1. The highest EC was 22.8 mmhos/cm with a pH of 8.4 (Figure 13, Appendix Table 54). No percolate was collected from the 2% slope.

80-cm Soil Cover --

The 25% slope lower drain started dripping on August 1. By September 1, a total of 1771 liters (3.9 cm) had been collected. The EC reached a maximum of 22.3 mmhos/cm with a pH of 10.5 on August 8 after 200 liters (0.44 cm) of percolate had been collected. The EC decreased to 15.5 mmhos/cm (pH 10.8) by September 1. No percolate was collected from the 2% slope.

Soil Control --

The upper drain and compacted zone were not installed in the soil control treatments. These treatment areas were filled with uncompacted soil material, and the surfaces were shaped to 25% and 2% slopes with a small John Deere 667 tracked loader.

Percolate was observed dripping from the lower drain of the 25% slope on August 1. The initial EC was 5.8 mmhos/cm with a pH of 7.2, and it reached a maximum of 8.3 mmhos/cm on August 25 after 4990 liters (11.1 cm) of percolate had been collected. By September 1, the EC had decreased to 4.8 mmhos/cm. The total percolate collected was 5649 liters (12.5 cm).

Only 219 liters (0.48 cm) of percolate was collected from the 2% slope drain between August 1 and September 1. The maximum EC was 6 mmhos/cm, with a pH of 7.7.

In summary, for the leached treatments in the high-elevation lysimeter, a greater volume of percolate was collected from the 25% slope than from the 2% slope in each treatment; and a greater volume of percolate was collected from the retorted shale treatment than from the 20 cm of soil-cover treatment. A reduction in the EC and pH of the percolate was measured for each leached treatment by the end of August. The greatest reduction was observed on the retorted shale 25% slope treatment where the EC decreased from 31 mmhos/cm (pH 10.7) to 11 mmhos/cm (pH 8.6) after one pore volume of water had passed through the uncompacted zone.

On the unleached soil-cover treatments, there was some percolate from the 25% slopes, but little or none from the 2% slopes.

On the unleached soil control treatments water applied during plant establishment moved through both the 2% and 25% slope treatments but the largest volume of percolate was collected from the 25% slope. The maximum EC measured on the soil percolate was 8.3 mmhos/cm and the average EC was 6 mmhos/cm.

Low-Elevation Lysimeter

Retorted Shale --

Over the leaching period of June 2-15 considerably less percolate was collected from the low- than from the high-elevation lysimeter. But soluble salt concentrations in the percolate were similar for both lysimeters.

On the 25% slope retorted shale treatment 580 liters (1.3 cm) of percolate was collected by June 16. This amount is in sharp contrast to the 8900 liters (19.7 cm) of percolate collected by this date from the same treatment on the high-elevation lysimeter. The leach water input was nearly the same in both lysimeters. The difference in percolate volume cannot be explained by the available data, but differences may exist in the amount of water held in the compacted zone.

The maximum EC of the percolate during the leaching phase was 34 mmhos/cm (Figure 14). During the irrigation for plant establishment only 126 liters (0.3 cm) of percolate was collected, the EC of this percolate averaged 27 mmhos/cm (Appendix Table 75). Note that the low-elevation lysimeter received considerably less irrigation (37.6 cm) during plant establishment than did the high-elevation lysimeter (83.6 cm).

There was slightly more percolate from the 2% slope than from the 25% slope treatment (Figure 14, Appendix Tables 75 and 81). The EC of the percolate from the 2% slope averaged 22 mmhos/cm.

20-cm Soil Cover --

The initial percolate from the 25% slope was collected on June 8 and had an EC of 26.7 mmhos/cm. By June 16, at the end of leaching, the EC had dropped to 19.5 mmhos/cm and a total of 3307 liters (7.3 cm) of percolate had been collected (Figure 14, Appendix Table 76).

During the plant establishment irrigation 1331 liters (3.0 cm) of percolate were collected. The EC of the percolate collected on September 1 was 21 mmhos/cm (Figure 14, Appendix Table 76).

The initial percolate from the 2% slope was collected on June 10 and had an EC of 24.8 mmhos/cm. By June 16, 539 liters (1.2 cm) of percolate had been collected.

During plant establishment irrigation, only 232 liters of percolate was collected from the 2% slope. The EC of this percolate was 22 mmhos/cm on July 28, which was the last date a sample was collected (Figure 14, Appendix Table 82).

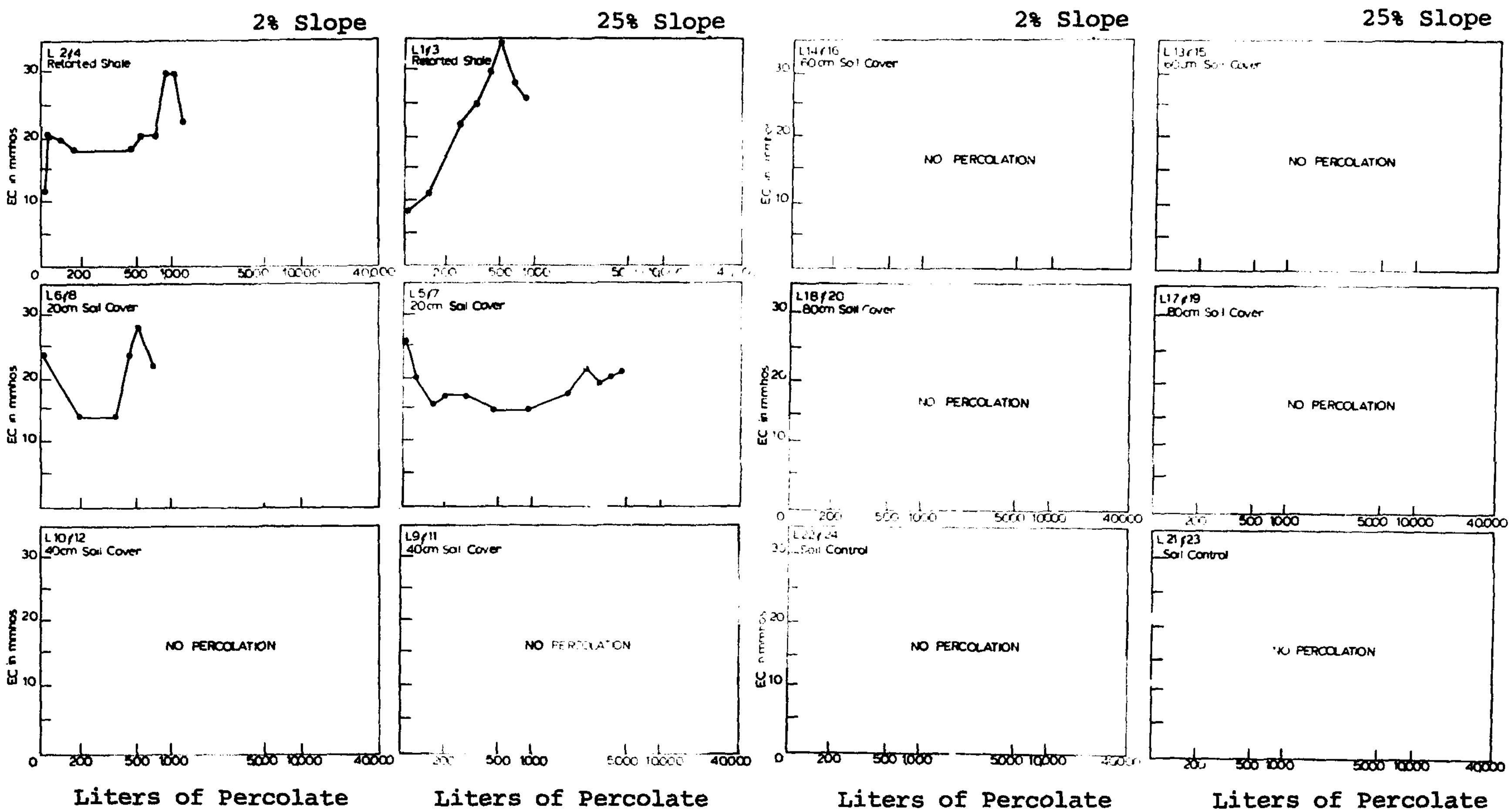

Figure 14. Electrical conductivity and volume of percolate from lower drains of the low-elevation lysimeter.

40-cm through 80-cm Soil Cover and Soil Control --

No percolate was collected from either drain on these treatments (Figure 14). Note that water penetrated only to a depth of 105 cm (Figure 12) on these soil-cover treatments which received no leach water and 37.6 cm of irrigation for plant establishment. Thus no percolate would be expected.

In summary, the total volume of percolate from the leached treatments on the low-elevation lysimeters as very low except for the 20-cm soil-cover treatment on the 25% slope where 4638 liters (10.3 cm) of percolate was collected. The EC of the percolate ranged from a low of 14.0 mmhos/cm on the 2% slope 20-cm soil-cover treatment to a maximum of 34.0 mmhos/cm for the 25% slope retorted shale treatment.

No percolate was collected from the unleached soil-cover and soil control treatments.

Results from the two lysimeters show that the EC values of the percolate water were similar; but that the total volume of percolate from the low-elevation lysimeter was much less (Table 6). A general decrease in maximum EC of the percolate with increase in soil-cover is shown for the high-elevation lysimeter treatments (Table 6).

Percolate Water Quality

Analyses for EC, pH, TDS, and common cations and anions were made to document the quality of the percolate and to verify the field measurements of EC and pH. Laboratory analyses of selected percolate samples from the lower drain of the 25% slope retorted shale and soil control treatments on the high-elevation lysimeter are shown in Table 7, all percolate analyses are in Appendix Tables 100 through 106.

The EC determined in the laboratory analysis tended to be slightly lower than those determined in the field (Appendix Tables 51-82). This difference probably occurred because some salt precipitation had occurred by the time the laboratory analyses were made. The pH was considerably lower in the laboratory analyses than in those made in the field. This result is consistent with the findings of Skogerboe et al. (1978) who attribute the drop in pH to oxidation of thiosulfate in the percolate.

Total dissolved solids and EC show a close relationship (Table 7, Appendix Tables 100-106), with total dissolved solids expressed in ppm usually being somewhat greater than EC expressed in μmhos/cm. This is a relationship that might be expected in these concentrated solutions. In less concentrated solutions (100 to 500 μmhos/cm) the conversion equation shown below is often used (Richards, 1954).

$$0.64 \times \text{EC in mmhos/cm} = \text{ppm total dissolved solids}$$

The soluble salt content of the percolate from the retorted shale treatments is quite high. Since these salt contents are reflections of percolation through 60-150 cm of retorted shale, and probably another 90 cm, as apparently the water is moving through the compacted shale zone, it can be extrapolated that percolate moving through a retorted shale pile several hundred meters thick could be extremely salty.

The SAR of the percolate from the retorted shale treatments is high (Table 8, Appendix Tables 100 to 106). Thus, the percolate could pose soil dispersion problems in irrigated agriculture. The SAR of the percolate from the soil is at a moderate level indicating a possible sodium dispersion hazard (Richards, 1954).

TABLE 6. SUMMARY OF MAXIMUM EC, pH, AND TOTAL PERCOLATE COLLECTED FROM THE LOWER DRAIN ON EACH TREATMENT ON BOTH LYSIMETERS.

Measurement	Retorted Shale	20-cm Soil	40-cm Soil	60-cm Soil	80-cm Soil	Soil Control
HIGH-ELEVATION LYSIMETER, 2% Slope:						
Maximum EC, mmhos/cm	34.4	35.1	22.3	*	*	5.9
Maximum pH	11.5	11.4	11.2	*	*	7.8
Total percolate, cm	21.4	4.9	0.2	*	*	0.5
HIGH-ELEVATION LYSIMETER, 25% Slope:						
Maximum EC, mmhos/cm	31.0	28.4	24.4	22.8	22.3	8.3
Maximum pH	11.3	11.4	10.5	8.4	11.4	8.3
Total percolate, cm	76.6	55.4	8.7	0.1	4.0	12.7
LOW-ELEVATION LYSIMETER, 2% Slope:						
Maximum EC, mmhos/cm	29.3	28.1	*	*	*	*
Maximum pH	11.2	10.9	*	*	*	*
Total percolate, cm	2.3	1.7	*	*	*	*
LOW-ELEVATION LYSIMETER, 25% Slope:						
Maximum EC, mmhos/cm	34.0	26.7	*	*	*	*
Maximum pH	10.9	11.3	*	*	*	*
Total percolate, cm	1.6	10.4	*	*	*	*

* No percolate collected.

TABLE 7. LABORATORY ANALYSIS OF PERCOLATE FROM RETORTED SHALE AND SOIL CONTROL TREATMENTS. LOWER DRAIN, HIGH-ELEVATION LYSIMETER.

Parameter	Percolate From Retorted Shale			Percolate From Soil		
	6/8/77	6/17/77	9/2/77	8/1/77	8/23/77	8/31/77
EC, μmhos/cm	12,983	27,222	10,500	4600	5100	5100
pH	6.3	7.1	7.0	7.5	8.2	8.3
TDS, ppm	14,328	31,984	*	*	*	*
SAR	52.8	116.8	30.0	10.8	9.7	9.7
Cations, meq/l						
Ca	16.4	23.0	17.4	8.8	6.9	5.4
Mg	9.0	5.1	1.5	8.5	21.4	19.8
Na	148.8	429.3	90.0	31.5	36.1	34.0
K	11.2	45.1	11.3	2.9	1.1	1.0
Anions, meq/l						
Cl	30.6	28.2	4.8	11.5	17.1	15.3
SO_4	157.7	449.6	119.0	35.6	37.5	36.2

* Not determined

Trace Elements in Percolate

Percolate was collected for trace element analysis from each treatment during both the leaching and plant establishment phases. Results of those analyses are in Appendix Tables 129 through 135. An interpretation of the data is not included in this report. For further information regarding procedures or interpretations, contact R.E. Wildung or Tom Garland, Battelle Northwest Laboratory, Richland, Washington 99352.

CORE SAMPLE ANALYSIS

Analyses were made for EC, pH, and common cations and anions in the retorted shale treatments following leaching and plant establishment irrigation. Core samples were taken on 1 September 1977 in the uncompacted zone of the spent shale treatments. The soil-cover treatments were not core sampled.

The EC decreased from 7.1 mmhos/cm to 3.2 mmhos/cm on the retorted shale from the high-elevation lysimeter and to 3.9 mmhos/cm on the low-elevation lysimeter after leaching and plant establishment irrigation (Table 8).

The pH's of the core samples were within the narrow range of 8.8 to 9.4, with a mean of 9.1. This is a considerable reduction in pH since the shale exited the retort at a pH of about 11.4. Two factors are probably responsible:

TABLE 8. ANALYSIS OF RETORTED SHALE BEFORE AND AFTER LEACHING AND PLANT ESTABLISHMENT.

Measurement	Before Leaching and Irrigation*	After Leaching And Irrigation†	
		High Elevation	Low Elevation
EC, mmhos/cm §	7.1	3.6	3.9
pH §	9.7	9.1	9.1
SAR§	19.0	2.5	3.0
Cations, meq/l §			
Ca	21.6	11.6	11.1
Mg	24.3	19.5	29.7
Na	91.5	11.3	13.1
K	7.1	1.6	1.8
Anions, meq/l §			
HCO_3	1.7	1.9	2.2
Cl	3.6	3.5	3.5
SO_4	131.3	33.5	45.0

* Mean value for four samples.

† Mean value for 23 to 45 core samples, all data are in Appendix Tables 107 and 108.

§ Analyses were on a 1:1 ratio of retorted shale to water by weight extract.

1. Recarbonization from CO_2 in the atmosphere and leach water, and 2. Displacement of alkaline anions (CO_3 and possibly OH) by neutral salts in the moderately saline irrigation water. It is impossible to tell from the laboratory data how much recarbonation occurred in place and how much occurred after the core samples were taken and prepared for laboratory analysis. Some evidence for pH reduction in place is indicated by the reduced percolate pH after extended leaching on 3 of 4 treatments that had substantial amounts (>10 cm) of percolate (Appendix Tables 51, 52, 57, and 76).

The SAR decreased from 19.0 to 2.5 and 3.0 in the high- and low-elevation lysimeters, respectively. This drop in SAR values shows that the irrigation water was effective in removing the soluble sodium from the shale.

A high proportion of Mg to Ca showed up in the core sample extracts after irrigation, particularly in surface samples, where there is 6 to 13 times more water-extractable Mg than Ca (Appendix Tables 107 and 108). This could result in a nutrient imbalance and might be a reason for the restricted plant growth on the retorted shale treatments.

Salinity sensors were installed in the treatments and readings were made periodically during leaching and plant establishment irrigation (Appendix Tables 109-128). However, the sensor data appears to be erratic and is not discussed in this report.

WATER BALANCE

Water balance calculations were made for all treatments in both lysimeters as of September 1, 1977. These calculations were made in an attempt to account for the total volume of water applied to each treatment. Since the lysimeters are closed containers, it should be possible to measure the inputs (precipitation, irrigation) and certain losses (percolation, moisture storage) in the uncompacted zone. The evapotranspiration component of the calculation was not measured directly on the lysimeters but was estimated for the study site.

The water balance calculations in Table 9 are based on the following parameters:

(1) Before leaching and irrigation, the retorted shale contained some water as the result of water applied for dust control during the filling operation, this averaged out to 7.4% by volume. The soil cover contained an average of 19.9% moisture by volume (Appendix Table 27-50).

(2) A total of 1570 liters of water was applied to the retorted shale treatments during the wet-dry cycles. This volume equals 3.4 cm of input water.

(3) The high-elevation lysimeter was leached with 76.7 cm, and the low-elevation lysimeter was leached with 78.0 cm of water (as measured by small rain gauges set on the lysimeters. Surface runoff did not occur as the application rate did not exceed the infiltration rate.

(4) The percolate values used were the means of the 25% and 2% slope treatments. The percolate from the upper drains accounted for less than 1% of the total percolate volume and was not included in the calculations.

(5) The water storage in the upper 150 cm was calculated from the September 1 neutron probe readings. These values are the mean of the 2% and 25% slope treatments.

(6) If there was percolate from the bottom drain, moisture storage in the compacted zone was calculated by use of the core sample data in Table 5 and a bulk density of 1.53.

TABLE 9. CALCULATED WATER BALANCE FOR THE LYSIMETERS.

	Shale	20-cm Soil	40-cm Soil	60-cm Soil	80-cm Soil	Soil
HIGH-ELEVATION LYSIMETER						
Inputs						
Filling Operation						
Retorted Shale	17.8	16.3	14.8	13.3	11.8	0
Soil	0	4.0	8.0	12.0	16.0	47.8
Wet/Dry Cycles	3.4	0	0	0	0	0
Leaching	76.7	76.7	0	0	0	0
Establishment Irrigation	83.6	83.6	83.6	83.6	83.6	83.6
Precipitation	9.7	9.7	9.7	9.7	9.7	9.7
Subtotal	191.2	190.3	116.1	118.6	121.1	141.1
Losses						
Percolation	49.0	30.2	4.4	Trace	2.0	6.6
Moisture storage top 150 cm	53.3	51.8	49.8	55.6	53.5	49.7
Moisture storage bottom 90 cm	30.0	30.0	30.0	30.0	30.0	30.0
Evapotranspiration	45.5	45.5	45.5	45.5	45.5	45.5
Subtotal	177.8	157.5	129.7	131.1	130.1	131.8
Difference						
Inputs Losses	+13.4	+32.8	-13.6	-12.5	9.9	+ 9.3
LOW-ELEVATION LYSIMETER						
Inputs						
Filling Operation						
Retorted Shale	17.8	16.3	14.8	13.3	11.8	0
Soil	0	4.0	8.0	12.0	16.0	47.8
Wet/Dry Cycles	3.4	0	0	0	0	0
Leaching Irrigation	78.0	78.0	0	0	0	0
Establishment Irrigation	37.6	37.6	37.6	37.6	37.6	37.6
Precipitation	9.7	9.7	9.7	9.7	9.7	9.7
Subtotal	146.5	145.6	70.1	72.6	75.1	95.1
Losses						
Percolation	1.9	6.5	0	0	0	0
Moisture storage top 150 cm	55.5	50.4	33.5	37.0	40.9	38.1
Moisture storage bottom 90 cm	30.0	30.0	6.7	6.7	6.7	17.9
Evapotranspiration	45.5	45.5	45.5	45.5	45.5	45.5
Subtotal	132.9	132.4	85.7	89.2	93.1	101.5
Inputs - Losses	+13.6	+13.2	-15.6	-16.6	-18.0	- 6.4

(7) Evapotranspiration was calculated from the pan evaporation data and compared with estimates by Wymore (1974) for the oil shale region of western Colorado. The gross pan evaporation for the site was approximately 61.5 cm of water between June 15 and September 1. Since the pan evaporation is assumed to be greater than the actual evapotranspiration on the plots an adjusted estimate based on the work of Wymore (1974) was used. Wymore (1974) estimated evapotranspiration from a 5000 feet revegetated site seeded in June would be 45.5 cm.

(8) The total precipitation received at the site between April sixth and the first of September was included.

All the leached treatments on both lysimeters show more water applied than can be accounted for by a summation of losses from ET, moisture storage in the 150-cm uncompacted and 90-cm compacted zones, and percolate (Table 9).

By contrast, water losses calculated out to be greater than water inputs for all the unleached soil-cover treatments (Table 9). Moisture measurements on the soil control treatments most nearly balanced out the inputs and losses.

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APPENDIX TABLE 1. BULK DENSITY (g/cm^3) FOR THE COMPACTED RETORTED SHALE ZONE. HIGH AND LOW ELEVATION LYSIMETERS. MARCH AND APRIL, 1977.

HIGH ELEVATION LYSIMETER

	Compacted Shale Zone (25% slope)					Compacted Shale Zone (2% slope)				
	Retorted Shale	20 cm Soil Cover	40 cm Soil Cover	60 cm Soil Cover	80 cm Soil Cover	Retorted Shale	20 cm Soil Cover	40 cm Soil Cover	60 cm Soil Cover	80 cm Soil Cover
Lifts No.*	H1 & H3	H5 & H7	H9 & H11	H13 & H15	H17 & H19	H2 & H4	H6 & H8	H10 & H12	H14 & H16	H18 & H20
1	1.48	1.47	1.47	1.53	1.50	1.56	1.50	1.48	1.52	1.53
2	1.52	1.48	1.52	1.48	1.50	1.55	1.52	1.50	1.48	1.55
3	1.48	1.50	1.50	1.52	1.52	1.48	1.52	1.55	1.55	1.55
4	1.56	1.56	1.53	1.55	1.55	1.52	1.53	1.52	1.58	1.56
5	1.60	1.56	1.48	1.56	1.63	1.56	1.52	1.48	1.52	1.60
$\bar{X}$	1.53	1.51	1.50	1.53	1.54	1.53	1.52	1.51	1.53	1.56
SD	0.05	0.04	0.02	0.03	0.05	0.03	0.01	0.03	0.03	0.02

LOW ELEVATION LYSIMETER

	Compacted Shale Zone (25% slope)					Compacted Shale Zone (2% slope)				
	Retorted Shale	20 cm Soil Cover	40 cm Soil Cover	60 cm Soil Cover	80 cm Soil Cover	Retorted Shale	20 cm Soil Cover	40 cm Soil Cover	60 cm Soil Cover	80 cm Soil Cover
Lifts No.*	L1 & L3	L5 & L7	L9 & L11	L13 & L15	L17 & L19	L2 & L4	L6 & L8	L10 & L12	L14 & L16	L18 & L20
1	1.50	1.50	1.47	1.48	1.53	1.50	1.56	1.52	1.48	1.53
2	1.52	1.60	1.52	1.52	1.48	1.52	1.60	1.50	1.52	1.55
3	1.52	1.56	1.53	1.50	1.52	1.55	1.48	1.48	1.53	1.52
4	1.48	1.50	1.52	1.53	1.55	1.53	1.52	1.55	1.56	1.52
5	1.56	1.48	1.56	1.55	1.55	1.56	1.52	1.55	1.55	1.56
$\bar{X}$	1.52	1.53	1.52	1.52	1.53	1.53	1.54	1.52	1.53	1.54
SD	0.03	0.05	0.03	0.03	0.05	0.05	0.06	0.03	0.05	0.06

* Lift no. 1 is located next to the concrete pad; lift 2, 3, 4, and 5 increase in height above the pad; lifts were 20-30 cm thick.

APPENDIX TABLE 2. REGRESSION READ-OUT FOR NEUTRON PROBE MOISTURE CALIBRATION CURVE FOR PARAHO (DIRECT) HEATED RETORTED OIL SHALE. 1977

CR*	Θ†	CR	Θ	CR	Θ
0.02	1.5	0.32	24.7	0.60	46.8
0.04	2.6	0.33	25.5	0.61	47.6
0.06	4.2	0.34	26.3	0.62	48.4
0.07	5.0	0.35	27.0	0.63	49.2
0.08	5.7	0.36	27.8	0.64	49.9
0.09	6.5	0.37	28.6	0.65	50.7
0.10	7.3	0.38	29.4	0.66	51.5
0.11	8.2	0.39	30.2	0.67	52.3
0.12	8.9	0.40	31.0	0.68	53.1
0.13	9.7	0.41	31.8	0.69	53.9
0.14	10.5	0.42	32.6	0.70	54.7
0.15	11.3	0.43	33.4	0.71	55.5
0.16	12.1	0.44	34.2	0.72	56.3
0.17	12.8	0.45	34.9	0.73	57.0
0.18	13.6	0.46	35.7	0.74	57.8
0.19	14.4	0.47	36.5	0.75	58.6
0.20	15.2	0.48	37.3	0.76	59.4
0.21	16.0	0.49	38.1	0.77	60.2
0.22	16.8	0.50	38.9	0.78	61.0
0.23	17.6	0.51	39.7	0.79	61.8
0.24	18.4	0.52	40.5	0.80	62.6
0.25	19.2	0.53	41.3		
0.26	19.9	0.54	42.1		
0.27	20.7	0.55	42.8		
0.28	21.5	0.56	43.6		
0.29	22.4	0.57	44.4		
0.30	23.2	0.58	45.2		
0.31	23.9	0.59	46.0		

* Count Ratio

† Percent moisture by volume

APPENDIX TABLE 3. SOIL MOISTURE CALIBRATION CURVE USED IN THIS STUDY.

Troxler Electronic Laboratories, Inc.
Depth Moisture Gauge

Gauge Model - 1257 SN 409
Probe Serial No. - H-1975
Operating Voltage - 1350

Source - Type - AM-BE
Serial No. - AM-118
Date of Calibration - 05-04-73

Moisture Standard Count - 38127.0

CALIBRATED IN THINWALL ELECTRICAL CONDUIT, 1.745 O.D., 1.610 I.D.
Moisture Content

Precision = +/-0.2161 PCT (Std. Dev.)
CR = Measurement Count/Standard Count

CR	Vol PCT	CR	Vol PCT	CR	Vol PCT	CR	Vol PCT
0.084	0.25	0.249	10.25	0.413	20.25	0.577	30.25
0.093	0.75	0.257	10.75	0.421	20.75	0.585	30.75
0.101	1.25	0.265	11.25	0.429	21.25	0.594	31.25
0.109	1.75	0.273	11.75	0.438	21.75	0.602	31.75
0.117	2.25	0.281	12.25	0.446	22.25	0.610	32.25
0.125	2.75	0.290	12.75	0.454	22.75	0.618	32.75
0.134	3.25	0.298	13.25	0.462	23.25	0.626	33.25
0.142	3.75	0.306	13.75	0.470	23.75	0.635	33.75
0.150	4.25	0.314	14.25	0.479	24.25	0.643	34.25
0.158	4.75	0.323	14.75	0.487	24.75	0.651	34.75
0.166	5.25	0.331	15.25	0.495	25.25	0.659	35.25
0.175	5.75	0.339	15.75	0.503	25.75	0.668	35.75
0.183	6.26	0.347	16.25	0.511	26.25	0.676	36.25
0.191	6.75	0.355	16.75	0.520	26.75	0.684	36.75
0.199	7.25	0.364	17.25	0.528	27.25	0.692	37.25
0.208	7.75	0.372	17.75	0.536	27.75	0.700	37.75
0.216	8.25	0.380	18.25	0.544	28.25	0.709	38.25
0.224	8.75	0.388	18.75	0.553	28.75	0.717	38.75
0.232	9.25	0.396	19.25	0.561	29.25	0.725	39.25
0.240	9.75	0.405	19.75	0.569	29.75	0.733	39.75

APPENDIX TABLE 4. IRRIGATION WATER ANALYSIS, pH AND EC FOR BOTH THE HIGH AND LOW ELEVATION LYSIMETERS. 1977.

Date	EC μmhos/cm @ 25°C	pH @ 25°C
6/ 1	1350	7.7
6/ 2	1000	7.5
6/ 3	975	8.1
6/ 4	1123	8.2
6/ 5	1136	8.0
6/ 6	1115	8.2
6/ 7	891	8.2
6/ 8	946	8.2
6/ 9	858	8.3
6/10	843	8.3
6/11	878	8.3
6/12	798	7.8
6/13	834	7.2
6/14	840	7.4
6/17	868	8.2
6/19	844	8.1
7/ 1	1334	8.2
7/11	1232	7.5
7/12	1383	7.5
7/13	1252	7.8
7/14	1411	7.6
7/15	1355	7.6
7/18	1355	7.4
7/19	1355	7.6
7/20	1521	8.0
7/21	1428	7.8
7/25	1326	7.7
7/26	1326	7.5
7/27	1270	8.0
7/28	1245	7.9
7/29	1287	7.7
8/ 1	1356	7.6
8/ 2	1326	7.9
8/ 3	1349	7.5
8/ 4	1300	7.3
8/ 8	1370	7.7
8/ 9	1417	7.7
8/10	1404	7.8
8/11	1270	7.7
8/12	1338	7.7
8/15	1417	7.1
8/16	1417	7.9
8/17	1823	8.0

APPENDIX TABLE 5. DAILY IRRIGATION TOTALS (in cm) FOR THE HIGH ELEVATION LYSIMETER. JUNE THROUGH AUGUST, 1977.

Date	Inches Applied *	Total	cm Applied	Total
6/ 2	Start †			
6/ 3	2.2	2.2	5.5	5.5
6/ 4	1.5	3.7	3.8	9.3
6/ 5	1.7	5.4	4.3	13.6
6/ 6	2.1	7.5	5.3	18.9
6/ 7	1.7	9.2	4.3	23.2
6/ 8	3.0	12.2	7.6	30.8
6/ 9	3.1	15.3	7.8	38.6
6/10	2.9	18.2	7.3	45.9
6/11	2.4	20.6	6.1	52.0
6/12	3.9	24.5	9.9	61.9
6/13	3.1	27.6	7.8	69.7
6/14	2.3	29.9	5.8	75.5
6/15	0.5	30.4	1.2	76.7
	Stopped leaching, started irrigation of entire lysimeter.			
6/19	2.6	33.0	6.6	83.3
	Seeded plots and started daily (establishment) irrigation.			
6/28	2.0	35.0	5.0	88.3
6/30	2.0	37.0	5.0	93.3
7/ 1	2.5	39.5	6.3	99.6
7/ 3	2.4	41.9	6.1	105.7
7/ 7	2.3	44.2	5.8	111.5
7/11	0.6	44.8	1.5	113.0
7/12	0.6	45.4	1.5	114.5
7/13	-			
7/14	0.9	46.3	2.2	116.7
7/18	0.8	47.2	2.2	118.9
7/19	0.7	47.8	1.7	120.6
7/22	0.7	48.5	1.8	122.4
7/25	2.7	51.2	6.8	129.3
7/26	0.8	52.1	2.1	131.3
7/28	0.7	52.8	1.9	133.2
7/29	0.8	53.7	2.2	135.4
8/ 1	2.4	56.1	6.1	141.5
8/ 3	0.8	56.9	2.0	143.5
8/ 8	2.4	59.4	6.2	149.7
8/ 9	0.8	60.2	2.0	151.7
8/10	0.1	60.3	0.3	152.0
8/11	0.6	60.9	1.6	153.6
8/15	1.4	62.3	3.5	157.1
8/16	0.3	62.7	0.8	158.0
8/17	0.9	63.6	2.3	160.3
	Stopped irrigation.			

* Inches or centimeters of water applied at surface.

† Only the shale-to-the-surface and 20 cm soil covered treatments were leached.

APPENDIX TABLE 6. DAILY IRRIGATION TOTALS (in cm) FOR THE LOW ELEVATION LYSIMETER. JUNE THROUGH AUGUST, 1977.

Date	Inches Applied*	Total	cm Applied	Total
6/ 2	Start †			
6/ 3	1.7	1.7	4.3	4.3
6/ 4	2.7	4.4	6.8	11.1
6/ 5	2.3	6.7	5.8	16.9
6/ 6	2.1	8.8	5.3	22.2
6/ 7	1.9	10.7	4.8	27.0
6/ 8	2.9	13.6	7.3	34.3
6/ 9	2.5	16.1	6.3	40.6
6/10	2.5	18.6	6.3	46.9
6/11	2.4	21.0	6.0	52.9
6/12	3.8	24.8	9.6	62.5
6/13	2.8	27.6	7.1	69.6
6/14	2.8	30.4	7.1	76.7
6/15	0.5	30.9	1.3	78.0
	Stopped leaching, started irrigation of entire lysimeter.			
6/19	2.0	32.9	5.0	83.0
	Seeded plots and started daily (establishment) irrigation.			
6/28	3.0	35.9	7.6	90.6
7/ 1	0.5	36.4	1.3	91.9
7/ 6	0.9	37.3	2.2	94.1
7/ 7	0.5	37.8	1.3	95.4
7/11	0.5	38.3	1.3	96.7
7/12	0.4	38.7	1.0	97.7
7/14	0.3	39.0	0.7	98.4
7/18	0.4	39.4	1.0	99.4
7/19	0.3	39.8	0.9	100.4
7/22	0.1	39.9	0.4	100.8
7/25	0.6	40.5	1.5	102.3
7/26	0.2	40.7	0.5	102.8
7/29	0.4	41.2	1.1	103.9
8/ 1	1.1	42.3	2.8	106.7
8/ 2	0.1	42.4	0.2	107.0
8/ 3	0.1	42.4	0.3	107.3
8/ 8	0.7	43.1	1.7	109.0
8/ 9	0.3	43.4	0.7	109.8
8/10	0.1	43.5	0.3	110.1
8/11	0.4	44.0	1.2	111.3
8/15	0.8	44.8	2.0	113.3
8/16	0.5	45.3	1.3	114.6
8/17	0.4	45.7	1.0	115.6
	Stopped irrigation.			

* Inches or centimeters of water applied at surface.

† Only the shale-to-the-surface and 20 cm soil covered treatments were leached.

APPENDIX TABLE 7. DAILY PRECIPITATION (mm) FOR PARAHO RETORTED SHALE. HIGH AND LOW ELEVATION LYSIMETER STUDY SITE. 1977

Day	April	May	June	July	August	September
1		--	--	--	--	--
2		1.0	--	--	--	--
3	Start	--	--	--	--	2.5
4	--	1.0	--	--	--	--
5	--	3.0	2.5	--	--	--
6	--	--	--	--	--	--
7	--	--	--	--	--	--
8	--	--	--	--	--	--
9	--	--	2.5	--	--	--
10	1.0	--	--	--	--	--
11	--	7.8	--	--	--	10.6
12	--	8.6	--	--	--	--
13	--	--	--	--	--	--
14	---	1.1	--	--	--	1.0
15	--	9.9	--	--	--	5.3
16	--	4.3	--	--	1.0	Stopped
17	--	0.2	--	--	1.2	
18	--	--	--	0.5	--	
19	--	--	--	2.2	9.9	
20	--	--	--	--	0.2	
21	--	--	--	0.2	0.7	
22	--	--	--	0.2	--	
23	--	0.5	--	2.7	0.2	
24	--	2.7	--	3.3	11.1	
25	--	9.6	--	--	--	
26	--	0.5	0.5	--	--	
27	--	--	0.7	--	5.8	
28	--	0.2	--	--	--	
29	--	--	--	--	--	
30	--	--	--	--	--	
31	--	--	--	--	--	
TOTAL	1.0	50.4	6.2	9.2	29.2	

APPENDIX TABLE 8. DAILY PAN EVAPORATION (mm) FOR PARAHO RETORTED OIL SHALE. HIGH AND LOW ELEVATION LYSIMETER STUDY SITE, 1977

Day	April	May	June	July	August	September
1			10.1	11.1	Leak	8.1
2			11.6	10.1	Leak	8.8
3			9.9	10.1	Leak	
4			10.1	10.1	Leak	
5			10.1	10.1	Leak	
6			9.6	10.1	Leak	
7			11.6	12.1	Leak	
8			9.1	10.9	Leak	
9			5.0	--	Leak	
10			9.1	--	7.6	
11			14.4	12.7	11.4	
12			10.1	12.1	11.6	
13			10.1	7.6	11.6	
14			11.9	5.5	11.6	
15			9.1	12.1	11.6	
16			10.4	10.6	8.6	
17			10.4	10.6	5.0	
18			10.1	10.6	5.0	
19			10.4	Leak	7.6	
20			--	Leak	Rain	
21			3.8	Leak	Rain	
22			--	Leak	Rain	
23			6.0	Leak	10.1	
24			14.2	Leak	12.7	
25		Start	--	Leak	--	
26		--	Rain	Leak	15.2	
27		5.5	16.2	Leak	Rain	
28		7.1	10.1	Leak	Rain	
29		7.1	14.2	Leak	8.8	
30		7.1	12.7	Leak	8.6	
31		7.1	--	Leak	6.3	
TOTAL		33.9	270.3	166.4	153.3	

APPENDIX TABLE 9. RETORTED SHALE HANDLING AND SAMPLING PROCEDURES FOR ANALYSES OF PARAHO RETORTED SHALE DURING THE COMPACTION AND FILLING OPERATION PROCEDURE PROVIDED BY DEVELOPMENT ENGINEERING, INC.

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1. Retorted shale from retort is diverted by a motorized flop gate to a sample hopper.

2. Material is conveyed continuously from the hopper to a hammer-mill crusher.

3. The crushed material drops through a seven-stage splitter where a lab sample is obtained once every 24 hours. The balance of the crushed material is discarded.

4. The laboratory sample is further split for various tests. The split used for pH and conductivity requires no further preparation. Size distribution of this sample is given below:

Size	Texture	Wt %
>300 µm	coarse sand	25.9
250 µm	coarse sand	2.2
150 µm	coarse sand	4.2
106 µm	fine sand	3.5
75 µm	fine sand	7.8
< 75 µm	silt	56.4

5. pH and conductivity analysis were determined on a 1:1 sample by weight according to procedures outlined in Saline and Alkali Soils (USDA Handbook 60).

APPENDIX TABLE 10. DAILY ANALYSIS AND PRODUCTION TOTALS FOR DIRECT HEATED PARAHO RETORTED SHALE DURING THE COMPACTION AND FILLING OPERATION. HIGH AND LOW ELEVATION LYSIMETER. 1977. DATA PROVIDED BY DEVELOPMENT ENGINEERING, INC.

Date	3-21-77	3-22-77	3-23-77	3-24-77	3-25-77	3-26-77	3-27-77
Oil Wt%	0.16 *	0.12	0.15	0.16	0.09	0.08	0.24
Water Wt%	0.12	0.14	0.07	0.18	0.29	0.25	0.08
Gas + Loss Wt%	0.00	0.11	0.00	0.02	0.30	0.17	0.00
Oil GPT	0.43	0.32	0.38	0.42	0.23	0.21	0.64
Water GPT	0.28	0.33	0.16	0.43	0.69	0.59	0.19
Mineral CO_2 Wt%	15.31	15.84	16.10	15.59	15.61	15.59	15.55
Ash Wt%	81.08	80.31	80.06	80.14	80.22	79.92	78.84
Moisture Wt%	0.04	0.00	0.00	0.02	0.00	0.00	0.02
Carbon Wt%	6.40	6.41	6.64	6.52	6.49	6.71	6.30
Hydrogen Wt%	0.19	0.18	0.19	0.20	0.19	0.19	0.18
Nitrogen Wt%	0.28	0.27	0.25	0.24	0.22	0.24	0.23
Sulfur Wt%	0.89	0.69	0.66	0.57	0.71	0.81	0.72
pH	11.30	11.30	11.40	11.50	11.55	11.60	11.40
Conductivity μMHOS	2900.00	2600.00	2825.00	3150.00	2400.00	2650.00	2200.00
Background Water							
pH	6.40	5.55	5.60	5.70	6.05	5.95	6.95
Conductivity μMHOS	1.40	1.22	2.00	2.00	1.85	2.00	2.00
Tons/Day	234.6	235.7	235.0	231.7	228.1	232.6	229.3

* Analysis performed by Development Engineering's Testing Laboratory, Anvil Points, Colorado.

APPENDIX TABLE 10. CONTINUED.

Date	3-28-77	3-29-77	3-30-77	3-31-77	4-1-77	4-2-77	4-3-77
Oil Wt%	0.17 *	0.14	0.19	0.18	0.02	0.04	0.19
Water Wt%	0.10	0.12	0.57	0.07	0.38	0.37	0.23
Gas + Loss Wt%	0.02	0.25	0.09	0.00	0.17	0.15	0.38
Oil GPT	0.45	0.38	0.50	0.47	0.05	0.10	0.52
Water GPT	0.23	0.30	1.36	0.16	0.92	0.90	0.55
Mineral CO_2 Wt%	15.03	15.01	16.44	15.94	16.63	16.54	17.80
Ash Wt%	81.46	80.55	79.85	79.96	79.60	79.74	80.00
Moisture Wt%	0.00	0.00	0.00	0.09	0.05	0.11	0.00
Carbon Wt%	6.13	6.38	6.70	6.78	7.09	6.86	6.74
Hydrogen Wt%	0.17	0.18	0.18	0.18	0.20	0.20	0.19
Nitrogen Wt%	0.22	0.22	0.25	0.24	0.25	0.27	0.25
Sulfur Wt%	0.71	0.85	0.80	0.84	0.95	0.81	0.66
pH	11.60	11.35	11.50	11.40	11.50	11.60	11.60
Conductivity μMHOS	2700.00	3500.00	3950.00	3900.00	3900.00	4300.00	3930.00
Background Water							
pH	6.30	7.75	5.70	6.20	6.70	6.70	6.00
Conductivity μMHOS	2.00	1.50	1.80	1.40	1.40	1.40	2.00
Tons/Day	223.5	228.5	230.8	228.9	233.4	234.2	234.5

* Analysis performed by Development Engineering's Testing Laboratory, Anvil Points, Colorado.

APPENDIX TABLE 10. CONTINUED.

Date	4-4-77	4-5-77	4-6-77
Oil Wt%	0.06 *	0.08	0.13
Water Wt%	0.30	1.33	0.24
Gas + Loss Wt%	0.14	0.00	0.20
Oil GPT	0.16	0.21	0.34
Water GPT	0.70	3.18	0.58
Mineral CO_2 Wt%	16.37	15.86	16.60
Ash Wt%	79.79	80.07	79.65
Moisture Wt%	0.07	0.04	0.00
Carbon Wt%	7.15	6.85	6.77
Hydrogen Wt%	0.18	0.20	0.20
Nitrogen Wt%	0.24	0.28	0.26
Sulfur Wt%	0.78	0.87	0.56
pH	11.35	11.40	11.35
Conductivity μMHOS	3400.00	3750.00	3100.00
Background Water			
pH	6.20	6.20	5.60
Conductivity μMHOS	1.40	1.40	1.35
Tons / Day	238.2	237.8	207.0

* Analysis performed by Development Engineering's Testing Laboratory, Anvil Points, Colorado.

APPENDIX TABLE 11. CHEMICAL AND PHYSICAL ANALYSIS OF RETORTED SHALE BEFORE (6/2) AND AFTER (6/22) LEACHING FOR SAMPLE COLLECTED AT THE SURFACE AND 15 cm. HIGH ELEVATION LYSIMETER. 1977.

	Plot H1, 25% slope				Plot H3, 25% slope				Plot H2, 2% slope				Plot H4, 2% slope			
	6/2		6/22		6/2		6/22		6/2		6/22		6/2		6/22	
Analysis	Surface	15 cm	Surface	15 cm	Surface	15 cm	Surface	15 cm	Surface	15 cm	Surface	15 cm	Surface	15 cm	Surface	15 cm
EC mmhos/cm @ 25°C	4.6*	4.4	2.3	2.0	7.6	5.1	2.5	2.2	6.6	5.1	3.4	2.1	5.7	5.1	2.9	2.7
pH	9.1	9.2	9.0	9.1	9.1	9.3	9.0	9.2	9.2	9.5	9.0	9.2	9.2	9.1	9.0	9.2
SAR	5.7	5.4	3.3	2.5	9.6	7.6	2.4	2.6	8.7	8.4	5.0	2.8	8.9	5.9	3.4	2.7
Cation (meq/l)																
Ca	10.8	24.3	1.5	3.9	21.5	24.3	2.2	6.6	8.0	25.1	2.4	8.3	4.2	24.4	2.0	6.0
Mg	26.2	9.5	17.3	14.3	35.9	10.4	22.7	13.8	32.7	3.9	24.1	9.3	29.3	15.1	22.8	20.6
Na	24.2	22.2	10.2	7.4	51.3	31.5	8.5	8.2	39.3	32.0	18.3	8.2	36.7	26.2	12.1	10.0
K	2.6	2.8	0.6	0.7	3.1	3.0	0.5	0.7	3.4	3.7	0.8	0.9	3.1	2.8	0.7	0.8
Anion (meq/l)																
HCO_3	1.4	0.7	2.5	1.1	1.3	0.5	2.3	0.9	1.5	0.7	1.7	0.6	2.0	0.7	2.0	1.2
Cl	5.6	3.8	5.2	3.1	4.8	3.8	3.9	2.8	8.0	4.8	8.4	2.7	6.8	4.2	5.4	3.8
SO_4	51.9	51.9	20.8	20.0	100.0	63.8	25.0	23.8	71.2	56.9	33.4	21.9	61.2	58.8	28.4	30.0
NO_3-N	0.1	0.3	<0.1	<0.1	0.1	0.4	<0.1	0.1	0.1	0.3	<0.1	0.1	0.1	0.4	<0.1	<0.1
Textural Analysis																
Gravel % >2 mm	60.8	74.6	60.2	64.8	58.7	61.4	48.2	56.0	53.1	34.9	50.0	61.6	54.1	45.1	47.6	44.2
Sand % >0.074 mm	22.3	15.2	23.4	20.4	24.3	23.2	29.5	25.5	26.7	38.4	31.0	21.8	26.1	31.8	30.9	32.9
Silt % >0.005 mm	11.7	6.8	10.7	10.2	11.1	11.6	15.0	12.3	15.0	18.8	14.0	11.5	15.6	17.0	15.7	14.5
Clay % <0.005 mm	5.1	3.3	5.6	4.6	5.8	3.8	7.2	6.2	5.2	7.8	5.0	4.9	4.1	6.0	5.7	8.4

* Shale analyses were on a 1:1 extract.

APPENDIX TABLE 12. CHEMICAL AND PHYSICAL ANALYSIS OF RETORTED SHALE BEFORE (6/2) AND AFTER (6/22) LEACHING FOR SAMPLE COLLECTED AT THE SURFACE AND 15 cm. LOW ELEVATION LYSIMETER. 1977

	Plot L1, 25% slope				Plot L3, 25% slope				Plot L2, 2% slope				Plot L4, 2% slope			
	6/2		6/22		6/2		6/22		6/2		6/22		6/2		6/22	
Analysis	Surface	15 cm	Surface	15 cm	Surface	15 cm	Surface	15 cm	Surface	15 cm	Surface	15 cm	Surface	15 cm	Surface	15 cm
EC mmhos/cm @ 25°C	3.5*	4.0	2.0	2.2	5.1	6.1	2.0	2.7	9.2	7.1	2.0	1.8	4.6	5.7	2.0	1.6
pH	9.0	9.1	9.0	9.0	9.0	9.1	9.2	9.3	9.3	9.1	9.1	9.4	9.1	9.3	9.0	9.1
SAR	3.3	2.5	3.5	2.3	6.2	7.7	2.8	3.7	17.0	8.2	3.6	2.7	5.1	8.2	3.4	2.3
Cation (meq/l)																
Ca	1.8	4.6	1.2	2.0	11.2	22.8	1.3	12.2	11.5	21.8	1.3	8.8	21.2	23.6	1.6	1.0
Mg	33.1	40.8	13.0	20.3	28.4	23.1	16.0	8.3	30.3	28.6	12.1	5.0	16.4	12.3	13.7	12.4
Na	13.6	12.0	9.2	7.7	27.8	36.7	8.1	11.9	77.8	41.0	9.4	7.2	22.1	34.0	9.4	6.0
K	1.7	1.4	0.5	0.8	2.6	3.6	0.5	1.2	4.5	3.5	0.7	0.8	2.7	4.0	0.5	0.6
Anion (meq/l)																
HCO_3	3.7	1.5	2.4	2.2	1.2	0.7	3.3	0.5	1.8	1.1	2.4	0.4	0.7	0.7	1.8	2.9
Cl	5.2	1.8	5.8	2.7	3.5	3.1	3.6	3.5	7.4	2.4	4.8	2.4	4.4	3.1	3.9	1.4
SO_4	38.1	50.6	15.8	22.7	63.4	78.1	17.5	30.0	107.8	86.2	16.5	18.1	52.5	69.4	18.1	14.2
NO_3-N	0.1	<0.1	<0.1	<0.1	<0.1	0.4	0.1	0.1	0.1	0.3	0.1	<0.1	0.1	0.4	<0.1	<0.1
Textural Analysis																
Gravel % >2 mm	49.5	52.9	48.1	53.0	61.8	57.6	58.0	35.5	57.8	65.2	56.4	56.8	43.2	68.3	50.0	56.7
Sand % >0.074 mm	29.8	25.9	29.6	27.3	22.1	24.1	23.9	38.0	24.0	19.8	24.8	25.0	31.8	18.4	28.0	24.7
Silt % >0.005 mm	16.1	16.5	16.6	13.1	10.7	13.6	13.0	19.9	13.5	11.1	13.1	12.5	17.6	10.1	15.0	13.4
Clay % <0.005 mm	5.5	4.7	5.7	6.6	5.3	4.7	5.0	6.5	4.6	3.8	5.7	5.6	7.4	3.2	7.0	5.2

* Shale analyses were on a 1:1 extract.

APPENDIX TABLE 13. TEMPERATURES (^oC) OF RETORTED SHALE AT 100 cm DEPTH FOLLOWING FILLING AND COMPACTION OPERATION. HIGH ELEVATION LYSIMETER. 1977.

Date	Retorted Shale	Air	
	^oC	Max ^oC	Min ^oC
4/ 8	79 *	18	-3 †
4/ 9	74	19	-3
4/10	71	19	-1
4/11	68	11	-1
4/12	66	9	-3
4/13	62	9	-6
4/14	59	16	-1
4/15	57	14	-3
4/16	54	18	-3
4/17	51	18	-1
4/18	50	13	-1
4/19	49	10	-3
4/20	48	14	-8
4/21	46	19	-6
4/22	44	22	0
4/23	44	19	1
4/24	44	18	0
4/25	44	18	0
4/26	44	17	1
4/27	43	10	0
4/28	42	16	-1
4/29	41	16	-1
4/30	41	11	-1
5/ 1	41		
5/ 2	41		
5/ 3	39		
5/ 4	37		

* Values are in degree celcius and mean of three thermocouples.

† Maximum and minimum air temperatures from temperature recorder at study site.

APPENDIX TABLE 14. TEMPERATURE (°C) OF RETORTED SHALE AT 100 cm DEPTH IN BOTH HIGH ELEVATION AND LOW ELEVATION LYSIMETERS. 1977

HIGH ELEVATION

	Retorted Shale		20 cm Soil Cover		40 cm Soil Cover		60 cm Soil Cover		80 cm Soil Cover	
Date	H1&H3	H2&H4	H5&H7	H6&H8	H9&H11	H10&H12	H13&H15	H14&H16	H17&H19	H18&H20
3/31	154*†	157	143	143	140	137	135	126	121	123
4/ 8	71	71	71	71	54	51	48	48	37	40
5/20	32	35	26	26	26	24	26	26	24	24

LOW ELEVATION

	Retorted Shale		20 cm Soil Cover		40 cm Soil Cover		60 cm Soil Cover		80 cm Soil Cover	
Date	L1&L3	L2&L4	L5&L7	L6&L8	L9&L11	L10&L12	L13&L15	L14&L16	L17&L19	L18&L20
3/31	204*†	154	121	140	137	121	135	126	121	121
4/ 8	82	87	63	63	60	57	49	49	32	29
5/20	35	32	24	24	24	27	24	21	21	21

* Temperatures were taken with a thermocouple probe.

† Temperatures of retorted shale as it exists is 232°C.

APPENDIX TABLE 15. VEGETATION ANALYSIS (QUADRAT METHOD) FOR RETORTED SHALE AND 20 cm OF SOIL OVER RETORTED SHALE. HIGH ELEVATION LYSIMETER. 25% SLOPE, 1977

	Retorted Shale												20 cm Soil Over Retorted Shale											
	Plot H1						Plot H3						Plot H5						Plot H7					
	Quadrat						Quadrat						Quadrat						Quadrat					
	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6
GRASSES																								
Wheatgrass spp.	7*	2	5	4	4	5	2	4	5	4	4	2	5	6	2	5	4	3	3	6	3	3	3	3
Galleta	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Indian ricegrass	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cheatgrass	-	-	-	-	-	-	1	-	-	-	-	-	-	-	1	1	2	-	-	-	-	-	-	-
SHRUBS																								
Big sagebrush	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Winterfat	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Fourwing saltbush	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
FORBS																								
Penstemon spp.	-	-	1	-	-	-	-	-	-	2	1	2	2	1	-	-	-	-	2	2	-	1	3	-
Utah sweetvetch	-	-	-	1	1	-	-	1	-	2	1	-	-	2	1	-	-	-	-	1	-	-	-	-
Alfalfa	2	-	3	2	6	7	1	4	-	-	-	2	4	3	2	-	4	3	6	-	3	-	1	3
Plantain spp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	2	-	4	-	-	1	-	-	2
Lupine spp.	-	-	-	-	-	- -	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-
White clover	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Weeds spp.	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	2	2	-	2	-	2	2	-
TOTALS	9	2	9	7	11	12	4	9	5	8	7	6	11	12	9	8	12	12	11	12	7	6	9	8
% Vegetation Cover	15	5	10	10	20	15	5	10	5	15	10	10	60	70	75	70	80	75	65	55	60	45	60	75

* Number of individual plants per 20 x 40 cm quadrat randomly placed on each plot.

APPENDIX TABLE 16. VEGETATION ANALYSIS (QUADRAT METHOD) FOR 40 cm AND 60 cm OF SOIL OVER RETORTED SHALE. HIGH ELEVATION LYSIMETER. 25% SLOPE, 1977

	40 cm Soil Over Retorted Shale												60 cm Soil Over Retorted Shale											
	Plot H9						Plot H11						Plot H13						Plot H15					
	Quadrat						Quadrat						Quadrat						Quadrat					
	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6
<u>GRASSES</u>																								
Wheatgrass spp.	4*	-	4	2	6	4	1	2	5	-	4	9	4	-	6	4	6	6	2	6	5	4	4	5
Galletaq	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Indian ricegrass	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cheatgrass	1	2	-	-	-	-	2	-	-	1	2	-	-	-	-	-	2	-	-	-	-	-	-	-
<u>SHRUBS</u>																								
Big sagebrush	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Winterfat	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Fourwing saltbush	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Willow spp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-
<u>FORBS</u>																								
Penstemon spp.	-	-	-	-	3	2	2	-	4	2	-	2	1	1	-	4	2	2	-	-	-	-	-	-
Utah sweetvetch	-	-	1	-	2	-	-	-	-	1	-	1	1	-	1	2	1	2	1	1	1	1	-	1
Alfalfa	3	2	6	4	1	5	-	3	2	6	5	-	-	5	3	3	5	4	2	4	4	2	2	2
Plantain spp.	2	4	-	4	1	-	3	2	1	6	7	8	-	-	-	-	-	-	-	-	-	2	-	3
Lupine spp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
White clover	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-
Weeds spp.	2	2	2	2	1	2	-	3	-	2	-	2	2	2	2	-	-	-	3	-	2	-	-	4
TOTALS	12	10	13	12	14	13	8	11	12	18	18	22	8	8	12	13	16	14	9	12	12	9	6	15
% Vegetation Cover	50	100	75	85	75	80	55	65	70	80	100	90	40	50	50	65	90	70	70	75	70	75	70	55

* Number of individual plants per 20 x 40 cm quadrat randomly placed on each plot.

APPENDIX TABLE 17. VEGETATION ANALYSIS (QUADRAT METHOD) FOR 80 cm OF SOIL OVER RETORTED SHALE AND SOIL CONTROL. HIGH ELEVATION LYSIMETER. 25% SLOPE, 1977

	80 cm Soil Over Retorted Shale												Soil Control											
	Plot H17						Plot H19						Plot H21						Plot H23					
	Quadrat						Quadrat						Quadrat						Quadrat					
	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6
GRASSES																								
Wheatgrass spp.	4*	5	3	4	5	4	2	4	4	4	3	4	4	5	3	5	5	4	4	3	5	3	7	5
Galleta	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Indian ricegrass	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cheatgrass	-	-	-	-	-	-	1	-	2	-	-	-	2	-	1	-	-	-	-	1	-	-	-	-
SHRUBS																								
Big sagebrush	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Winterfat	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Fourwing saltbush	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Willow spp.	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-
FORBS																								
Penstemon spp.	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	2	-	-	2	2	-	2	2
Utah sweetvetch	-	-	-	-	1	2	-	-	-	1	-	2	-	-	-	-	1	-	1	-	2	-	-	1
Alfalfa	7	6	6	8	6	5	-	-	2	2	2	3	-	-	-	3	-	3	-	-	-	-	-	-
Plantain spp.	6	8	10	7	7	3	-	-	-	3	-	-	2	-	4	-	2	-	3	-	-	2	-	-
Lupine spp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
White clover	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Weed spp.	-	-	-	3	-	-	3	2	2	-	3	3	-	-	1	2	-	-	3	2	2	2	-	-
TOTALS	17	19	19	22	19	14	6	6	11	10	10	12	8	5	9	11	10	7	11	8	11	7	9	8
% Vegetation Cover	100	100	100	100	90	80	40	50	65	75	65	70	65	45	55	70	70	60	45	50	60	50	60	50

* Number of individual plants per 20 x 40 cm quadrat randomly placed on each plot.

APPENDIX TABLE 18. VEGETATION ANALYSIS (QUADRAT METHOD) FOR RETORTED SHALE AND 20 cm OF SOIL OVER RETORTED SHALE. HIGH ELEVATION LYSIMETER. 2% SLOPE, 1977

	Retorted Shale												20 cm Soil Over Retorted Shale											
	Plot H2						Plot H4						Plot H6						Plot H8					
	Quadrat						Quadrat						Quadrat						Quadrat					
	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6
GRASSES																								
Wheatgrass spp.	6*	9	4	6	3	7	6	5	6	4	8	5	4	4	6	4	4	4	5	4	7	4	5	4
Galleta	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Indian ricegrass	-	-	-	-	-	-	-	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cheatgrass	-	-	-	-	2	-	-	-	-	-	-	-	-	-	1	1	-	-	-	-	-	-	-	-
SHRUBS																								
Big sagebrush	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Winterfat	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Fourwing saltbush	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	1	-	-	-	-	-	-	-
Willow spp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-
FORBS																								
Penstemon spp.	-	-	-	-	-	1	-	-	-	-	-	1	-	-	-	-	-	-	-	-	1	-	-	-
Utah sweetvetch	-	-	1	-	1	1	-	1	1	-	1	1	-	-	-	1	-		2	-	2	-	-	1
Alfalfa	3	2	2	-	1	-	3	4	2	-	2	-	4	3	2	-	3	-	3	4	2	4	3	2
Plantain spp.	-	-	-	-	-	-	4	3	-	-	-	-	6	3	2	-	-	-	-	-	-	-	2	-
Lupine spp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
White clover	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Weed spp.	-	-	-	-	-	-	-	-	-	2	-	-	1	2	-	-	2	-	-	2	-	2	-	2
TOTALS	9	11	7	6	7	9	13	14	10	6	11	7	15	13	11	6	10	55	11	10	12	10	10	9
% Vegetation Cover	10	20	10	15	10	20	20	15	15	5	20	15	85	75	70	55	60	45	60	60	65	60	70	55

* Number of individual plants per 20 x 40 cm quadrat randomly placed on each plot.

APPENDIX TABLE 19. VEGETATION ANALYSIS (QUADRAT METHOD) FOR 40 cm AND 60 cm OF SOIL OVER RETORTED SHALE. HIGH ELEVATION LYSIMETER. 2% SLOPE, 1977

	40 cm Soil Over Retorted Shale												60 cm Soil Over Retorted Shale											
	Plot H10 Quadrat						Plot H12 Quadrat						Plot H14 Quadrat						Plot H16 Quadrat					
	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6
GRASSES																								
Wheatgrass spp.	4*	2	4	6	4	5	8	6	4	6	4	4	3	2	4	4	4	3	6	5	5	5	6	5
Galleta	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Indian ricegrass	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cheatgrass	-	1	1	-	1	-	-	-	-	1	1	-	-	-	-	-	-	-	-	-	-	1	-	-
SHRUBS																								
Big sagebrush	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Utah sweetvetch	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Fourwing saltbush	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Willow spp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
FORBS																								
Penstemon spp.	-	-	-	-	-	-	2	-	1	-	-	2	-	-	-	-	-	-	-	-	-	2	2	-
Utah sweetvetch	-	-	-	-	-	-	2	2	-	-	1	-	-	-	-	-	-	-	1	1	-	1	-	2
Alfalfa	7	2	-	2	2	-	3	2	2	-	4	3	2	3	4	3	3	5	3	4	-	-	-	3
Plantain spp.	-	4	3	-	-	-	3	2	3	4	-	3	2	4	9	7	8	9	5	2	3	-	2	2
Lupine spp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
White clover	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Weed spp.	-	2	2	2	2	2	-	-	-	2	-	-	-	-	-	-	-	-	2	-	2	2	-	-
TOTALS	11	11	10	10	9	7	18	12	10	13	10	12	7	9	17	14	15	17	17	12	10	11	10	12
% Vegetation Cover	65	70	65	50	55	60	70	65	70	75	70	60	50	65	100	90	100	100	85	70	80	65	65	70

* Number of individual plants per 20 x 40 cm quadrat randomly placed on each plot.

APPENDIX TABLE 20. VEGETATION ANALYSIS (QUADRAT METHOD) FOR 80 cm OF SOIL OVER RETORTED SHALE AND SOIL CONTROL. HIGH ELEVATION LYSIMETER. 2% SLOPE, 1977

	80 cm Soil Over Retorted Shale												Soil Control											
	Plot H18						Plot H20						Plot H22						Plot H24					
	Quadrat						Quadrat						Quadrat						Quadrat					
	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6
<u>GRASSES</u>																								
Wheatgrass spp.	5	3	4	5	6	5	3	4	4	5	8	5	4	6	7	5	4	5	3	3	4	3	6	7
Galleta	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Indian ricegrass	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-
Cheatgrass	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-
<u>SHRUBS</u>																								
Big sagebrush	-	-	-	-	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Winterfat	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Fourwing saltbush	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Willow spp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<u>FORBS</u>																								
Penstemon spp.	-	-	-	-	-	1	-	-	2	-	-	-	-	2	2	-	1	2	3	2	2	2	3	-
Utah sweetvetch	-	-	-	1	-	1	-	-	-	-	1	1	-	-	1	1	1	1	1	1	-	2	2	2
Alfalfa	7	8	6	5	6	3	5	6	-	2	4	3	2	3	-	-	3	-	-	-	-	-	-	-
Plantain spp.	7	7	6	6	4	6	8	8	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Lupine spp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
White clover	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Weeds spp.	-	-	-	-	2	-	-	-	2	-	-	2	2	4	-	2	-	-	2	-	2	-	-	-
TOTALS	19	18	16	17	18*	19	16	18	12	7	13	11	8	15	10	10	9	8	9	6	8	7	11	9
% Vegetation Cover	100	100	90	75	90	85	80	90	60	50	60	60	50	60	75	60	60	55	60	55	70	60	60	75

* Number of individual plants per 20 x 40 cm quadrat randomly placed on each plot.

APPENDIX TABLE 21. VEGETATION ANALYSIS (QUADRAT METHOD) FOR RETORTED SHALE AND 20 cm OF SOIL OVER RETORTED SHALE. LOW ELEVATION LYSIMETER. 25% SLOPE, 1977

	Retorted Shale												20 cm Soil Over Retorted Shale											
	Plot L1						Plot L3						Plot L5						Plot L7					
	Quadrat						Quadrat						Quadrat						Quadrat					
	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6
GRASSES																								
Wheatgrass spp.	2*	3	1	2	3	2	2	1	1	1	-	1	1	2	7	4	3	2	2	1	3	4	2	1
Galleta	3	4	1	1	4	3	3	1	2	3	2	3	2	4	8	5	12	4	4	7	5	4	9	3
Indian ricegrass	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cheatgrass	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SHRUBS																								
Big sagebrush	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Winterfat	-	-	-	-	-	-	-	-	-	-	-	-	1	-	1	2	-	1	1	-	-	-	-	-
Fourwing saltbush	2	2	1	-	2	1	1	-	1	1	2	2	-	-	-	-	-	-	-	2	-	1	-	3
Willow spp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
FORBS																								
Penstemon spp.	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	1	-	-	-	-
Utah sweetvetch	-	-	-	-	-	-	-	-	-	-	-	-	-	3	-	2	1	-	1	-	-	1	-	-
Alfalfa	-	1	-	-	-	2	-	-	3	-	-	2	15	9	4	9	3	2	10	8	10	3	2	3
Plantain spp.	-	-	-	-	-	-	-	-	-	-	-	-	-	1	3	-	4	-	-	-	-	-	-	-
Lupine spp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
White clover	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Weed spp.	1	2	-	-	-	-	-	2	-	-	-	-	2	2	1	-	-	-	2	-	1	1	1	-
TOTALS	8	12	3	3	9	8	6	4	7	5	4	8	21	22	24	22	23	9	20	19	19	14	14	10
% Vegetation Cover	10	10	2	2	7	5	5	2	10	5	2	7	100	90	80	80	75	90	90	100	85	80	80	80

* Number of individual plants per 20 x 40 cm quadrat randomly placed on each plot.

APPENDIX TABLE 22. VEGETATION ANALYSIS (QUADRAT METHOD) FOR 40 cm AND 60 cm OF SOIL OVER RETORTED SHALE. LOW ELEVATION LYSIMETER. 25% SLOPE, 1977

	40 cm Soil Over Retorted Shale												60 cm Soil Over Retorted Shale											
	Plot L9						Plot L11						Plot L13						Plot L15					
	Quadrat						Quadrat						Quadrat						Quadrat					
	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6
<u>GRASSES</u>																								
Wheatgrass spp.	1*	3	7	-	2	3	2	3	3	2	4	2	2	2	3	1	3	-	3	7	4	2	2	4
Galleta	2	4	6	9	7	10	5	7	9	5	9	11	3	4	11	3	9	10	4	5	7	8	9	5
Indian ricegrass	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cheatgrass	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<u>SHRUBS</u>																								
Big sagebrush	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Winterfat	-	-	-	-	-	-	1	-	1	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-
Fourwing saltbush	-	1	-	-	-	-	-	-	-	-	1	-	-	1	1	-	2	2	-	1	-	-	-	-
Willow	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<u>FORBS</u>																								
Penstemon spp.	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-
Utah sweetvetch	-	-	1	-	-	-	1	-	-	-	1	-	1	-	-	-	-	-	1	-	1	1	-	2
Alfalfa	3	2	3	1	3	4	3	5	1	1	3	-	7	6	4	3	3	2	8	9	7	5	-	-
Plantain spp.	8	9	-	3	-	-	2	2	-	-	-	-	7	4	2	-	-	-	1	-	-	3	6	10
Lupine spp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
White clover	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Weed spp.	-	3	3	-	-	-	2	1	-	1	2	1	2	3	-	3	2	1	2	-	-	2	1	-
TOTALS	14	22	20	14	12	17	16	18	14	9	20	14	22	20	21	10	19	15	21	22	19	21	19	21
% Vegetation Cover	95	80	85	80	85	75	70	75	80	60	90	85	90	90	85	65	80	90	80	90	70	85	80	100

* Number of individual plants per 20 x 40 cm quadrat randomly placed on each plot.

APPENDIX TABLE 23. VEGETATION ANALYSIS (QUADRAT METHOD) FOR 80 cm OF SOIL OVER RETORTED SHALE AND SOIL CONTROL. LOW ELEVATION LYSIMETER. 25% SLOPE, 1977

	80 cm of Soil Over Retorted Shale												Soil Control											
	Plot L17						Plot L19						Plot L21						Plot L23					
	Quadrat						Quadrat						Quadrat						Quadrat					
	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6
GRASSES																								
Wheatgrass spp.	4*	2	2	4	1	3	2	3	5	2	2	5	2	3	3	4	2	2	3	2	8	3	4	2
Galleta	3	6	4	8	5	9	3	5	9	7	6	11	4	7	6	5	6	5	3	4	7	6	7	10
Indian ricegrass	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	1	-	-	-	-	-	-	-	-
Cheatgrass	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-
SHRUBS																								
Big sagebrush	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Winterfat	-	1	-	-	1	-	1	2	-	-	-	-	-	2	1	1	-	3	-	-	-	1	1	2
Fourwing saltbush	-	2	-	2	-	3	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	2	-
Willow spp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	2	1	-	-	-
FORBS																								
Penstemon spp.	-	-	-	-	-	-	-	-	-	-	1	1	-	-	-	-	-	-	-	-	-	-	-	-
Utah sweetvetch	-	2	-	-	1	-	1	1	1	-	1	-	2	-	-	-	-	1	-	1	-	-	1	-
Alfalfa	2	10	-	10	7	3	8	3	7	3	4	2	2	-	1	2	1	-	2	3	3	4	3	3
Plantain spp.	7	-	4	-	2	9	-	-	-	3	-	2	-	-	-	-	-	-	-	-	-	-	-	-
Lupine spp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
White clover	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Weed spp.	2	-	1	1	-	3	-	2	2	1	2	-	-	1	-	2	-	-	-	2	1	-	-	-
TOTALS	18	23	11	25	17	30	15	16	24	16	16	21	11	13	11	15	9	12	9	12	20	14	19	17
% Vegetation Cover	85	70	75	90	70	85	90	80	90	85	80	90	70	80	80	80	75	80	60	65	80	75	85	90

* Number of individual plants per 20 x 40 cm quadrat randomly placed on each plot.

APPENDIX TABLE 24. VEGETATION ANALYSIS (QUADRAT METHOD) FOR RETORTED SHALE AND 20 cm OF SOIL OVER RETORTED SHALE. LOW ELEVATION LYSIMETER. 2% SLOPE, 1977

	Retorted Shale												20 cm Soil Over Retorted Shale											
	Plot L2						Plot L4						Plot L6						Plot L8					
	Quadrat						Quadrat						Quadrat						Quadrat					
	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6
GRASSES																								
Wheatgrass spp.	5*	7	6	1	3	3	3	2	3	5	2	3	3	4	4	5	3	4	3	2	3	3	3	3
Galleta	2	1	3	1	2	1	4	3	4	3	6	4	6	7	5	7	4	6	5	4	3	5	4	5
Indian ricegrass	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	1	-	-	1
Cheatgrass	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-
SHRUBS																								
Big sagebrush	-	-	-	-	-	- -	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Winterfat	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	1	-	2	-	-	-	1	-
Fourwing saltbush	1	2	1	-	1	1	-	2	-	-	1	1	-	-	1	2	2	2	1	-	1	-	1	1
Willow spp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
FORBS																								
Penstemon spp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Utah sweetvetch	-	-	-	-	1	1	-	-	-	-	-	-	2	1	4	1	1	2	1	-	1	1	1	1
Alfalfa	-	-	-	-	1	-	1	-	-	1	-	-	3	5	7	6	4	3	3	1	-	1	2	2
Plantain spp.	-	-	-	-	2	1	-	-	-	-	-	-	5	2	3	2	3	1	2	-	1	2	-	1
Lupine spp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
White clover	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Weed spp.	2	-	-	-	-	-	-	1	-	-	1	1	-	-	-	-	-	-	1	2	-	-	2	-
TOTALS	10	10	10	2	10	7	8	8	7	9	10	9	19	19	24	23	18	18	19	9	11	12	14	14
% Vegetation Cover	5	5	5	1	10	7	5	5	2	7	7	5	75	70	80	75	75	75	70	60	70	65	75	70

* Number of individual plants per 20 x 40 cm quadrat randomly placed on each plot.

APPENDIX TABLE 25. VEGETATION ANALYSIS (QUADRAT METHOD) FOR 40 cm AND 60 cm OF SOIL OVER RETORTED SHALE. LOW ELEVATION LYSIMETER. 2% SLOPE, 1977

	40 cm Soil Over Retorted Shale												60 cm Soil Over Retorted Shale											
	Plot L10						Plot L12						Plot L14						Plot L16					
	Quadrat						Quadrat						Quadrat						Quadrat					
	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6
GRASSES																								
Wheatgrass spp.	2*	2	3	2	3	2	4	4	2	4	3	2	1	2	2	4	2	2	2	3	2	4	1	4
Galleta	3	3	4	5	3	6	4	6	4	3	3	4	4	5	3	7	5	8	6	5	2	2	1	4
Indian ricegrass	-	-	-	-	-	1	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-
Cheatgrass	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	1	4	3
SHRUBS																								
Big sagebrush	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Winterfat	1	-	-	-	2	-	-	-	1	-	1	-	-	-	1	-	1	-	-	-	-	-	-	1
Fourwing saltbush	-	-	1	1	-	1	-	2	-	-	-	-	-	1	-	-	2	-	-	1	1	-	1	-
Willow spp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
FORBS																								
Penstemon spp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	1	-	-	-	-	-
Utah sweetvetch	-	1	1	2	-	1	2	1	-	-	1	1	-	1	-	1	-	1	2	-	1	-	-	-
Alfalfa	3	4	1	-	2	2	2	3	3	2	3	2	7	3	3	4	2	3	1	4	2	2	2	2
Plantain spp.	2	-	-	-	1	-	-	-	2	2	2	-	2	1	1	-	4	-	-	4	-	-	-	3
Lupine spp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
White clover	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Weed spp.	-	2	2	-	-	-	1	1	-	-	-	1	-	-	-	2	2	-	2	2	-	-	-	1
TOTALS	11	12	12	10	11	13	13	15	12	11	13	10	14	13	11	19	18	14	14	19	11	9	9	18
% Vegetation Cover	70	65	60	70	75	85	75	75	65	80	70	75	85	85	70	85	80	90	75	85	95	60	100	100

* Number of individual plants per 20 x 40 cm quadrat randomly placed on each plot.

APPENDIX TABLE 26. VEGETATION ANALYSIS (QUADRAT METHOD) FOR 80 cm OF SOIL OVER RETORTED SHALE AND SOIL CONTROL. LOW ELEVATION LYSIMETER. 2% SLOPE, 1977

	80 cm Soil Over Retorted Shale											
	Plot L18						Plot L20					
	Quadrat						Quadrat					
	1	2	3	4	5	6	1	2	3	4	5	6
GRASSES												
Wheatgrass spp.	2*	2	1	1	2	3	3	3	2	3	2	2
Galleta	3	7	3	3	5	9	5	12	5	4	5	6
Indian ricegrass	-	-	-	-	-	-	-	-	-	-	-	-
Cheatgrass	-	-	1	1	2	2	-	-	-	-	-	-
SHRUBS												
Big sagebrush	-	-	-	-	-	-	-	-	-	-	-	-
Winterfat	-	-	-	-	1	-	1	-	-	1	1	-
Fourwing saltbush	1	-	2	-	-	-	-	-	-	-	1	-
Willow spp.	-	-	-	-	-	-	-	-	-	-	-	-
FORBS												
Penstemon spp.	-	1	-	-	-	-	2	-	-	1	-	1
Utah sweetvetch	1	1	-	-	-	1	1	-	1	1	1	1
Alfalfa	3	-	-	-	2	2	2	1	3	3	2	4
Plantain spp.	-	-	1	-	-	3	-	-	-	-	-	-
Lupine spp.	-	-	-	-	-	-	-	-	-	-	-	-
White clover	-	-	-	-	-	-	-	-	-	-	-	-
Weed spp.	2	1	-	-	-	-	2	1	-	-	-	-
Halogeton	-	-	-	-	-	-	-	-	-	-	-	-
TOTALS	12	12	8	5	12	20	16	17	11	13	12	14
% Vegetation Cover	60	85	85	55	90	95	80	100	80	70	75	85

	Soil Control											
	Plot L22						Plot L24					
	Quadrat						Quadrat					
	1	2	3	4	5	6	1	2	3	4	5	6
GRASSES												
Wheatgrass spp.	4	4	2	3	2	4	2	2	5	5	2	5
Galleta	10	4	6	4	3	5	4	16	7	9	7	7
Indian ricegrass	-	-	-	-	-	-	-	-	-	-	-	-
Cheatgrass	-	3	-	-	1	-	-	-	-	2	-	-
SHRUBS												
Big sagebrush	-	-	2	-	-	-	-	-	-	-	-	-
Winterfat	-	1	-	-	1	1	1	1	-	-	1	1
Fourwing saltbush	-	2	-	-	1	1	-	-	-	-	1	-
Willow spp.	-	-	-	-	-	-	-	-	-	-	-	-
FORBS												
Penstemon spp.	-	-	-	-	-	-	-	1	1	-	-	-
Utah sweetvetch	1	-	2	-	2	-	2	2	2	1	-	2
Alfalfa	-	2	3	4	-	3	-	-	3	3	-	3
Plantain spp.	2	-	-	2	-	3	2	-	-	-	1	-
Lupine spp.	-	-	-	-	-	-	-	-	-	-	-	-
White clover	-	-	-	-	-	-	-	-	-	-	-	-
Weed spp.	2	-	2	4	3	-	2	-	1	-	-	1
Halogeton	-	-	-	-	-	-	-	-	-	-	-	1
TOTALS	19	16	17	17	13	17	13	22	19	20	12	20
% Vegetation Cover	95	85	80	95	80	95	80	85	80	85	65	75

* Number of individual plants per 20 x 40 cm quadrat randomly placed on each plot.

APPENDIX TABLE 27. MOISTURE MEASUREMENTS (% BY VOLUME) OF RETORTED SHALE. HIGH ELEVATION LYSIMETER. 25% SLOPE, 1977

PLOT H1.

Depth cm	Reading Dates																					
	6/5	6/6	6/7	6/8	6/9	6/10	6/11	6/12	6/13	6/14	6/15	6/17	6/21	6/29	7/1	7/6	7/7	7/11	7/13	7/22	8/16	9/1
15	44.4	46.8	49.2	42.8	43.6	42.8	48.4	45.2	44.4	39.7	38.9	34.2	38.1	38.1	40.5	38.9	45.2	40.5	38.9	39.7	35.7	38.1
30	48.4	47.6	49.2	49.2	49.9	49.9	49.2	49.9	48.4	46.0	47.6	41.3	43.6	44.4	46.8	44.4	47.6	42.1	42.1	42.8	31.8	38.1
45	45.2	47.6	46.0	42.8	46.8	45.2	46.0	45.2	46.0	44.4	42.8	38.9	38.1	42.1	42.8	40.5	40.5	46.8	40.5	40.5	31.0	32.0
60	45.2	47.6	48.4	48.4	49.2	47.6	50.7	48.4	49.2	44.4	43.6	38.1	38.9	40.5	42.8	38.9	38.9	40.5	37.3	38.9	31.0	32.0
75	15.2	43.6	43.6	44.4	46.0	45.2	46.0	46.0	46.0	42.1	38.9	34.9	37.3	38.1	40.5	36.5	38.9	37.3	35.7	36.5	31.8	31.0
90	7.3	36.5	42.1	41.3	42.9	42.9	42.1	43.6	42.8	38.9	39.7	36.5	38.1	38.9	40.5	40.5	39.7	35.7	37.3	37.3	35.7	31.0
105	5.7	19.9	44.4	47.6	48.4	49.2	49.9	47.6	48.4	45.2	47.6	43.6	45.2	38.1	44.4	42.8	42.8	36.5	46.0	43.6	39.7	42.8
120	5.7	8.2	38.1	50.7	53.1	54.7	53.1	53.9	53.9	50.7	51.5	43.6	53.1	50.7	50.7	49.2	56.3	42.8	49.9	50.7	39.7	42.8
135	5.7	7.3	38.1	49.2	52.3	53.1	53.1	54.7	57.0	50.7	53.9	51.5	53.1	52.3	55.5	49.2	56.3	47.6	52.3	50.7	39.7	46.0
150	5.7	7.3	38.1	49.2	52.3	53.1	53.1	54.7	51.0	50.7	53.9	51.5	53.1	52.3	55.5	49.2	56.3	50.7	52.3	50.7	39.7	46.0

Plot H3.

Depth cm	Reading Dates																					
	6/5	6/6	6/7	6/8	6/9	6/10	6/11	6/12	6/13	6/14	6/15	6/17	6/21	6/29	7/1	7/6	7/7	7/11	7/13	7/22	8/16	9/1
15	49.2	52.3	53.9	50.7	50.7	55.5	50.7	53.1	53.1	53.9	49.2	44.4	46.0	49.9	51.5	48.4	48.4	49.2	48.4	51.5	39.7	45.2
30	52.3	55.5	55.5	54.7	53.9	57.8	53.1	55.5	56.3	57.0	52.3	49.9	51.5	52.3	51.5	53.1	53.1	49.2	49.9	51.5	35.7	31.8
45	44.4	46.8	46.8	50.7	48.4	52.3	44.4	49.9	48.4	49.9	38.1	41.3	42.8	43.6	46.8	44.4	44.4	42.8	44.4	43.6	31.8	30.2
60	38.9	40.5	40.5	42.8	39.7	43.6	39.7	42.8	41.3	42.8	37.3	35.7	35.7	38.1	41.3	38.1	39.7	36.5	43.6	35.7	31.8	30.1
75	36.5	39.7	39.7	40.5	40.5	44.4	31.0	39.7	40.5	42.8	39.7	34.2	34.2	34.9	34.9	39.7	35.7	34.9	41.3	34.9	31.0	31.3
90	36.5	42.1	42.1	42.1	41.3	45.2	40.5	42.8	42.8	42.1	42.1	35.7	35.7	38.1	36.5	38.1	38.1	34.9	36.5	36.5	32.6	30.2
105	24.7	43.6	44.4	45.2	45.2	49.2	42.8	46.8	46.0	48.4	46.0	49.7	40.5	41.3	42.8	42.1	42.1	38.1	39.7	41.3	36.5	35.6
120	12.1	42.1	46.8	50.7	49.9	52.3	48.4	49.9	--	51.5	64.2	45.2	44.4	44.4	45.2	45.2	47.6	38.1	46.0	45.2	36.5	38.1
135	8.2	35.7	47.6	51.5	51.5	53.9	48.4	54.7	52.3	54.7	64.2	46.0	46.8	47.6	46.0	48.4	47.6	38.1	46.0	48.4	36.5	38.1
150	8.2	35.7	47.6	51.5	51.5	53.9	48.4	54.7	52.3	54.7	64.2	46.0	46.8	47.6	46.0	48.4	47.6	38.1	38.9	48.4	36.5	41.3

APPENDIX TABLE 28. MOISTURE MEASUREMENTS (% BY VOLUME) OF 20 cm OF SOIL OVER RETORTED SHALE. HIGH ELEVATION LYSIMETER. 25% SLOPE, 1977

PLOT H5.

Depth cm	Reading Dates																					
	6/5	6/5	6/7	6/8	6/9	6/10	6/11	6/12	6/13	6/14	6/15	6/17	6/21	6/29	7/1	7/6	7/7	7/11	7/13	7/22	8/16	9/1
15	49.9	48.4	53.9	47.6	47.6	47.6	53.1	53.9	47.6	48.4	42.8	42.8	40.5	41.3	53.1	41.3	41.3	47.6	39.7	41.3	38.1	37.3
30	49.9	53.1	54.8	51.5	55.5	55.5	53.1	59.4	51.5	55.5	52.3	55.5	48.4	53.1	53.1	51.5	51.5	47.6	48.4	48.4	36.5	42.8
45	48.4	51.5	51.5	52.3	50.7	52.3	49.9	56.3	50.7	50.7	49.2	49.2	47.6	49.9	51.5	49.9	47.6	47.6	50.7	47.6	38.1	42.4
60	35.7	49.2	49.2	38.1	51.5	53.9	49.9	56.3	49.9	52.3	49.9	49.9	47.6	49.2	51.5	47.6	47.6	48.4	48.4	47.6	31.8	40.7
75	12.1	27.0	32.6	21.5	37.3	38.1	35.7	42.1	37.3	38.1	37.3	37.3	34.2	35.7	38.9	34.9	36.5	46.0	53.1	34.9	31.0	34.2
90	6.5	8.9	17.6	19.2	24.7	27.0	25.5	28.6	26.3	29.4	25.5	24.7	23.9	23.9	26.3	27.0	24.7	24.7	38.1	22.4	17.6	34.2
105	6.5	5.0	11.3	12.8	22.4	23.2	23.2	24.7	21.5	23.2	22.4	23.9	22.4	23.2	24.7	22.4	19.9	21.5	27.0	23.2	23.2	34.2
120	5.7	5.7	6.5	9.7	27.8	28.6	33.4	31.0	29.4	30.2	25.5	28.6	27.8	28.6	26.3	31.0	36.5	28.6	24.7	30.2	23.2	34.2
135	5.0	5.0	6.5	9.7	35.7	38.9	38.9	43.6	38.9	40.5	39.7	38.1	38.1	39.7	34.9	31.0	36.5	35.7	20.7	36.5	23.2	34.2
150	5.0	5.0	6.5	9.7	35.7	38.9	38.9	43.6	38.9	40.5	39.7	38.1	38.1	39.7	34.9	31.0	36.5	35.7	24.7	36.5	23.2	34.2

Plot H7.

Depth cm	Reading Dates																					
	6/5	6/6	6/7	6/8	6/9	6/10	6/11	6/12	6/13	6/14	6/15	6/17	6/21	6/29	7/1	7/6	7/7	7/11	7/13	7/22	8/16	9/1
15	50.7	56.3	53.9	56.3	56.3	56.3	53.9	56.3	59.4	53.9	53.1	52.3	49.2	51.5	51.5	48.4	48.4	46.0	53.9	53.1	39.7	41.3
30	49.2	53.1	52.3	54.7	54.7	55.5	52.3	53.9	57.8	49.9	51.5	48.4	48.4	52.3	53.1	46.8	51.5	48.4	46.0	49.2	38.1	38.1
45	43.6	49.9	51.5	52.3	53.1	52.3	48.4	52.3	65.8	50.7	50.7	47.6	47.6	49.9	51.5	45.2	47.6	49.2	47.6	47.6	36.5	32.6
60	19.2	38.1	46.0	47.6	46.0	48.4	46.0	47.6	50.7	44.4	46.0	44.4	44.4	46.0	49.2	42.8	45.2	47.6	46.0	45.2	31.8	37.3
75	7.3	14.4	38.9	42.8	44.4	43.6	39.7	42.8	46.0	42.1	42.1	41.3	40.5	40.5	42.8	34.9	41.3	41.3	39.7	41.3	32.6	39.7
90	5.0	6.5	20.7	40.5	43.6	43.6	45.2	43.6	47.6	41.3	42.8	39.7	40.5	42.8	42.8	38.9	42.1	40.2	39.7	41.3	33.9	39.7
105	5.0	6.5	8.2	32.6	48.4	49.2	46.8	46.8	51.5	45.2	44.4	42.1	41.3	44.4	42.8	40.5	41.3	42.1	42.1	41.3	34.9	39.7
120	5.0	5.0	5.7	8.9	48.4	48.4	46.0	46.8	49.9	46.0	45.2	41.3	41.3	42.8	42.8	38.9	41.3	45.7	42.1	41.3	35.7	39.7
135	4.2	0.8	5.0	5.0	47.6	51.5	46.0	50.7	52.3	45.2	46.8	42.8	44.4	45.2	45.2	40.5	42.8	46.5	43.6	42.8	35.7	39.7
150	4.2	0.8	5.0	5.0	47.6	51.5	46.0	50.7	52.3	45.2	46.8	42.8	44.4	45.2	45.2	40.5	42.8	46.5	43.6	42.8	35.7	39.7

APPENDIX TABLE 29. MOISTURE MEASUREMENTS (% BY VOLUME) OF 40 cm OF SOIL OVER RETORTED SHALE. HIGH ELEVATION LYSIMETER. 25% SLOPE, 1977

PLOT H9.

Depth cm	Reading Dates										
	6/17	6/21	6/29	7/1	7/6	7/7	7/11	7/13	7/22	8/16	9/1
15	21.5	38.1	45.2	48.4	40.5	43.6	51.5	42.1	46.8	42.8	41.3
30	31.0	42.1	53.1	55.5	50.7	51.5	51.5	52.3	53.1	42.8	45.2
45	32.6	34.2	52.3	55.5	48.4	56.3	49.9	53.9	56.3	42.8	46.8
60	33.4	33.4	53.9	56.3	46.8	51.5	49.9	56.3	53.1	42.8	34.9
75	31.8	36.6	49.9	53.1	50.7	49.2	49.2	52.3	54.7	42.8	39.7
90	18.4	20.7	21.5	46.8	48.4	46.0	41.3	50.7	52.3	42.1	39.7
105	8.9	8.9	8.9	13.6	38.9	34.2	38.6	43.6	46.8	34.9	39.7
120	6.5	7.3	7.3	9.7	19.2	17.6	26.0	31.0	36.5	38.1	39.7
135	7.3	6.5	5.7	7.3	8.9	9.7	9.7	16.8	32.6	41.3	39.7
150	7.3	6.5	5.7	7.3	8.9	9.7	9.7	9.7	23.9	41.3	39.7

Plot H11.

Depth cm	Reading Dates										
	6/17	6/21	6/29	7/1	7/6	7/7	7/11	7/13	7/22	8/16	9/1
15	23.2	42.1	50.7	53.1	48.4	55.5	52.3	51.5	52.3	42.8	42.1
30	28.6	41.3	51.5	53.1	49.9	49.2	55.2	49.2	53.1	42.1	34.2
45	26.3	28.6	44.4	48.4	42.8	44.4	41.3	46.0	47.6	34.2	33.4
60	16.8	17.6	31.0	41.3	37.3	35.7	32.6	38.9	48.4	34.2	35.7
75	12.1	11.3	14.4	23.2	28.6	26.3	30.2	31.0	32.6	34.9	38.9
90	10.5	9.7	8.9	12.1	20.7	12.8	16.0	20.7	34.9	34.9	38.9
105	7.3	8.2	7.3	9.7	9.7	8.2	9.7	10.5	30.2	34.9	38.9
120	6.5	6.5	6.5	6.5	5.0	8.2	7.3	8.9	16.0	34.9	38.9
135	7.3	6.5	5.7	6.5	5.0	8.2	7.3	10.5	13.6	34.9	38.9
150	7.3	6.5	5.7	6.5	5.0	8.2	7.3	10.5	13.6	34.9	38.9

APPENDIX TABLE 30. MOISTURE MEASUREMENTS (% BY VOLUME) OF 60 cm OF SOIL OVER RETORTED SHALE. HIGH ELEVATION LYSIMETER. 25% SLOPE, 1977.

PLOT H13

Depth cm	Reading Dates										
	6/17	6/21	6/29	7/1	7/6	7/7	7/11	7/13	7/22	8/16	9/1
15	17.6	39.7	46.8	49.2	46.0	44.4	51.5	52.3	51.5	42.8	42.8
30	29.4	43.6	53.1	51.5	49.9	50.7	48.4	54.7	55.5	40.5	41.3
45	30.2	39.7	50.7	53.1	48.4	49.2	44.4	52.3	51.5	41.3	40.5
60	25.5	27.8	45.2	48.4	44.4	42.8	45.2	47.6	47.6	37.3	38.1
75	16.8	18.4	33.4	49.2	46.0	43.6	38.9	46.0	45.2	40.5	37.3
90	9.7	8.9	12.1	30.2	43.6	36.5	30.2	41.3	41.3	41.3	37.3
105	6.5	6.5	7.3	9.7	36.5	21.5	26.0	31.8	41.3	39.7	37.3
120	8.2	8.2	8.2	9.7	16.8	11.3	19.7	17.6	32.6	39.7	37.3
135	7.3	8.2	7.3	7.3	11.3	7.3	8.9	12.1	18.4	39.7	37.3
150	7.3	6.5	7.3	9.7	11.3	7.3	8.9	8.9	12.1	39.7	37.3

Plot H15.

Depth cm	Reading Dates										
	6/17	6/21	6/29	7/1	7/6	7/7	7/11	7/13	7/22	8/16	9/1
15	22.4	42.1	50.7	53.1	49.2	49.9	49.2	50.7	53.1	38.9	42.1
30	29.4	35.7	53.9	55.5	46.8	51.5	49.9	51.5	55.5	38.9	46.8
45	30.2	29.4	52.3	57.8	50.7	50.7	59.2	50.7	52.3	38.9	46.8
60	25.5	27.0	47.6	49.9	47.6	48.4	52.1	49.9	51.5	38.9	46.8
75	16.0	16.0	22.4	41.3	44.4	49.2	47.0	49.9	53.1	38.9	35.7
90	13.6	12.8	13.6	16.0	33.4	39.7	39.7	42.8	45.2	34.9	35.7
105	10.5	11.3	10.5	12.1	12.8	19.9	26.5	30.2	35.7	37.3	35.7
120	6.5	7.3	6.5	7.3	7.3	7.3	6.5	12.1	18.4	35.7	35.7
135	5.7	5.7	5.7	7.3	5.0	6.5	6.5	8.2	8.2	35.7	35.7
150	5.7	5.7	5.7	7.3	7.3	6.5	6.5	8.9	8.2	35.7	35.7

APPENDIX TABLE 31. MOISTURE MEASUREMENTS (% BY VOLUME) OF 80 cm OF SOIL OVER RETORTED SHALE. HIGH ELEVATION LYSIMETER. 25% SLOPE, 1977

PLOT H17.

Depth cm	Reading Dates										
	6/17	6/21	6/29	7/1	7/6	7/7	7/11	7/13	7/22	8/16	9/1
15	19.2	34.9	46.8	43.6	46.8	53.1	49.2	48.4	52.3	43.6	38.1
30	31.8	42.1	51.5	53.1	51.5	52.3	49.9	50.7	50.7	45.2	44.4
45	32.6	35.7	53.9	57.8	53.1	55.5	51.5	53.9	53.1	45.2	44.4
60	33.4	34.2	52.3	53.1	52.3	56.3	57.6	54.7	56.3	45.2	42.1
75	31.0	28.6	45.2	51.5	49.2	51.5	57.6	50.7	51.5	45.2	23.2
90	20.7	18.4	27.0	42.8	45.2	46.8	51.3	53.1	49.2	44.4	23.2
105	9.7	8.9	9.7	19.9	36.5	38.9	36.3	44.4	42.1	45.2	23.2
120	6.5	5.7	6.5	9.7	13.6	15.2	19.7	31.8	36.5	38.1	23.2
135	5.7	5.7	5.0	8.2	5.7	7.3	8.9	9.7	16.0	38.1	23.2
150	5.7	5.7	5.0	8.2	5.7	7.3	8.9	8.9	16.0	38.1	23.2

Plot H19.

Depth cm	Reading Dates										
	6/17	6/21	6/29	7/1	7/6	7/7	7/11	7/13	7/22	8/16	9/1
15	15.2	35.7	42.8	51.5	42.8	49.9	46.0	44.4	46.8	38.9	39.7
30	25.5	40.5	49.2	51.5	53.1	51.5	48.4	48.4	49.2	38.9	46.8
45	29.4	33.4	49.2	51.5	53.9	53.9	59.2	50.7	53.1	38.1	40.5
60	23.2	23.2	45.2	51.5	51.5	55.5	56.8	53.1	51.5	34.2	38.9
75	16.8	16.8	27.0	47.6	49.9	56.3	51.3	47.6	45.2	34.9	30.2
90	11.3	11.3	27.0	22.4	42.8	41.3	40.2	44.4	42.8	32.6	30.2
105	7.3	7.3	11.3	9.7	20.7	23.2	22.1	39.4	41.3	29.4	30.2
120	5.7	5.7	7.3	7.3	8.2	22.6	24.7	22.1	26.3	29.4	30.2
135	5.0	5.0	5.0	7.3	5.7	8.2	6.5	6.5	9.7	29.4	30.2
150	5.0	5.0	5.0	7.3	5.7	8.2	6.5	5.7	9.7	29.4	30.2

APPENDIX TABLE 32. MOISTURE MEASUREMENTS (% BY VOLUME) FOR SOIL CONTROL. HIGH ELEVATION LYSIMETER. 25% SLOPE, 1977

PLOT H21.

Depth cm	Reading Dates										
	6/17	6/21	6/29	7/1	7/6	7/7	7/11	7/13	7/22	8/16	9/1
15	9.2	20.5	30.5	34.2	32.5	36.2	38.5	33.0	32.0	30.5	29.0
30	18.5	25.0	29.0	38.5	35.7	39.5	50.7	36.2	40.0	30.5	34.5
45	19.2	20.0	36.0	40.0	37.2	39.5	50.7	38.0	40.0	30.5	25.2
60	20.5	20.2	37.2	50.7	38.7	50.0	38.2	39.5	50.7	30.5	35.7
75	21.7	22.5	38.0	50.2	40.5	60.7	36.7	60.2	50.2	30.5	36.2
90	20.0	21.0	37.5	40.0	37.2	50.2	35.2	39.5	40.0	30.5	36.2
105	21.2	20.5	23.5	35.2	35.7	39.5	33.5	39.5	40.0	30.5	36.2
120	21.7	21.7	20.7	32.0	34.2	36.2	33.5	36.2	38.5	30.5	36.2
135	16.7	21.7	22.0	25.5	29.5	33.0	33.5	38.0	38.5	30.5	36.2
150	16.7	22.5	22.0	24.0	29.5	33.0	33.5	36.2	40.0	30.5	36.2

Plot H23.

Depth cm	Reading Dates									
	6/17	6/21	6/29	7/1	7/6	7/7	7/13	7/22	8/16	9/1
15	6.2	13.2	26.5	28.0	28.7	37.5	35.2	38.2	27.5	27.7
30	15.2	21.5	34.5	36.7	35.2	36.0	38.2	50.7	27.5	40.5
45	19.0	18.7	35.7	60.5	40.0	36.7	60.5	60.5	27.5	37.0
60	18.5	18.7	28.7	40.0	39.2	39.2	40.0	40.7	27.5	36.5
75	20.5	20.0	20.0	35.2	40.0	40.0	38.2	40.0	27.5	30.5
90	22.0	20.5	20.0	25.5	36.7	40.7	35.2	39.2	27.5	30.5
105	20.0	20.5	18.7	17.5	25.7	40.0	23.2	30.2	27.5	30.5
120	16.7	16.7	16.0	17.5	17.5	33.5	20.0	28.7	27.5	30.5
135	19.0	18.7	17.2	17.5	16.0	31.2	20.0	28.7	27.5	30.5
150	19.0	18.7	17.2	17.5	16.0	31.2	20.0	28.7	27.5	30.5

APPENDIX TABLE 33. MOISTURE MEASUREMENTS (% BY VOLUME) OF RETORTED SHALE. HIGH ELEVATION LYSIMETER. 2% SLOPE, 1977.

PLOT H2.

Depth cm	Reading Dates																					
	6/5	6/6	6/7	6/8	6/9	6/10	6/11	6/12	6/13	6/14	6/15	6/17	6/21	6/29	7/1	7/6	7/7	7/11	7/13	7/22	8/16	8/21	9/1
15	45.2	48.4	31.0	30.2	32.6	31.8	41.1	49.9	34.2	36.5	28.6	44.4	21.5	25.5	17.6	11.3	20.7	46.0	16.8	16.0	42.8	18.4	40.5
30	42.8	52.3	48.4	51.5	52.3	51.5	52.3	43.6	48.4	49.9	45.2	35.7	42.8	47.6	46.8	50.7	48.4	42.1	45.2	45.2	35.7	42.8	40.5
45	37.6	47.6	47.6	44.7	43.6	46.0	52.3	44.4	43.6	42.9	40.5	35.7	35.7	40.5	40.5	46.0	39.7	38.9	39.7	36.5	37.3	37.3	35.7
60	24.4	44.4	43.6	46.0	46.0	46.8	53.1	49.2	45.2	44.4	41.3	41.3	35.7	43.6	40.8	48.4	43.6	42.1	40.5	36.5	39.7	37.3	35.7
75	6.8	49.9	48.4	50.7	49.2	50.7	53.9	50.7	51.5	49.9	45.2	45.2	41.3	43.6	46.0	46.8	42.8	45.2	42.1	40.5	42.8	39.7	41.3
90	6.5	49.9	50.7	49.9	51.5	52.3	52.3	51.5	49.9	48.4	47.6	45.2	45.2	48.4	50.7	50.7	48.4	49.9	46.8	46.0	45.2	42.8	41.3
105	5.7	49.9	50.7	49.9	51.5	53.9	53.1	53.1	49.9	51.5	49.9	40.5	45.2	52.3	50.7	55.1	51.5	46.0	50.7	47.6	42.8	46.8	43.6
120	5.7	49.9	50.7	49.9	51.5	53.9	53.1	53.1	49.9	51.5	49.9	40.5	45.2	44.4	49.2	61.0	48.4	45.2	48.4	44.4	42.1	44.4	43.6
135	5.7	49.9	50.7	49.9	51.5	53.9	53.1	53.1	49.9	51.5	49.9	40.5	45.2	44.4	46.8	50.7	46.0	43.6	48.4	44.4	42.1	42.9	39.7
150	5.7	49.9	50.7	49.9	51.5	53.9	53.1	53.1	49.95	51.5	49.9	40.5	45.2	44.4	46.8	56.3	45.2	43.6	46.8	42.8	42.1	42.1	40.5

Plot H4.

Depth cm	Reading Dates																					
	6/5	6/6	6/7	6/8	6/9	6/10	6/11	6/12	6/13	6/14	6/15	6/17	6/21	6/29	7/1	7/6	7/7	7/11	7/13	7/22	8/16	8/22	9/1
15	51.5	44.4	44.4	44.4	43.6	44.4	45.2	46.0	46.0	46.8	40.5	34.2	32.2	40.5	40.5	39.7	40.5	34.2	44.4	42.8	34.9	34.9	32.6
30	38.1	38.1	38.9	39.7	40.5	39.7	39.7	42.1	42.1	38.9	38.1	34.9	34.9	38.9	38.9	35.7	38.9	37.8	39.7	38.9	25.5	31.0	32.6
45	31.8	30.2	28.6	30.2	29.4	27.8	32.6	31.0	31.0	29.4	29.4	23.9	24.7	26.3	43.6	25.5	27.8	26.0	39.7	26.3	17.6	22.4	16.8
60	16.0	20.7	19.9	20.7	21.5	21.5	23.9	21.5	22.4	23.2	19.9	18.4	17.6	19.2	19.9	19.2	19.9	23.9	21.5	19.9	19.9	16.8	16.8
75	10.5	18.4	20.7	20.7	21.5	27.0	23.9	22.4	22.4	19.9	19.9	18.4	18.4	19.9	20.7	21.5	20.7	39.7	23.2	21.5	26.3	17.6	19.9
90	6.5	16.8	27.0	16.8	26.3	39.7	31.8	26.3	31.8	24.7	25.5	23.9	23.2	25.5	26.3	27.0	26.3	44.4	26.3	27.8	33.4	23.2	19.9
105	7.3	10.5	28.6	38.9	39.7	45.2	43.6	41.3	--	38.9	38.1	35.7	34.2	37.3	36.5	33.4	34.2	39.7	37.3	33.4	43.6	31.0	34.9
120	7.3	9.7	31.0	42.8	45.2	45.2	45.2	41.3	47.6	44.4	42.8	40.5	38.9	41.3	40.5	39.7	35.7	39.7	40.5	39.7	43.6	33.4	34.9
135	7.3	9.7	31.0	42.8	45.2	45.2	45.2	41.3	47.6	44.4	42.8	40.5	38.9	41.3	40.5	39.7	35.7	39.7	40.5	39.7	43.6	33.4	34.9
150	7.3	9.7	31.0	42.8	45.2	45.2	45.2	41.3	47.6	44.4	42.8	40.5	38.9	41.3	40.5	39.7	35.7	39.7	40.5	39.7	43.6	33.4	34.9

APPENDIX TABLE 34. MOISTURE MEASUREMENTS (% BY VOLUME) OF 20 cm OF SOIL OVER RETORTED SHALE. HIGH ELEVATION LYSIMETER. 2% SLOPE, 1977

PLOT H6.

Depth cm	Reading Dates																						
	6/5	6/6	6/7	6/8	6/9	6/10	6/11	6/12	6/13	6/14	6/15	6/17	6/21	6/29	7/1	7/6	7/7	7/11	7/13	7/22	8/16	8/22	9/1
15	50.7	46.8	52.3	48.4	46.0	49.9	50.7	51.5	49.9	46.8	43.6	38.9	35.7	38.9	42.8	37.3	37.3	38.1	37.3	38.9	42.8	31.0	38.1
30	53.1	53.1	56.3	53.1	53.1	53.9	52.3	53.9	57.0	50.7	50.7	52.3	46.8	49.2	50.7	47.6	47.6	48.1	50.7	49.2	36.5	40.5	38.1
45	51.5	49.9	53.9	52.3	52.3	53.1	52.3	53.1	56.3	52.3	49.2	47.6	47.6	47.6	49.9	45.2	49.9	49.4	48.4	46.8	31.0	42.8	35.7
60	34.9	38.1	42.8	44.4	44.4	44.4	40.5	44.4	49.2	42.1	41.3	38.1	38.9	41.3	44.4	35.7	39.7	37.0	44.4	38.9	29.4	36.5	35.7
75	12.8	25.5	35.7	37.3	36.5	38.9	36.5	38.1	39.7	34.2	34.9	34.2	34.2	34.9	37.3	33.4	33.4	33.9	37.3	34.2	26.3	31.0	27.0
90	7.3	9.7	25.5	32.6	33.4	33.4	33.4	34.2	36.5	32.6	32.6	30.2	29.4	31.8	33.4	30.2	29.4	33.2	32.6	30.2	30.2	27.8	27.0
105	8.2	5.7	11.3	29.4	31.0	32.6	31.8	31.8	34.2	31.0	31.0	27.8	28.7	29.4	30.2	27.8	28.6	26.3	29.4	27.8	30.2	24.7	26.3
120	5.7	5.7	8.9	29.4	34.9	36.5	34.9	36.5	38.1	34.2	33.4	31.8	31.8	31.0	32.6	30.2	31.8	36.3	34.9	30.2	30.2	27.8	26.3
135	5.7	5.7	8.9	29.4	34.9	36.5	34.9	36.5	38.9	33.4	33.4	31.8	31.8	31.0	32.6	30.2	31.8	36.3	34.9	30.2	30.2	27.8	19.9
150	5.7	5 7	8.9	29.4	34.9	36.5	34.9	36.5	38.9	33.4	33.4	31.8	31.8	31.0	32.6	30.2	31.8	36.3	34.9	30.2	30.2	27.8	19.9

Plot H8.

Depth cm	Reading Dates																						
	6/5	6/6	6/7	6/8	6/9	6/10	6/11	6/12	6/13	6/14	6/15	6/17	7/21	6/29	7/1	7/6	7/7	7/11	7/13	7/22	8/16	8/22	9/1
15	47.6	49.9	51.5	51.5	49.2	51.5	47.6	49.2	54.7	51.5	46.8	41.3	40.5	39.7	44.4	44.4	49.2	39.7	46.8	46.8	44.4	34.2	38.9
30	48.4	51.5	53.1	49.2	52.3	53.9	48.4	51.5	54.7	52.3	50.7	45.2	47.6	46.0	49.2	46.8	50.7	46.5	48.4	47.6	42.1	41.3	38.9
45	42.1	49.2	48.4	38.9	51.5	50.7	46.8	50.7	50.7	49.2	49.2	44.4	46.0	44.4	46.8	47.6	46.8	48.6	47.6	44.4	34.9	40.5	32.6
60	23.9	35.7	36.5	30.2	39.7	40.5	37.3	38.1	40.5	39.7	38.1	34.2	36.5	34.9	38.9	36.5	36.5	39.9	38.9	35.7	27.0	30.2	32.6
75	5.7	16.8	22.4	21.5	27.8	28.6	26.3	28.6	28.6	29.4	29.4	24.7	26.3	25.5	31.0	30.2	27.8	39.2	28.6	27.8	21.5	24.7	19.9
90	2.6	6.5	12.1	17.6	23.9	23.9	22.4	24.7	26.3	28.6	23.2	22.4	23.2	21.5	23.9	23.9	23.9	25.5	23.9	23.9	25.5	21.5	19.9
105	2.6	5.0	6.5	8.9	27.8	29.4	30.2	28.6	30.2	32.6	28.6	26.3	27.0	27.0	30.2	30.2	27.8	29.7	27.0	27.8	46.0	27.0	38.9
120	2.6	5.0	5.0	7.3	42.1	49.9	49.2	51.5	53.9	52.3	51.5	47.6	48.4	47.6	49.2	49.2	50.7	50.5	53.1	46.8	46.0	46.0	46.8
135	2.6	5.0	5.0	7.3	42.1	51.5	49.2	51.5	57.8	56.3	54.7	52.3	52.3	47.6	50.7	49.2	50.7	50.5	54.7	50.7	46.0	46.0	46.8
150	2.6	5.0	5.0	7.3	42.1	51.5	49.2	51.5	57.8	56.3	54.7	52.3	52.3	47.6	50.7	49.2	50.7	50.5	54.7	50.7	46.0	46.0	46.8

APPENDIX TABLE 35. MOISTURE MEASUREMENTS (% BY VOLUME) OF 40 cm OF SOIL OVER RETORTED SHALE. HIGH ELEVATION LYSIMETER. 2% SLOPE, 1977

PLOT H10

Depth cm	Reading Dates											
	6/17	6/21	6/29	7/1	7/6	7/7	7/11	7/13	7/22	8/16	8/22	9/1
15	14.4	33.4	41.3	49.2	45.2	48.4	42.8	44.4	47.6	43.6	37.3	42.1
30	26.3	42.8	54.7	57.0	56.3	52.3	54.2	55.5	57.0	42.1	48.4	42.1
45	22.4	28.6	45.2	49.9	49.2	42.8	41.8	48.4	50.7	38.9	40.5	34.2
60	12.8	13.6	34.2	46.0	45.2	40.5	42.6	42.1	42.1	42.1	39.7	34.2
75	7.3	7.3	13.6	27.8	42.8	36.5	41.8	44.4	44.4	43.6	42.8	41.3
90	5.7	5.7	6.5	9.7	29.4	31.0	32.8	44.4	46.8	43.6	46.0	41.3
105	5.7	5.7	5.0	6.5	9.7	11.3	17.3	24.7	38.9	43.6	44.4	45.2
120	5.7	5.0	5.7	6.5	8.9	5.7	7.3	12.8	23.9	43.6	43.6	45.2
135	5.7	5.0	5.7	6.5	8.9	5.7	7.3	12.8	23.0	43.6	43.6	45.2
150	5.7	5.0	5.7	6.5	8.9	5.7	7.3	12.8	23.9	43.6	43.6	45.2

Plot H12.

Depth cm	Reading Dates											
	6/17	6/21	6/29	7/1	7/6	7/7	7/11	7/13	7/22	8/16	8/22	9/1
15	37.3	39.7	44.4	49.2	47.6	48.4	41.3	48.4	46.8	48.4	33.4	42.1
30	46.8	51.5	53.1	53.1	56.3	57.0	50.5	55.5	55.5	48.4	44.4	42.1
45	46.0	49.9	51.5	53.9	53.9	55.5	50.5	54.7	55.5	48.4	44.4	45.2
60	45.2	49.9	51.5	50.7	51.5	52.3	54.2	55.5	53.9	48.4	44.4	45.2
75	38.1	42.1	41.3	46.0	47.6	46.0	40.2	46.8	49.2	37.3	40.5	34.9
90	17.6	22.4	25.5	32.6	40.5	39.7	39.4	40.5	35.7	40.5	33.4	34.9
105	5.7	8.2	10.5	19.9	34.2	36.5	38.9	38.9	38.9	48.4	36.5	38.1
120	4.2	2.6	4.2	7.3	14.4	14.4	20.5	34.2	42.8	48.4	42.8	38.1
135	2.6	2.6	2.6	4.2	5.7	6.5	10.5	12.8	39.7	48.4	42.8	42.8
150	2.6	2.6	2.6	4.2	5.7	6.5	10.5	12.8	39.7	48.4	42.8	42.8

APPENDIX TABLE 36. MOISTURE MEASUREMENTS (% BY VOLUME) OF 60 cm OF SOIL OVER RETORTED SHALE. HIGH ELEVATION LYSIMETER. 2% SLOPE, 1977

PLOT H14.

Depth cm	Reading Dates											
	6/17	6/21	6/29	7/1	7/6	7/7	7/11	7/13	7/22	8/16	8/22	9/1
15	15.2	31.8	49.9	49.2	44.4	57.0	42.8	45.2	49.2	46.0	39.7	40.5
30	27.8	39.8	50.7	53.1	53.1	55.5	59.7	53.1	55.5	46.0	44.4	40.5
45	29.4	33.4	49.2	52.3	50.7	52.3	56.5	53.1	50.7	46.0	43.6	40.5
60	30.2	21.5	42.1	49.2	49.2	51.5	52.6	50.7	44.4	40.5	42.8	40.5
75	20.7	12.8	23.2	32.6	40.5	42.1	48.6	44.4	40.5	34.9	36.5	31.8
90	12.1	11.3	12.8	16.0	30.2	33.4	32.4	34.9	34.2	32.6	32.6	31.8
105	10.5	12.1	10.5	12.8	17.6	20.7	27.6	32.6	32.6	35.7	29.4	30.2
120	12.1	11.3	12.1	11.3	13.6	14.4	13.6	23.9	34.2	42.1	32.6	30.2
135	11.3	11.3	11.3	11.3	11.3	12.1	13.6	18.4	34.2	42.1	41.3	38.1
150	11.3	11.3	11.3	11.3	11.3	12.1	13.6	18.4	34.2	42.1	41.3	38.1

Plot H16.

Depth cm	Reading Dates											
	6/17	6/21	6/29	7/1	7/6	7/7	7/11	7/13	7/22	8/16	8/22	9/1
15	17.6	31.8	44.4	44.4	48.4	46.8	40.5	42.1	44.4	45.2	39.7	42.8
30	28.6	41.3	53.9	53.9	57.8	57.8	51.3	53.1	53.1	45.2	44.4	42.8
45	30.2	32.6	50.7	55.5	58.6	55.5	58.1	55.5	53.1	45.2	45.2	44.4
60	28.6	27.8	39.7	49.2	53.1	50.7	52.6	50.7	49.2	42.1	42.1	44.4
75	21.5	20.7	20.7	36.5	44.4	43.6	40.7	44.4	44.4	31.0	36.5	32.6
90	9.7	9.7	9.7	11.3	26.3	20.7	28.9	31.0	30.2	24.7	30.2	32.6
105	4.2	5.0	7.3	7.3	10.5	8.9	5.0	15.2	17.6	25.5	23.9	23.2
120	2.6	4.2	4.2	4.2	7.3	5.7	5.0	8.2	9.7	35.7	24.7	23.2
135	4.2	4.2	4.2	5.0	5.7	4.2	5.0	66.6	5.0	35.7	32.6	31.8
150	4.2	4.2	4.2	5.0	5.7	4.2	5.0	66.6	5.0	35.7	32.6	31.8

APPENDIX TABLE 37. MOISTURE MEASUREMENTS (% BY VOLUME) OF 80 cm OF SOIL OVER RETORTED SHALE. HIGH ELEVATION LYSIMETER. 2% SLOPE, 1977

PLOT H18.

Depth cm	Reading Dates											
	6/17	6/21	6/29	7/1	7/6	7/7	7/11	7/13	7/22	8/16	8/22	9/1
15	--	--	26.3	30.2	29.4	29.4	39.7	28.6	27.8	45.2	21.5	36.5
30	--	--	49.2	53.1	49.9	49.9	48.9	50.7	50.7	47.6	46.0	36.5
45	--	--	48.4	53.1	51.5	50.7	58.1	53.1	53.1	47.6	41.3	42.8
60	--	--	44.4	50.7	49.9	47.6	54.9	50.7	50.7	47.6	44.4	42.8
75	--	--	34.2	46.8	47.6	46.8	52.6	49.9	49.9	45.2	44.4	42.8
90	--	--	19.2	26.3	37.3	41.3	41.5	47.6	47.6	41.3	39.7	42.8
105	--	--	12.1	16.8	21.5	25.5	28.4	34.9	34.9	37.3	34.9	31.8
120	--	--	16.8	17.6	17.6	17.6	16.0	26.3	26.3	36.5	31.8	31.8
135	--	--	16.8	19.9	19.9	19.9	16.0	23.9	23.9	36.5	32.6	33.4
150	--	--	16.8	19.9	19.9	19.9	16.0	23.2	23.2	36.5	32.6	33.4

Plot H20.

Depth cm	Reading Dates											
	6/17	6/21	6/29	7/1	7/6	7/7	7/11	7/13	7/22	8/16	8/22	9/1
15	16.0	31.8	44.4	49.2	26.3	11.3	38.9	12.8	13.6	44.4	13.6	34.9
30	26.3	35.7	49.9	50.7	49.2	49.9	49.7	48.4	50.7	46.0	46.0	34.9
45	30.2	35.7	49.2	53.1	50.7	53.1	58.9	53.1	53.1	46.0	49.2	42.8
60	31.8	33.4	46.8	49.2	49.2	50.7	57.3	52.3	50.7	46.0	48.4	42.8
75	29.4	29.4	31.0	44.4	46.8	49.2	57.3	50.7	46.0	45.2	46.0	44.4
90	13.6	14.4	16.0	19.9	38.9	44.4	47.0	46.8	43.6	42.8	46.0	44.4
105	5.7	5.7	9.7	7.3	17.6	19.9	28.9	34.9	40.5	40.5	46.0	42.1
120	4.2	4.2	11.3	4.2	5.0	7.3	8.2	15.2	26.3	40.5	39.7	42.1
135	4.2	4.2	4.2	4.2	5.0	6.5	8.2	10.5	19.9	40.5	38.9	34.9
150	4.2	4.2	4.2	4.2	5.0	6.5	8.2	10.5	19.9	40.5	38.9	34.9

APPENDIX TABLE 38. MOISTURE MEASUREMENTS (% BY VOLUME) FOR SOIL CONTROL. HIGH ELEVATION LYSIMETER. 2% SLOPE, 1977

PLOT H22.

Depth cm	Reading Dates											
	6/17	6/21	6/29	7/1	7/6	7/7	7/11	7/13	7/22	8/16	8/22	9/1
15	7.3	20.3	33.3	34.8	28.8	35.5	28.8	31.8	27.8	18.5	10.5	29.0
30	16.5	24.7	38.5	43.0	38.5	42.0	48.3	38.5	39.3	33.6	30.5	31.3
45	23.5	25.0	36.0	42.0	36.8	39.7	45.8	41.0	38.5	34.5	31.3	32.0
60	24.0	25.0	28.8	36.8	34.8	37.3	35.8	36.5	37.3	35.6	31.3	33.0
75	36.0	27.0	25.7	37.3	36.7	38.0	34.8	38.5	33.5	33.5	30.5	33.0
90	24.7	24.5	23.5	28.8	35.0	35.5	34.8	38.5	34.8	33.0	31.3	32.0
105	23.7	24.3	22.5	24.8	31.8	33.5	35.8	35.0	34.5	33.0	31.3	33.0
120	22.5	22.5	21.5	22.0	25.8	29.0	32.5	36.5	34.7	32.0	32.0	33.8
135	21.0	21.5	22.0	20.8	24.3	23.8	28.3	34.3	33.5	33.3	31.3	36.0
150	19.0	22.7	20.8	21.5	24.3	25.8	28.3	28.3	33.8	34.5	33.0	35.5

Plot H24.

Depth cm	Reading Dates											
	6/17	6/21	6/29	7/1	7/6	7/7	7/11	7/13	7/22	8/16	8/22	9/1
15	9.0	16.0	29.3	30.2	27.0	33.0	28.0	30.0	25.7	34.3	22.3	26.3
30	12.7	16.0	33.5	38.5	34.7	37.7	38.0	36.7	38.5	36.2	27.5	31.7
45	15.2	14.0	28.0	38.5	35.5	42.0	48.7	39.5	38.5	38.8	31.7	32.0
60	20.0	18.5	22.0	36.5	33.0	36.0	46.7	41.0	38.5	39.3	32.5	33.3
75	22.5	22.5	24.3	34.0	33.0	37.7	37.5	38.7	36.0	39.5	36.0	33.7
90	23.7	23.5	22.0	24.5	35.0	35.5	36.7	41.0	36.0	41.2	36.0	32.0
105	22.3	21.5	21.7	22.2	33.0	33.0	35.7	37.7	34.5	43.6	38.9	36.5
120	20.5	20.7	20.2	19.3	22.5	31.2	33.5	36.0	34.5	44.6	40.3	34.3
135	20.7	20.5	20.7	19.3	20.7	23.7	30.7	34.7	36.0	44.2	40.3	36.5
150	22.3	21.5	22.0	21.2	20.7	22.5	20.7	32.3	36.0	44.5	41.2	38.2

APPENDIX TABLE 39. MOISTURE MEASUREMENTS (% BY VOLUME) OF RETORTED SHALE. LOW ELEVATION LYSIMETER. 25% SLOPE, 1977

PLOT L1.

Depth cm	Reading Dates																						
	6/5	6/6	6/7	6/8	6/9	6/10	6/11	6/12	6/13	6/14	6/15	6/17	6/21	6/29	7/6	7/8	7/12	7/15	7/25	7/27	8/11	8/19	9/1
15	31.8	27.8	27.0	23.9	24.7	23.9	31.8	29.4	23.2	22.4	19.9	21.5	19.2	27.8	31.0	32.6	27.8	21.5	21.5	17.6	21.5	28.6	27.0
30	39.7	41.3	38.1	38.1	37.3	37.3	38.9	38.9	35.7	33.4	35.7	35.7	28.6	36.5	37.3	34.9	29.4	31.8	36.5	33.4	31.0	30.2	27.0
45	37.3	37.3	38.1	38.9	38.1	38.1	41.3	38.1	41.3	33.4	36.5	37.3	31.8	35.7	39.7	38.9	31.8	34.9	34.9	34.2	33.4	34.2	33.4
60	22.4	37.2	40.5	42.1	42.1	41.3	43.6	44.4	39.7	36.5	41.3	40.5	37.3	38.9	44.4	37.3	35.7	37.3	39.7	35.7	38.9	32.6	33.4
75	6.5	21.5	38.1	42.8	42.8	41.3	44.4	44.4	40.5	37.3	43.6	42.1	38.9	40.5	42.8	42.8	36.5	38.9	42.8	39.7	38.9	35.7	37.3
90	3.4	6.5	34.2	45.2	45.2	44.4	46.0	47.6	44.4	39.7	46.0	44.4	42.1	43.6	44.4	40.5	40.5	43.6	46.8	42.1	42.1	34.9	37.3
105	2.6	3.4	13.6	40.5	44.4	43.6	46.8	46.0	42.8	42.1	45.2	43.6	41.3	40.5	46.8	38.9	39.7	41.3	45.2	42.8	43.6	33.4	36.5
120	3.4	2.6	4.2	24.7	38.1	41.3	43.6	44.4	41.3	38.9	42.8	41.3	38.1	37.3	44.4	38.9	37.3	38.9	44.4	40.5	39.7	33.4	36.5
135	3.4	2.6	2.6	7.3	33.4	38.1	42.1	44.4	40.5	40.5	42.8	39.7	38.9	39.7	42.8	38.9	37.3	38.1	44.4	39.7	42.1	32.6	37.3
150	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--

Plot L3.

Depth cm	Reading Dates																						
	6/5	6/6	6/7	6/8	6/9	6/10	6/11	6/12	6/13	6/14	6/15	6/17	6/21	6/29	7/6	7/8	7/12	7/15	7/25	7/27	8/11	8/19	9/1
15	46.0	46.0	25.5	47.6	44.4	44.4	51.5	49.9	49.9	45.2	42.1	47.6	29.4	38.9	61.0	50.7	39.7	34.2	44.4	36.5	38.9	36.5	41.3
30	46.8	52.3	52.3	55.5	53.9	50.7	53.9	53.1	52.3	50.7	49.9	49.9	45.2	49.9	64.2	48.4	42.8	45.2	49.9	46.0	43.6	39.7	41.3
45	47.6	51.5	53.9	53.9	51.5	51.5	52.3	53.1	53.2	52.3	50.7	50.7	44.4	49.2	68.2	49.2	42.8	44.4	49.2	46.0	46.0	40.5	42.1
60	46.8	53.1	53.1	55.5	52.3	49.9	55.5	53.1	53.2	50.7	50.7	53.1	46.0	48.4	61.0	48.4	43.6	45.2	49.2	46.0	46.0	40.5	42.1
75	43.6	53.9	53.9	55.5	51.5	49.9	56.1	53.1	49.9	49.9	49.2	50.7	45.2	46.8	65.8	47.6	43.6	45.2	49.9	46.0	46.0	40.5	41.3
90	36.5	51.5	51.5	53.9	50.7	50.7	56.1	53.1	51.5	51.5	50.7	49.9	44.4	46.8	61.0	48.4	42.8	44.4	49.2	46.0	43.6	42.1	41.3
105	17.6	50.7	50.7	53.1	53.9	52.3	53.9	53.1	53.9	50.7	51.5	51.5	46.0	46.0	61.0	47.6	43.6	45.2	49.2	46.0	46.0	41.3	42.8
120	5.0	47.6	52.3	53.9	52.3	50.7	53.9	55.5	53.9	53.1	51.5	52.3	46.8	46.0	59.4	45.2	43.6	45.2	49.9	45.2	47.6	38.9	42.8
135	5.0	44.4	48.4	54.7	50.7	49.2	52.3	53.1	51.5	51.5	49.2	48.4	42.8	42.8	58.6	45.2	44.4	43.6	46.8	43.6	45.2	38.9	39.7
150	5.0	22.4	48.4	51.5	51.5	49.2	52.3	52.3	53.1	50.7	49.9	48.4	43.6	42.8	58.6	45.2	44.4	43.6	46.8	43.6	43.6	38.9	39.7

APPENDIX TABLE 40. MOISTURE MEASUREMENTS (% BY VOLUME) OF 20 cm OF SOIL OVER RETORTED SHALE. LOW ELEVATION LYSIMETER. 25% SLOPE, 1977

PLOT L5.

Depth cm	Reading Dates																					
	6/5	6/6	6/7	6/8	6/9	6/10	6/11	6/12	6/13	6/14	6/15	6/17	6/21	6/29	7/6	7/8	7/12	7/15	7/25	7/27	8/11	8/19	9/1
15	41.3	38.9	36.5	42.1	45.2	27.0	49.9	11.3	17.3	18.4	17.3	17.3	16.0	15.0	10.5	46.8	18.2	14.2	18.2	16.5	14.2	30.2	26.3
30	46.8	51.5	52.3	53.9	57.8	46.0	53.1	46.8	44.4	43.6	48.4	42.1	42.8	42.8	40.5	53.1	39.7	41.3	45.2	42.1	37.3	36.5	26.3
45	43.6	49.9	50.7	53.9	55.5	53.1	49.2	51.5	53.1	51.5	53.9	49.9	46.8	48.4	49.9	54.7	43.6	46.8	49.9	48.4	39.7	34.9	38.9
60	26.3	40.5	43.6	43.6	48.4	50.7	38.9	51.5	53.9	49.9	51.5	49.9	47.6	49.2	56.3	39.7	46.8	46.8	49.9	47.6	40.5	30.2	38.9
75	7.3	21.5	32.6	33.4	35.7	42.1	38.1	41.3	49.9	41.3	41.3	40.5	36.5	38.9	47.6	31.8	37.3	37.3	41.3	36.5	31.0	25.5	24.7
90	4.2	8.2	23.2	30.2	32.6	36.5	32.6	33.4	42.1	32.6	32.6	32.6	28.6	28.6	31.8	28.6	29.4	29.4	31.0	29.4	24.7	22.4	24.7
105	3.4	4.2	9.7	31.8	36.5	34.2	37.3	31.0	34.2	29.4	30.2	34.9	28.6	26.3	33.4	33.4	25.5	27.8	29.4	27.0	24.7	27.0	27.0
120	3.4	3.4	4.2	30.2	38.1	36.5	38.1	36.5	31.8	35.7	35.7	33.4	31.0	31.0	36.5	34.2	28.6	31.0	33.4	31.0	29.4	27.0	27.0
135	3.4	4.2	4.2	21.5	36.5	38.9	38.6	38.1	39.7	37.3	35.7	33.4	33.4	31.8	37.3	34.2	30.2	31.8	34.2	33.4	31.0	27.8	30.2
150	3.4	4.2	4.2	20.7	42.8	38.1	38.1	39.7	38.1	38.1	35.7	33.4	32.6	31.8	37.3	34.2	29.4	31.0	34.9	33.4	31.0	27.8	30.2

Plot L7.

Depth cm	Reading Dates																					
	6/5	6/6	6/7	6/8	6/9	6/10	6/11	6/12	6/13	6/14	6/15	6/17	6/21	6/29	7/6	7/8	7/12	7/15	7/25	7/27	8/11	8/19	9/1
15	46.0	40.5	39.7	38.9	39.7	41.3	49.2	36.5	42.1	42.1	28.6	34.9	25.5	36.5	46.0	49.2	43.6	38.1	37.3	39.7	35.7	40.5	31.8
30	51.5	50.7	50.7	49.9	49.9	49.2	51.5	50.7	49.9	53.9	47.6	47.6	43.6	48.4	43.6	47.6	42.1	43.6	47.6	42.8	40.5	44.4	31.8
45	55.5	52.3	53.1	52.3	53.1	52.3	53.1	53.1	51.5	55.5	49.2	55.5	47.6	48.4	52.3	43.6	43.6	46.8	50.7	46.0	43.6	47.6	38.1
60	55.5	51.5	53.1	53.1	53.9	53.1	55.5	52.3	53.1	57.0	49.9	53.1	46.8	53.1	50.7	44.4	46.8	48.4	53.1	48.4	46.0	43.6	38.1
75	47.6	48.4	48.4	49.2	49.2	48.4	50.7	49.2	49.2	50.7	47.6	48.4	43.6	47.6	50.7	46.0	43.6	45.2	46.8	45.2	40.5	40.5	35.7
90	44.4	47.6	48.4	49.2	47.6	48.4	48.4	47.6	47.2	49.2	46.0	46.0	42.1	45.2	46.0	46.8	40.5	43.6	45.2	43.6	39.7	39.7	35.7
105	32.6	48.4	50.7	50.7	49.2	49.2	52.3	49.9	50.7	52.3	47.6	49.9	46.0	47.6	47.6	44.4	42.8	48.4	47.6	48.4	40.5	42.8	38.1
120	8.2	47.6	52.3	52.3	52.3	53.2	57.0	51.5	50.7	54.7	48.4	52.3	47.6	46.0	50.7	44.4	43.6	46.8	50.7	46.0	40.5	42.8	38.1
135	5.0	34.2	52.3	53.1	53.1	52.3	53.1	52.3	51.5	55.5	48.4	53.1	45.2	46.0	52.3	44.4	42.8	44.4	46.8	43.6	40.5	43.6	38.9
150	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--

APPENDIX TABLE 41. MOISTURE MEASUREMENTS (% BY VOLUME) OF 40 cm OF SOIL OVER RETORTED SHALE. LOW ELEVATION LYSIMETER. 25% SLOPE, 1977

PLOT L9.

Depth cm	Reading Dates										
	6/21	6/29	7/6	7/8	7/12	7/15	7/25	7/27	8/11	8/19	9/1
15	--	25.5	22.4	49.2	23.2	35.7	25.5	22.4	21.5	37.3	30.2
30	--	51.5	50.7	45.2	40.5	43.6	49.9	46.0	31.0	27.8	30.2
45	--	40.5	48.4	44.2	42.1	43.6	44.4	42.1	31.0	34.9	31.8
60	--	20.7	37.3	33.9	37.3	38.9	42.1	39.7	30.2	27.8	31.8
75	--	16.8	20.7	26.0	27.8	27.8	34.9	32.6	28.6	15.2	27.0
90	--	16.0	18.4	14.4	19.2	18.4	20.7	20.7	17.6	14.4	27.0
105	--	14.4	17.6	13.6	12.1	16.0	13.6	14.4	12.1	20.7	14.4
120	--	14.4	16.0	13.6	13.6	15.2	15.2	14.4	12.1	21.5	14.4
135	--	13.6	15.2	13.6	14.4	13.6	18.4	18.4	16.8	21.5	23.2
150	--	--	--	--	--	--	--	--	--	--	--

Plot L11.

Depth cm	Reading Dates										
	6/21	6/29	7/6	7/8	7/12	7/15	7/25	7/27	8/11	8/19	9/1
15	18.4	35.7	32.6	44.4	23.2	[illegible]1.8	34.9	33.4	23.2	31.8	30.2
30	32.6	47.6	45.2	40.7	40.5	43.6	45.2	45.2	30.2	31.8	30.2
45	27.8	35.7	44.4	49.7	42.1	41.3	46.8	46.0	31.0	28.6	27.8
60	14.4	14.4	18.4	17.3	37.3	27.8	33.4	32.6	25.5	17.6	27.8
75	9.7	9.7	9.7	6.5	27.8	12.8	17.6	15.2	12.1	10.5	11.3
90	8.2	8.2	7.3	7.3	19.2	8.9	9.7	9.7	6.5	7.3	11.3
105	6.5	6.5	8.9	7.3	12.1	7.3	7.3	8.2	5.0	7.3	5.7
120	7.3	6.5	5.7	8.2	13.6	6.5	8.2	8.2	4.2	7.3	5.7
135	8.2	7.3	4.2	8.2	14.4	7.3	8.2	8.2	5.0	7.3	7.3
150	8.2	7.3	4.2	8.2	14.4	7.3	8.2	8.9	7.3	7.3	7.3

APPENDIX TABLE 42. MOISTURE MEASUREMENTS (% BY VOLUME) OF 60 cm OF SOIL OVER RETORTED SHALE. LOW ELEVATION LYSIMETER. 25% SLOPE, 1977

PLOT L13.

Depth cm	Reading Dates										
	6/21	6/29	7/6	7/8	7/12	7/15	7/25	7/27	8/11	8/19	9/1
15	19.9	42.8	38.9	42.1	42.8	38.9	44.4	37.3	--	31.8	33.4
30	33.4	50.7	44.4	33.4	39.7	43.6	49.2	43.6	--	24.7	33.4
45	30.2	36.5	38.9	25.5	35.7	41.3	46.8	42.1	--	16.0	33.4
60	30.2	31.8	28.7	35.5	22.4	38.9	42.8	42.1	--	10.5	33.4
75	23.2	23.9	19.2	25.2	17.6	22.4	28.6	25.5	--	8.9	18.4
90	14.4	16.0	15.2	21.3	11.3	16.0	17.6	18.4	--	8.9	18.4
105	11.3	12.1	11.3	8.9	10.5	12.1	11.3	12.1	--	8.9	8.2
120	9.7	9.7	8.9	8.9	9.7	9.7	10.5	9.7	--	8.9	8.2
135	9.7	9.7	8.2	8.9	8.2	8.9	10.5	9.7	--	8.9	8.2
150	--	--	--	--	--	--	--	--	--	--	--

Plot L15.

Depth cm	Reading Dates										
	6/21	6/29	7/6	7/8	7/12	7/15	7/25	7/27	8/11	8/19	9/1
15	24.7	46.0	45.2	54.7	42.1	37.3	45.2	37.3	49.2	38.9	36.5
30	35.7	53.9	53.9	46.8	49.2	51.5	55.5	50.7	44.4	37.3	36.5
45	29.4	39.7	48.4	38.9	46.0	47.6	50.7	49.2	43.6	34.2	34.2
60	25.5	25.5	25.5	25.2	37.3	40.5	46.8	46.0	34.9	31.8	34.2
75	12.8	12.1	20.7	37.3	39.7	16.8	26.3	29.4	12.8	16.8	22.4
90	7.3	7.3	10.5	18.2	19.2	8.9	10.5	12.1	14.2	9.7	22.4
105	8.9	8.2	8.9	8.9	8.2	8.9	9.7	9.7	9.4	8.2	8.2
120	8.9	8.9	11.3	8.9	8.2	9.7	9.7	8.9	9.4	8.2	8.2
135	8.9	8.9	10.5	8.9	9.7	9.7	9.7	8.9	9.4	8.2	8.2
150	--	--	--	--	--	--	--	--	--	--	--

APPENDIX TABLE 43. MOISTURE MEASUREMENTS (% BY VOLUME) OF 80 cm OF SOIL OVER RETORTED SHALE. LOW ELEVATION LYSIMETER. 25% SLOPE, 1977

PLOT L17.

Depth cm	Reading Dates										
	6/21	6/29	7/6	7/8	7/12	7/12	7/25	7/27	8/11	8/19	9/1
15	23.9	42.1	·42.1	47.6	37.3	34.9	42.1	35.7	46.0	34.9	35.7
30	34.9	53.1	53.1	46.0	42.1	47.6	49.9	46.0	49.9	33.4	35.7
45	31.8	38.9	49.2	49.7	42.8	45.2	50.7	48.4	49.9	33.4	34.9
60	30.2	31.8	41.3	37.8	42.8	43.6	49.2	43.6	49.9	29.4	34.9
75	26.3	24.7	28.6	29.2	29.4	31.0	37.3	35.7	51.5	22.4	28.6
90	19.2	17.6	19.2	17.6	19.2	19.2	21.5	20.7	28.6	16.8	28.6
105	19.2	19.2	21.5	19.2	17.6	18.4	21.5	18.4	29.4	16.0	17.6
120	19.2	19.2	20.7	16.0	18.4	19.2	21.5	18.4	33.4	15.2	17.6
135	19.9	19.9	19.2	16.0	17.6	18.4	18.4	17.6	23.2	15.2	15.2
150	--	--	--	--	--	--	--	--	--	--	--

Plot L19.

Depth cm	Reading Dates										
	6/21	6/29	7/6	7/8	7/12	7/15	7/25	7/27	8/11	8/19	9/1
15	27.0	39.7	35.7	49.9	36.5	32.6	37.3	34.2	43.6	36.5	35.7
30	36.5	51.5	37.3	47.6	42.8	45.2	49.2	47.6	49.2	37.3	35.7
45	30.2	38.1	46.0	50.5	42.1	45.2	47.6	45.2	48.4	12.8	34.9
60	29.4	34.2	49.2	47.8	42.1	42.1	45.2	43.6	46.8	8.2	34.9
75	25.5	31.8	46.0	27.6	29.4	27.8	37.3	37.3	46.0	10.5	27.0
90	16.0	23.9	20.7	10.5	15.2	15.2	18.4	16.0	21.5	23.2	27.0
105	9.7	17.6	12.4	8.9	10.5	9.7	10.5	9.7	9.7	7.3	8.9
120	8.2	10.5	9.2	10.5	8.2	8.9	9.7	8.2	6.5	12.8	8.9
135	7.3	9.7	6.0	10.5	7.3	8.9	8.2	8.2	6.5	12.1	6.5
150	8.9	9.7	6.0	10.5	7.3	8.9	9.7	8.2	9.7	12.1	7.3

APPENDIX TABLE 44. MOISTURE MEASUREMENTS (% BY VOLUME) FOR SOIL CONTROL. LOW ELEVATION LYSIMETER. 25% SLOPE, 1977.

PLOT L21.

Depth cm	Reading Dates										
	6/21	6/29	7/6	7/8	7/12	7/15	7/25	7/27	8/11	8/19	9/1
15	18.5	25.0	17.0	36.5	28.2	21.0	27.2	22.2	29.0	31.5	26.2
30	25.5	38.7	20.0	34.0	32.5	18.5	38.5	35.5	36.2	30.0	26.2
45	21.5	36.7	27.7	30.5	31.0	17.0	35.0	33.0	32.7	24.7	25.2
60	18.2	38.0	31.7	27.2	30.2	15.2	35.0	32.0	31.7	24.0	25.2
75	17.5	32.0	27.7	22.0	24.7	27.5	28.0	28.0	31.0	22.5	22.5
90	16.0	22.2	26.2	22.0	23.2	22.7	26.5	24.7	30.0	21.7	22.5
105	17.7	20.0	25.5	22.0	20.0	21.0	24.5	23.7	30.0	19.5	19.7
120	19.5	19.7	23.2	22.0	20.0	20.2	23.0	21.5	30.0	18.7	19.7
135	17.7	19.5	22.2	22.0	18.5	20.2	21.2	19.7	25.5	17.7	17.5
150	--	--	--	--	--	--	--	--	--	--	--

Plot L23.

Depth cm	Reading Dates										
	6/21	6/29	7/6	7/8	7/12	7/15	7/25	7/27	8/11	8/19	9/1
15	17.2	21.2	24.0	29.5	--	12.2	13.2	14.7	10.0	24.7	19.5
30	23.2	33.0	25.5	31.2	--	29.2	33.2	28.0	25.5	24.2	19.5
45	20.7	18.5	28.5	28.0	--	29.2	31.5	29.5	26.2	26.2	26.0
60	21.2	5.7	31.5	25.5	--	29.2	32.5	31.2	27.2	25.5	26.0
75	23.0	11.2	29.2	24.7	--	26.0	29.7	28.0	27.2	24.2	26.5
90	26.7	1.7	30.0	24.7	--	26.0	28.0	26.2	26.2	24.2	26.5
105	26.7	0.2	24.0	24.7	--	26.0	28.0	26.2	26.2	24.2	27.7
120	26.7	1.5	20.2	24.7	--	26.0	28.0	26.2	26.2	24.2	27.7
135	26.7	2.0	18.0	24.7	--	26.0	28.0	26.2	26.2	24.2	27.7
150	--	--	--	--	--	--	--	--	--	--	--

APPENDIX TABLE 45. MOISTURE MEASUREMENTS (% BY VOLUME) OF RETORTED SHALE. LOW ELEVATION LYSIMETER. 2% SLOPE, 1977

PLOT L2.

Depth cm	Reading Dates																						
	6/5	6/6	6/7	6/8	6/9	6/10	6/11	6/12	6/13	6/14	6/15	6/17	6/21	6/29	7/6	7/8	7/12	7/15	7/25	7/27	8/11	8/19	9/1
15	37.3	34.9	35.7	39.7	36.5	38.9	40.5	40.5	42.8	38.1	34.9	38.1	28.6	34.9	34.2	33.4	31.8	29.4	31.8	31.8	35.7	34.9	33.4
30	44.4	41.3	42.8	47.6	44.4	45.2	42.1	48.4	47.6	44.4	41.3	41.3	35.7	35.7	36.5	37.3	34.8	35.7	37.3	34.9	36.5	34.9	31.8
45	45.2	42.1	43.6	49.2	46.0	46.0	44.4	49.2	48.4	45.2	41.3	43.6	36.5	41.3	38.9	39.7	36.5	35.7	36.5	34.9	34.2	34.9	34.9
60	43.6	42.1	42.1	48.4	43.6	45.2	43.6	48.4	47.6	43.8	40.5	42.8	36.5	41.3	37.3	37.3	37.3	34.2	34.9	34.9	32.6	38.9	38.9
75	42.8	42.1	45.2	49.9	43.6	46.8	47.6	51.5	49.9	47.6	45.2	45.2	42.1	42.1	40.5	42.1	40.5	39.7	42.1	42.1	39.7	41.3	38.9
90	38.9	42.1	44.4	50.7	48.4	50.8	47.6	53.1	52.3	49.2	48.4	46.8	45.2	45.2	44.4	45.2	50.7	41.3	43.6	42.1	41.3	41.3	38.9
105	31.8	40.5	44.4	52.3	49.2	51.5	48.4	54.7	54.7	50.7	50.7	48.4	47.6	47.6	46.0	48.4	46.0	43.6	45.2	43.6	41.3	40.5	38.9
120	24.7	32.6	39.7	51.5	47.2	50.7	46.8	53.9	53.9	50.7	46.8	46.0	43.6	43.6	42.8	42.8	46.0	42.8	42.8	42.1	40.5	38.9	38.9
135	19.9	21.5	34.9	49.9	46.8	48.4	47.6	53.9	53.1	50.7	46.8	46.0	42.8	42.8	40.5	43.6	42.1	39.7	43.6	40.5	40.5	38.9	38.1
150	20.7	19.9	31.0	48.4	46.0	48.4	47.6	53.9	53.9	50.7	46.8	43.6	42.8	42.8	40.5	43.6	40.5	39.7	42.1	42.1	39.7	38.9	38.9

Plot L4.

Depth cm	Reading Dates																						
	6/5	6/6	6/7	6/8	6/9	6/10	6/11	6/12	6/13	6/14	6/15	6/17	6/21	6/29	7/1	7/8	7/12	7/15	7/25	7/27	8/11	8/19	9/1
15	39.7	44.4	37.3	41.3	40.5	45.2	46.0	45.2	43.6	42.1	42.1	39.7	31.8	42.1	46.8	36.5	40.5	34.2	38.9	37.3	38.9	34.9	33.4
30	43.6	64.0	44.4	43.6	43.6	42.8	42.8	46.0	42.1	42.1	41.3	40.5	34.9	42.1	42.1	31.0	39.7	35.7	39.7	39.7	35.7	31.0	28.6
45	38.1	43.6	37.3	36.5	37.3	36.5	35.7	38.1	34.9	34.9	33.4	34.2	29.4	35.7	37.3	32.6	31.8	29.4	31.0	31.8	32.6	30.2	33.4
60	42.1	42.8	38.1	38.9	38.1	38.9	39.7	40.5	37.3	38.1	37.3	35.7	32.6	38.1	39.7	34.9	36.5	31.8	34.2	34.9	34.9	31.0	33.4
75	44.4	43.6	42.8	43.6	42.8	43.6	42.8	46.0	42.8	40.5	42.1	39.7	38.9	42.1	42.1	36.5	37.3	36.5	39.7	39.7	34.9	34.9	35.7
90	42.1	44.4	42.8	44.4	44.4	45.2	45.2	43.6	43.6	42.8	41.3	40.5	38.9	41.3	44.4	38.9	39.8	35.7	38.9	39.7	38.9	37.3	37.3
105	43.6	46.8	49.2	48.4	48.4	49.9	48.4	49.2	48.4	48.4	46.0	46.0	42.1	43.6	46.8	42.8	42.8	39.7	42.1	42.8	39.7	39.7	39.7
120	34.9	47.6	50.7	50.7	52.3	50.7	50.7	53.1	51.5	53.9	51.5	46.0	46.0	45.2	48.4	38.9	45.2	42.8	43.6	43.6	37.3	36.5	36.5
135	16.0	41.3	46.0	46.8	48.4	48.4	47.6	51.5	49.9	49.2	46.8	42.8	41.3	40.5	45.2	38.9	42.8	40.5	40.5	42.1	37.3	36.5	36.5
150	14.0	41.3	46.0	46.8	47.6	48.4	47.6	50.7	49.2	49.2	46.8	42.8	41.3	40.5	45.2	38.9	42.8	40.5	40.5	42.1	37.3	36.5	35.7

APPENDIX TABLE 46. MOISTURE MEASUREMENTS (% BY VOLUME) OF 20 cm OF SOIL OVER RETORTED SHALE. LOW ELEVATION LYSIMETER. 2% SLOPE, 1977

PLOT L6.

Depth cm	Reading Dates																						
	6/5	6/6	6/7	6/8	6/9	6/10	6/11	6/12	6/13	6/14	6/15	6/17	6/21	6/29	7/6	7/8	7/12	7/15	7/25	7/27	8/11	8/19	9/1
15	--	52.3	52.3	65.0	57.0	53.9	51.5	57.0	51.5	50.7	54.7	53.1	45.2	52.3	50.7	48.4	46.0	34.9	48.4	48.4	50.7	35.7	37.3
30	--	48.4	47.6	51.5	51.5	49.2	48.4	52.3	49.9	53.1	51.5	46.8	42.1	46.8	45.2	45.2	42.1	35.7	43.6	43.6	45.2	34.9	37.3
45	--	48.4	47.6	59.4	52.3	47.6	46.8	50.7	49.2	46.8	49.2	45.2	41.3	44.4	38.9	37.3	40.5	29.4	42.1	42.1	42.1	30.2	31.0
60	--	39.7	40.5	46.0	44.4	42.8	41.3	42.8	42.1	38.9	40.5	39.7	34.9	37.3	36.5	38.9	35.7	31.8	35.7	35.7	37.3	30.2	31.0
75	--	30.2	42.1	44.4	46.8	42.1	42.1	45.	43.6	41.3	42.1	38.9	34.9	35.7	23.9	36.5	33.4	36.5	35.7	35.7	36.5	27.8	27.8
90	--	9.7	36.5	40.5	42.8	40.5	39.7	41.3	40.5	38.1	39.7	37.3	32.6	32.6	34.2	35.7	33.2	35.7	35.7	33.4	34.9	30.2	27.8
105	--	5.0	27.8	42.1	42.8	41.3	48.4	43.6	39.7	38.9	41.3	38.9	34.9	34.9	35.7	35.7	33.4	39.7	35.7	35.7	37.3	30.2	30.2
120	--	5.0	25.5	42.8	44.4	42.1	39.7	42.8	40.5	39.7	41.3	38.9	34.9	34.9	35.7	35.7	33.4	42.8	35.7	35.7	37.3	30.2	30.2
135	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
150	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--

Plot L8.

Depth cm	Reading Dates																						
	6/5	6/6	6/7	6/8	6/9	6/10	6/11	6/12	6/13	6/14	6/15	6/17	6/21	6/29	7/6	7/8	7/12	7/15	7/25	7/27	8/11	8/19	9/1
15	34.2	20.7	24.7	27.8	26.3	30.2	57.8	31.8	28.6	33.4	23.2	27.8	47.6	17.6	18.4	19.9	29.4	19.2	29.4	18.4	19.9	45.2	38.1
30	57.0	57.8	54.7	57.8	55.5	57.8	55.5	57.8	57.8	55.5	54.7	55.5	53.9	55.5	54.7	52.3	49.2	49.9	52.3	50.7	46.8	47.6	38.1
45	55.5	57.0	55.5	57.8	56.3	57.0	50.7	57.8	56.3	57.0	55.5	64.2	46.8	55.5	55.5	51.5	49.2	51.5	54.7	51.5	46.8	41.3	39.7
60	49.2	53.9	50.7	53.9	50.7	52.3	47.6	53.1	52.3	51.5	49.2	49.2	42.8	49.9	48.4	46.0	43.6	44.4	46.0	48.4	40.5	39.7	39.7
75	25.5	48.4	49.9	49.9	47.6	50.7	42.8	50.7	49.2	49.2	44.4	49.2	37.3	45.2	43.6	42.1	39.7	40.5	39.7	42.8	36.5	32.6	33.4
90	7.3	26.3	38.9	42.8	41.3	42.8	40.5	44.4	44.4	43.6	39.7	49.2	36.5	38.9	42.1	38.9	36.5	35.7	37.3	37.3	32.6	32.6	33.4
105	5.0	8.2	23.2	39.7	40.5	41.3	42.1	42.1	41.3	42.8	38.1	59.4	38.9	34.9	37.3	37.3	34.2	33.4	34.2	36.5	31.0	34.2	32.6
120	5.7	5.0	7.3	15.2	34.2	42.8	42.1	44.4	43.6	42.1	42.1	38.9	47.6	36.5	39.7	38.9	36.5	34.9	37.3	37.3	33.4	40.5	32.6
135	5.0	5.7	5.0	6.5	12.8	31.8	42.1	47.6	49.9	48.4	49.2	47.6	47.6	44.4	46.0	37.3	42.1	42.8	46.0	45.2	39.7	40.5	42.1
150	5.0	5.7	5.7	5.7	11.3	31.8	42.1	49.9	49.2	50.7	49.2	47.6	47.6	44.4	46.0	44.4	43.6	43.6	46.0	46.0	39.7	40.5	42.1

APPENDIX TABLE 47. MOISTURE MEASUREMENTS (% BY VOLUME) OF 40 cm OF SOIL OVER RETORTED SHALE. LOW ELEVATION LYSIMETER. 2% SLOPE, 1977

PLOT L10.

Depth cm	Reading Dates										
	6/21	6/29	7/6	7/8	7/12	7/15	7/25	7/27	8/11	8/19	9/1
15	35.7	41.3	38.1	46.0	36.5	34.9	36.5	33.4	34.9	43.6	42.8
30	49.2	53.9	49.9	35.7	46.0	46.8	48.4	49.2	44.4	41.3	42.8
45	41.3	42.1	47.6	46.0	45.2	44.4	47.6	46.0	41.3	38.9	39.7
60	31.8	20.7	29.4	39.7	35.7	37.3	35.7	39.7	34.2	29.4	39.7
75	21.5	12.8	15.2	17.3	20.7	22.4	27.0	29.4	27.0	16.0	21.5
90	12.1	7.3	7.3	5.0	8.9	8.2	9.7	14.4	13.6	8.9	21.5
105	9.7	5.7	6.5	5.0	6.5	7.3	8.2	8.2	7.3	6.5	6.5
120	8.2	6.5	7.3	5.0	5.7	6.5	5.7	6.5	5.7	5.0	6.5
135	8.2	5.0	5.0	5.0	5.7	6.5	5.7	5.7	5.0	5.0	5.0
150	--	--	--	--	--	--	--	--	--	--	--

Plot L12.

Depth cm	Reading Rates										
	6/21	6/29	7/6	7/8	7/12	7/15	7/25	7/27	8/11	8/19	9/1
15	38.9	49.2	51.5	48.4	43.6	42.1	48.4	43.6	41.3	43.6	42.8
30	48.4	50.7	50.7	42.1	46.0	46.0	48.4	49.2	42.1	39.7	42.8
45	38.1	42.8	42.1	48.1	45.2	42.1	42.8	45.2	39.7	38.1	38.1
60	23.9	22.4	35.7	31.5	38.9	39.7	42.1	42.1	38.1	31.8	38.1
75	14.4	10.5	17.6	19.7	24.7	24.7	32.6	35.7	31.8	24.7	30.2
90	9.7	7.3	11.3	6.5	14.4	9.7	15.2	18.4	23.9	11.3	30.2
105	7.3	5.7	7.3	5.0	8.2	6.5	5.7	8.2	8.9	5.7	6.5
120	6.5	5.7	5.0	5.0	5.7	5.0	4.2	5.7	5.0	5.7	6.5
135	5.7	6.5	7.3	5.0	8.2	5.0	4.2	5.7	5.0	6.5	5.0
150	6.5	6.5	7.3	5.0	8.2	5.0	5.7	5.7	5.0	6.5	5.0

APPPENDIX TABLE 48. MOISTURE MEASUREMENTS (% BY VOLUME) OF 60 cm OF SOIL OVER RETORTED SHALE. LOW ELEVATION LYSIMETER. 2% SLOPE, 1977

PLOT L14.

Depth cm	Reading Dates										
	6/21	6/29	7/6	7/8	7/12	7/15	7/25	7/27	8/11	8/19	9/1
15	41.3	50.7	49.2	53.9	46.0	42.1	46.0	43.6	38.1	42.8	42.8
30	47.6	54.7	53.1	56.8	49.2	49.9	52.3	52.3	40.5	39.7	42.8
45	38.9	40.5	49.9	47.3	48.4	46.8	48.4	46.8	36.5	35.7	38.1
60	36.5	27.8	38.9	41.5	42.1	40.5	43.6	42.8	35.7	33.4	38.1
75	31.0	20.7	23.9	31.3	47.6	26.3	32.6	37.3	32.6	24.7	33.4
90	16.8	12.8	17.6	19.7	12.8	31.8	14.4	17.6	18.4	10.5	33.4
105	13.6	8.2	9.7	7.3	9.7	8.2	9.7	9.7	8.9	5.7	7.3
120	11.3	8.2	10.5	7.3	8.2	7.3	8.2	8.2	6.5	5.7	7.3
135	11.3	8.2	8.9	8.2	6.5	7.3	8.2	8.2	6.5	6.5	7.3
150	11.3	8.2	8.9	8.2	8.2	8.2	8.9	8.2	7.3	6.5	7.3

Plot L16.

Depth cm	Reading Dates										
	6/21	6/29	7/6	7/8	7/12	7/15	7/25	7/27	8/11	8/19	9/1
15	28.6	42.1	42.1	54.7	39.7	35.7	42.1	39.7	33.4	44.4	40.5
30	39.7	53.9	50.7	62.6	48.4	46.0	50.7	50.7	40.5	42.1	40.5
45	33.4	46.0	44.4	59.4	45.2	43.6	48.4	48.4	38.1	38.1	38.9
60	26.3	29.4	40.5	54.7	40.5	40.5	42.1	43.6	36.5	34.9	38.9
75	19.9	19.2	23.9	35.7	30.2	29.4	37.3	36.5	32.6	30.2	34.9
90	12.8	12.8	13.6	19.2	14.4	14.4	20.7	22.4	27.0	19.9	34.9
105	12.8	12.8	11.3	15.2	12.1	11.3	14.4	12.8	16.8	14.4	19.2
120	15.2	16.8	15.2	19.9	15.2	16.0	16.0	17.6	15.2	22.4	19.2
135	7.0	8.6	4.4	3.4	4.7	6.3	7.0	7.0	0.7	6.3	24.7
150	8.6	8.6	4.4	3.4	9.7	6.3	7.0	9.4	3.9	6.3	24.7

APPENDIX TABLE 49. MOISTURE MEASUREMENTS (% BY VOLUME) OF 80 cm OF SOIL OVER RETORTED SHALE. LOW ELEVATION LYSIMETER. 2% SLOPE, 1977

PLOT L18.

Depth cm	Reading Dates										
	6/21	6/29	7/6	7/8	7/12	7/15	7/25	7/27	8/11	8/19	9/1
15	28.6	42.8	45.2	47.6	39.7	37.3	43.6	42.1	35.7	42.1	42.8
30	42.1	52.3	53.9	56.0	50.7	46.8	53.9	51.5	42.1	42.1	42.8
45	33.4	44.4	51.5	49.7	51.5	47.6	49.2	49.2	52.3	40.5	41.3
60	31.8	30.2	45.2	43.4	48.4	46.0	48.4	48.4	38.9	38.1	41.3
75	32.6	29.4	36.5	43.2	42.1	40.5	43.6	43.6	36.5	38.1	39.7
90	31.8	24.7	34.2	39.2	48.4	35.7	42.1	42.1	36.5	32.6	39.7
105	26.3	18.4	27.8	20.7	27.8	24.7	34.2	35.7	34.2	27.8	15.7
120	19.9	18.4	19.2	18.4	20.7	19.2	13.9	14.7	17.8	10.7	15.7
135	19.2	16.0	17.6	18.4	19.2	18.4	19.4	10.7	12.4	10.7	10.2
150	17.6	16.0	17.6	18.4	18.4	17.6	18.4	18.4	17.6	10.7	10.2

Plot L20.

Depth cm	Reading Dates										
	6/21	6/29	7/6	7/8	7/12	7/15	7/25	7/27	8/11	8/19	9/1
15	35.7	39.7	50.7	52.3	37.3	33.4	42.1	38.9	36.5	42.1	41.3
30	40.5	53.1	52.3	50.7	49.2	46.8	50.7	52.3	47.6	41.3	41.3
45	35.7	43.6	48.4	46.0	46.0	46.0	48.4	48.4	44.4	39.7	40.5
60	36.5	36.5	42.1	45.7	45.2	42.8	46.0	46.0	45.2	38.9	40.5
75	35.7	35.7	31.0	34.7	39.7	37.3	42.1	43.6	41.3	34.2	41.3
90	23.2	22.4	22.4	21.3	23.9	22.4	24.7	27.0	33.4	20.7	41.3
105	11.3	12.8	14.4	--	12.1	13.6	12.8	12.8	16.8	9.7	17.6
120	8.9	8.9	12.1	11.3	9.7	9.7	9.7	11.3	8.9	9.7	17.6
135	11.3	8.9	14.4	16.0	11.3	11.3	12.1	12.1	9.7	12.8	12.1
150	14.4	8.9	14.4	16.0	15.2	15.2	16.0	16.0	12.1	12.8	12.1

APPENDIX TABLE 50. MOISTURE MEASUREMENTS (% BY VOLUME) FOR SOIL CONTROL. LOW ELEVATION LYSIMETER. 2% SLOPE, 1977

PLOT L22.

Depth cm	Reading Dates										
	6/21	6/29	7/6	7/8	7/12	7/15	7/25	7/27	8/11	8/19	9/1
15	26.0	34.7	34.0	40.2	33.0	32.5	36.2	33.0	29.7	60.5	27.7
30	25.7	39.0	39.0	32.5	36.2	35.7	38.7	37.0	31.2	38.2	27.7
45	24.2	39.7	37.2	33.2	36.2	34.7	37.0	36.2	31.2	27.5	29.2
60	23.0	34.5	34.0	31.0	32.0	31.0	33.7	33.7	29.0	28.2	29.2
75	21.5	32.0	32.2	31.7	33.0	32.5	33.0	34.5	29.7	26.7	28.7
90	21.0	23.2	33.2	22.2	31.2	31.0	32.0	33.7	29.0	35.7	28.7
105	21.0	22.5	25.5	20.0	33.0	31.0	34.5	35.5	31.2	27.5	31.5
120	21.7	21.2	23.7	20.0	31.2	29.5	33.0	34.5	30.5	24.7	31.5
135	21.7	20.7	22.0	20.0	31.2	24.7	29.5	30.5	27.0	24.2	27.0
150	21.2	20.7	22.0	20.0	23.7	23.2	28.0	28.0	25.5	24.2	27.0

Plot L24.

Depth cm	Reading Dates										
	6/21	6/29	7/6	7/8	7/12	7/15	7/25	7/27	8/11	8/19	9/1
15	19.7	31.5	30.2	32.5	33.0	24.7	31.2	28.0	23.5	22.2	24.2
30	22.7	33.5	35.0	26.0	26.2	27.0	31.2	28.0	18.7	20.2	24.2
45	16.2	26.2	36.0	25.0	25.5	23.2	23.0	25.5	20.0	19.5	19.2
60	18.7	20.7	36.7	26.0	27.2	23.2	24.7	24.7	22.0	22.2	19.2
75	21.0	19.7	32.0	22.7	24.7	24.7	29.5	27.2	23.5	24.2	26.2
90	21.2	19.7	35.0	21.0	22.2	24.7	28.7	28.0	23.5	24.7	26.2
105	21.2	19.7	25.5	20.2	21.5	21.5	26.2	25.5	22.7	24.7	27.2
120	21.2	20.7	21.5	19.5	21.5	21.5	25.5	25.5	22.7	24.7	27.2
135	21.2	20.7	19.0	17.7	19.7	20.0	25.5	25.5	22.7	24.7	27.2
150	--	--	--	--	--	--	--	--	--	--	--

APPENDIX TABLE 51. FLOW RATE, EC, pH, AND TOTAL LITERS OF PERCOLATE FROM LOWER DRAIN OF RETORTED SHALE. HIGH ELEVATION LYSIMETERS. 25% SLOPE, 1977.

PLOT H1 & H3.

Date	Time	Flow Rate (ℓ/hr)	Total liters	EC x 10^6	pH	Comments
6/ 8	2000	< 1	0.5	18,750	8.2	← sampled
6/ 8	2230	< 1	2	18,081	8.5	← sampled
6/ 9	0030	< 1	3.5	21,850	9.3	
6/ 9	0630	11.3	71.3	19,460	11.3	
6/ 9	0800	13.2	91.1	18,090	11.2	
6/ 9	1000	11.8	114.7	18,620	11.2	
6/ 9	1200	10.0	134.7	19,480	11.2	
6/ 9	1400	8.7	152.1	20.340	11.2	
6/ 9	1600	8.0	168.1	20,110	10.9	
6/ 9	2000	12.0	192.1	20.430	11.2	
6/10	0630	22.5	428.3	22,430	11.0	
6/10	1500	25.7	646.7	25,670	10.9	
6/10	2130	15.0	744.2	26,320	11.1	
6/11	0900	49.8	1,316.9	22,730	11.1	
6/11	2000	46.5	1,828.4	23,910	10.9	
6/12	0600	51.1	2,434.7	21,680	11.1	← sampled
6/12	1200	85.1	2,946.4	-	-	
6/13	0730	69.3	4,298.9	24,000	10.7	← sampled
6/13	1400	92.2	4,898.5	25,000	10.5	
6/14	0800	89.3	6,507.6	27,509	8.0	← sampled
6/14	1400	57.5	7,453.1	29,100	10.5	
6/15	0900	76.6	8,908.9	31,000	10.7	← stopped leaching
6/16	0800	43.0	9,898	30,240	10.7	← sampled
6/17	0800	22.3	10,434.7	30,247	10.9	← sampled
6/19	0800	14.3	11,124.4	23,970	10.6	← sampled
6/21	0800	13.7	11,782.3	-	-	
6/22	0800	13.4	12,104	-	-	
6/23	0800	8.9	12,318.2	-	-	
6/27	0800	7.3	13,023.4	-	-	
6/29	0800	15.8	13,783.8	28,400	10.8	
6/30	0800	17.9	14,213.8	-	-	
7/ 1	0800	30.7	14,950.8	-	-	
7/ 7	0800	18.8	17,660.3	-	-	
7/11	0800	12.3	18,846.2	-	-	
7/12	0800	7.9	19,037.3	-	-	

APPENDIX TABLE 51. PLOT H1 & H3 CONTINUED.

Date	Time	Flow Rate (ℓ/hr)	Total liters	EC x 10^6	pH	Comments
7/13	0800	7.4	19,215.9	-	-	
7/14	0800	7.0	19,385.4	23,460	10.7	← sampled
7/15	0800	6.1	19,532.6	-	-	
7/18	0800	4.4	19.850.5	-	-	
7/19	0800	1.8	19,895.1	-	-	
7/20	0800	22.6	20,439	22,240	10.6	
7/21	0800	7.6	20,622.2	-	-	
7/22	0800	6.5	20.778.9	-	-	
7/25	0800	6.9	21,280.8	-	-	
7/26	0800	16.4	21,675.9	-	-	
7/27	0800	25.3	22,285.3	-	-	
7/28	0700	19.7	22,740.3	-	-	
7/29	0900	15.4	23,140.7	20,910	9.5	
8/ 1	1100	16.9	24,430.3	19,074	8.3	← sampled
8/ 2	0830	23.6	24,939.0	20,400	9.0	
8/ 3	0900	15.1	25,294.4	-	-	
8/ 4	0900	5.0	25,416.2	-	-	
8/ 5	0900	17.0	25,826.1	-	-	
8/ 8	1030	22.4	27,475.4	17,703	8.6	← sampled
8/ 9	1130	7.5	27,664.6	-	-	
8/10	1000	41.1	28,591.2	17,850	8.9	
8/11	0800	28.5	29,218.4	17,850	8.8	
8/12	0800	21.4	29,734.3	-	-	
8/15	0930	15.4	30,868.7	-	-	
8/16	0800	13.3	31,168.2	-	-	
8/17	0800	11.5	31,444.9	-	-	← stopped daily irrigation
8/18	0800	13.2	31,762.8	14,029	9.1	
8/19	0830	12.3	32,065.2	14,393	9.0	
8/22	0830	11.6	32,906.3	12,786	9.0	
8/23	0830	8.9	33,122.0	15,076	9.0	← sampled
8/24	0800	8.0	33,311.2	11,890	9.1	← sampled
8/26	0800	7.9	33,628.2	12,342	8.9	
8/29	0900	7.9	33,845.2	11,787	8.9	
8/30	0800	7.9	34,062.2	11,820	8.9	← sampled
9/2	0800	5.0	34,113.3	11,473	8.6	← sampled

APPENDIX TABLE 52. FLOW RATE, EC, pH, AND TOTAL LITERS OF PERCOLATE FROM LOWER DRAIN OF 20 cm OF SOIL OVER RETORTED SHALE. HIGH ELEVATION LYSIMETER. 25% SLOPE, 1977.

PLOT H5 & H7.

Date	Time	Flow Rate (ℓ/hr)	Total liters	EC x 10^6	pH	Comments
6/ 9	0500	-	-	24,760	9.7	
6/ 9	0500	2.5	2.5	22,620	10.3	← sampled
6/ 9	0800	3.8	13.9	22,240	10.8	
6/ 9	1000	3.8	21.5	22,240	10.9	
6/ 9	1200	3.0	27.5	22,152	10.9	
6/ 9	1400	3.8	35.1	22,080	11.0	
6/ 9	1600	3.8	42.7	21,580	11.1	
6/ 9	2000	6.0	66.7	21,740	11.0	
6/10	0700	8.7	162.4	23,040	11.2	
6/10	1500	10.2	244	23,990	11.1	
6/10	2130	6.0	283	25,550	11.2	
6/11	0900	20.8	543	23,110	11.3	
6/11	1600	36.3	597.5	-	-	
6/11	2000	26.2	702.3	22,240	11.2	
6/12	0600	35.6	1,059.2	18,750	11.4	
6/12	1200	33.8	1,262.4	-	-	
6/13	0730	29.5	1,837.7	18,200	10.8	
6/13	1400	31.7	2,075.8	16,320	10.8	
6/14	0800	39.8	2,792.7	16,500	10.8	← sampled
6/14	1400	56.6	3,132.6	18,601	10.9	stopped
6/15	0900	33.7	3,773.8	24,480	10.9	← leaching
6/16	0800	25.4	4,359	26,075	10.8	← sampled
6/17	0800	14.8	4,714.8	28,400	11.0	
6/18	0800	10.7	5,230.3	25,001	11.0	← sampled
6/21	0800	11.6	5,790.9	-	-	
6/22	0800	8.3	5,991.5	-	-	
6/23	0800	6.3	6,143.2	-	-	
6/27	0800	5.7	6,696.6	-	-	
6/29	0800	11.9	7,270.8	25,576	10.9	
6/30	0800	16.3	7,664.1	-	-	
7/ 1	0800	24.4	8,250.4	-	-	
7/ 7	0800	15.1	10,426.2	-	-	
7/11	0800	9.9	11,380.1	-	-	
7/12	0800	5.8	11,520.1	-	-	

APPENDIX TABLE 52. PLOT H5 & H7 CONTINUED.

Date	Time	Flow Rate (ℓ/hr)	Total liters	EC x 10^6	pH	Comments
7/13	0800	6.8	11,684.3	-	-	
7/14	0800	5.9	11,827	22,176	10.9 ←	sampled
7/15	0800	6.5	11,984.8	-	-	
7/18	0800	6.6	12,465.5	-	-	
7/19	0800	7.1	12,638.1	-	-	
7/20	0800	4.5	12,746.7	20,448	11.1	
7/21	0800	6.5	12,903.7	-	-	
7/22	0800	5.9	13,047.5	-	-	
7/25	0800	6.0	13,483.2	-	-	
7/26	0800	11.5	13,761	-	-	
7/27	0800	25.3	14,370.4	20,216	10.8	
7/28	0700	0	14,370.4	-	-	
7/28	0900	0.5	14,399.5	26,530	10.7	
8/ 1	1100	18.0	16,166.5	19,817	10.4	
8/ 2	0830	10.5	16,393.2	19,722	10.2	
8/ 3	0900	11.6	16,678.2	-	-	
8/ 4	0900	18.8	17,092.7	-	-	
8/ 8	1030	16.0	18,660.2	18,921	10.0	
8/ 9	1130	10.6	18,926.6	-	-	
8/10	1000	39.7	19,820.3	17,850	10.0	
8/11	0800	25.8	20,388.4	16,830	9.4	
8/12	0800	14.9	20,746.8	17,731	9.7	
8/15	0930	12.3	21,655.6	-	-	
8/16	0800	10.9	21,902.7	16,430	10.2	stopped
8/17	0800	21.6	22,421.6	15,747	10.4 ←	daily
8/18	0800	8.0	22,613.8	15,765	10.4	irrigation
8/19	0830	7.9	22,808.3	16,430	10.3	
8/22	0830	9.8	23,516.1	15,192	10.2	
8/23	0830	7.4	23,695.5	15,076	10.3	
8/24	0800	0.6	23,711	15,019	10.2	
8/26	0800	5.7	23,988.8	15,006	9.9	
8/29	0800	0	23,988.8	14,400	9.8	
8/30	0800	24.7	24,583.8	-	-	
8/31	0800	2.2	24,637.1	15,000	9.9	
9/2	0800	0	24,637.1	14,783.2	9.6	

APPENDIX TABLE 53. FLOW RATE, EC, pH, AND TOTAL LITERS OF PERCOLATE FROM LOWER DRAIN OF 40 cm OF SOIL OVER RETORTED SHALE. HIGH ELEVATION LYSIMETER. 25% SLOPE, 1977.

PLOT H9 & H11.

Date	Time	Flow Rate (ℓ/hr)	Total liters	EC x 10^6	pH	Comments
6/29	0800	-	58.0	3,635.2	10.2	
6/30	0800	4.4	165.5			
7/ 1	0800	0.09	167.7		-	
7/ 7	0800	0	167.7			
7/11	0800	0	167.7		-	
7/12	0800	0	167.7			
7/13	0800	0	167.7			
7/14	0800	0	167.7	-		
7/15	0800	0.6	183.9	-		
7/26	0800	No flow				
7/28	0800	No flow				
8/ 1	1100	1.0	581.9	24,472	10.4	
8/ 2	0830	4.3	675.7	-	-	
8/ 3	0900	1.9	721.5	20,748	10.5	
8/ 4	0900	3.7	810.8			
8/ 8	1030	4.0	1,204.4			
8/ 9	1130	6.4	1,366.4	-	-	
8/10	1000	21.5	1,852	16,830	10.1	← sampled
8/11	0800	13.2	2,143	-		
8/12	0800	6.9	2,310.3		-	
8/15	0930	4.9	2,677.4			
8/16	0800	4.4	2,777.3	-	-	stopped
8/17	0800	4.0	2,874.2		-	← daily
8/18	0800	5.7	3,011.6	18,774	10.1	irrigation
8/19	0830	5.9	3,156.5	17,731	10.0	
8/22	0830	4.1	3,456.6	-		
8/23	0830	3.5	3,541	17,360	10.1	
8/24	0800	3.1	3,615.9	17,799	10.2	← sampled
8/26	0800	0.9	3,661.7	17,622	9.6	
8/29	0800	0	3,661.7	17,760	10.2	
8/30	0800	6.8	3,825.2	-	-	← sampled
8/31	0800	1.5	3,863	19,152	10.6	← sampled
9/ 1	0800	0	3,863	18,734	10.6	

APPENDIX TABLE 54. FLOW RATE, EC, pH, AND TOTAL LITERS OF PERCOLATE FROM LOWER DRAIN OF 60 cm OF SOIL OVER RETORTED SHALE. HIGH ELEVATION LYSIMETER. 25% SLOPE, 1977.

PLOT H13 & H15.

Date	Time	Flow Rate (ℓ/hr)	Total liters	EC x 10^6	pH	Comments
8/24	0800	<1	-	22,876	7.8	← sampled
8/26	0800	<1		21,684	8.3	
8/29	0800	<1	-	21,000	8.4	
8/30	0800	1.8	44.2	-	-	← sampled
8/31	0800	0.4	55.9	21,318	8.1	← sampled
9/ 2	0800	0	55.9	19,380	8.1	

APPENDIX TABLE 55. FLOW RATE, EC, pH, AND TOTAL LITERS OF PERCOLATE FROM LOWER DRAIN OF 80 cm OF SOIL OVER RETORTED SHALE. HIGH ELEVATION LYSIMETER. 25% SLOPE, 1977.

PLOT H17 & H19.

Date	Time	Flow Rate (ℓ/hr)	Total liters	EC x 10^6	pH	Comments
6/29	0800	No flow				
6/30	0800	No flow				
7/ 1	0800	No flow				
7/26	0800	No flow				
7/28	0800	No flow				
8/ 1	0800	Dripping	2.0	9,163	11.4	← sampled
8/ 2	0800	No flow				
8/ 3	0800	No flow				
8/ 4	0800	Dripping	10.0	5,100	7.2	← sampled
8/ 8	1030	4.0	199.4	22,344	10.5	
8/ 9	1130	2.4	259.5	-	-	
8/10	1000	4.1	352.9		-	
8/11	0800	4.1	443.7	-	-	
8/12	0800	5.4	573.9			
8/15	0930	3.8	853.6	-	-	
8/16	0800	2.8	917.0	15,960	10.7	stopped
8/17	0800	3.2	995.8	11,660	10.5	← daily
8/18	0800	5.5	1,129	14,840	10.5	irrigation
8/19	0830	5.0	1,253.9	-		
8/22	0830	3.6	1,516.2	-	-	
8/23	0830	2.6	1,580.9	-	-	
8/24	0800	2.7	1,644.8	14,770	10.8	← sampled
8/26	0800	0.9	1,689.8	15,218	10.6	
8/29	0800	0	1,689.8	14,400	10.5	
8/30	0800	2.4	1,749.6	-	-	← sampled
8/31	0800	0.9	1,771.9	15,554	10.8	← sampled
9/ 2	0800	0	1,771.9	15,554	10.7	

APPENDIX TABLE 56. FLOW RATE, EC, pH, AND TOTAL LITERS OF PERCOLATE FROM <u>LOWER DRAIN</u> OF SOIL CONTROL. HIGH ELEVATION LYSIMETER. 25% SLOPE, 1977.

PLOT H21 & H23.

Date	Time	Flow Rate (ℓ/hr)	Total liters	EC x 10^6	pH	Comments
6/27	0800	No flow				
6/30	0800	No flow				
7/26	0800	No flow				
7.28	0800	No flow				
8/ 1	0800	Dripping	1.0	5,382.2		← sampled
8/ 4	0800	Dripping		5,362.1	7.2	
8/ 8	1030	-	112.5	7,483.9	7.8	
8/ 9	1130	5.0	239.3	-	-	
8/10	1000	14.4	564.4	6,200	7.8	← sampled
8/11	0800	23.8	1,088.6	6,120	8.0	
6/12	0800	17.2	1,503.1	5,840.8	8.1	
8/15	0930	13.6	2,507.7	-	-	
8/16	0800	11.8	2,774.5	5,512	8.1	← stopped daily irrigation
8/17	0800	12.9	3,085.2	5,512	8.1	
8/18	0800	13	3,399.3	5,532	8.0	
8/19	0830	10.7	3,662.7	-	-	
8/22	0830	11.4	4,484.1	5,406	7.9	
8/23	0830	8.9	4,699.8	5,560	7.9	← sampled
8/24	0800	8.1	4,890.9	5,339.7	7.9	← sampled
8/26	0800	2.6	4,990.4	8,326.3	8.3	
8/29	0800	0	4,990.4	8,179.2	8.2	
8/30	0800	26.4	5,624.4	-	-	← sampled
8/31	0800	1.0	5,649	4,978.4	8.2	← sampled
9/ 2	0800	0	5,649	4,806	8.3	

APPENDIX TABLE 57. FLOW RATE, EC, pH, AND TOTAL LITERS OF PERCOLATE FROM LOWER DRAIN OF RETORTED SHALE. HIGH ELEVATION LYSIMETERS. 2% SLOPE, 1977.

PLOT H2 & H4.

Date	Time	Flow Rate (ℓ/hr)	Total liters	EC x 10^6	pH	Comments
6/10	0900	15.6	15.6	14,840	11.0	
6/10	1100	8.7	33	14,260	11.2	← sampled
6/10	1300	12.1	57.2	14,780	11.2	
6/10	1500	5.8	68.8	14,390	11.2	
6/10	2130	5.2	102.6	14,060	11.2	
6/11	0900	29.4	440.7	13,650	11.2	
6/11	2000	22.8	691.5	11,220	11.3	
6/12	0600	45	1,147.2	13,630	11.3	← sampled
6/12	1200	53.6	1,469.3	-	-	
6/13	0730	35.9	2,169.9	15,300	10.9	
6/13	1400	47.9	2,529.8	15,091	11.0	← sampled
6/14	0800	37.6	3,208.1	13,400	10.9	
6/14	1400	59.9	3,567.7	17,209	11.1	
6/15	0900	21.9	3,984	23,970	11.2	← stopped leaching
6/16	0800	20.4	4,457.5	34,176	11.1	← sampled
6/17	0800	13.8	4,789.4	34,472	11.3	← sampled
6/19	0800	5.2	5,043	31,290	11.1	← sampled
6/21	0800	6.4	5,352.2	-	-	
6/22	0900	0	5,352.2	-	-	
6/23	1000	0	5,352.2	-	-	
6/27	0800	1.6	5,510.4	-	-	
6/29	0800	5.9	5,796.5	34,080	11.5	
6/30	0800	2.5	5,858.5	-	-	
7/ 1	0800	13.8	6,191.2	-	-	
7/ 7	0800	7.2	7,230.6	-	-	
7/11	0800	1.6	7,388	-	-	
7/12	0800	1.2	7,418.2	-	-	
7/13	0800	0.5	7,418.2	-	-	
7/14	0800	0.6	7,446.1	-	-	
7/15	0800	1.2	7,477.1	-	-	
7/18	0800	0.8	7,538.4	26,130	11.3	

APPENDIX TABLE 57. PLOT H2 & H4 CONTINUED.

Date	Time	Flow Rate (ℓ/hr)	Total liters	EC x 10^6	pH	Comments
7/19	0800	0.6	7,553.5		-	
7/20	0800	0.6	7,568.6	-	-	
7/21	0800	0.8	7,573.7	-	-	
7/22	0800	0.4	7,585	-		
7/25	0800	0.6	7,629.6	-	-	
7/26	0800	1.3	7,662.1	22,430	10.9	
7/27	0800	5.4	7,792.6	-	-	
7/28	0700	3.4	7,871.3	-		
7/29	0900	1.8	7.919.3	-	-	
8/ 1	1100	2.3	8,097.5	-	-	
8/ 2	0830	4.4	8,198.1	-	-	
8/ 3	0900	2.0	8,245.4	-	-	
8/ 4	0900	2.3	8,301.4	-	-	
8/ 8	1030	6.1	8,458.4	-		
8/ 9	1130	4.6	8,574.2	-	-	
8/10	1000	9.1	8,779.3	-	-	
8/11	0800	0	8,779.3	-	-	
8/12	0800	4.7	8,894.3	-	-	
8/15	0830	1.0	8,970	-	-	stopped
8/16	0800	0.4	8,980.5	-	-	← irrigation
8/17	0800	1.1	9,009.2	-	-	
8/18	0800	0.6	9,024.3	-		
8/19	0830	2.1	9,077.6	-	-	
8/22	0830	0.3	9,099.5	-	-	
8/23	0830	0.7	9,117.6	-	-	
8/24	0800	0.5	9,131.6	-	-	
8/26	0800	0.1	9,135.3	17,130	11.2	
8/30	0800	0	9,135.3		-	
9/ 1	0800	7.8	9,513.8	-	-	

APPENDIX TABLE 58. FLOW RATE, EC, pH, AND TOTAL LITERS OF PERCOLATE FROM <u>LOWER DRAIN</u> OF 20 cm OF SOIL OVER RETORTED SHALE. HIGH ELEVATION LYSIMETER. 2% SLOPE, 1977.

PLOT H6 & H8.

Date	Time	Flow Rate (ℓ/hr)	Total liters	EC x 10^6	pH	Comments
6/10	0900	No flow				
6/10	1100	No flow				
6/10	1300	No flow				
6/10	1500	No flow				
6/10	2130	No flow				
6/11	0900	2.6	2.6	10,620	10.8	
6/11	2000	13.6	152.2	7,280	11.2	
6/12	0600	18.7	339.5	5,510	11.3 ←	sampled
6/12	1200	5.1	370.5	-	-	
6/13	0730	20.2	766	7,300	11.0	
6/13	1400	15.4	866.3	14,131	11.3	
6/14	0800	22.5	1,272	14,602	10.7	
6/14	1400	13.8	1,354.9	16,000	11.4	
6/15	0900	9.2	1,529.7	20,860	11.4	
6/16	0800	5.2	1,651.2	35,112	11.2	
6/17	0800	1.7	1,692.4	34,080	11.2 ←	sampled
6/19	0800	3.2	1,847.6	31,523	11.0	
6/21	0800	0.5	1,874.4	-		
6/22	0800	0	1,874.4	-	-	
6/23	0800	0	1,874.4	-	-	
6/27	0800	0.3	1,911.4		-	
6/29	0800	0.2	1,925.7	31,808	10.6	
6/30	0800	0	1,925.7	-	-	
7/ 1	0800	3.5	2,012		-	
7/ 7	0800	0.7	2,118.3			
7/11	0800	0.1	2,118.4		-	
7/12	0800	0.1	2,133.4		-	
7/13	0800	0	2,133.4			
7/14	0800	0	2,133.4			
7/15	0800	0	2,133.4	-	-	
7/18	0800	0.2	2,148.5	-		
7/19	0800	0	2,148.5	-		
7/20	0800	0	2,148.5			
7/21	0800	0	2,148.5		-	
7/22	0800	0	2,148.5	-		
7/25	0800	0	2,148.5	-		
7/26	0800	0	2,148.5	-		
7/27	0800	0	2,148.5	-		
7/28	0700	0	2,148.5	-		
7/29	0900	No flow				
8/ 3	0800	No flow				
8/ 4	0900	0.6	2,164.3	27,310	10.8	
8/ 8	1030	No flow				
8/ 9	1130	No flow				
8/11	0800	No flow				
8/15	0930	0.5	2,179.0	-	-	stopped
8/16	0800	0	2,179.0	-	←	daily irrigation
9/ 1	0800	No flow				

APPENDIX TABLE 59. FLOW RATE, EC, pH, AND TOTAL LITERS OF PERCOLATE FROM LOWER DRAIN OF 40 cm OF SOIL OVER RETORTED SHALE. HIGH ELEVATION LYSIMETER. 2% SLOPE, 1977.

PLOT H10 & H12.

Date	Time	Flow Rate (ℓ/hr)	Total liters	EC x 10^6	pH	Comments
6/29	0800	< 0.5	2.0	19,760	9.9	
6/30	0800	3.5	86.0	22,310	10.9	
7/ 1	0800	< 0.5	93.0	19,710	11.2	
7/ 7	0800	No flow				
7/26	0900	No flow				
7/28	0800	No flow				
8/ 1	0900	No flow				
8/ 5	0800	No flow				
8/10	0800	0.01	94.7	-	-	← sampled
8/11	0800	No flow				stopped
8/25	0800	No flow				← daily irrigations
9/ 1	0800	No flow				

APPENDIX TABLE 60. FLOW RATE, EC, pH, AND TOTAL LITERS OF PERCOLATE FROM LOWER DRAIN OF 60 cm OF SOIL OVER RETORTED SHALE. HIGH ELEVATION LYSIMETER. 2% SLOPE, 1977.

PLOT H14 & H16.

Date	Time	Flow Rate (ℓ/hr)	Total liters	EC x 10^6	pH	Comments
7/ 1	0800	No flow				
8/ 1	0800	No flow				
9/ 1	0800	No flow				

APPENDIX TABLE 61. FLOW RATE, EC, pH, AND TOTAL LITERS OF PERCOLATE FROM LOWER DRAIN OF 80 cm OF SOIL OVER RETORTED SHALE. HIGH ELEVATIONLYSIMETER. 2% SLOPE, 1977.

PLOT H18 & H20.

Date	Time	Flow Rate (/hr)	Total liters	EC x 10^6	pH	Comments
7/ 1	0800	No flow				
8/ 1	0800	No flow				
9/ 1	0800	No flow				

APPENDIX TABLE 62. FLOW RATE, EC, pH, AND TOTAL LITERS OF PERCOLATE FROM LOWER DRAIN OF SOIL CONTROL. HIGH ELEVATION LYSIMETER. 2% SLOPE, 1977.

PLOT H22 & H24.

Date	Time	Flow Rate (ℓ/hr)	Total liters	EC x 10^6	pH	Comments
6/29	0800	No flow	-	-	-	
6/30	0800	No flow	-		-	
7/ 1	0800	No flow				
7/26	0800	No flow				
7/28	0800	No flow				
8/ 1	1100	Dripping	83.9	5,985	7.7	- sampled
8/ 2	0800	Dripping				
8/ 3	0800	Dripping				
8/ 4	0800	Dripping				
8/ 8	1030	-	145.4	5,566	7.8	
8/ 9	1130	0	145.4	-		
8/10	1000	1.1	172.2	-	-	
8/11	0800	0.8	191.8	-	-	
8/15	0930	0.1	205.4		-	stopped
8/19	0830	0.1	219	-		← daily irrigations
9/ 1	No flow					

APPENDIX TABLE 63. FLOW RATE, EC, pH, AND TOTAL LITERS OF PERCOLATE FROM UPPER DRAIN OF RETORTED SHALE. HIGH ELEVATION LYSIMETERS. 25% SLOPE, 1977.

PLOT H1 & H3.

Date	Time	Flow Rate (ℓ/hr)	Total liters	EC x 10^6	pH	Comments
6/10	1000	< 0.5	2.0	8,700	8.0	- sampled
5/10	1300	No flow				
6/10	1500	No flow				
6/10	2130	< 0.5	3.1	8,350	9.1	
6/11	0900	< 0.5	6.3	8,140	7.9	
6/11	2000	< 0.1	9.5	7,850	7.8	
6/12	0600	< 0.4	22.3	7,726	7.9	
6/13	0730	0.5	55.8	15,310	9.6	- sampled
6/14	0800	0.3	62.6	22,568	10.5	
6/15	0900	0.3	70.2	30,000	11.3	
6/16	0800	0.3	77.4	31,230	11.0	
6/17	0800	0.05	78.2	28,760	11.0	
6/21	0730	No flow				
6/23	0800	No flow				
7/ 5	0800	No flow				
8/ 4	0800	No flow				
8/ 3	0200	2.8	82.6	6,885	8.2	
8/ 9	0800	dripping	83.5	6,324	8.1	
8/11	0800	No flow				
8/20	0800	No flow				
9/ 1	0900	No flow				

APPENDIX TABLE 64. FLOW RATE, EC, pH, AND TOTAL LITERS OF PERCOLATE FROM UPPER DRAIN OF 20 cm OF SOIL OVER RETORTED SHALE. HIGH ELEVATION LYSIMETER. 25% SLOPE, 1977.

PLOT H5 & H7.

Date	Time	Flow Rate (ℓ/hr)	Total liters	EC x 10^6	pH	Comments
6/10	0600	No flow				
6/11	0730	No flow				
6/14	0800	< 0.5	3.7	25,120	10.4	
6/14	1400	No flow				
6/23	0800	No flow				
7/10	0800	No flow				
8/ 4	0800	No flow				
9/ 1	0800	No flow				

APPENDIX TABLE 65. FLOW RATE, EC, pH, AND TOTAL LITERS OF PERCOLATE FROM UPPER DRAIN OF 40 cm OF SOIL OVER RETORTED SHALE. HIGH ELEVATION LYSIMETER. 25% SLOPE, 1977.

PLOT H9 & H11.

Date	Time	Flow Rate (ℓ/hr)	Total liters	EC x 10^6	pH	Comments
7/ 1	0800	No flow				
8/ 1	0800	No flow				
9/ 1	0800	No flow				

APPENDIX TABLE 66. FLOW RATE, EC, pH, AND TOTAL LITERS OF PERCOLATE FROM UPPER DRAIN OF 60 cm OF SOIL OVER RETORTED SHALE. HIGH ELEVATION LYSIMETER. 25% SLOPE, 1977.

PLOT H13 & H15.

Date	Time	Flow Rate (ℓ/hr)	Total liters	EC x 10^6	pH	Comments
7/ 1	0800	No flow				
8/ 1	0800	No flow				
9/ 1	0800	No flow				

APPENDIX TABLE 67. FLOW RATE, EC, pH, AND TOTAL LITERS OF PERCOLATE FROM UPPER DRAIN OF 80 CM OF SOIL OVER RETORTED SHALE. HIGH ELEVATION LYSIMETER. 25% SLOPE, 1977.

PLOT H17 & H19.

Date	Time	Flow Rate (ℓ/hr)	Total liters	EC x 10^6	pH	Comments
6/27	0800	No flow				
7/26	0800	No flow				
7/28	0800	No flow				
8/ 1	0800	No flow				
8/ 4	0800	No flow				
8/ 8	1030	Dripping	0.4			
8/ 9	1130	Dripping				
8/10	1000	Dripping				
8/11	0800	Dripping				
8/12	0800	Dripping	1.0	3,632.8	7.5	
9/ 1	0800	No flow				

APPENDIX TABLE 68. FLOW RATE, EC, pH, AND TOTAL LITERS OF PERCOLATE FROM UPPER DRAIN OF SOIL CONTROL. HIGH ELEVATION LYSIMETER. 25% SLOPE, 1977.

PLOT H21 & H23.

Date	Time	Flow Rate (ℓ/hr)	Total liters	EC x 10^6	pH	Comments
7/ 1	0800	No flow				
8/ 1	0800	No flow				
9/ 1	0800	No flow				

APPENDIX TABLE 69. FLOW RATE, EC, pH, AND TOTAL LITERS OF PERCOLATE FROM UPPER DRAIN OF RETORTED SHALE. HIGH ELEVATION LYSIMETER. 2% SLOPE, 1977.

PLOT H2 & H4.

Date	Time	Flow Rate (ℓ/hr)	Total liters	EC x 10^6	pH	Comments
6/15	0800	No flow				
7/ 1	0800	No flow				
8/ 1	0800	No flow				
9/ 1	0800	No flow				

APPENDIX TABLE 70. FLOW RATE, EC, pH, AND TOTAL LITERS OF PERCOLATE FROM UPPER DRAIN OF 20 cm OF SOIL OVER RETORTED SHALE. HIGH ELEVATION LYSIMETER. 2% SLOPE, 1977.

PLOT H6 & H8.

Date	Time	Flow Rate (ℓ/hr)	Total liters	EC x 10^6	pH	Comments
6/12	1200	< 0.5	1.5	1,400	8.4	← sampled
6/13	0730	< 0.5	3.2	1,326	8.8	
6/13	1400	< 0.5	4.8	1,931	8.8	
6/14	0800	< 0.5	6.7	1,224	8.5	
6/14	1400	< 0.5	9.2	2,607	9.0	
6/15	0900	< 0.5	11.2	-	-	
6/16	0800	< 0.5	13.2	-	-	
6/17	0800	< 0.5	15.3	1,987	9.0	
6/19	0800	< 0.5	17.5	1,917	9.2	
6/21	080	< 0.5	20.1	-	-	
6/22	0800	< 0.5	22.3	1,878	9.0	
6/23	0800	< 0.5	25.6	1,786	8.9	
7/ 5	0800	No flow				
8/ 4	0800	No flow				
9/ 1	0900	No flow				

APPENDIX TABLE 71. FLOW RATE, EC, pH, AND TOTAL LITERS OF PERCOLATE FROM UPPER DRAIN OF 40 cm OF SOIL OVER RETORTED SHALE. HIGH ELEVATION LYSIMETER. 2% SLOPE, 1977.

PLOT H10 & H12.

Date	Time	Flow Rate (ℓ/hr)	Total liters	EC x 10^6	pH	Comments
6/29	0800	< 0.01	0.5	4,328	7.9	
7/ 5	0800	No flow				
7/26	0800	No flow				
8/ 1	0830	< 0.01	3.2	2,160	8.3	
8/ 4	0800	No flow				
8/10	1000	< 0.05	5.2	2,448	8.4	
8/11	0800	No flow				
8/26	0800	No flow				
9/1	0800	No flow				

APPENDIX TABLE 72. FLOW RATE, EC, pH, AND TOTAL LITERS OF PERCOLATE FROM UPPER DRAIN OF 60 cm OF SOIL OVER RETORTED SHALE. HIGH ELEVATION LYSIMETER. 2% SLOPE, 1977.

PLOT H14 & H16.

Date	Time	Flow Rate (ℓ/hr)	Total liters	EC x 10^6	pH	Comments
7/ 1	0800	No flow				
8/ 1	0800	No flow				
9/ 1	0800	No flow				

APPENDIX TABLE 73. FLOW RATE, EC, pH, AND TOTAL LITERS OF PERCOLATE FROM UPPER DRAIN OF 80 cm OF SOIL OVER RETORTED SHALE. HIGH ELEVATION LYSIMETER. 2% SLOPE, 1977.

PLOT H18 & H20.

Date	Time	Flow Rate (ℓ/hr)	Total liters	EC x 10^6	pH	Comments
7/ 1	0800	No flow				
8/ 1	0800	No flow				
9/ 1	0800	No flow				

APPENDIX TABLE 74. FLOW RATE, EC, pH, AND TOTAL LITERS OF PERCOLATE FROM UPPER DRAIN OF SOIL CONTROL. HIGH ELEVATION LYSIMETER. 2% SLOPE, 1977.

PLOT H22 & H24.

Date	Time	Flow Rate (ℓ/hr)	Total liters	EC x 10^6	pH	Comments
7/ 1	0800	No flow				
8/ 1	0800	No flow				
9/ 1	0800	No flow				

APPENDIX TABLE 75. FLOW RATE, EC, pH, AND TOTAL LITERS OF PERCOLATE FROM LOWER DRAIN OF RETORTED SHALE. LOW ELEVATION LYSIMETER. 25% SLOPE, 1977.

Plot L1 & L3.

Date	Time	Flow Rate (ℓ/hr)	Total liters	EC x 10^6	pH	Comments
6/ 8	2100	< 0.2	0.2	8,214	8.6	← sampled
6/ 9	1400	No flow				
6/ 9	1600	No flow				
6/ 9	2000	No flow				
6/10	0700	No flow				
6/10	1200	No flow				
6/10	1500	No flow				
6/11	0900	< 0.2	3.8	11,800	8.3	
6/11	2000	No flow				
6/12	0600	0	3.8	11,800	8.3	
6/12	1200	26.4	162.4	-	-	
6/13	0730	1.6	194.9	8,160	7.2	
6/13	1400	8.5	250.5	22,876	10.9	
6/14	0800	7.2	381.4	25,000	10.6	
6/14	1400	7.8	428.7	29,000	10.9	
6/15	0900	5.1	526.3	34,048	10.2	← stopped leaching
6/16	0800	2.3	580.4	-	-	
6/17	0800	0	580.4	22,827	10.5	
6/19	0800	0	580.4	-		
6/21	0800	0	580.4			
6/22	0800	0	580.4	-	-	
6/23	0800	0	580.4			
6/27	0800	0	580.4	-	-	
6/29	0800	0	580.4	-	-	
6/30	0800	0	580.4	-	-	
7/ 1	0800	0.3	580.7		-	
7/ 7	0800	0	580.7	-	-	
7/11	0800	0	580.7	-	-	
7/21	0800	No flow				
7/26	0800	0.6	595.1		-	
7/28	0700	No flow				
7/29	0900	No flow				
8/ 3	0900	No flow				
8/ 4	0900	0.3	609.8	27,560	10.5	
8/10	1000	0.2	624.9	-	-	
8/11	0800	No flow				
8/15	0930	0.3	639.6	-	-	
8/16	0800	No flow				
8/17	0800	No flow				← stopped daily irrigations
8/18	0800	0.2	654.7	27,430	8.0	
8/22	0830	0.1	669.8	-	-	
8/23	0830	0.1	686.4	-	-	
8/24	0800	0.3	706.8	25,760	10.5	
9/ 1	0800	No flow				

APPENDIX TABLE 76. FLOW RATE, EC, pH, AND TOTAL LITERS OF PERCOLATE FROM LOWER DRAIN OF 20 cm OF SOIL OVER RETORTED SHALE. LOW ELEVATION LYSIMETER. 25% SLOPE, 1977.

PLOT L5 & L7.

Date	Time	Flow Rate (ℓ/hr)	Total liters	EC x 10^6	pH	Comments
6/ 8	0730	~3.7	3.7	26,796	10.2	← sampled
6/ 8	1000	4.1	13.9	21,683	10.5	
6/ 8	1200	3.0	19.9	21,586	10.4	
6/ 8	1400	2.5	24.9	20,100	10.3	
6/ 8	1530	2.4	28.5	20,830	10.3	
6/ 8	2100	2.4	41.7	21,924	10.2	
6/ 9	0600	6.4	99.3	17,280	10.7	
6/ 9	0800	7.5	114.3	16,120	10.8	
6/ 9	1000	7.9	130.1	17,390	10.8	
6/ 9	1200	6.3	142.7	17,390	10.8	
6/ 9	1400	4.7	152.1	17,020	10.6	
6/ 9	1800	4.0	160.1	17,560	10.6	
6/ 9	2000	7.1	188.5	17,380	10.7	
6/10	0700	15.0	353.5	17,420	11.0	
6/10	1500	7.8	415.9	15,570	11.0	
6/10	2130	9.7	478.9	15,340	11.0	
6/11	0900	28.2	803.2	14,890	11.0	
6/11	1600	51.9	881.1	-	-	
6/11	2000	45.9	973	15,570	11.2	
6/12	0600	34.8	1,321.6	15,080	11.3	
6/12	1200	47.8	1,608.9	-	-	
6/13	0730	5.0	1,706.9	17,000	10.8	
6/13	1400	0.8	1,712.1	21,500	10.8	
6/14	0800	70.3	2,977.5	21,903	10.7	
6/14	1400	1.2	2,985	20,910	11.0	← sampled
6/15	0900	15.9	3,287.4	21,420	11.0	← stop leaching
6/16	0800	0.8	3,307.4	19,551	10.8	← sampled
6/17	0800	1.5	3,345.2	17,792	10.9	
6/19	0800	1.2	3,405.3	-	-	
6/21	0800	0	3,405.3		-	
6/22	0800	0	3,405.3			
6/23	0800	0	3,405.3			
6/27	0800	0	3,405.3			
6/29	0800	0.7	3,440.8	-	-	
6/30	0800	0.03	3,441.5	-		
7/ 1	0800	0	3,441.5	-		
7/ 7	0800	0.1	3,459.6	-	-	
7/11	0800	0.01	3,460.7			
7/12	0800	0.2	3,465.9	-		
7/13	0800	0.2	3,471.5	-	-	
7/14	0800	0.1	3,474.1	19,610	10.8	
7/15	0800	0	3,474.1	-	-	
7/18	0800	0	3,474.1	-		
7/19	0800	0	3,474.1		-	
7/20	0800	0.1	3,477.8		-	
7/21	0800	11.4	3,753.7		-	
7/22	0800	0	3,753.7	-		
7/25	0800	0.05	3,757.2	-	-	
7/26	0800	0.7	3,774.5	18,750	10.8	
7/27	0800	0	3,774.5	-	-	
7/28	0700	1.6	3,812.7	-	-	
7/29	0900	0.7	3,832.7	-		

APPENDIX TABLE 76. PLOT L5 & L7 CONTINUED.

Date	Time	Flow Rate (ℓ/hr)	Total liters	EC x 10^6	pH	Comments
8/ 1	1100	1	3,914	19,203	7.7	
8/ 2	0830	13.9	4,214.1	-	-	
8/ 3	0900	0	4,214.1	20,292	8.1	
8/ 4	0900	0	4,214.1	-	-	
8/ 8	1030	0	4,214.1	21,740	8.0	
8/11	0800	No flow				
8/16	0800	0.1	4,228.7	-	-	
8/17	0800	0.1	4,232.4	-	-	← stopped daily irrigations
8/18	0800	0	4,232.4	21,903	7.8	
8/19	0830	7.1	4,406.9	-	-	
8/22	0830	0	4,406.9	20,910	7.9	
8/23	0830	0	4,406.9	20,828	8.0	
8/24	0800	0	4,406.9	20,748	7.5	
8/26	0800	4.8	4,638.5	22,344	8.1	
8/29	0800	0	4,638.5	20,748	7.9	
8/30	0800	0	4,638.5	-		
8/31	0800	0	4,638.5	24,978	8.2	
9/ 2	0800	0	4,638.5	21,033	8.2	

APPENDIX TABLE 77. FLOW RATE, EC, pH, AND TOTAL LITERS OF PERCOLATE FROM LOWER DRAIN OF 40 cm OF SOIL OVER RETORTED SHALE. LOW ELEVATION LYSIMETER. 25% SLOPE, 1977.

PLOT L9 & L11.

Date	Time	Flow Rate (ℓ/hr)	Total liters	EC x 10^6	pH	Comments
7/ 1	0800	No flow				
8/ 1	0800	No flow				
9/ 1	0800	No flow				

APPENDIX TABLE 78. FLOW RATE, EC, pH, AND TOTAL LITERS OF PERCOLATE FROM LOWER DRAIN OF 60 cm OF SOIL OVER RETORTED SHALE. LOW ELEVATION LYSIMETER. 25% SLOPE, 1977.

PLOT L13 & L15.

Date	Time	Flow Rate (ℓ/hr)	Total liters	EC x 10^6	pH	Comments
7/ 1	0800	No flow				
8/ 1	0800	No flow				
9/ 1	0800	No flow				

APPENDIX TABLE 79. FLOW RATE, EC, pH, AND TOTAL LITERS OF PERCOLATE FROM LOWER DRAIN OF 80 cm OF SOIL OVER RETORTED SHALE. LOW ELEVATION LYSIMETER. 25% SLOPE, 1977.

PLOT L17 & L19.

Date	Time	Flow Rate (ℓ/hr)	Total liters	EC x 10^6	pH	Comments
7/ 1	0800	No flow				
8/ 1	0800	No flow				
9/ 1	0800	No flow				

APPENDIX TABLE 80. FLOW RATE, EC, pH, AND TOTAL LITERS OF PERCOLATE FROM LOWER DRAIN OF SOIL CONTROL. LOW ELEVATION LYSIMETER. 25% SLOPE, 1977.

PLOT L21 & L23.

Date	Time	Flow Rate (ℓ/hr)	Total liters	EC x 10^6	pH	Comments
7/ 1	0800	No flow				
8/ 1	0800	No flow				
9/ 1	0800	No flow				

APPENDIX TABLE 81. FLOW RATE, EC, pH, AND TOTAL LITERS OF PERCOLATE FROM LOWER DRAIN OF RETORTED SHALE. LOW ELEVATION LYSIMETER. 2% SLOPE, 1977.

PLOT L2 & L4.

Date	Time	Flow Rate (ℓ/hr)	Total liters	EC x 10^6	pH	Comments
6/10	0900	0.2	0.2	12,680	8.8 ←	sampled
6/10	1100	1.0	2.2	21,620	8.6	
6/10	1300	1.0	4.2	22,400	8.5	
6/10	1500	1.0	6.2	23,990	8.4	
6/10	2130	1.0	12.7	23,200	8.3	
6/11	0900	3.5	52.9	22,830	9.7	
6/11		7.8	108.1	-	-	
6/11	2000	2.5	118.35	20,240	10.3	
6/12	0600	5.7	175.85	18,180	11.0	
6/12	1200	10.8	240.9	-	-	
6/13	0730	7.9	395.3	18,720	10.6	
6/13	1400	13.6	484.2	20,000	10.7	
6/14	0800	11.8	697.6	20,000	10.7	
6/14	1430	16.2	803.2	23,040	11.0	stopped
6/15	0900	4.7	891.4	24,500	10.8 ←	leaching
6/16	0800	1.9	936.4	29,000	10.6	
6/17	0800	0.5	950	28,912	10.6	
6/19	0800	1.0	1,001.4	29,310	11.2	
6/21	0800	0.2	1,015	-		
6/22	0800	0	1,015	-		
6/23	0800	0	1,015		-	
6/27	0800	0	1,015	-		
6/29	0800	0	1,015	-	-	
6/30	0800	0	1,015			
7/ 1	0800	0.5	1,028,6	22,610	10.8	
7/ 7	0800	0	1,028.6	-	-	
7/11	0800	0.1	1,042.6			
7/12	0800	0	1,042.6		-	
7/13	0800	0	1,042.6		-	
7/14	0800	0	1,042.6	-		
7/15	0800	0	1,042.6			
7/18	0800	0	1,042.6	-		
8/19	0800	0	1,042.6	-		
8/20	0800	0	1,042.6	-	-	stopped
8/21	0800	0	1,042.6	21,610	10.8 ←	daily
8/22	0800	0	1,042.6	-	-	irrigations
7/28	0700	No flow				
7/29	0900	No flow				
8/ 1	0800	No flow				
8/ 2	0800	No flow				
8/ 3	0800	No flow				
8/ 4	0800	No flow				
8/11	0800	No flow				
8/17	0800	No flow				

APPENDIX TABLE 82. FLOW RATE, EC, pH, AND TOTAL LITERS OF PERCOLATE FROM LOWER DRAIN OF 20 cm OF SOIL OVER RETORTED SHALE. LOW ELEVATION LYSIMETER. 2% SLOPE, 1977.

PLOT L6 & L8.

Date	Time	Flow Rate (ℓ/hr)	Total liters	EC x 10^6	pH	Comments
6/10	0900	<0.2	0.2	24,885	9.0 ←	sampled
6/10	1100	<1.0	2.2	24,780	9.7	
6/10	1300	<1.0	4.2	22,280	9.9	
6/10	2130	<1.0	12.5	22,720	9.2	
6/11	0900	3.2	49.3	19,680	10.3	
6/11	1600	4.5	81.4	-	-	
6/11	2000	0	81.4	17,240	10.3	
6/12	0600	8.5	167.3	14,690	11.2	
6/12	1200	5.9	202.8	-	-	
6/13	0730	3.9	279.6	14,400	10.7	
6/13	1400	0.5	283.3	14,896	10.7	
6/14	0800	5.6	385.1	14,603	10.7	
6/14	1430	13.1	470.6	15,300	10.9	stopped
6/15	0900	1.4	496.7	18,774	10.7 ←	leaching
6/16	0800	1.8	539.4	24,000	10.7	
6/17	0800	0.6	554.5	22,827	10.5	
6/19	0800	2.0	652.5	28,140	10.9	
6/21	0800	0.03	653.2	-	-	
6/22	0800	0.6	667.9	-		
6/23	0800	0	667.9	-	-	
6/27	0800	0	667.9	-	-	
6/29	0800	0	667.9	-		
6/30	0800	0	667.9	-		
7/ 1	0800	0.1	671.6			
7/ 7	0800	0.3	718.5	-		
7/11	0800	0.3	749.9		-	
7/12	0800	0	749.9		-	
7/13	0800	0	749.9			
7/14	0800	0	749.9	-	-	
7/15	0800	0	749.9		-	
7/18	0800	0	749.9	-		
7/19	0800	0	749.9			
7/20	0800	0	749.9	-	-	
7/21	0800	0.8	771.4	22,340	10.8	
7/28	0700	No Flow				
8/ 4	0800	No flow				stopped
8/11	0800	No flow				← daily
8/17	0800	No flow				irrigation

APPENDIX TABLE 83. FLOW RATE, EC, pH, AND TOTAL LITERS OF PERCOLATE FROM LOWER DRAIN OF 40 cm OF SOIL OVER RETORTED SHALE. LOW ELEVATION LYSIMETER. 2% SLOPE, 1977.

PLOT L 10 & L12.

Date	Time	Flow Rate (ℓ/hr)	Total liters	EC x 10^6	pH	Comments
7/ 1	0800	No flow				
8/ 1	0800	No flow				
9/ 1	0800	No flow				

APPENDIX TABLE 84. FLOW RATE, EC, pH, AND TOTAL LITERS OF PERCOLATE FROM LOWER DRAIN OF 60 cm OF SOIL OVER RETORTED SHALE. LOW ELEVATION LYSIMETER. 2% SLOPE, 1977.

PLOT L14 & L16.

Date	Time	Flow Rate (ℓ/hr)	Total liters	EC x 10^6	pH	Comments
7/ 1	0800	No flow				
8/ 1	0800	No flow				
9/ 1	0800	No flow				

APPENDIX TABLE 85. FLOW RATE, EC, pH, AND TOTAL LITERS OF PERCOLATE FROM LOWER DRAIN OF 80 cm OF SOIL OVER RETORTED SHALE. LOW ELEVATION LYSIMETER. 2% SLOPE, 1977.

PLOT L18 & L20.

Date	Time	Flow Rate (ℓ/hr)	Total liters	EC x 10^6	pH	Comments
7/ 1	0800	No flow				
8/ 1	0800	No flow				
9/ 1	0800	No flow				

APPENDIX TABLE 86. FLOW RATE, EC, pH, AND TOTAL LITERS OF PERCOLATE FROM LOWER DRAIN OF SOIL CONTROL. LOW ELEVATION LYSIMETER. 2% SLOPE, 1977.

PLOT L22 & L24.

Date	Time	Flow Rate (ℓ/hr)	Total liters	EC x 10^6	pH	Comments
7/ 1	0800	No flow				
8/ 1	0800	No flow				
9/ 1	0800	No flow				

APPENDIX TABLE 87. FLOW RATE, EC, pH, AND TOTAL LITERS OF PERCOLATE FROM UPPER DRAIN OF RETORTED SHALE. LOW ELEVATION LYSIMETER. 25% SLOPE, 1977.

PLOT L1 & L3.

Date	Time	Flow Rate (ℓ/hr)	Total liters	EC x 10^6	pH	Comments
6/12	0800	No flow				
7/ 1	0800	No flow				
8/ 1	0800	No flow				
9/ 1	0800	No flow				

APPENDIX TABLE 88. FLOW RATE, EC, pH, AND TOTAL LITERS OF PERCOLATE FROM UPPER DRAIN OF 20 cm OF SOIL OVER RETORTED SHALE. LOW ELEVATION LYSIMETER. 25% SLOPE, 1977.

PLOT L5 & L7.

Date	Time	Flow Rate (ℓ/hr)	Total liters	EC x 10^6	pH	Comments
6/12	0800	No flow				
7/ 1	0800	No flow				
8/ 1	0800	No flow				
9/ 1	0800	No flow				

APPENDIX TABLE 89. FLOW RATE, EC, pH, AND TOTAL LITERS OF PERCOLATE FROM UPPER DRAIN OF 40 cm OF SOIL OVER RETORTED SHALE. LOW ELEVATION LYSIMETER. 25% SLOPE, 1977.

PLOT L9 & L11.

Date	Time	Flow Rate (ℓ/hr)	Total liters	EC x 10^6	pH	Comments
7/ 1	0800	No flow				
8/ 1	0800	No flow				
9/ 1	0800	No flow				

APPENDIX TABLE 90. FLOW RATE, EC, pH, AND TOTAL LITERS OF PERCOLATE FROM UPPER DRAIN OF 60 cm OF SOIL OVER RETORTED SHALE. LOW ELEVATION LYSIMETER. 25% SLOPE, 1977.

PLOT L13 & L15.

Date	Time	Flow Rate (ℓ/hr)	Total liters	EC x 10^6	pH	Comments
7/ 1	0800	No flow				
8/ 1	0800	No flow				
9/ 1	0800	No flow				

APPENDIX TABLE 91. FLOW RATE, EC, pH, AND TOTAL LITERS OF PERCOLATE FROM UPPER DRAIN OF 80 cm OF SOIL OVER RETORTED SHALE. LOW ELEVATION LYSIMETER. 25% SLOPE, 1977.

PLOT L17 & L19.

Date	Time	Flow Rate (ℓ/hr)	Total liters	EC x 10^6	pH	Comments
7/ 1	0800	No flow				
8/ 1	0800	No flow				
9/ 1	0800	No flow				

APPENDIX TABLE 92. FLOW RATE, EC, pH, AND TOTAL LITERS OF PERCOLATE FROM UPPER DRAIN OF SOIL CONTROL. LOW ELEVATION LYSIMETER. 25% SLOPE, 1977.

PLOT L21 & L23.

Date	Time	Flow Rate (ℓ/hr)	Total liters	EC x 10^6	pH	Comments
7/ 1	0800	No flow				
8/ 1	0800	No flow				
9/ 1	0800	No flow				

APPENDIX TABLE 93. FLOW RATE, EC, pH, AND TOTAL LITERS OF PERCOLATE FROM UPPER DRAIN OF RETORTED SHALE. LOW ELEVATION LYSIMETER. 2% SLOPE, 1977.

PLOT L2 & L4.

Date	Time	Flow Rate (ℓ/hr)	Total liters	EC x 10^6	pH	Comments
7/ 1	0800	No flow				
8/ 1	0800	No flow				
9/ 1	0800	No flow				

APPENDIX TABLE 94. FLOW RATE, EC, pH, AND TOTAL LITERS OF PERCOLATE FROM UPPER DRAIN OF 20 cm OF SOIL OVER RETORTED SHALE. LOW ELEVATION LYSIMETER. 2% SLOPE, 1977.

PLOT L6 & L8.

Date	Time	Flow Rate (ℓ/hr)	Total liters	EC x 10^6	pH	Comments
7/ 1	0800	No flow				
8/ 1	0800	No flow				
9/ 1	0300	No flow				

APPENDIX TABLE 95. FLOW RATE, EC, pH, AND TOTAL LITERS OF PERCOLATE FROM UPPER DRAIN OF 40 cm OF SOIL OVER RETORTED SHALE. LOW ELEVATION LYSIMETER. 2% SLOPE, 1977.

PLOT L10 & L12.

Date	Time	Flow Rate (ℓ/hr)	Total liters	EC x 10^6	pH	Comments
7/ 1	0800	No flow				
8/ 1	0800	No flow				
9/ 1	0800	No flow				

APPENDIX TABLE 96. FLOW RATE, EC, pH, AND TOTAL LITERS OF PERCOLATE FROM UPPER DRAIN OF 60 cm OF SOIL OVER RETORTED SHALE. LOW ELEVATION LYSIMETER. 2% SLOPE, 1977.

PLOT L14 & L16.

Date	Time	Flow Rate (ℓ/hr)	Total liters	EC x 10^6	pH	Comments
7/ 1	0800	No flow				
8/ 1	0800	No flow				
9/ 1	0800	No flow				

APPENDIX TABLE 97. FLOW RATE, EC, pH, AND TOTAL LITERS OF PERCOLATE FROM UPPER DRAIN OF 80 cm OF SOIL OVER RETORTED SHALE. LOW ELEVATION LYSIMETER. 2% SLOPE, 1977

PLOT L18 & L20.

Date	Time	Flow Rate (ℓ/hr)	Total liters	EC x 10^6	pH	Comments
7/ 1	0800	No flow				
8/ 1	0800	No flow				
9/ 1	0800	No flow				

APPENDIX TABLE 98. FLOW RATE, EC, pH, AND TOTAL LITERS OF PERCOALTE FROM UPPER DRAIN OF SOIL CONTROL. LOW ELEVATION LYSIMETER. 2% SLOPE, 1977.

PLOT L22 & L24.

Date	Time	Flow Rate (ℓ/hr)	Total liters	EC x 10^6	pH	Comments
7/ 1	0800	No flow				
8/ 1	0800	No flow				
9/ 1	0800	No flow				

APPENDIX TABLE 99. ANALYSIS OF IRRIGATION WATER USED IN THIS STUDY. SAMPLE WAS COLLECTED ON JUNE 3 DURING LEACHING PHASE. 1977

Analyses	
EC µmhos/cm @25°C	1038
pH @ 25°C	7.5
TDS	620
Cation (meq/l)	
Ca	2.1
Mg	1.4
Na	6.2
K	0.08
Anion (meq/l)	
HCO_3	2.6
Cl	4.2
SO_4	3.6
SAR	4.7

APPENDIX TABLE 100. ANALYSIS OF LOWER DRAIN PERCOLATE WATER FROM RETORTED SHALE. HIGH ELEVATION LYSIMETER. 25% SLOPE, 1977

PLOT H1 & H3.

Analysis *	Reading Dates														
	6/8	6/8	6/12	6/13	6/14	6/16	6/17	6/19	7/14	8/1	8/8	8/23	8/24	8/30	9/ 2
EC μmhos/cm @25°C	12,983	14,389	18,972	19,893	17,731	19,500	27,222	18,774	14,602	19,000	15,000	11,000	11,000	11,000	10,500
pH @25°C	6.3	6.5	6.6	6.8	9.0	8.8	7.1	9.0	10.2	8.8	8.9	9.2	9.4	7.5	7.0
TDS	14,328	15,460	20,452	22,732	26,776	32,252	31,984	29,672	22,324						
Cation (meq/l)															
Ca	16.4	14.2	25.2	24.7	22.5	18.6	23.0	19.7	20.8	20.5	11.8	21.7	22.0	21.9	17.4
Mg	9.0	9.0	12.6	7.2	0.4	0.2	5.1	0.2	0.4	3.3	2.8	2.2	2.0	1.7	1.5
Na	148.8	166.5	199.0	233.0	294.7	369.3	429.3	320.5	252.1	221.0	167.0	109.0	108.0	108.0	90.0
K	11.2	10.9	18.0	22.5	23.9	30.9	45.1	31.2	24.1	22.8	15.0	13.8	13.8	13.7	11.3
Anions (meq/l)															
HCO_3	6.3	7.4	6.8	9.4	10.7	10.3	13.8	11.2	8.1	3.3	1.9	1.0	1.0	0.7	0.7
Cl	30.6	37.3	29.9	34.7	42.8	37.5	28.2	30.2	7.6	11.5	9.3	7.3	7.3	5.1	4.8
SO_4	157.7	177.7	235.5	247.7	257.7	299.9	449.6	288.8	235.5	250.0	169.0	133.0	127.0	134.0	119.0
SAR	52.8	29.2	46.2	59.7	89.3	123.1	116.0	103.4	78.8	65.0	61.8	32.0	31.7	31.7	30.0

* Analyses 6/8 thru 7/14 performed by CSU Agricultural Engineering Testing Laboratory, Grand Junction, Colorado; analyses 7/15 thru 8/31 performed by CSU Soil and Water Testing Laboratory, Fort Collins, Colorado.

APPENDIX TABLE 101. ANALYSIS OF PERCOLATE WATER FROM LOWER DRAIN OF 20 cm OF SOIL OVER RETORTED SHALE. HIGH ELEVATION LYSIMETER. 25% SLOPE, 1977 PLOT H5 & H7.

Analysis*	Reading Dates											
	6/9	6/14	6/16	6/19	7/14	7/27	8/1	8/19	8/23	8/24	8/30	8/31
EC μmhos/cm @25°C	20,940	14,344	17,731	21,000	14,341	16,500	18,500	13,500	14,000	14,000	14,000	14,000
pH @25°C	9.9	10.5	7.2	10.5	9.1	10.5	10.1	10.3	10.5	10.6	10.1	10.2
TDS	24,172	15,660	27,040	25,304	20,484	- - - - - - - - - - - - - - - - - - not determined - - - - - - - - - - - - - - - - - -						
<u>Cation</u> (meq/l)												
Ca	26.3	23.0	22.6	24.1	20.3	16.1	19.1	14.5	23.0	23.1	22.9	23.4
Mg	38.9	< 0.1	0.4	< 0.1	< 0.2	0.3	1.0	0.7	0.5	0.4	0.5	0.5
Na	238.7	159.3	311.9	287.0	240.6	228.0	217.0	144.0	148.0	148.0	148.0	149.0
K	16.8	14.0	20.5	21.6	20.8	19.9	19.0	13.0	14.6	14.6	14.6	14.8
<u>Anion</u> (meq/l)												
HCO_3	7.2	9.9	12.7	10.7	8.3	0.8	1.3	0.7	0.5	0.4	0.9	0.8
Cl	70.2	30.3	57.4	40.6	19.1	21.9	17.7	14.3	16.5	18.3	15.3	15.3
SO_4	235.5	177.7	235.5	255.5	188.8	249.0	238.0	164.0	153.0	177.0	153.0	170.0
SAR	41.8	46.7	94.5	84.4	74.2	114.0	70.0	53.3	43.5	43.5	44.8	43.8

* Analyses 6/8 thru 7/14 performed by CSU Agricultural Engineering Testing Laboratory, Grand Junction, Colorado; analyses 7/15 thru 8/31 performed by CSU Soil and Water Testing Laboratory, Fort Collins, Colorado.

APPENDIX TABLE 102. ANALYSIS OF PERCOLATE WATER FROM LOWER DRAIN OF 40 cm AND 60 cm OF SOIL OVER RETORTED SHALE. HIGH ELEVATION LYSIMETER. 25% SLOPE, 1977

PLOT H9 & H11, H13 & H15.

Analysis*	Sampling Dates									
	Plot H9 & H11					Plot H13 & H15				
	8/10	8/24	8/30	8/30	8/31	8/10	8/24	8/30	8/30	8/31
EC µmhos/cm @25°C	16,000	16,500	17,500	17,000	17,500	13,000	21,000	20,000	19,000	17,000
pH @25°C	9.7	10.2	10.3	10.3	10.7	8.5	7.9	7.1	8.1	8.6
TDS	- - - - - - - - - - - - - not determined - - - - - - - - - -					- - - - - - - - - - - - - not determined - - - - - - - - - - -				
<u>Cation</u> (meq/l)										
Ca	17.6	22.8	22.7	22.8	22.7	13.6	17.6	18.2	18.7	17.4
Mg	1.1	1.2	1.1	1.1	1.2	18.0	11.9	12.7	13.1	12.2
Na	183.0	184.0	194.0	195.0	195.0	145.0	246.0	245.0	233.0	216.0
K	15.1	16.8	17.8	17.7	17.9	7.9	18.2	18.3	18.1	16.8
<u>Anion</u> (meq/l)										
HCO_3	1.9	0.8	0.6	0.6	0.2	4.9	3.9	3.0	2.7	2.3
Cl	25.2	22.7	17.7	22.7	19.0	22.7	28.1	26.1	23.5	13.3
SO_4	193.0	209.0	222.0	225.0	225.0	156.0	268.0	275.0	266.0	238.0
SAR	61.0	54.1	57.0	57.3	57.3	37.1	64.7	62.8	59.7	40.0

* Analyses performed by CSU Soil and Water Testing Laboratory, Fort Collins, Colorado.

APPENDIX TABLE 103. ANALYSIS OF PERCOLATE WATER FROM LOWER DRAIN OF 80 cm OF SOIL OVER RETORTED SHALE AND SOIL CONTROL. HIGH ELEVATION LYSIMETER. 25% SLOPE, 1977

PLOT H17 & H19, H21 & H23.

Analysis*	Reading Dates												
	Plot H17 & H19						Plot H21 & H23						
	8/1	8/10	8/24	8/30	8/30	8/31	8/1	8/10	8/23	8/24	8/30	8/30	8/31
EC umhos/cm @25°C	8,300	3,500	13,500	13,500	14,500	14,500	4,600	3,500	5,100	5,100	5,100	5,100	5,100
pH @25°C	12.1	6.8	11.1	11.1	10.8	11.1	7.5	8.0	8.2	8.1	8.3	8.2	8.3
TDS	not determined						not determined						
Cation (meq/l)													
Ca	17.0	14.6	21.8	21.6	21.9	21.2	8.8	6.8	6.9	6.0	5.6	5.5	5.4
Mg	0.1	0.8	0.6	0.5	0.5	0.5	8.5	13.6	21.4	19.2	17.7	20.0	19.8
Na	71.8	23.6	163.0	156.0	166.0	156.0	31.5	22.5	36.1	32.2	31.4	34.7	34.0
K	7.5	1.7	11.3	11.4	12.3	11.2	2.9	1.0	1.1	0.9	1.1	1.0	1.0
Anion (meq/l)													
HCO_3	0.0	0.9	0.3	0.2	0.3	0.3	2.2	2.5	6.2	5.7	6.0	6.5	6.5
Cl	27.1	8.7	30.1	36.0	40.0	36.0	11.5	12.0	17.1	14.3	15.3	15.3	15.3
SO_4	52.8	29.4	163.0	143.0	170.0	160.0	35.6	26.2	37.5	33.1	31.9	34.4	36.2
SAR	24.7	8.7	49.3	47.2	50.3	47.2	10.8	7.0	9.7	9.2	9.2	9.9	9.7

* Analysis performed by CSU Soil and Water Testing Laboratory, Fort Collins, Colorado.

APPENDIX TABLE 104. ANALYSIS OF PERCOLATE WATER FROM LOWER DRAIN OF 20 cm AND 40 cm OF SOIL OVER RETORTED SHALE AND SOIL CONTROL. HIGH ELEVATION LYSIMETER. 2% SLOPE, 1977

PLOT H2 & H4, H6 & H8, H10 & H12, H22 & H24.

	Reading Dates									
	Plot H2 & H4						Plot H6 & H8		Plot H10 & H12	Plot H22 & H24
	6/12	6/13	6/16	6/17	6/19	8/10	6/12	6/17	8/10	8/1
EC μmhos/cm @25°C	11,342	13,611	20,860	23,728	19,556	15,500	7,121	30,363	2,400	5,400
pH	10.1	10.5	11.2	11.2	11.2	11.4	11.3	10.9	8.8	7.2
TDS	12,080	14,028	36,452	36,496	32,472		6,676	37,008		
Cation (meq/l)										
Ca	23,3	21.4	24.1	25.1	21.9	14.4	16.4	24.1	3.6	15.6
Mg	< 0.1	< 0.1	< 0.2	< 0.2	< 0.2	0.1	< 0.1	< 0.1	9.8	18.5
Na	117.9	149.7	423.9	415.6	369.3	173.0	66.2	401.9	13.2	37.1
K	8.9	10.1	23.9	29.0	23.6	15.2	3.9	31.6	0.2	1.0
Anion (meq/l)										
HCO_3	4.6	14.9	22.4	29.4	16.9	0.4	7.4	21.0	7.2	2.5
Cl	24.1	29.5	99.5	93.5	76.5	32.4	13.9	95.2	8.4	16.5
SO_4	145.4	176.7	311.0	339.3	309.3	174.0	76.9	409.3	9.7	50.0
SAR	34.7	46.8	42.7	121.1	111.9	66.5	23.6	118.2	5.1	9.0

* Analyses 6/8 thru 7/14 performed by CSU Agricultural Engineering Testing Laboratory, Grand Junction, Colorado; analyses 7/15 thru 8/31 performed by CSU Soil and Water Testing Laboratory, Fort Collins, Colorado.

APPENDIX TABLE 105. ANALYSIS OF PERCOLATE WATER FROM LOWER DRAIN OF RETORTED SHALE, AND 20 cm OF SOIL OVER RETORTED SHALE. LOW ELEVATION LYSIMETER. 2% AND 25% SLOPE, 1977

PLOT L1 & L3, L5 & L7, L2 & L4, L6 & L8.

Analysis*	Reading Dates									
	Plot L1 & L3		Plot L5 & L7						Plot L2 & L4	Plot L6 & L8
	6/8	6/9	6/8	6/14	6/16	8/1	8/24	8/30	6/10	6/10
EC µmhos/cm @25°C	13,754	5,737	18,374	12,516	13,298	19,000	19,000	13,000	9,126	13,013
pH @25°C	4.8	6.1	4.3	10.0	7.0	8.0	7.4	10.2	6.7	7.2
TDS	18,848	6,472	26,544	18,360	17,636				13,216	18,275
Cation (meq/l)										
Ca	18.6	8.6	19.7	23.6	21.4	24.0	25.0	22.5	23.9	18.6
Mg	1.4	2.4	2.8	< 0.2	< 0.2	33.0	9.8	0.5	1.4	1.9
Na	200.4	73.3	283.7	197.6	200.4	218.0	224.0	146.0	142.2	197.6
K	11.8	4.4	14.9	16.6	13.2	16.9	18.2	14.4	7.3	12.9
Anion (meq/l)										
HCO_3	5.2	4.9	5.2	10.5	9.0	2.5	1.2	0.8	4.6	11.8
Cl	61.2	4.6	80.3	34.8	30.6	22.7	12.8	15.3	38.0	46.7
SO_4	166.6	60.6	199.9	138.9	177.7	250.0	267.0	170.0	103.0	179.9
SAR	64.6	31.8	85.5	58.1	60.7	41.1	54.6	43.0	40.6	61.7

* Analyses 6/8 thru 7/14 performed by CSU Agricultural Engineering Testing Laboratory, Grand Junction, Colorado; analyses 7/15 thru 8/31 performed by CSU Soil and Water Testing Laboratory, Fort Collins, Colorado.

APPENDIX TABLE 106. ANALYSIS OF PERCOLATE WATER FROM UPPER DRAIN OF RETORTED SHALE AND 20 cm OF SOIL OVER RETORTED SHALE ON BOTH THE HIGH AND LOW ELEVATION LYSIMETERS. 25% AND 2% SLOPES. 1977

PLOT H1 & H3, H6 & H8, L6 & L8.

Analysis*	Sampling Dates			
	Plot H1 & H3		Plot H6 & H8	Plot L6 & L8
	6/10	6/13	6/12	6/13
EC µmhos/cm @25°C	6,246	6,387	1,088	7,224
pH @25°C	7.3	7.8	7.1	6.8
TDS	8,676	8,012	732	9,096
Cation (meq/l)				
Ca	31.4	32.0	1.8	39.8
Mg	32.5	2.9	1.8	37.0
Na	47.2	43.5	6.8	46.4
K	1.3	0.9	0.2	0.4
Anion (meq/l)				
HCO_3	7.2	9.2	2.3	5.6
Cl	16.9	10.8	2.7	16.3
SO_4	78.7	112.1	4.5	93.9
SAR	8.4	10.6	5.2	7.4

* Analyses performed by CSU Agricultural Engineering Testing Laboratory, Grand Junction, Colorado.

APPENDIX TABLE 107. ANALYSIS OF CORE SAMPLES FROM RETORTED SHALE. HIGH ELEVATION LYSIMETER. SEPTEMBER 1, 1977.

	25% Slope																					
	H1 Retorted Shale											H3 Retorted Shale										
Depth cm	pH	EC mmhos/cm @ 25°C	Cations (meq/l)				Anions (meq/l)				SAR	pH	EC mmhos/cm @ 25°C	Cations (meq/l)				Anions (meq/l)				SAR
			Ca	Mg	Na	K	HCO_3	SO_4	Cl	NO_3				Ca	Mg	Na	K	HCO_3	SO_4	Cl	NO_3	
Surface	9.2	2.2	2.3*	19.6	7.4	0.5	2.5	17.5	4.2	2.5	2.2	8.9	2.4	3.9	22.1	5.3	0.3	0.9	18.1	3.3	7.2	1.4
15	9.0	1.9	---	--	--	--	--	--	--	--	--	9.0	2.5	--	--	--	--	--	--	--	--	--
30	9.4	1.8	3.6	10.3	7.8	0.8	1.5	13.1	5.4	1.6	2.9	9.1	3.8	18.7	30.9	8.7	0.8	1.2	44.4	5.8	2.2	1.7
45	9.0	2.1	---	--	--	--	--	--	--	--	--	8.9	4.0	--	--	--	--	--	--	--	--	--
60	9.0	4.2	26.6	31.4	9.2	1.3	1.1	54.8	6.0	1.4	1.7	9.1	2.7	3.2	22.9	9.6	0.8	1.6	25.6	4.3	2.2	2.6
75	9.1	4.8	--	--	--	--	--	--	--	--	--	8.9	1.8	--	--	--	--	--	--	--	--	--
90	--	--	--	--	--	--	--	--	--	--	--	9.2	2.4	1.3	21.7	7.2	1.4	3.5	21.9	2.3	2.5	1.4
105	--	--	--	--	--	--	--	--	--	--	--	8.9	1.8	--	--	--	--	--	--	--	--	--
120	9.3	3.0	6.4	19.4	11.6	1.8	1.6	26.9	4.3	2.5	3.2	9.4	2.4	1.2	22.6	7.3	1.1	3.7	21.2	2.3	3.6	2.1
135	9.1	2.5	--	--	--	--	--	--	--	--	--	9.2	3.0	--	--	--	--	--	--	--	--	--
150	9.2	1.8	5.0	11.0	6.2	1.0	1.7	15.6	2.8	1.7	2.3	9.1	2.2	1.6	20.5	7.6	1.0	5.7	19.4	2.2	2.4	2.2
165	8.9	4.5	--	--	--	--	--	--	--	--	--	9.1	3.3	--	--	--	--	--	--	--	--	--
180	8.9	5.7	23.0	29.3	26.8	4.6	1.4	71.2	2.2	1.2	3.6	9.3	3.3	1.5	31.6	11.1	2.0	3.4	37.5	2.3	1.5	2.7

	2% Slope																					
	H2 Retorted Shale											H4 Retorted Shale										
Depth cm	pH	EC mmhos/cm @ 25°C	Cations (meq/l)				Anions (meq/l)				SAR	pH	EC mmhos/cm @ 25°C	Cations (meq/l)				Anions (meq/l)				SAR
			Ca	Mg	Na	K	HCO_3	SO_4	Cl	NO_3				Ca	Mg	Na	K	HCO_3	SO_4	Cl	NO_3	
Surface	9.4	1.5	2.0*	14.1	3.0	0.2	4.1	10.6	1.4	3.4	1.0	9.2	1.4	1.6	13.4	2.5	0.2	2.6	10.0	1.1	1.4	0.9
15	9.0	2.2	--	--	--	--	--	--	--	--	--	9.2	2.0	--	--	--	--	--	--	--	--	--
30	9.2	3.3	16.4	20.6	10.7	1.1	1.4	35.6	5.8	1.6	2.5	9.3	2.1	4.8	11.9	6.5	0.7	1.1	17.5	5.4	0.9	1.6
45	8.8	3.5	--	--	--	--	--	--	--	--	--	9.0	2.4	--	--	--	--	--	--	--	--	--
60	9.3	4.2	24.5	25.0	11.6	1.6	0.9	48.1	6.4	1.3	2.3	9.3	3.0	20.2	8.5	10.1	1.4	0.7	31.9	2.8	1.7	2.6
75	--	--	--	--	--	--	--	--	--	--	--	9.0	3.8	--	--	--	--	--	--	--	--	--
90	--	--	--	--	--	--	--	--	--	--	--	9.2	3.8	26.6	11.8	13.5	2.4	0.7	45.6	3.2	0.9	3.1
105	--	---	--	--	--	--	--	--	--	--	--	8.9	4.2	--	--	--	--	--	--	--	--	--
120	9.4	3.2	12.9	14.7	18.5	3.0	0.9	38.8	4.3	1.2	5.0	9.0	4.2	23.2	21.0	15.6	2.6	3.3	49.4	2.5	3.1	3.2
135	--	--	--	--	--	--	--	--	--	--	--	8.9	4.2	--	--	--	--	--	--	--	--	--
150	9.3	4.6	12.4	16.9	24.6	4.0	0.2	48.1	3.2	1.7	4.4	9.2	4.2	22.7	12.8	13.4	2.4	1.5	47.5	2.6	1.1	3.2
165	8.8	4.8	--	--	--	--	--	--	--	--	--	8.8	4.4	--	--	--	--	--	--	--	--	--
180	--	--	--	--	--	--	--	--	--	--	--	8.9	5.7	23.6	23.0	29.0	4.8	1.2	67.5	2.4	1.2	

* Analysis were determined on a 1:1 extract (shale to distilled water by weight) CSU Soil and Water Testing Laboratory.

APPENDIX TABLE 108. ANALYSIS OF CORE SAMPLES FROM RETORTED SHALE. LOW ELEVATION LYSIMETER. SEPTEMBER 1, 1977.

	25% Slope																					
	L1 Retorted Shale											L3 Retorted Shale										
Depth cm	pH	EC mmhos/cm @ 25°C	Cations (meq/l)				Anions (meq/l)				SAR	pH	EC mmhos/cm @ 25°C	Cations (meq/l)				Anions (meq/l)				SAR
			Ca	Mg	Na	K	HCO_3	SO_4	Cl	NO_3				Ca	Mg	Na	K	HCO_3	SO_4	Cl	NO_3	
Surface	9.3	1.6	1.7*	12.0	5.0	0.5	2.7	10.6	3.4	2.2	1.9	9.1	3.1	2.8	29.7	9.8	0.9	2.4	26.2	7.6	3.2	2.4
15	8.8	2.1	--	--	--	--	--	--	--	--	--	9.1	3.0	--	--	--	--	--	--	--	--	--
30	9.3	2.4	1.5	21.6	6.9	0.8	3.1	20.0	3.8	2.7	3.1	9.2	3.5	11.7	27.2	12.3	1.3	1.4	38.8	7.1	1.4	2.8
45	9.0	3.9	--	--	--	--	--	--	--	--	--	9.1	4.9	--	--	--	--	--	--	--	--	--
60	9.1	5.7	23.2	50.4	10.3	2.0	1.4	73.8	3.1	2.2	1.7	--	--	--	--	--	--	--	--	--	--	--
75	8.9	5.2	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
90	9.1	4.6	23.8	35.2	8.7	1.7	1.0	61.2	2.6	1.5	1.6	9.4	2.4	4.2	21.7	6.9	0.9	1.9	25.0	4.5	1.1	1.9
105	8.9	5.2	--	--	--	--	--	--	--	--	--	9.2	3.3	--	--	--	--	--	--	--	--	--
120	--	--	--	--	--	--	--	--	--	--	--	9.3	3.7	7.8	27.5	13.1	2.0	1.7	39.4	4.1	1.9	3.1
135	9.0	4.4	--	--	--	--	--	--	--	--	--	9.2	3.6	--	--	--	--	--	--	--	--	--
150	8.9	5.1	23.4	35.4	15.5	3.7	1.4	65.6	2.4	1.2	2.9	9.2	4.4	4.8	24.2	25.8	3.4	2.1	47.5	2.6	2.2	6.7
165	--	--	--	--	--	--	--	--	--	--	--	9.1	4.2	--	--	--	--	--	--	--	--	--
180	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--

	2% Slope																					
	L2 Retorted Shale											L4 Retorted Shale										
Depth cm	pH	EC mmhos/cm @ 25°C	Cations (meq/l)				Anions (meq/l)				SAR	pH	EC mmhos/cm @ 25°C	Cations (meq/l)				Anions (meq/l)				SAR
			Ca	Mg	Na	K	HCO_3	SO_4	Cl	NO_3				Ca	Mg	Na	K	HCO_3	SO_4	Cl	NO_3	
Surface	9.3	2.4	1.6*	19.3	8.3	0.8	3.4	15.6	6.0	6.3	2.5	9.2	2.3	1.4	18.9	5.9	0.4	2.3	14.4	3.8	7.9	1.8
15	8.9	3.6	--	--	--	--	--	--	--	--	--	9.1	2.0	--	--	--	--	--	--	--	--	--
30	9.1	4.6	21.4	34.5	13.4	1.6	1.1	65.6	4.3	1.5	2.5	9.3	2.6	0.6	23.6	9.7	1.0	6.3	23.1	3.4	2.1	2.8
45	8.8	4.4	--	--	--	--	--	--	--	--	--	9.0	2.1	--	--	--	--	--	--	--	--	--
60	9.1	4.7	25.4	27.0	17.6	3.0	1.1	62.5	3.3	0.4	3.4	9.2	2.5	1.0	21.9	8.9	1.4	5.1	20.6	2.3	3.7	2.6
75	9.0	4.4	--	--	--	--	--	--	--	--	--	8.9	4.2	--	--	--	--	--	--	--	--	--
90	9.0	4.0	16.0	26.7	10.1	2.2	0.9	46.2	2.4	1.4	2.2	9.2	4.8	8.3	50.7	14.0	2.4	2.5	62.5	2.5	2.7	2.6
105	8.9	4.2	--	--	--	--	--	--	--	--	--	9.0	4.0	--	--	--	--	--	--	--	--	--
120	9.1	4.4	10.1	31.3	18.5	2.8	1.7	53.1	1.9	3.6	4.0	9.1	5.0	21.6	35.1	19.1	4.0	1.1	71.2	2.6	1.8	3.6
135	8.9	3.3	--	--	--	--	--	--	--	--	--	9.0	4.8	--	--	--	--	--	--	--	--	--
150	9.1	4.8	4.9	43.5	19.1	2.6	3.5	56.2	2.8	2.7	3.8	9.2	5.0	21.4	35.1	18.5	3.8	1.1	66.9	2.4	1.5	3.5
165	8.8	4.2	--	--	--	--	--	--	--	--	--	9.0	4.9	--	--	--	--	--	--	--	--	--
180	--	--	--	--	--	--	--	--	--	--	--	9.0	5.4	17.2	30.9	24.1	4.5	1.4	70.0	2.5	1.2	6.0

* Analysis were determined on a 1:1 extract (shale to distilled water by weight) CSU Soil and Water Testing Laboratory.

APPENDIX TABLE 109. SALINITY SENSOR READINGS (mmhos/cm @ 25^{o}C) OF RETORTED SHALE. HIGH ELEVATION LYSIMETER. 25% SLOPE, 1977

PLOT H1.

Depth cm	Serial No.	Reading Dates																	
		6/2	6/8	6/9	6/10	6/11	6/12	6/13	6/14	6/15	6/17	6/21	6/27	7/1	8/2	8/8	8/15	8/22	8/29
15	5944	< 1.5	2.5	2.2	2.1	< 1.5	1.6	1.7	1.6	< 1.5	< 1.5	< 1.5	--	1.6	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5
30	5965	2.2	11.0	11.5	12.6	9.0	6.9	6.0	5.3	5.0	3.8	3.0	--	3.1	3.9	3.9	3.7	5.1	3.5
60	6026	1.9	3.1	3.3	4.7	4.5	7.8	8.0	7.3	7.0	5.8	5.0	--	11.0	5.5	5.0	5.2	5.5	5.5
90	5975	1.9	36.0	26.6	27.6	16.0	9.9	7.5	6.3	6.0	5.8	5.5	--	6.3	5.8	4.8	6.0	5.5	5.7
120	6129	--	22.0	11.5	6.5	5.0	4.3	3.9	3.9	3.5	3.2	3.5	--	4.3	4.7	3.6	4.4	4.6	4.4
150	5949	7.6	26.0	16.0	11.0	8.0	5.4	4.3	4.0	3.8	4.2	4.0	--	4.2	4.5	3.7	4.3	4.2	4.4

Plot H3.

Depth cm	Serial No.	Reading Dates																	
		6/2	6/8	6/9	6/10	6/11	6/12	6/13	6/14	6/15	6/17	6/21	6/27	7/1	8/2	8/8	8/15	8/22	8/29
15	6112	2.2	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5	1.7	< 1.5	< 1.5	< 1.5	< 1.5	--	>40.0	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5
30	6084	11.0	8.0	6.4	5.7	5.2	< 1.0	3.9	3.8	3.5	3.4	2.7	--	3.3	3.9	3.4	3.2	3.0	3.1
60	6069	11.0	4.9	3.7	3.6	2.9	2.4	2.4	1.9	2.3	1.8	2.1	--	3.2	3.9	3.2	3.2	3.3	3.7
90	6038	< 1.5	13.0	10.0	9.6	8.0	6.3	5.9	5.0	5.0	4.4	3.8	--	4.0	4.7	3.6	4.8	4.6	4.9
120	6030	< 1.5	26.0	25.0	25.0	20.0	8.8	10.5	9.0	7.0	6.8	5.6	--	4.5	5.3	4.8	5.2	5.0	5.2
150	5936	--	32.0	30.0	35.0	40.2	24.0	18.0	13.0	9.4	8.0	7.2	--	7.0	6.5	5.5	6.0	6.0	6.3

-- No reading.

APPENDIX TABLE 110. SALINITY SENSOR READINGS (mmhos/cm @ 25°C) FOR 20 cm OF SOIL OVER RETORTED SHALE. HIGH ELEVATION LYSIMETER. 25% SLOPE, 1977

PLOT H5.

Depth cm	Serial No.	Reading Dates																	
		6/2	6/8	6/9	6/10	6/11	6/12	6/13	6/14	6/15	6/17	6/21	6/27	7/1	8/2	8/8	8/15	8/22	8/29
15	6101	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5	1.6	< 1.5	< 1.5	< 1.5
30	6037	< 1.5	6.9	5.3	4.7	3.7	2.9	2.6	2.4	2.2	2.2	3.9	>40.0	2.5	2.2	2.5	2.5	3.1	5.6
60	6148	< 1.5	7.2	6.9	6.9	6.0	4.9	4.9	4.2	4.1	3.3	2.7	< 1.5	3.5	>40.0	3.0	3.0	2.9	2.9
90	6099	< 1.5	22.0	16.0	11.0	10.0	6.8	5.2	4.0	4.0	3.6	3.0	< 1.5	5.0	3.8	3.4	3.6	3.7	3.6
120	5928	< 1.5	< 1.5	< 1.5	1.7	< 1.5	1.8	2.7	2.9	3.0	2.8	2.7	10.0	3.4	3.4	2.8	3.4	3.4	3.7
150	6113	3.7	< 1.5	12.5	19.0	26.0	18.0	16.0	15.0	11.0	9.5	10.0	< 1.5	7.0	5.5	5.0	5.3	5.1	5.5

Plot H7.

Depth cm	Serial No.	Reading Dates																	
		6/2	6/8	6/9	6/10	6/11	6/12	6/13	6/14	6/15	6/17	6/21	6/27	7/1	8/2	8/8	8/15	8/22	8/29
15	6039	1.4	3.6	2.8	2.7	< 1.5	1.7	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5	25.0	20.0	2.0	2.5	2.5	2.5	3.2
30	6163	< 1.5	1.9	2.8	3.1	2.0	2.7	3.7	2.4	2.6	2.3	2.2	>40.0	3.4	2.8	1.9	2.4	2.1	2.9
60	5972	< 1.5	25.0	21.0	15.0	13.0	8.4	6.6	5.4	4.9	3.5	3.5	>40.0	30.0	4.3	4.0	4.0	3.8	4.1
90	6151	--	13.5	19.5	15.5	13.5	8.8	6.9	5.5	4.3	2.9	2.5	< 1.5	>40.0	4.8	4.5	4.6	3.9	4.1
120	6089	< 1.5	< 1.5	19.0	15.6	14.0	9.0	7.0	5.6	4.4	3.2	2.4	< 1.5	3.7	5.0	4.0	4.9	4.4	4.6
150	6163	< 1.5	--	< 1.5	17.0	22.0	14.0	10.9	9.0	7.3	6.0	5.5	< 1.5	6.5	7.8	8.0	7.2	6.9	7.2

-- No reading.

APPENDIX TABLE 111. SALINITY SENSOR READINGS (mmhos/cm @ 25°C) FOR 40 cm OF SOIL OVER RETORTED SHALE. HIGH ELEVATION LYSIMETER. 25% SLOPE, 1977

PLOT H9.

Depth cm	Serial No.	Reading Dates						
		6/27	7/1	8/2	8/8	8/15	8/22	8/29
15	6086	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5
30	6014	< 1.5	6.5	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5
60	5955	< 1.5	7.0	1.5	< 1.5	< 1.5	< 1.5	1.7
90	6035	< 1.5	< 1.5	7.6	6.1	5.0	3.9	4.2
120	6090	< 1.5	< 1.5	15.0	13.0	18.0	16.0	15.0
150	6032	8.2	10.0	20.4	18.0	20.6	22.0	22.0

Plot H11.

Depth cm	Serial No.	Reading Dates						
		6/27	7/1	8/2	8/8	8/15	8/22	8/29
15	6033	3.2	< 1.5	< 1.5	1.9	< 1.5	< 1.5	1.7
30	5938	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5
60	6118	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5
90	5967	< 1.5	< 1.5	12.5	10.5	8.5	6.7	6.9
120	6087	< 1.5	2.0	18.0	14.5	12.0	9.0	9.0
150	6011	2.1	3.6	25.5	21.0	17.0	11.5	12.0

APPENDIX TABLE 112. SALINITY SENSOR READINGS (mmhos/cm @ 25^{o}C) FOR 60 cm OF SOIL OVER RETORTED SHALE. HIGH ELEVATION LSYIMETER. 25% SLOPE, 1977

PLOT H13.

Depth cm	Serial No.	Reading Dates						
		6/27	7/1	8/2	8/8	8/15	8/22	8/29
15	6018	< 1.5	< 1.5	< 1.5	< 1.5	2.5	2.0	3.0
30	6088	4.5	< 1.5	2.0	1.8	< 1.5	< 1.5	< 1.5
60	6021	9.0	< 1.5	3.0	3.0	3.2	2.7	4.4
90	6125	2.5	3.0	4.0	4.0	3.1	2.3	2.7
120	6029	9.3	3.2	8.4	7.5	6.3	4.9	5.6
150	6076	7.1	3.7	13.0	12.0	10.2	7.5	7.9

Plot H15.

Depth cm	Serial No.	Reading Dates						
		6/27	7/1	8/2	8/8	8/15	8/22	8/29
15	5946	3.6	< 1.5	1.8	1.9	2.7	2.7	2.7
30	6092	4.0	2.5	< 1.5	1.6	1.6	< 1.5	1.6
60	5945	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5	1.7
90	6040	< 1.5	3.9	4.7	5.1	5.1	4.7	6.2
120	5991	1.7	4.1	13.0	16.0	14.5	11.5	12.0
150	6094	< 1.5	4.7	11.0	19.0	< 1.5	14.0	12.0

APPENDIX TABLE 113. SALINITY SENSOR READINGS (mmhos/cm @ 25^{o}C) FOR 80 cm OF SOIL OVER RETORTED SHALE. HIGH ELEVATION LYSIMETER. 25% SLOPE, 1977

PLOT H17.

Depth cm	Serial No.	Reading Dates						
		6/27	7/1	8/2	8/8	8/15	8/22	8/29
15	6034	2.5	< 1.5	< 1.5	< 1.5	>40.0	< 1.5	< 1.5
30	5982	2.4	< 1.5	1.6	2.0	2.2	< 1.5	2.3
60	6016	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5
90	5943	4.4	8.0	4.0	3.2	3.3	2.5	3.1
120	6009	5.1	< 1.5	8.0	6.1	7.2	5.6	6.5
150	5956	5.6	< 1.5	13.0	7.8	7.0	5.1	5.9

Plot H19.

Depth cm	Serial No.	Reading Dates						
		6/27	7/1	8/2	8/8	8/15	8/22	8/29
15	6124	2.3	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5
30	6093	3.5	< 1.5	1.6	< 1.5	< 1.5	< 1.5	1.8
60	3266	20.0	6.0	< 1.5	1.6	1.9	1.8	3.1
90	5980	8.0	5.0	1.5	< 1.5	2.0	2.0	3.0
120	5942	9.1	< 1.5	2.4	< 1.5	8.6	6.5	6.7
150	6152	10.5	2.0	11.0	8.0	1.7	1.5	2.3

APPENDIX TABLE 114. SALINITY SENSOR READINGS (mmhos/cm @ 25°C) OF RETORTED SHALE. HIGH ELEVATION LYSIMETER. 2% SLOPE, 1977

PLOT H2.

Depth cm	Serial No.	Reading Dates																	
		6/2	6/8	6/9	6/10	6/11	6/12	6/13	6/14	6/15	6/17	6/21	6/27	7/1	8/2	8/8	8/15	8/22	8/29
15	6169	< 1.5	3.3	2.9	2.7	1.8	< 1.5	1.7	1.9	1.6	< 1.5	< 1.5	< 1.5	1.9	< 1.5	4.1	< 1.5	< 1.5	1.6
30	6164	3.8	5.7	4.7	4.0	2.7	2.9	2.6	2.4	2.0	1.8	< 1.5	< 1.5	1.7	2.4	1.8	2.3	2.1	2.0
60	5978	< 1.5	4.5	3.6	3.3	3.0	2.7	2.4	2.4	2.4	2.2	2.4	3.4	3.5	4.2	4.2	4.1	4.2	4.0
90	6049	< 1.5	8.2	6.4	5.2	5.6	4.1	3.5	3.3	3.2	3.0	3.4	5.0	4.5	5.9	6.0	5.3	5.4	5.5
120	6168	9.6	12.0	7.6	4.0	2.7	2.4	2.2	2.0	2.0	2.5	3.0	4.4	3.9	>40.0	3.1	4.0	4.0	10.5
150	6085	9.6	11.5	7.0	5.1	5.5	3.9	3.6	3.3	3.0	3.5	3.8	4.7	1.6	6.7	6.5	5.8	5.6	8.2

Plot H4.

Depth cm	Serial No.	Reading Dates																	
		6/2	6/8	6/9	6/10	6/11	6/12	6/13	6/14	6/15	6/17	6/21	6/27	7/1	8/2	8/8	8/15	8/22	8/29
15	6109	12.6	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5	2.6	2.1	2.4	2.1	1.7	2.3
30	6110	16.0	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5	1.9	1.9	2.1	2.0	2.0	1.9	2.2
60	6105	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5
90	6100	3.5	16.0	11.9	8.8	7.2	5.5	4.5	2.5	3.7	3.3	3.5	4.0	5.5	4.8	4.1	4.3	3.3	3.7
120	6106	4.3	8.1	6.3	4.4	2.9	2.7	1.9	1.7	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5	2.6	2.0	< 1.5	< 1.5	< 1.5
150	6050	6.2	10.5	10.5	8.4	8.0	5.0	2.6	1.6	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5	4.1	4.1	3.6	3.1	3.3

APPENDIX TABLE 115. SALINITY SENSOR READINGS (mmhos/cm @ 25^{o}C) FOR 20 cm OF SOIL OVER RETORTED SHALE. HIGH ELEVATION LYSIMETER. 2% SLOPE, 1977

PLOT H6.

Depth cm	Serial No.	Reading Dates																	
		6/2	6/8	6/9	6/10	6/11	6/12	6/13	6/14	6/15	6/17	6/21	6/27	7/1	8/2	8/8	8/15	8/22	8/29
15	6072	2.0	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5	2.2	3.0	2.8	2.7	2.3
30	6160	< 1.5	4.3	3.4	2.7	1.9	1.8	1.6	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5	>40.0	1.6	1.6	2.1	1.7
60	6053	1.4	6.3	4.8	3.9	3.8	2.9	3.6	2.5	2.4	1.5	2.3	3.0	2.9	3.3	3.4	3.0	2.9	3.2
90	6144	6.0	7.9	5.7	4.2	2.5	2.9	3.6	2.5	2.3	2.3	2.4	2.1	2.7	3.0	< 1.5	2.8	1.6	2.6
120	6071	< 1.5	37.0	>40.0	35.0	>40.0	27.0	22.0	18.0	14.0	10.0	7.0	6.4	>40.0	5.6	4.9	4.8	4.3	4.5
150	6098	6.3	2.8	30.0	38.0	40.5	35.0	35.0	30.0	25.0	20.0	12.0	10.0	7.2	5.0	4.7	4.6	3.7	4.4

Plot H8.

Depth cm	Serial No.	Reading Dates																	
		6/2	6/8	6/9	6/10	6/11	6/12	6/13	6/14	6/15	6/17	6/21	6/27	7/1	8/2	8/8	8/15	8/22	8/29
15	6165	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5	>40.0	1.9	1.7	1.6	< 1.5
30	6097	< 1.5	3.0	2.3	1.9	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5	2.3	2.9	2.8	3.0	3.2
60	6062	< 1.5	3.6	3.1	2.7	2.9	2.3	2.2	33.0	2.0	1.7	1.9	2.6	2.7	>40.0	3.0	2.9	3.1	3.0
90	5947	1.6	3.7	3.2	2.9	2.8	2.7	2.6	3.5	2.4	2.5	2.5	3.0	3.0	3.0	3.0	2.9	2.9	3.4
120	6117	< 1.5	13.5	11.5	7.8	6.0	4.5	3.9	11.0	2.7	2.5	2.7	2.7	4.2	3.5	3.5	3.2	3.4	3.5
150	6052	4.6	12.7	9.9	33.0	40.3	23.0	15.0	29.1	6.0	7.2	6.2	7.0	6.0	< 1.5	7.0	7.1	7.0	7.0

APPENDIX TABLE 116. SALINITY SENSOR READINGS (mmhos/cm @ 25°C) FOR 40 cm OF SOIL OVER RETORTED SHALE. HIGH ELEVATION LYSIMETER. 2% SLOPE, 1977

PLOT H10.

Depth cm	Serial No.	Reading Dates						
		6/27	7/1	8/2	8/8	8/15	8/22	8/29
15	6046	2.2	< 1.5	>40.0	< 1.5	< 1.5	< 1.5	< 1.5
30	6140	5.0	< 1.5	< 1.5	< 1.5	2.3	1.7	2.0
60	6096	< 1.5	20.0	2.0	2.0	2.2	1.9	2.0
90	6149	< 1.5	< 1.5	5.0	3.5	5.0	4.6	4.5
120	5957	1.7	< 1.5	13.5	9.8	7.7	6.7	6.6
150	6020	< 1.5	>40.0	>40.0	29.0	14.0	11.9	10.5

Plot H12.

Depth cm	Serial No.	Reading Dates						
		6/27	7/1	8/2	8/8	8/15	8/22	8/29
15	6156	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5
30	5958	< 1.5	< 1.5	2.1	2.5	< 1.5	< 1.5	< 1.5
60	6073	1.8	1.8	2.1	2.2	2.0	2.0	1.9
90	6161	< 1.5	< 1.5	6.8	5.4	3.3	3.1	3.3
120	6147	< 1.5	< 1.5	10.5	7.9	8.5	7.7	7.6
150	6135	< 1.5	2.0	22.0	17.0	18.0	13.5	12.5

APPENDIX TABLE 117. SALINITY SENSOR READINGS (mmhos/cm @ 25^{o}C) FOR 60 cm OF SOIL OVER RETORTED SHALE. HIGH ELEVATION LYSIMETER. 2% SLOPE, 1977

PLOT H14.

Depth cm	Serial No.	Reading Dates 6/27	7/1	8/2	8/8	8/15	8/22	8/29
15	6074	5.4	< 1.5	< 1.5	< 1.5	< 1.6	< 1.5	< 1.5
30	5959	6.5	< 1.5	< 1.5	2.0	2.2	2.3	2.6
60	6075	14.0	6.0	2.3	2.3	2.4	2.4	2.8
90	6070	3.9	3.6	4.5	3.4	3.2	3.2	3.2
120	6120	13.0	11.0	10.0	6.3	5.5	4.9	4.6
150	6019	< 1.5	< 1.5	3.9	3.9	< 1.5	4.8	4.9

Plot H16.

Depth cm	Serial No.	Reading Dates 6/27	7/1	8/2	8/8	8/15	8/22	8/29
15	6107	2.1	3.9	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5
30	6102	6.0	6.5	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5
60	6066	< 1.5	3.4	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5
90	6045	2.5	3.0	5.0	4.6	4.6	4.9	5.6
120	5952	3.3	2.9	5.8	4.5	4.8	4.6	4.8
150	6134	4.0	3.5	7.0	6.3	4.8	6.0	6.8

APPENDIX TABLE 118. SALINITY SENSOR READINGS (mmhos/cm @ 25^{o}C) FOR 80 cm OF SOIL OVER RETORTED SHALE. HIGH ELEVATION LYSIMETER. 2% SLOPE, 1977

PLOT H18.

Depth cm	Serial No.	Reading Dates 6/27	7/1	8/2	8/8	8/15	8/22	8/29
15	5992	2.1	< 1.5	>40.0	2.0	1.9	1.9	2.2
30	5961	3.6	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5
60	6064	3.2	< 1.5	2.5	2.5	2.4	2.2	2.5
90	5954	< 1.5	< 1.5	>40.0	2.6	2.1	1.9	1.9
120	5941	< 1.5	< 1.5	7.4	5.3	4.1	3.8	3.8
150	6015	< 1.5	< 1.5	12.0	8.4	7.2	5.6	5.3

Plot H20.

Depth Serial cm	Serial No.	Reading Dates 6/27	7/1	8/2	8/8	8/15	8/22	8/29
15	6105	< 1.5	1.9	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5
30	5968	>40.0	8.0	2.2	2.4	2.5	3.5	3.1
60	6127	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5
90	5966	>40.0	2.0	2.5	1.9	1.9	1.9	2.0
120	6155	1.7	1.9	3.8	3.8	3.5	3.0	2.8
150	6162	< 1.5	< 1.5	4.6	3.1	3.0	2.6	2.6

APPENDIX TABLE 119. SALINITY SENSOR READINGS (mmhos/cm @ 25^{o}C) OF RETORTED SHALE. LOW ELEVATION LYSIMETER. 25% SLOPE, 1977

PLOT L1.

Depth cm	Serial No.	Reading Dates																
		6/2	6/8	6/9	6/10	6/11	6/12	6/13	6/14	6/15	6/17	6/21	6/27	8/3	8/10	8/17	8/24	8/31
15	5925	12.5	2.6	2.6	2.5	< 1.5	2.9	2.9	3.2	2.8	2.9	3.1	3.0	2.8	< 1.5	4.4	>40.0	2.6
30	5932	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5	1.6	< 1.5	< 1.5
60	5985	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5
90	6042	< 1.5	12.0	7.2	5.3	4.9	3.9	3.5	3.9	3.3	3.7	3.5	4.2	4.8	5.0	5.6	5.0	5.2
120	6131	9.4	16.0	30.0	20.0	19.0	9.8	7.3	6.4	5.4	4.8	4.2	4.4	>40.0	5.5	4.1	5.4	5.5
150	5931	6.2	12.5	25.0	17.0	14.0	7.7	6.5	6.5	5.1	5.1	4.1	4.5	5.6	5.6	6.5	5.8	5.8

Plot L3.

Depth cm	Serial No.	Reading Dates																
		6/2	6/8	6/9	6/10	6/11	6/12	6/13	6/14	6/15	6/17	6/21	6/27	8/3	8/10	8/17	8/24	8/31
15	6060	1.8	2.8	2.3	2.0	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5	2.1	< 1.5	< 1.5
30	6025	< 1.5	3.2	2.6	2.5	1.7	2.6	1.8	2.0	< 1.5	< 1.5	< 1.5	< 1.5	3.1	3.4	5.2	3.6	3.2
60	5926	< 1.5	6.6	2.7	2.3	2.6	2.4	1.8	1.7	< 1.5	< 1.5	< 1.5	< 1.5	2.8	3.5	5.4	4.1	3.6
90	5935	1.9	7.2	4.5	4.2	3.5	3.2	2.4	3.0	2.2	1.7	2.3	< 3.5	6.6	10.5	7.6	6.6	6.4
120	5990	5.8	5.5	5.5	5.0	3.0	4.2	3.9	4.0	2.0	3.9	4.0	< 4.5	7.6	7.8	9.2	8.5	8.5
150	5930	7.5	5.6	4.0	3.5	3.7	3.1	2.8	2.9	2.8	2.8	2.9	< 3.4	6.2	6.4	7.0	6.8	6.7

APPENDIX TABLE 120. SALINITY SENSOR READINGS (mmhos/cm @ 25°C) FOR 20 cm OF SOIL OVER RETORTED SHALE. LOW ELEVATION LYSIMETER. 25% SLOPE, 1977

PLOT L5.

Depth cm	Serial No.	Reading Dates																
		6/2	6/8	6/9	6/10	6/11	6/12	6/13	6/14	6/15	6/17	6/21	6/27	8/3	8/10	8/17	8/24	8/31
15	5923	< 1.5	1.9	1.8	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5	2.3	< 1.5	4.7	6.0	4.0	4.9
30	5989	< 1.5	4.7	3.9	3.2	< 1.5	2.7	2.4	2.7	2.0	< 1.5	1.6	2.3	4.6	5.6	9.3	8.4	8.6
60	5963	< 1.5	13.5	8.9	6.1	5.0	3.9	2.9	3.0	2.3	2.1	2.3	3.9	< 1.5	7.2	8.6	7.8	7.2
90	6012	< 1.5	26.0	19.0	14.0	12.0	7.9	6.3	6.0	6.2	4.9	4.4	5.5	8.6	8.4	8.6	9.0	8.8
120	5997	< 1.5	--	10.0	14.1	16.0	11.4	9.9	9.1	8.0	7.5	5.7	6.0	9.6	< 1.5	9.2	9.8	9.8
150	6057	< 1.2	--	24.0	20.0	25.0	15.0	11.5	7.3	7.0	8.0	6.7	7.8	9.6	9.7	9.6	10.5	10.9

Plot L7.

Depth cm	Serial No.	Reading Dates																
		6/2	6/8	6/9	6/10	6/11	6/12	6/13	6/14	6/15	6/17	6/21	6/27	8/3	8/10	8/17	8/24	8/31
15	6139	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5	0	< 1.5	< 1.5	2.0	2.6	4.8	5.2	4.4
30	5921	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5	2.4	2.8	3.9	4.7	4.5
60	6004	< 1.5	9.9	8.8	7.0	6.2	4.6	3.9	4.2	3.3	3.2	2.4	3.9	7.0	7.1	7.4	4.4	7.0
90	6000	< 1.5	3.3	2.8	2.2	1.9	1.8	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5	5.0	5.0	5.4	5.4	5.2
120	5933	3.6	9.0	7.5	6.0	5.9	4.9	4.5	4.9	4.0	1.5	3.3	3.5	6.2	6.5	6.9	6.8	6.8
150	6055	5.3	6.0	4.3	< 1.5	< 1.5	3.8	3.5	< 1.5	6.0	3.8	< 1.5	4.0	6.2	6.3	7.0	7.0	7.0

-- No reading.

APPENDIX TABLE 121. SALINITY SENSOR READINGS (mmhos/cm @ 25^{o}C) FOR 40 cm OF SOIL OVER RETORTED SHALE. LOW ELEVATION LYSIMETER. 25% SLOPE, 1977

PLOT L9.

Depth cm	Serial No.	Reading Dates					
		6/27	8/3	8/10	8/17	8/24	8/31
15	5939	1.6	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5
30	5951	7.5	7.0	7.4	8.4	8.6	8.5
60	5987	4.5	4.2	5.8	6.6	8.6	10.5
90	6005	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5
120	6002	11.5	16.0	< 1.5	11.0	15.0	< 1.5
150	5981	16.0	20.0	24.0	18.0	>40.0	< 1.5

Plot L11.

Depth cm	Serial No.	Reading Dates					
		6/27	8/3	8/10	8/17	8/24	8/31
15	5027	9.0	4.0	4.0	6.1	6.7	3.8
30	6007	5.0	< 1.5	< 1.5	3.1	< 1.5	4.8
60	5940	< 1.5	1.8	1.9	3.1	2.1	2.2
90	5962	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5
120	5999	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5
150	6154	< 1.5	< 1.5	< 1.5	< 1.5	20.0	< 1.5

APPENDIX TABLE 122. SALINITY SENSOR READINGS (mmhos/cm @ 25°C) FOR 60 cm OF SOIL OVER RETORTED SHALE. LOW ELEVATION LYSIMETER. 25% SLOPE, 1977

PLOT L13.

Depth cm	Serial No.	Reading Dates					
		6/27	8/3	8/10	8/17	8/24	8/31
15	6079	8.0	4.3	4.0	3.8	5.6	4.4
30	6150	< 1.5	12.0	11.5	8.6	11.3	11.0
60	6001	< 1.5	4.5	4.4	4.9	3.3	2.8
90	5984	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5
120	6078	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5
150	6116	7.8	< 1.5	< 1.5	1.6	< 1.5	< 1.5

Plot L15.

Depth cm	Serial No.	Reading Dates					
		6/27	8/3	8/10	8/17	8/24	8/31
15	6095	5.5	3.0	3.0	2.3	2.4	3.2
30	6103	4.3	2.3	2.8	1.7	3.5	2.6
60	6022	2.1	5.0	8.0	5.4	< 1.5	6.2
90	6128	3.9	2.5	2.5	2.8	14.5	2.3
120	6123	6.0	< 1.5	< 1.5	< 1.5	11.0	< 1.5
150	5973	< 1.5	< 1.5	< 1.5	< 1.5	8.4	< 1.5

APPENDIX TABLE 123. SALINITY SENSOR READINGS (mmhos/cm @ 25^{o}C) FOR 80 cm OF SOIL OVER RETORTED SHALE. LOW ELEVATION LYSIMETER. 25% SLOPE, 1977

PLOT L17.

Depth cm	Serial No.	Reading Dates 6/27	8/3	8/10	8/17	8/24	8/31
15	5983	2.4	2.2	2.1	2.7	2.4	2.0
30	6115	2.6	3.5	< 1.5	2.1	3.5	3.0
60	6082	< 1.5	< 1.5	< 1.5	2.0	< 1.5	< 1.5
90	5971	11.0	13.0	13.5	10.1	14.5	14.0
120	5974	7.5	10.5	10.5	9.2	11.0	11.5
150	5976	7.4	>40.0	< 1.5	6.5	8.4	8.5

Plot L19.

Depth cm	Serial No.	Reading Dates 6/27	8/3	8/10	8/17	8/24	8/31
15	6091	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5
30	6077	5.0	3.8	3.5	3.2	3.2	3.4
60	6114	3.5	8.2	7.8	5.6	7.0	6.2
90	6119	1.7	2.8	3.3	4.6	6.0	8.0
120	6031	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5
150	5979	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5

APPENDIX TABLE 124. SALINITY SENSOR READINGS (mmhos/cm @ 25^{o}C) OF RETORTED SHALE. LOW ELEVATION LYSIMETER. 2% SLOPE, 1977

PLOT L2.

Depth cm	Serial No.	Reading Dates																
		6/2	6/8	6/9	6/10	6/11	6/12	6/13	6/14	6/15	6/17	6/21	6/27	8/3	8/10	8/17	8/24	8/31
15	6122	< 1.5	2.1	2.2	2.4	< 1.5	1.9	1.8	2.0	1.9	< 1.5	1.9	1.9	< 1.5	< 1.5	2.4	2.9	< 1.5
30	6017	< 1.5	7.0	6.0	5.4	5.0	4.1	3.7	3.2	3.2	2.6	2.4	2.7	4.4	4.9	4.7	4.9	5.0
60	5953	< 1.5	6.5	4.8	4.0	3.4	2.9	2.6	2.5	2.4	1.7	2.2	2.6	4.3	4.2	4.2	4.5	4.2
90	6121	< 1.5	14.5	11.5	9.6	8.2	6.4	5.2	4.5	3.8	2.9	2.5	2.5	4.2	4.3	4.5	4.5	4.5
120	5970	6.4	11.0	8.2	7.3	6.1	4.8	4.1	3.8	3.3	3.3	3.3	3.6	5.8	6.0	6.0	6.4	6.5
150	6006	10.0	19.0	18.0	17.0	21.0	12.5	9.4	6.1	6.7	6.4	4.7	4.6	5.7	5.8	6.0	6.4	6.5

Plot L4.

Depth cm	Serial No.	Reading Dates																
		6/2	6/8	6/9	6/10	6/11	6/12	6/13	6/14	6/15	6/17	6/21	6/27	8/3	8/10	8/17	8/24	8/31
15	5948	1.8	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5
30	5998	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5	0	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5
60	6159	5.0	3.3	2.9	2.5	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5	2.9	3.0	3.0	3.0	3.1	2.7
90	5960	9.0	6.5	5.9	5.6	5.5	4.5	4.2	4.2	4.0	4.2	4.0	2.5	5.3	4.0	5.4	5.5	5.5
120	6158	8.0	4.7	4.4	3.9	3.0	3.5	3.2	2.8	3.1	2.8	3.1	3.0	5.2	5.5	5.3	5.6	5.4
150	6166	9.0	19.0	22.0	20.0	16.0	10.5	8.4	6.5	5.7	4.9	4.0	3.9	5.8	6.0	5.8	6.3	6.4

APPENDIX TABLE 125. SALINITY SENSOR READINGS (mmhos/cm @ 25°C) FOR 20 cm OF SOIL OVER RETORTED SHALE. LOW ELEVATION LYSIMETER. 2% SLOPE, 1977

PLOT L6.

Depth cm	Serial No.	Reading Dates																
		6/2	6/8	6/9	6/10	6/11	6/12	6/13	6/14	6/15	6/17	6/21	6/27	8/3	8/10	8/17	8/24	8/31
15	6157	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5
30	6153	< 1.5	3.9	2.8	2.4	3.4	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5	4.8	6.6	7.4	6.1	3.2
60	6065	3.2	4.1	3.5	3.1	2.1	2.3	1.8	2.1	1.9	2.5	2.4	2.9	5.9	6.8	7.0	7.1	7.9
90	6013	6.2	5.0	3.5	3.0	1.9	1.9	1.6	< 1.5	< 1.5	< 1.5	1.7	2.5	5.4	5.2	5.4	5.9	5.8
120	5977	4.0	13.5	9.1	6.9	6.0	4.8	4.2	3.9	3.4	3.4	2.8	3.0	5.4	5.5	5.4	6.1	6.5
150	6167	13.0	13.5	14.0	10.5	9.0	6.0	4.9	4.5	3.9	3.4	3.6	3.9	5.2	6.0	5.6	6.3	6.8

Plot L8.

Depth cm	Serial No.	Reading Dates																
		6/2	6/8	6/9	6/10	6/11	6/12	6/13	6/14	6/15	6/17	6/21	6/27	8/3	8/10	8/17	8/24	8/31
15	6133	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5	1.6	< 1.5	< 1.5
30	6056	2.2	7.6	5.8	5.0	< 1.5	3.4	2.9	3.1	2.6	2.4	2.4	2.6	3.7	3.9	4.0	4.6	4.8
60	6059	< 1.5	4.5	3.5	3.0	2.4	1.7	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5	1.6	< 1.5
90	6054	< 1.5	6.4	4.5	3.7	2.7	2.6	2.3	2.3	1.9	1.9	2.2	2.7	4.8	5.0	4.9	5.4	5.4
120	6080	6.6	6.9	5.1	4.0	3.9	2.7	2.3	2.5	2.2	2.1	2.0	2.2	4.3	4.3	4.5	4.5	4.7
150	5922	< 1.5	8.8	6.8	5.5	5.0	3.9	3.4	3.4	2.7	1.9	< 1.5	2.3	4.5	4.6	4.3	4.7	4.8

APPENDIX TABLE 126. SALINITY SENSOR READINGS (mmhos/cm @ 25°C) FOR 40 cm OF SOIL OVER RETORTED SHALE. LOW ELEVATION LYSIMETER. 2% SLOPE, 1977

PLOT L10.

Depth cm	Serial No.	Reading Dates					
		6/27	8/3	8/10	8/17	8/24	8/31
15	6081	1.6	1.9	2.2	2.5	3.0	2.9
30	6130	2.0	< 1.5	< 1.5	< 1.5	1.9	2.2
60	5993	4.5	16.0	10.5	12.5	12.5	11.3
90	6058	< 1.5	1.7	10.2	5.2	8.8	15.0
120	6047	1.6	2.4	5.5	2.2	2.3	2.6
150	5986	< 1.5	1.7	12.0	3.8	5.2	6.6

Plot L12.

Depth cm	Serial No.	Reading Dates					
		6/27	8/3	8/10	8/17	8/24	8/31
15	6063	2.2	2.6	3.3	4.3	2.8	< 1.5
30	6083	3.2	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5
60	6145	< 1.5	13.0	10.5	8.2	8.2	7.0
90	6061	< 1.5	12.0	10.2	8.6	9.0	8.8
120	6142	< 1.5	7.0	5.5	5.5	6.3	6.3
150	5996	< 1.5	< 1.5	12.0	< 1.5	< 1.5	< 1.5

APPENDIX TABLE 127. SALINITY SENSOR READINGS (mmhos/cm @ 25^{o}C) FOR 60 cm OF SOIL OVER RETORTED SHALE. LOW ELEVATION LYSIMETER. 2% SLOPE, 1977

PLOT L14.

Depth cm	Serial No.	Reading Dates					
		6/27	8/3	8/10	8/17	8/24	8/31
15	6068	3.5	< 1.5	< 1.5	3.4	4.2	< 1.5
30	5995	6.8	3.3	3.5	5.1	6.0	7.0
60	5988	5.4	9.0	9.0	8.7	8.4	8.3
90	5994	< 1.5	< 1.5	2.2	5.3	17.0	22.0
120	5920	< 1.5	< 1.5	< 1.5	< 1.5	11.0	< 1.5
150	6003	11.0	10.0	< 1.5	10.5	11.0	11.5

Plot L16.

Depth cm	Serial No.	Reading Dates					
		6/27	8/3	8/10	8/17	8/24	8/31
15	6028	6.9	2.6	2.7	< 1.5	2.3	1.9
30	6043	< 1.5	2.6	2.3	3.6	2.2	1.6
60	6048	3.5	6.2	5.9	6.6	5.3	5.4
90	5937	8.8	11.5	10.7	8.6	12.5	13.0
120	5950	< 1.5	< 1.5	< 1.5	11.8	< 1.5	< 1.5
150	6041	11.0	10.0	8.8	11.0	7.6	7.4

APPENDIX TABLE 128. SALINITY SENSOR READINGS (mmhos/cm @ 25°C) FOR 80 cm OF SOIL OVER RETORTED SHALE. LOW ELEVATION LYSIMETER. 2% SLOPE, 1977

PLOT L18.

Depth cm	Serial No.	Reading Dates					
		6/27	8/3	8/10	8/17	8/24	8/31
15	6137	3.1	2.3	< 1.5	< 1.5	2.2	< 1.5
30	5934	6.0	4.2	3.9	3.6	4.9	4.5
60	6132	< 1.5	2.8	8.6	6.6	7.8	7.0
90	6027	14.4	11.5	11.0	8.6	9.6	9.2
120	6051	10.5	< 1.5	13.5	11.8	13.0	13.0
150	6146	9.8	< 1.5	12.0	11.0	13.0	16.0

Plot L20.

Depth cm	Serial No.	Reading Dates					
		6/27	8/3	8/10	8/17	8/24	8/31
15	6036	4.0	2.3	2.6	4.8	3.5	4.2
30	6024	3.0	4.2	4.1	4.8	4.3	4.2
60	5929	2.0	2.8	3.8	3.9	3.8	3.7
90	6138	12.0	11.5	9.5	10.0	7.8	7.8
120	6023	2.6	< 1.5	< 1.5	< 1.5	8.6	< 1.5
150	6044	4.2	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5

APPENDIX TABLE 129. CHEMICAL ANALYSIS OF PERCOLATE WATER FROM LOWER DRAIN OF RETORTED SHALE TREATMENT, 25% SLOPE. HIGH ELEVATION LYSIMETER. ANALYSIS PERFORMED BY MR. TOM GARLAND, BATTELLE NORTHWEST LABORATORY, RICHLAND, WASHINGTON.

PLOT H1 & H3.

Date	Total Liters	pH	EC μmhos/cm	Organic C μg/ml	Inorganic C μg/ml	Cations μg/ml								Anions μg/ml			
						Ca	Mg	Na	K	Al	B	Zn	Mo	SO_4	Cl	F	NO_3
6/ 9	22.7	6.45	20,800	241	45	440	6.84	5,360	663	0.11	1.09	1.09	3.73	10,800	1,200	11.4	<0.1
6/12	2,271.2	9.40	20,600	130	9	513	0.92	5,360	772	<0.01	1.32	0.10	3.30	12,000	600	10.9	<0.1
6/13	3,051	10.25	22,600	118	30	493	5.76	5,980	916	<0.01	1.54	0.09	3.73	13,500	510	12.0	<0.1
6/14	4,542.5	10.45	26,300	169	39	480	5.20	7,250	1,090	0.055	1.03	0.11	4.62	15,000	940	12.5	<0.1
6/16	8,653.4	10.20	30,700	153	19	395	3.30	9,050	1,450	0.055	2.18	0.12	5.58	19,700	600	14.2	<0.1
6/17	9,187.2	10.10	30,050	140	26	394	3.01	8,090	1,460	0.055	2.00	0.13	5.36	20,000	510	14.0	<0.0
7/14	18,129.7	10.30	21,300	20	22	139	0.42	5,000	853	<0.01	0.99	0.06	2.53	11,600	140	8.4	<0.1
8/ 1	23,178	8.00	19,200	19	27	414	34.0	5,500	1,020	<0.01	1.59	0.08	3.03	13,700	110	9.6	<0.1
8/ 8	26,232.9	9.10	16,600	<2	13	198	13.9	4,270	620	<0.01	0.67	0.07	0.96	10,400	80	7.3	<0.1
8/23	31,876.9	7.95	12,200	3	9	445	23.8	2,550	620	<0.01	1.13	0.05	1.63	7,500	80	8.6	<0.1
8/25	32,066.2	7.45	11,800	<2	16	444	21.3	2,450	607	<0.01	1.11	0.05	1.62	7,100	130	8.0	0.1

Date	Total Liters	pH	EC μmhos/cm	Elements μg/ml													
				As	Ba	Be	Cr	Cu	Fe	Pb	Mn	Ni	Se	SiO_2	Ag	Sr	V
6/ 9	22.7	6.45	20,800	0.07	0.11	<0.005	0.020	0.17	0.29	0.016	0.075	0.04	0.025	24.1	0.004	10.5	0.23
6/12	2,271.2	9.40	20,600	0.07	0.11	<0.005	0.003	0.030	<0.01	0.014	<0.01	0.03	<0.02	6.55	0.003	11.6	0.30
6/13	3,051	10.25	22,600	0.05	0.15	0.007	0.005	0.060	<0.01	0.025	<0.01	0.02	0.03	11.9	0.001	11.9	0.30
6/14	4,542.5	10.45	26,300	0.05	0.20	0.007	0.008	0.060	<0.01	0.026	<0.01	<0.01	0.03	22.2	0.002	12.0	0.35
6/16	8,653.4	10.20	30,700	0.05	0.15	0.005	0.008	0.070	<0.01	0.042	<0.01	<0.01	0.03	27.3	0.002	11.6	0.35
6/17	9.187.2	10.10	30,850	0.13	0.12	0.005	0.016	0.070	<0.01	0.024	0.15	<0.01	0.04	25.7	0.002	11.8	0.30
7/14	18,139.7	10.30	21,300	0.04	0.047	<0.005	0.004	0.050	<0.01	<0.005	<0.01	<0.01	<0.02	7.70	0.001	6.3	0.18
8/ 1	23,178	8.00	19,200	0.06	0.091	0.006	0.005	0.016	<0.01	<0.005	0.26	<0.01	<0.02	19.4	0.001	10.1	0.18
8/ 8	26,232.9	9.10	16,600	0.04	0.071	<0.005	0.003	0.031	<0.01	<0.005	0.11	<0.01	<0.02	17.3	<0.001	6.1	0.10
8/23	31,876.9	7.95	12,200	0.04	0.061	0.006	0.002	0.006	<0.01	<0.005	0.043	<0.01	<0.02	14.2	<0.001	10.0	0.15
8/25	32,066.2	7.45	11,800	0.04	0.065	0.007	0.002	0.004	<0.01	<0.005	0.049	<0.01	<0.02	14.4	<0.001	9.9	0.10

APPENDIX TABLE 130. CHEMICAL ANLAYSIS OF PERCOLATE WATER FROM LOWER DRAIN OF 20 cm SOIL COVER TREATMENT, 25% SLOPE. HIGH ELEVATION LYSIMETER. ANALYSIS PERFORMED BY MR. TOM GARLAND, BATTELLE NORTHWEST LABORATORY, RICHLAND, WASHINGTON.

PLOT H5 & H7.

Date	Total Liters	pH	EC µmhos/cm	Organic C µg/ml	Inorganic C µg/ml	Cations µg/ml								Anions µg/ml			
						Ca	Mg	Na	K	Al	B	Zn	Mo	SO_4	Cl	F	NO_3
6/ 9	13.2	6.50	24,800	220	47	463	35.2	6,240	714	0.023	1.29	0.17	3.68	11,800	1,580	12.3	<0.01
6/14	2,271.2	11.0	18,600	110	18	463	1.34	3,700	610	<0.01	1.23	0.06	2.01	8,510	620	11.6	<0.01
6/16	4,300.2	9.25	26,100	192	35	529	6.11	7,400	995	<0.01	1.63	0.08	4.31	15,200	840	12.4	<0.01
7/14	11,435.7	10.95	22,200	77	27	461	1.09	5,530	845	0.075	1.31	0.05	2.30	12,900	480	11.8	<0.01
7/27	13,979.5	10.10	20,200	26	9	155	1.16	5,130	757	<0.01	0.94	0.05	1.71	11,700	210	8.8	<0.01
8/ 1	15,773.8	10.10	19,800	37	10	309	13.3	4,610	775	<0.01	1.16	0.05	1.89	11,000	250	9.6	<0.01
8/17	22,455	10.00	16,400	13	15	417	10.0	3,770	689	0.12	1.12	0.07	1.60	9,440	200	9.1	<0.01
8/23	23,340.8	10.30	15,100	8	22	481	5.24	3,520	662	0.020	1.04	0.06	1.50	8,980	190	9.0	<0.01
8/25	23,507.4	10.25	15,000	9	22	480	4.55	3,520	665	0.11	1.05	0.07	1.50	9,080	200	9.0	<0.01

Date	Total Liters	pH	EC µmhos/cm	Elements µg/ml													
				As	Ba	Be	Cr	Cu	Fe	Pb	Mn	Ni	Se	SiO_2	Ag	Sr	V
6/ 9	13.2	6.50	24,800	0.08	0.18	<0.005	0.017	0.32	<0.01	0.023	0.025	0.03	0.03	22.8	0.003	10.1	0.30
6/14	2,271.2	11.0	18,600	0.05	0.11	0.005	0.004	0.022	<0.01	0.005	<0.01	<0.01	0.03	17.4	0.001	12.1	0.20
6/16	4,300.2	9.25	26,100	0.07	0.25	0.013	0.009	0.060	<0.01	0.018	0.024	<0.01	0.03	17.9	0.003	13.6	0.35
7/14	11,435.7	10.95	22,200	0.05	0.079	<0.005	0.007	0.010	<0.01	0.020	<0.01	<0.01	<0.02	20.2	0.001	13.3	0.35
7/27	13,979.5	10.10	20,200	0.03	0.069	<0.005	0.005	0.020	<0.01	0.010	<0.01	<0.01	<0.02	22.4	<0.001	6.3	0.25
8/ 1	15,773.8	10.10	19,800	0.04	0.073	<0.005	0.005	0.008	<0.01	0.010	<0.01	<0.01	<0.02	15.6	<0.001	9.3	0.20
8/17	22,455	10.00	16,400	0.04	0.069	<0.005	0.003	0.008	<0.01	<0.005	<0.01	<0.01	<0.02	16.7	<0.001	11.2	0.18
8/23	23,340.8	10.30	15,100	0.04	0.063	<0.005	0.003	0.016	<0.01	<0.005	<0.01	<0.01	<0.02	16.7	<0.001	12.4	0.15
8/25	23,507.4	10.25	15,000	0.03	0.062	<0.005	0.003	0.007	<0.01	<0.005	<0.01	<0.01	<0.02	16.5	<0.001	12.4	0.15

APPENDIX TABLE 131. CHEMICAL ANALYSIS OF PERCOLATE WATER FROM LOWER DRAIN OF RETORTED SHALE TREATMENT, 2% SLOPE. LOW ELEVATION LYSIMETER. ANALYSIS PERFORMED BY MR. TOM GARLAND, BATTELLE NORTHWEST LABORATORY, RICHLAND, WASHINGTON.

PLOT H2 & H4.

Date	Total Liters	pH	EC μmhos/cm	Organic C μg/ml	Inorganic C μg/ml	Cations μg/ml								Anions μg/ml			
						Ca	Mg	Na	K	Al	B	Zn	Mo	SO_4	Cl	F	NO_3
6/10	113.6	7.40	13,900	114	4	523	11.2	3,300	370	<0.01	1.18	0.07	3.41	7,020	590	11.4	<0.1
6/12	2,271.2	11.00	13,600	109	6	510	0.22	3,150	415	<0.01	1.83	0.06	3.64	7,100	370	13.2	<0.1
6/13	3,440.9	11.30	15,400	106	20	508	0.65	3,530	480	0.12	1.84	0.06	3.80	7,940	440	13.3	<0.1
6/16	5,367.7	11.15	34,000	400	29	527	0.35	10,400	1,175	0.12	2.99	0.15	9.45	18,600	2,100	17.5	<0.1
6/17	5,700.8	11.25	34,100	393	10	525	0.21	10,300	1,230	0.14	3.18	0.15	9.10	19,000	220	18.3	<0.1
8/10	9,705.8	11.00	14,800	37	25	216	0.46	3,500	440	0.09	1.29	0.04	1.15	8,260	250	12.0	<0.1

Date	Total Liters	pH	EC μmhos/cm	Elements μg/ml													
				As	Ba	Be	Cr	Cu	Fe	Pb	Mn	Ni	Se	SiO_2	Ag	Sr	V
6/10	113.6	7.40	13,900	0.05	0.13	<0.005	0.004	0.070	<0.01	<0.005	<0.01	<0.01	<0.02	46.7	0.002	11.7	0.17
6/12	2,271.2	11.00	13,600	0.03	0.086	<0.005	0.001	0.017	<0.01	<0.005	<0.01	<0.01	<0.02	11.8	0.001	10.6	0.18
6/13	3,440.9	11.30	15,400	0.02	0.12	<0.005	0.003	0.017	<0.01	<0.005	<0.01	<0.01	<0.02	17.2	<0.001	11.3	0.18
6/16	5,367.7	11.15	34,000	0.07	0.24	<0.005	0.011	0.070	0.05	0.024	<0.01	<0.01	0.035	34.9	0.001	13.1	0.45
6/17	5,700.8	11.25	34,100	0.08	0.18	<0.005	0.008	0.070	<0.01	0.015	<0.01	<0.01	0.035	39.8	<0.001	10.7	0.42
8/10	9,705.8	11.00	14,800	0.06	0.055	<0.005	0.003	0.009	<0.01	<0.005	<0.01	<0.01	<0.02	21.9	0.001	7.0	0.20

APPENDIX TABLE 132. CHEMICAL ANALYSIS OF PERCOLATE WATER FROM LOWER DRAIN 40 cm, 60 cm, 80 cm, AND SOIL-COVERED RETORTED SHALE TREATMENTS, 2% AND 25% SLOPE. HIGH ELEVATION LYSIMETER. ANALYSIS PERFORMED BY MR. TOM GARLAND, BATTELLE NORTHWEST LABORATORY, RICHLAND, WASHINGTON.

PLOTS H6, H8, H9, H11, H13, H15, H17 & H19.

Date	Total Liters	pH	EC µmhos/cm	Organic C µg/ml	Inorganic C µg/ml	Cations µg/ml								Anions µg/ml			
						Ca	Mg	Na	K	Al	B	Zn	Mo	SO_4	Cl	F	NO_3
PLOT H6 & H8.																	
6/17	1,661.8	11.2	34,100	385	19	521	0.74	10,200	1,250	0.16	2.97	0.04	7.72	20,200	2,300	19.7	<0.1
PLOT H9 & H11.																	
8/10	1,794.2	10.1	16,800	24	17	194	6.1	3,760	420	<0.01	0.53	0.08	0.70	8,820	190	8.6	<0.1
8/25	3,558.2	10.2	17,800	10	14	460	12.4	4,360	775	<0.01	0.82	0.08	1.58	10,900	190	8.8	<0.1
PLOT H13 & H15.																	
8/10	3.78	--	--	88	28	0.50	202	3,190	343	<0.01	0.39	0.05	2.58	7,720	200	17.8	<0.1
8/25	1,514.2	7.8	22,900	25	39	366	142	5,960	805	<0.01	0.98	0.09	2.29	14,800	90	9.2	<0.1
PLOT H17 & H19.																	
8/ 1	3.78	11.8	9,490	39	15	136	0.87	1,360	330	0.045	0.34	0.01	0.77	2,660	310	2.9	<0.1
8/25	1,533.1	10.8	14,800	73	18	441	6.2	3,530	515	<0.01	0.87	0.05	1.64	8,330	420	8.8	<0.1

Date	Total Liters	pH	EC µmhos/cm	Elements µg/ml													
				As	Ba	Be	Cr	Cu	Fe	Pb	Mn	Ni	Se	SiO_2	Ag	Sr	V
PLOT H6 & H8.																	
6/17	1,661.8	11.2	34,100	0.15	0.030	<0.005	0.010	0.11	<0.01	0.023	<0.01	<0.01	<0.02	32.8	0.002	12.0	0.[illegible]
PLOT H9 & H11.																	
8/10	1,794.2	10.1	16,800	0.03	0.069	<0.005	0.005	0.012	<0.01	<0.005	0.011	<0.01	<0.02	13.0	0.001	7.0	0.15
8/25	3,558.2	10.2	17,800	0.04	0.073	<0.005	0.010	0.009	<0.01	<0.005	0.011	<0.01	<0.02	10.6	<0.001	12.9	0.15
PLOT H13 & H15.																	
8/10	3.78	--	--	0.05	0.064	<0.005	0.003	0.044	0.015	<0.005	0.029	<0.01	0.030	9.50	0.003	1.8	<0.10
8/25	1,514.2	7.8	22,900	0.06	0.16	<0.005	0.014	0.050	<0.01	<0.005	0.039	<0.01	0.020	20.4	0.001	8.9	<0.10
PLOT H17 & H19.																	
8/ 1	3.78	11.8	9,490	0.07	0.25	<0.005	0.070	0.035	<0.01	<0.005	0.01	0.03	<0.02	9.53	<0.001	10 2	<0.10
8/25	1,533.1	10.8	14,800	0.03	0 096	<0.005	0.004	0.014	<0.01	<0.005	0.01	<0.01	0.020	11.2	<0.001	13 2	<0 10

APPENDIX TABLE 133. CHEMICAL ANALYSIS OF PERCOLATE WATER FROM LOWER DRAIN OF SOIL CONTROL TREATMENT, 2% AND 25% SLOPE. HIGH ELEVATION LYSIMETER. ANALYSIS PERFORMED BY MR. TOM GARLAND, BATTELLE NORTHWEST LABORATORY, RICHLAND, WASHINGTON.

PLOT H21, H23, H22, & H24.

Date	Total Liters	pH	EC μmhos/cm	Organic C μg/ml	Inorganic C μg/ml	Cations μg/ml								Anions μg/ml			
						Ca	Mg	Na	K	Al	B	Zn	Mo	SO_4	Cl	F	NO_3
PLOT H21 & H23.																	
8/ 1	3.785	7.2	5,360	28	20	138	76.5	571	<0.02	<0.01	0.34	0.06	0.61	1.600	260	1.25	9.5
8/10	666.2	7.8	6,200	55	30	169	201	685	0.020	0.025	1.12	0.03	0.43	1,900	470	1.30	36.5
8/23	4,803.7	7.9	5,560	82	67	142	256	846	<0.02	<0.01	1.69	0.04	0.34	2,050	530	1.30	43.5
8/25	4,996.7	7.9	5,340	73	69	131	252	837	<0.02	<0.01	1.71	0.04	0.38	2,020	520	1.52	41.0
PLOT H22 & H24.																	
8/ 1	11.35	7.7	5,990	86	15	252	166	621	<0.02	0.18	0.83	0.05	0.43	2,200	360	1.20	27.5

Date	Total Liters	pH	EC mhos/cm	Elements μg/ml													
				As	Ba	Be	Cr	Cu	Fe	Pb	Mn	Ni	Se	SiO_2	Ag	Sr	V
PLOT H21 & H23.																	
8/ 1	3.785	7.2	5,360	0.06	0.082	<0.005	0.004	0.012	<0.01	<0.005	0.10	<0.01	<0.02	26.9	<0.001	2.67	<0.10
8/10	666.2	7.8	6,200	0.01	0.069	<0.005	0.006	0.016	<0.01	<0.005	0.026	<0.01	0.020	20.4	<0.001	2.53	<0.10
8/23	4,803.7	7.9	5,560	0.01	0.073	<0.005	0.006	0.018	<0.01	<0.005	0.021	<0.01	<0.02	25.9	<0.001	3.00	<0.10
8/25	4,996.7	7.9	5,340	0.01	0.077	<0.005	0.006	0.021	<0.01	<0.005	0.024	<0.01	<0.02	26.9	<0.001	2.93	<0.10
PLOT H22 & H24.																	
8/ 1	11.35	7.7	5,990	<0.01	0.073	<0.005	0.004	0.019	<0.01	<0.005	0.078	<0.01	<0.02	15.8	<0.001	2.74	<0.10

APPENDIX TABLE 134. CHEMICAL ANALYSIS OF PERCOLATE WATER FROM UPPER DRAIN OF TREATMENTS FROM HIGH ELEVATION LYSIMETER. 2% AND 25% SLOPE. ANALYSIS PERFORMED BY MR. TOM GARLAND, BATTELLE NORTHWEST LABORATORY, RICHLAND, WASHINGTON.

PLOTS H1, H3, H10, H12, H17, & H19.

Date	Total Liters	pH	EC µmhos/cm	Organic C µg/ml	Inorganic C µg/ml	Cations µg/ml								Anions µg/ml			
						Ca	Mg	Na	K	Al	B	Zn	Mo	SO_4	Cl	F	NO_3
PLOT H1 & H3.																	
6/13	32.93	8.00	7,590	75	53	648	390	1,020	38.7	<0.01	<0.005	3.92	0.35	4,440	60	0.90	47.0
PLOT H10 & H12.																	
8/10	3.78	8.15	1,600	10	61	434	80.4	194	5.65	<0.01	<0.005	0.07	0.36	774	60	0.82	4.0
PLOT H17 & H19.																	
8/ 1	3.78	6.90	3,040	9	4	201	10.9	474	61.6	<0.01	<0.005	1.54	0.45	1,320	230	4.8	<0.1

Date	Total Liters	pH	EC µmhos/cm	Elements µg/ml													
				As	Ba	Be	Cr	Cu	Fe	Pb	Mn	Ni	Se	SiO_2	Ag	Sr	V
PLOT H1 & H3.																	
6/13	32.93	8.00	7,590	0.02	0.10	<0.005	0.003	0.10	<0.01	0.008	0.048	<0.01	<0.02	21.3	<0.001	6.67	<0.1
PLOT H10 & H12.																	
8/10	3.78	8.15	1,600	0.01	0.036	<0.005	<0.001	0.090	<0.01	<0.001	0.36	<0.01	<0.02	21.3	<0.001	1.25	<0.1
PLOT H17 & H19.																	
8/ 1	3.78	6.90	3,040	<0.01	0.060	<0.005	0.001	0.83	<0.01	<0.001	0.074	<0.01	<0.02	12.0	<0.001	5.15	0.1

APPENDIX TABLE 135. CHEMICAL ANALYSIS OF PERCOLATE WATER FROM LOWER DRAIN OF RETORTED SHALE AND 20 cm SOIL COVER TREATMENTS, 2% AND 25% SLOPES. LOWER ELEVATION LYSIMETERS. ANALYSIS PERFORMED BY MR. TOM GARLAND, BATTELLE NORTHWEST LABORATORY, RICHLAND, WASHINGTON.

PLOTS L1, L3, L2, L4, L5, L7, L6, & L8.

Date	Total Liters	pH	EC µmhos/cm	Organic C µg/ml	Inorganic C µg/ml	Cations µg/ml								Anions µg/ml			
						Ca	Mg	Na	K	Al	B	Zn	Mo	SO_4	Cl	F	NO_3
PLOT L1 & L3																	
6/11	11.35	8.05	11,200	64	53	338	14.9	2,900	300	0.015	[illegible]	0.52	3.12	5,630	250	12.0	0.1
PLOT L2 & L4																	
6/10	0.946	8.05	11,400	140	108	282	6.1	2,600	510	<0.01	0.69	0.11	2.50	5,290	270	5.0	<0.1
PLOT L5 & L7.																	
6/ 8	34.06	6.45	26,400	221	70	525	40.9	7,160	745	0.81	1.77	0.15	5.36	14,500	1,600	13.5	<0.1
6/ 8	37.85	5.80	21,200	204	10	469	22.9	5,200	800	0.085	1.69	0.10	3.92	10,500	1,780	14.2	<0.1
6/ 9	189.2	6.60	16,400	140	9	486	14.9	3,950	460	<0.01	1.62	0.10	3.41	7,920	860	11.2	<0.1
6/12	908.5	10.55	16,500	141	5	507	1.81	4,030	516	<0.01	1.29	0.07	2.30	8,390	650	12.8	0.1
6/14	1,491.4	10.70	18,700	142	27	480	5.25	4,690	712	0.075	1.55	0.08	2.67	10,600	500	14.2	<0.1
6/16	1,816.9	10.65	18,600	121	23	501	2.24	4,590	606	0.14	1.50	0.06	2.70	10,600	350	14.0	<0.1
8/ 1	2,827.7	6.55	20,300	22	23	491	36.4	5,210	781	0.025	1.00	0.09	2.12	13,000	60	11.8	0.1
8/25	3,331.1	8.00	21,100	14	10	519	116	5,490	862	0.050	0.93	0.09	2.25	14,000	150	11.2	<0.1
PLOT L6 & L8.																	
6/10	1.89	6.80	23,400	263	64	615	6.23	6,300	752	<0.01	1.56	0.20	7.17	12,600	1,280	9.6	<

Date	Total Liters	pH	EC µmhos/cm	Elements µg/ml													
				As	Ba	Be	Cr	Cu	Fe	Pb	Mn	Ni	Se	SiO_2	Ag	Sr	V
PLOT L1 & L3.																	
6/11	11.35	8.05	11,200	0.040	0.37	0.009	0.004	2.44	0.060	0.008	0.063	0.04	0.025	2.32	0.004	7.24	0.28
PLOT L2 & L4.																	
6/10	0.946	8.05	11,400	0.080	0.29	<0.005	0.090	0.57	0.11	0.015	0.097	0.06	<0.02	53.6	0.002	6.43	0.40
PLOT L5 & L7.																	
6/ 8	34.85	6.45	26,400	0.20	0.19	<0.005	0.014	0.13	0.038	<0.001	0.027	0.03	0.030	22.5	0.005	11.4	0.38
6/ 8	37.85	5.80	21,200	0.08	0.20	<0.005	0.008	0.10	<0.01	<0.001	0.012	0.02	0.020	20.0	0.004	10.5	0.35
6/ 9	189.2	6.60	16,400	0.06	0.15	<0.005	0.005	0.041	<0.01	<0.001	0.010	0.10	<0.02	16.4	0.003	10.4	0.30
6/12	908.5	10.55	16,500	0.06	0.14	<0.005	0.002	0.020	<0.01	<0.001	<0.01	<0.02	<0.02	16.9	0.002	11.7	0.30
6/14	1,491.4	10.70	18,700	0.04	0.14	<0.005	0.041	0.020	<0.01	<0.001	0.012	<0.02	<0.02	12.2	0.001	12.2	0.40
6/16	1,816.9	10.65	18,600	0.04	0.13	<0.005	0.042	0.020	<0.01	<0.001	0.013	<0.02	<0.02	12.7	0.001	12.7	0.40
8/ 1	2,827.7	6.55	20,300	0.05	0.12	<0.005	0.033	0.019	<0.01	<0.001	0.16	<0.02	<0.02	12.6	0.001	12.6	0.35
8/25	3,331.1	8.00	21,100	0.05	0.12	<0.005	0.033	0.015	<0.015	<0.001	0.21	<0.02	<0.02	12.5	0.001	12.5	0.25
PLOT L6 & L8.																	
6/10	1.89	6.80	23,400	0.090	0.20	<0.005	0.029	1.20	1.20	0.031	0.083	0.03	<0.02	29.6	0.006	11.2	0.35

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15. SUPPLEMENTARY NOTES

16. ABSTRACT

This study used lysimeters to develop both a low-elevation (dry site) and a high-elevation (moist site) disposal scheme for Paraho (direct-heated) retorted shale. The objectives were to investigate: 1) vegetative stabilization of the surface of Paraho retorted shale and retorted shale covered with various soil depths; and (2) water and salt movement through both uncompacted and compacted Paraho retorted shale.

The lysimeters were constructed in western Colorado in 1976 and filled in March 1977.

Only a sparse vegetation cover (5% to 15%) was established on retorted shale following fertilization, mulching, and irrigation. In contrast, adequate plant cover (55% to 85%) was established on the soil cover over retorted shale and on soil control treatment areas.

Water balance calculations and drainage below the compacted zone indicated that water had moved into and through the compacted zone in the leached treatment areas. Further study is needed on the permeability of the compacted shale.

17. KEY WORDS AND DOCUMENT ANALYSIS

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