Hanford Protective Barriers Program Water-Erosion Studies - FY 1989

K. A. Hoover
L. L. Cadwell
W. H. Walters

EDMC

June 1990

Prepared for the U.S. Department of Energy
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Pacific Northwest Laboratory
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Pacific Northwest Laboratory
Richland, Washington 99352

SUMMARY

Pacific Northwest Laboratory (PNL) is conducting the water-erosion control task of the Hanford Protective Barriers Program to assess barrier stability against soil erosion and slumping. The Hanford Protective Barriers Program is a cooperative effort between Westinghouse Hanford Company and PNL, under the direction of the U.S. Department of Energy-Richland Operations Office. The purpose of the barriers is to protect shallow-burial waste sites at the Hanford Site from water infiltration, biointrusion, and surficial erosion for up to 10,000 years. These aboveground, mounded structures will consist of layered, fine-grained sediment and rock designed to direct surface- and ground-water pathways away from the buried waste. The fine-grained sediment for the barrier will be obtained from the McGee Ranch on the Hanford Site.

The water-erosion task is investigating the ability of the top surface, fine-grained sediment cover and the rock-covered side slopes to resist the erosional and destabilizing effects of precipitation (rain or snow), animal intrusion, and slumping. The task also will include study of the protective potential of rock mulches and vegetation cover. The task results will provide recommendations of barrier design criteria to minimize the impacts of precipitation on barrier soil erosion and the overall stability of the structure.

Work on this task commenced during FY 1989 with a brief review of pertinent literature, which led to the preliminary conclusion that the parameters governing soil erosion are site specific. Although a large volume of literature exists on the subject of erosion _per se_, there are no data concerning the erosional behavior of McGee Ranch soil or similar soils. The purpose of the FY 1989 field work was to test two hypotheses concerning the behavior of MeGee Ranch soil: 1) runoff may occur on very dry, fine-grained sediment prior to complete saturation and 2) rainsplash is an important erosional process for this type of sediment. To test these hypotheses, small field plots were installed at the McGee Ranch and rainfall runoff-erosion tests were performed during September 1989.

This report describes plot construction, sediment sampling, and calibration testing of the rainfall simulator. Baseline stratigraphic and sedimentologic data include bulk density and textural properties (when analysis is completed) of sediment in the test plots. Baseline precipitation data consist of predetermined raindrop sizes, rainfall intensities, plot coverage, and operational data for the simulator. The actual plot test results and interpretation of McGee Ranch soil erosional properties will be reported during FY 1990.

ACKNOWLEDGMENTS

The work described in this report was funded under the Hanford Protective Barriers Program sponsored by the U.S. Department of Energy. Support and encouragement for these studies came from Messrs. J. W. Cammann and N. R. Wing of Westinghouse Hanford Company and Dr. G. W. Gee of Pacific Northwest Laboratory (PNL). Emplacement of the field test plots could not have been completed without the assistance of Mr. P. B. Test of PNL.

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1.0 INTRODUCTION

Pacific Northwest Laboratory (PNL)[a] and Westinghouse Hanford Company are working together to develop protective barriers to isolate near-surface wastes at the U.S. Department of Energy's Hanford Site. The barriers will be constructed of layered sediment and rock material designed with the primary purpose of directing surface and ground-water pathways away from the buried waste. Because the barriers will have an earthen cover, soil erosion from rainfall- and snowmelt-runoff processes could remove significant quantities of soil, thus reducing the effectiveness of the cover and jeopardizing barrier performance.

To address soil erosion as it applies to barrier design and long-term stability, and, consequently, satisfy a technical concern (EROD-3 in Wing 1989), a task designed to study this problem has been included in the Hanford Protective Barriers Program at PNL. This study, which began in FY 1989, includes identification and field testing of the dominant processes contributing to erosion and barrier failure in accordance with the approved test plan (Walters et al. 1990).

A summary of the FY 1989 progress, including a description of the ongoing field tests, is contained in this report. Background information is provided on the physical processes considered in the study and the proposed hypotheses to be tested (Section 2.0). Section 3.0 describes the field plot construction and initial calibration of the rainfall simulator. Cited references are listed in Section 4.0.

(a) Operated for the U.S. Department of Energy by Battelle Memorial Institute.

2.0 BACKGROUND

The proposed barrier design consists of approximately 5 m of layered rock and sediment placed over and extending some distance beyond individual or clustered waste burial sites. The barriers will be roughly rectangular in shape with relatively flat top surfaces. The top surfaces of the barriers are expected to be up to thousands of square meters in area and have slopes of approximately 1% to 5% (1V:100H to 1V:20H). Side slopes, approximately 16 m long, will be much steeper, with slopes of about 30% (1V:3H). The top 1.5 m of the barrier will consist of fine sediment from the McGee Ranch site, which will serve to store moisture above the waste until it can be evapotranspirated back to the atmosphere. The fine soil will also provide a suitable environment for the establishment of vegetation. Rock mulch may be mixed into the fine sediment as an erosion inhibitor. Side slopes will be composed of rock riprap, with a sand-gravel filter layer between the rock and soil.

The barriers will be subjected to hydrologic and erosional processes from rainfall and snowmelt runoff. The top surface must resist water erosion and maintain sufficient moisture to support vegetation, but, together with the vegetation, must prevent deep percolation into the waste. Loss of soil by rainsplash, sheetwash, rilling, or gullying will reduce the thickness of the soil cover and jeopardize its ability to store water and control percolation. The steeper side slopes will require rock protection against severe erosion. Critical to side-slope stability is the effect of moisture build-up under the rock cover and the potential for slumping, as well as long-term erosion from beneath the cover. Further modification of the top and side slopes by animal burrowing and differential settlement may enhance infiltration, provide more direct access to the buried waste, and reduce overall stability of the barrier mound.

The loss of sediment from barrier tops and side slopes is the result of complex interactions among many variables. The amount and erosivity of runoff generated on the barrier are influenced by the form and dimension of the barrier tops. Especially important in this regard are the slope lengths, slope gradients, and slope form of the barriers, meaning whether the slopes are straight, concave, convex, or crested. Longer slopes generate more runoff, yielding deeper and potentially more erosive flows. Steeper slopes are more easily eroded, and recent research indicates that straight slopes have greater sediment losses than concave or convex slopes (Emmett 1978). Also critical to sediment yields from barriers are the types (rainfall or snowmelt) and amounts of precipitation to which the barriers are subjected. Important rainfall characteristics include raindrop size, rainfall intensity, and rainstorm duration. For snow, the critical variables are total amount and timing and rapidity of melting.

Once precipitation encounters the barrier surface, runoff and erosion are controlled, to a large extent, by the infiltration characteristics of the sediment. Infiltration characteristics depend on the soil or sediment characteristics, including structure, texture, clay mineralogy, porosity, permeability, and antecedent moisture conditions; the surface microtopography (microrelief); the quantity, type, and distribution of vegetation; the existence or formation of soil horizons; and the presence of animal burrows or other inhomogeneities in the barrier surface. As such, infiltration over the barrier surface is not uniform, either spatially or temporally, throughout the course of a single storm or the life of the barrier.

The amount and types of runoff influence the extent and location of erosion and sediment loss. Because infiltration characteristics are spatially and temporally variable, it is to be expected that the nature of the runoff, whether as sheetflow or channelized flow, will vary also. Corresponding sediment losses will depend on the gradient, depth of flow, flow velocity, water temperature, and resistance to flow at any particular location on the barrier top. Ground-surface lowering of the barrier mound may be somewhat uniformly distributed across the barrier surface or occur as a localized breach.

Given the number of salient variables that influence runoff and erosion, the complexities of their interactions, the spatial and temporal variability of the interactions, plus the fact that relationships between many of the variables are site specific, field work for the water-erosion control task in FY 1989 was designed to characterize the behavior of a two-component system composed of McGee Ranch soil and rainfall. Despite the large volume of literature generated on the subject of erosion, there are no data pertaining to the behavior of McGee Ranch soil or similar soil under rainstorms of varying intensities. Observations of the ground surface at the McGee Ranch indicated that under postagricultural, modern climatic conditions, the fine sediment tends to seal and forms crusts, the hydrologic properties of which are unknown.

The goal of the FY 1989 field tests was to determine the relationships between water and sediment runoff, sediment properties, and rainstorm characteristics, before adding the complexities of barrier form, microrelief, vegetation, and animal burrows. Two hypotheses concerning the behavior of McGee Ranch soil were generated. The first hypothesis is that in very dry, fine-grained soil (such as that found at the McGee Ranch), runoff will commence prior to complete saturation. This is postulated to occur in response to a number of factors. Fine-grained sediment has a low hydraulic conductivity; only a few millimeters of soil need to be saturated before its water transmission and/or infiltration capacity is exceeded. In addition, fine sediment has a tendency to be self-sealing, which may further reduce its infiltration capacity and promote runoff.

The second hypothesis is that rainsplash is an important erosional process in this two-component system. During a general field reconnaissance at the McGee Ranch, observations were made of raindrop imprints preserved on bare, crusted soil surfaces. Previous studies (e.g., McCarthy 1980) have indicated that rainsplash dominates where soils are saturated but unsubmerged by water with depths greater than a few raindrop diameters. Raindrops striking the soil surface dislodge particles that can bounce into the air, where they may be picked up and transported by the wind, or fall back onto the ground generally downslope of where they originated. Raindrops may also penetrate thin sheetflows, dislodging particles that are then picked up by the flow and transported downslope.

Rainsplash is postulated to be an important erosional process for three reasons. First, McGee Ranch soil is fine grained. McCarthy (1980) has demonstrated that sediment transport by rainsplash occurs only when the raindrop diameter exceeds a critical size in relation to sediment diameter. Silt- and sand-sized particles are most easily splashed (Dunne and Leopold 1978), and these sizes predominate in McGee Ranch soil (Last et al. 1987). Second, McGee Ranch soil lacks the high organic or clay content that may tend to inhibit rainsplash erosion by binding soil particles together. Finally, the rainfall events expected to generate runoff will probably be short-duration, high-intensity thunderstorms, composed of fairly large raindrops and accompanied by strong winds.

The research goal and hypotheses to be tested generated a number of questions concerning the behavior of the two-component system. Central to these questions are the conditions under which soil seals and crusts are formed and destroyed, and what influence they have on infiltration, runoff, and erosion. Other considerations include the relation of runoff to changing storm conditions, how infiltration is affected by the use of gravel admix as an erosion inhibitor, and the relationships between rainfall erosivity and soil erodibility for McGee Ranch soil. Previous research (Morgan 1983) indicates that erosivity and erodibility are not independent of one another; soil surfaces tend to evolve or mature throughout the course of a single storm. Morgan (1983) also demonstrated that soil loss does not increase as a simple linear function of rainfall intensity, and that any relationships between erodibility and erosivity are soil and site specific and must be evaluated for each system.

Field tests for FY 1989 for the water-erosion control task were designed with these considerations in mind. The tests consisted of applying "storms" with known raindrop sizes, intensities, and durations to small (1-m^2) plots equipped with flumes to trap water and sediment runoff. The plots contained various proportions of silt and pea gravel to test their effects on infiltration, surface sealing, and runoff generation. None of the plots were vegetated, they exhibited no microrelief, they contained no animal burrows, and all were graded to a uniform slope. Through these treatments and tests, the number of variables was restricted, so that the relationships between water and sediment runoff, sediment properties, and storm characteristics for the two-component system could be determined.

3.0 FIELD TESTS

3.1 TEST PLOT EMPLACEMENT

Field test plots were established at McGee Ranch on the Hanford Site (Figure 1). The test plots (Figure 2) consisted of four groups of three different sediment treatment plots located in a fairly level area just east of the Admix Gravel Test Plots. The plots were grouped such that each set of three falls within the radius of the rotating-boom rainfall simulator that

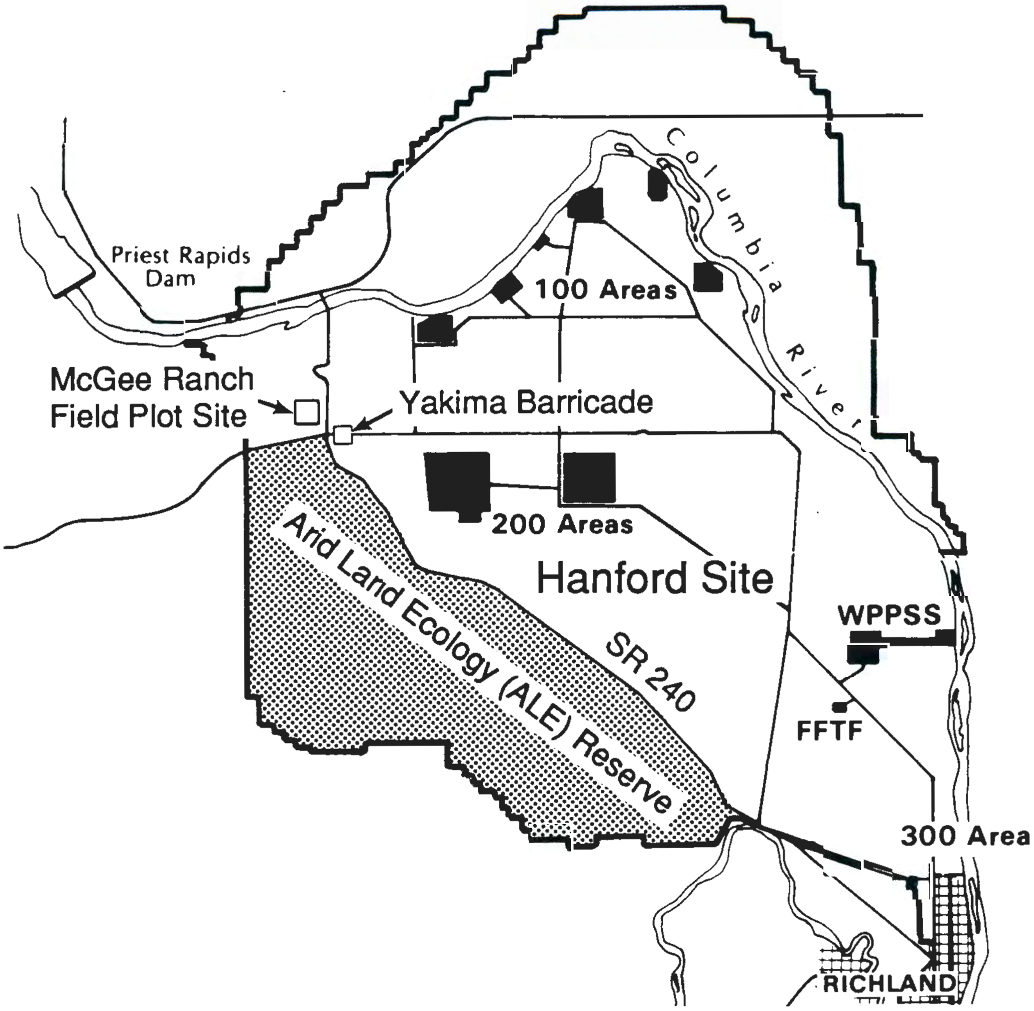

FIGURE 1. Location of the McGee Ranch Field Plot Studies on the Hanford Site

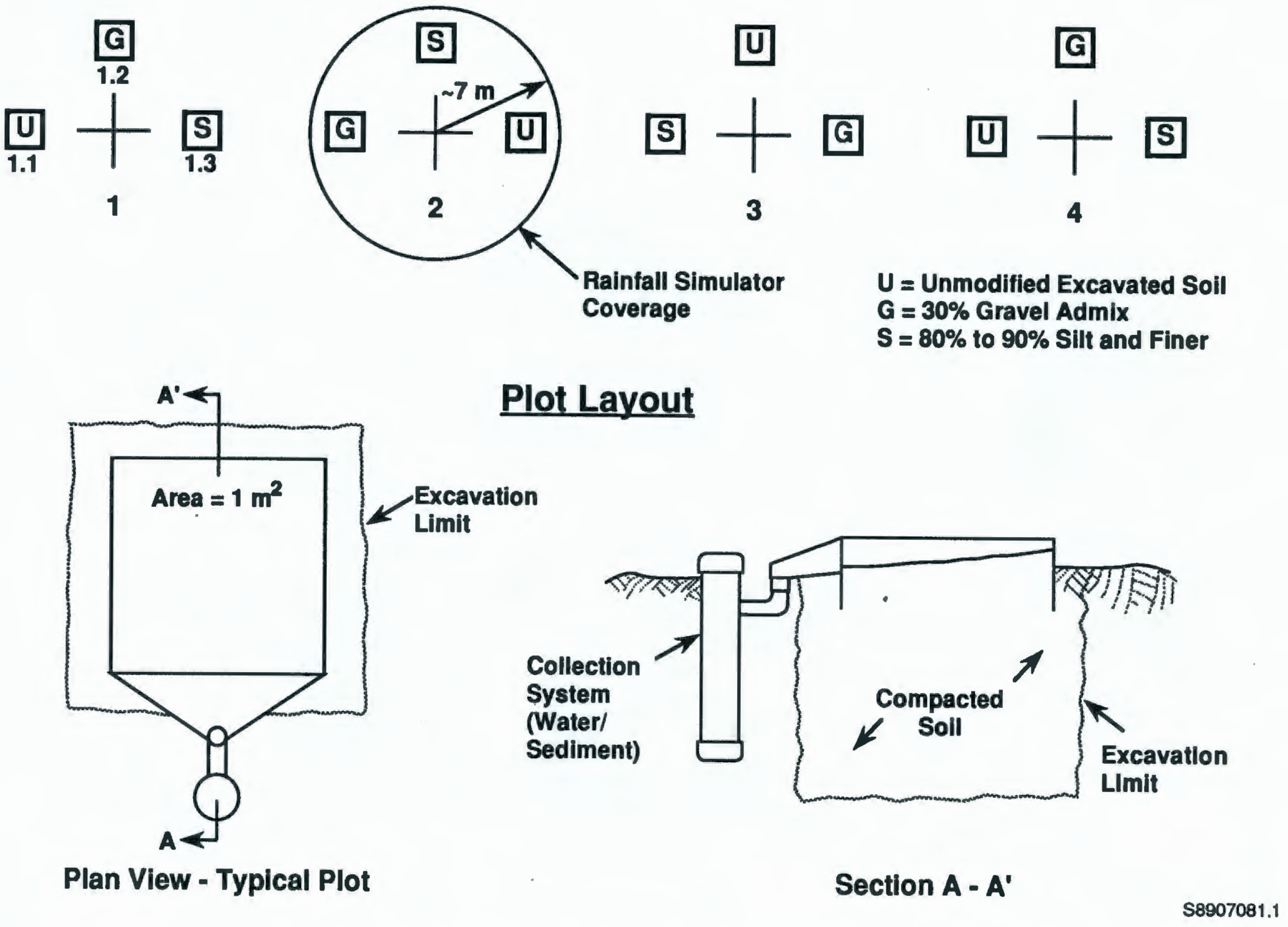

FIGURE 2. Plot Layout Configuration and Typical Plot Design

was used to apply rainfall. Each plot contained a 1-m^2 runoff flume connected to a collection tank placed below ground level outside the plot boundaries. All plot surfaces were graded to 5% (1V:20H).

Three different sediment treatments were applied to each group of plots. One plot in each set consists of unmodified soil from the open borrow area at the McGee Ranch, McGee Ranch soil with an admixture of 30% (by weight) pea gravel, or McGee Ranch soil with an enhanced silt content (up to 80% by weight) (see Figure 2). These sediment treatments were confined to the top 20 cm of each plot. The differing sediment treatments will be used to assess the effects of gravel and enhanced silt content on infiltration and soil sealing, and the results compared with the behavior of unmodified soil under similar meteorologic conditions.

All plots were constructed in a similar manner (Figure 3). A 1.4- x 1.4-m area was excavated by backhoe to a depth of 80 to 100 cm, and the soil replaced in 10-cm lifts. Small hand tampers were used to recompact the soil after each lift was emplaced. Moisture content and plot bulk density data (Table 1) were gauged every 20 cm, using a Troxler(a) moisture-density probe and the soil sampled for particle-size analysis. For the silt- and gravel-enriched sediment treatments, silt from the borrow area and pea gravel from a stockpile near the Admix Gravel Test Plots were emplaced in the top 20 cm of the plots using a small front-end loader. The silt and gravel were then uniformly mixed with unmodified McGee Ranch soil to a depth of 20 cm, using 15 to 20 passes of a small garden rototiller. Unmodified soil plots also were rototilled to simulate the mixing that will occur during mining, transport, and emplacement of McGee Ranch soil during barrier construction. All plots were tamped and graded to 5% by emplacing a wooden frame template and then shaving the surface of the plot. The top few centimeters of soil on each plot were left uncompacted. Runoff flumes, 1 m^2 in area, were emplaced in the center of each plot and attached to runoff-collection wells.

The plots were constructed in this manner for several reasons. An area larger than the runoff flumes was prepared to circumvent the problem of flume

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(a) Troxler is a tradename of Troxler Electronic Laboratories, Research Triangle Park, North Carolina.

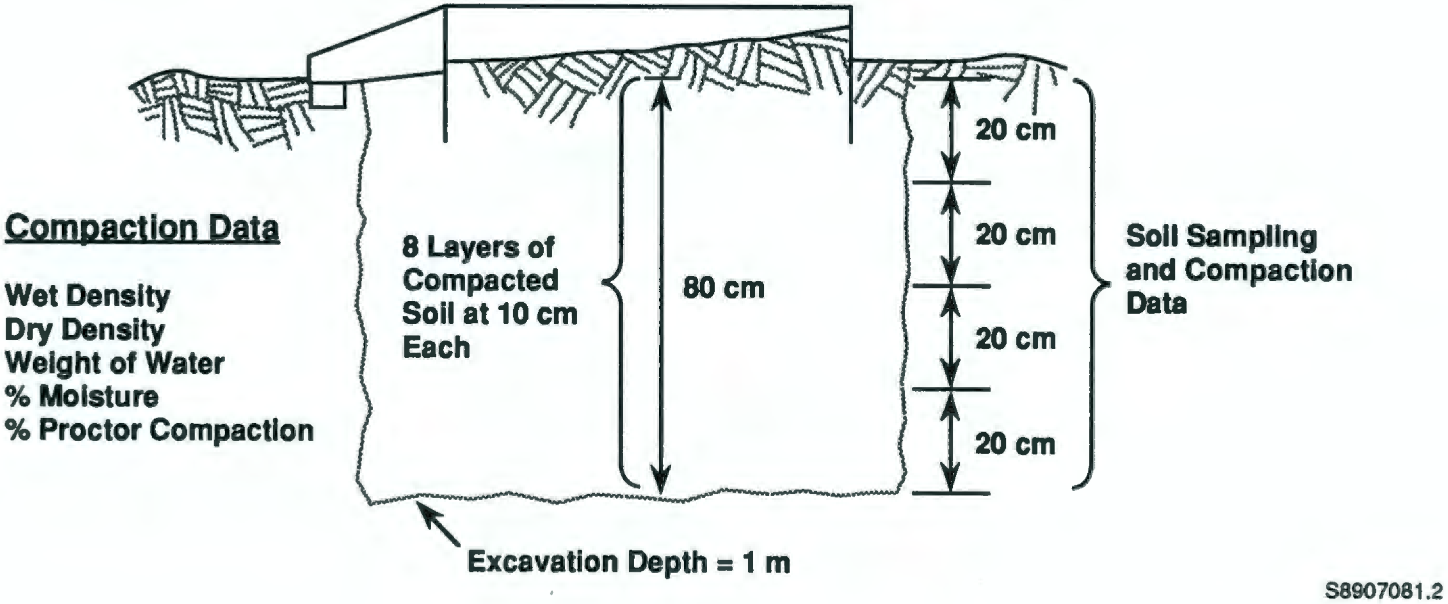

FIGURE 3. Plot Soil Compaction Scheme

TABLE 1. Moisture and Density Data

Plot	Treatment	Stratigraphic Level (cm below surface)	% Proctor Compaction	Dry Density (g/cm^3)	Wet Density (g/cm^3)	Moisture Content (g/m^2)	% Moisture
1.1	Unmodified	Top	62.9	1.461	1.589	127.9	8.8
		20	69.5	1.613	1.921	307.4	19.1
		40	69.3	1.608	1.849	240.4	14.9
		60	60.9	1.415	1.617	202.0	14.3
		80	66.5	1.543	1.750	206.9	13.4
		100	57.2	1.328	1.673	345.4	26.0
1.2	Gravel	Top	68.8	1.597	1.675	77.6	4.9
		30	69.0	1.603	1.924	320.5	20.0
		50	60.8	1.413	1.616	203.6	14.4
		70	58.9	1.368	1.651	283.5	20.7
		90	64.9	1.508	1.819	311.2	20.6
1.3	Silt	Top	58.3	1.353	1.413	59.7	4.4
		30	60.0	1.393	1.648	255.1	18.3
		50	65.0	1.509	1.837	327.5	21.7
		70	60.0	1.394	1.624	229.7	16.5
		90	58.3	1.353	1.654	301.4	22.3
2.1	Gravel	Top	67.9	1.577	1.643	66.2	4.2
		30	69.1	1.605	1.881	276.3	17.2
		50	59.9	1.392	1.547	155.3	11.2
		70	60.8	1.412	1.574	161.9	11.5
		90	60.9	1.415	1.623	207.6	14.7
2.2	Silt	Top	59.0	1.369	1.434	64.6	4.7
		30	61.2	1.421	1.679	258.3	18.2
		50	62.1	1.443	1.613	170.0	11.8
		70	64.0	1.486	1.679	192.9	13.0
		90	56.2	1.305	1.473	168.4	12.9

TABLE 1. (contd)

Plot	Treatment	Stratigraphic Level (cm below surface)	% Proctor Compaction	Dry Density (g/cm^3)	Wet Density (g/cm^3)	Moisture Content (g/m^2)	% Moisture
2.3	Unmodified	Top	62.9	1.460	1.648	187.9	12.9
		30	60.2	1.398	1.623	225.6	16.1
		50	68.6	1.592	1.834	242.0	15.2
		70	56.0	1.300	1.457	157.0	12.1
		90	61.0	1.418	1.629	210.9	14.9
3.1	Silt	Top	60.1	1.395	1.456	61.4	4.4
		20	61.0	1.417	1.796	379.3	26.8
		40	60.6	1.407	1.742	335.2	23.8
		60	60.8	1.413	1.735	322.1	22.8
		80	60.1	1.395	1.760	364.6	26.1
		100	60.4	1.402	1.713	310.7	22.2
3.2	Unmodified	Top	62.3	1.448	1.626	178.2	12.3
		30	59.8	1.388	1.617	228.9	16.5
		50	59.4	1.380	1.760	381.0	27.6
		70	59.9	1.391	1.621	230.5	16.6
		90	60.1	1.396	1.703	307.4	22.0
3.3	Gravel	Top	70.1	1.628	1.696	67.9	4.2
		30	68.7	1.595	1.839	243.6	15.3
		50	60.7	1.410	1.733	323.7	23.0
		70	56.7	1.318	1.620	302.5	23.0
		90	62.8	1.459	1.788	328.7	22.5
4.1	Silt	Top	58.7	1.362	1.430	67.9	5.0
		30	60.9	1.414	1.653	238.7	16.9
		50	62.4	1.450	1.689	238.7	16.5
		70	59.8	1.389	1.634	245.3	17.7
		90	59.1	1.374	1.625	251.8	18.3

TABLE 1. (contd)

Plot	Treatment	Stratigraphic Level (cm below surface)	% Proctor Compaction	Dry Density (g/cm^3)	Wet Density (g/cm^3)	Moisture Content (g/m^2)	% Moisture
4.2	Gravel	Top	66.7	1.549	1.639	90.6	5.8
		30	62.7	1.456	1.708	251.8	17.3
		50	62.8	1.459	1.771	312.3	21.4
		70	58.4	1.356	1.684	328.7	24.2
		90	58.4	1.357	1.594	237.1	17.5
4.3	Unmodified	Top	59.3	1.378	1.484	106.8	7.8
		20	62.9	1.461	1.741	279.6	19.1
		40	65.1	1.512	1.875	363.0	24.0
		60	56.4	1.311	1.604	292.7	22.3
		80	57.8	1.343	1.608	264.9	19.7

contamination by soil whose properties had not been characterized, as well as to provide an area for destructive sampling prior to and subsequent to test runs. Excavation to approximately 1 m and refilling the plots in lifts were necessary to characterize the soil at depth and establish a baseline stratigraphy (bulk density and soil texture) against which to interpret test results and observations. Plot construction also attempted to simulate barrier construction.

3.2 RUNOFF-EROSION TEST RUNS

Prior to the test runs, storm properties, including raindrop size and rainfall intensity, were characterized for the varying operation levels of the rainfall simulator. Drop sizes for individual nozzles, as well as those generated by multiple passes of the booms, were determined using the flour method of size measurement described by Bentley (1904). These sizes ranged from 0.7 to 4.0 mm (Table 2), well within the limits for natural rainfall at the Hanford Site (based on an extrapolation of data from Stone et al. 1983). Rainfall intensity was varied using two methods, and the results were compared. The first method entailed controlling intensity by varying the number of nozzles operating. The intensities generated using this method were limited to 60 or 120 mm/h by operating 15 or 30 nozzles, respectively. The second method entailed varying the water pressure at the pump by regulating the flow of water to the nozzles. Rainfall intensities ranged from 56 to 74.6 mm/h, corresponding to pump pressures of 12 to 46 psi (Table 3). Stationary plastic rain gauges were aligned along three radii of the rainfall simulator (two upwind and one downwind) at approximately the location of each test plot to examine plot coverage and ensure that every plot received the same amount of rainfall over its entire extent. Test results (Table 4) indicate that there is no systematic relationship between position on the plot and the amount of rainfall received in that location.

The field tests consisted of subjecting the plots to four different meteorological events (i.e., storms) on September 8, 13, 20, and 27, 1989. Plot surfaces were allowed to dry out between subsequent tests. Bulk density sampling, using the Troxler moisture-density probe, and sampling for

TABLE 2. Drop-Size Distribution

Run	Pressure (psi)	Nozzle Position	Drop-Size (mm) Distribution (% by volume) 4.0	2.8	2.0	1.4	1.0	0.7
1	Natural rainfall[(a)]		---	3.4	5.1	61.0	27.1	3.4
2	23	Stationary	---	27.8	34.3	32.7	4.8	0.4
3	17	Rotating						
		Upwind	2.6	12.7	35.9	35.9	10.3	2.6
		Downwind	9.0	32.4	30.2	20.1	7.2	1.1
4	24	Rotating	---	15.5	38.8	42.8	1.9	1.0
5	33.5	Rotating	---	12.8	35.3	36.4	14.9	0.6

(a) McGee Ranch on August 23, 1989.

NOTE: The specific sizes are not necessarily representative of all the drop sizes present, but are limited by the sieve sizes available for analysis.

TABLE 3. Rainfall Simulator Pressure - Intensity Tests

Run	Duration	Pressure (psi)	Average Nozzle Output (mL/s)	Rainfall Intensity (mm/h)
1	14.5	12	206.72	56
2	11.6	19	249.6	67
3	9.32	25	251.1	67.4
4	10.15	26.5	253.5	68.1
5	9.97	33	263.3	70.7
6	9.6	33	268.4	72.1
7	10.79	35	270.2	72.6
8	8.8	46	277.8	74.6

TABLE 4. Plot Coverage Tests

Run	Gauge Location	Gauge Position (m)[(a)]	Pressure (psi)	Rainfall Intensity (mm/h)
1	Upwind	4.7	33.5	61.0
		5.2		59.4
		5.2		53.3
		5.7		48.8
	Upwind	4.7	33.5	65.5
		5.2		61.0
		5.7		76.2
	Downwind	4.7	33.5	64.0
		5.2		76.2
		5.7		65.5
2	Upwind	4.7	17	61.0
		5.2		53.3
		5.2		48.8
		5.7		48.8
	Upwind	4.7	17	61.0
		5.2		53.3
		5.7		53.3
	Downwind	4.7	17	45.7
		5.2		45.7
		5.7		47.2

(a) Measured from center of rainfall simulator.

particle-size analysis were performed before and after each storm to document changing boundary conditions. During each storm, plots were instrumented with a continuously recording tipping-bucket rain gauge and pressure transducers installed in the collection wells to continuously monitor runoff. Runoff was sampled periodically throughout the course of each storm for particle-size analysis of the sediment being eroded. Trained observers were on hand with stopwatches, rulers, and notebooks to record the formation and destruction of seals and crusts, the timing and spatial location of the different types of runoff that occurred, and sediment movement. Post-run measurements and observations included trenching in the prepared area outside the flume to measure the depth of water infiltration, the thickness of the saturated zone, and the thickness of any seals or crusts that may have developed. The interpretation and presentation of these data will be provided in the annual report for FY 1990.

3.3 DATA ANALYSIS AND INTERPRETATION

To date, data have been collected on the bulk-density properties of the plot soils, the range of drop sizes produced by the rainfall simulator and one natural rainstorm at the McGee Ranch, the range of rainfall intensities produced by the simulator, and plot coverage. Although the data are not extensive, they allow characterization of key components of the system that is under study.

Bulk-density measurements will, in conjunction with particle-size information, establish the baseline stratigraphy against which test results can be interpreted. Especially important in this regard are the bulk-density readings for the top 20 cm of each plot (see Table 1). Note that when moisture contents and percent proctor compactions are comparable, the measurements indicate a continuum of increasing bulk densities from silt (generally around 1.35 g/cm^3) to unmodified soil (around 1.45 g/cm^3) to gravel (1.55+ g/cm^3). Prior to analyzing sediment particle size, this is the only indication that this method of plot construction successfully yielded the specified plot treatments.

Nozzles on the rotating-boom rainfall simulator produce raindrops comparable in size to natural rainfall observed at the McGee Ranch (see Table 2), as well as postulated sizes extrapolated from the drop size-intensity data of Laws and Parsons (1943) and Hanford Site storm-intensity characteristics documented by Stone et al. (1983). Natural raindrops range in size from 0.7 to 2.8 mm, and exhibit a strong peak at approximately 1.5 mm. Stationary and rotating nozzles on the simulator exhibit the same range of sizes, but the peak is spread over the 1.5- to 3.0-mm range. The extrapolated range of drop sizes for storms recorded between 1947 and 1969 is 1.5 to 3.5 mm, which corresponds well to those sizes produced by the simulator. Simulated drop sizes do not appear to vary with intensity, but position with respect to the wind does seem to be a factor. Drops measured downwind of the simulator were flattened, torpedo shaped, and coalesced (4.0-mm size) more frequently than drops measured upwind of the unit.

Rainfall intensities were varied by varying water pressure at the simulator, although the range of variation was not large (see Table 3). Comparison of these intensities, from 56 to 74.6 mm/h, with intensity data collected at Hanford between 1947 and 1969 (Stone et al. 1983) indicates that storms at these intensities lasting approximately 20 min have an average return interval of 1000 years. This places the types of simulated storms at the high end of the intensity scale under modern climatic conditions. However, the information generated under these conditions should be useful in assessing the behavior of the two-component system (McGee Ranch soil and rainfall) under extreme meteorologic events.

Finally, the plot coverage tests indicate that all areas of the plots should receive approximately equal rainfall intensities, whether the simulator is run at high or low pressures (see Table 4). There appears to be no consistent pattern of either the inner, middle, or outer edges of the plots receiving more or less water. The application of rainfall to each plot, however, is not continuous. With 15 nozzles operating, the time lag between passages of a boom that applies water to a single plot is up to 5 s. The effects of this discontinuous "rain" on runoff and erosion are, as yet, unknown, but further tests are being planned that will use a more continuous, stationary application of moisture for comparison.

Once the runoff-erosion tests have been completed, these baseline data will allow relationships to be established between rainfall intensity and the timing and amounts of water and sediment runoff and between raindrop size and the sizes of sediment being eroded. The formation of crusts and seals and their effect on infiltration also can be tied to storm properties. Rainfall erosivity and soil erodibility characteristics can be established for McGee Ranch soil and soil treatments, and a first-cut assessment of barrier stability under diverse meteorologic conditions can be generated.

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