QUARTERLY REPORT

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PROJECT TITLE: Continuation of Geologic and Hydrologic Studies of Fort Hancock, Texas.

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GEOLOGY

Rainfall and Erosion Monitoring

Personnel from the Texas Low-Level Radioactive Waste Disposal Authority office in Fort Hancock, Texas, assumed responsibility for all field service of rain gauges and erosion pins in January 1990. Since then they have monitored the rain gauges monthly and have measured the erosion pins five times: once in March, twice in July, once in August, and once in October. All monitoring activities have been carried out as prescribed in Specific Work Instruction (SWI) 3.6. Data collection has been quite satisfactory, with no data losses because of operator error, and only minor errors in record keeping. The system of repairing gauges has functioned reasonably well by balancing the economics of repairing gauges only when necessary against possible data loss caused by occasional lack of a spare gauge when one in operation fails unexpectedly.

Heavy rains (>12.7 mm [>0.5 in]) were recorded at the site on several occasions during 1990 (table 1). The daily total for July 14, 1990, at the Center gauge is the largest recorded at that station since it was installed in July 1988. None of the daily totals for the other gauges is as large as maxima previously recorded; none of the 1-hr or 1/2-hr totals equals previously recorded maxima; and none of the daily 1-hr or 1/2-hr totals exceeds a 1-yr recurrence interval.

Erosion and deposition were quite variable from one pin field to another (table 2). The total number of pins showing a greater than 0.3-cm (>0.1-in) change in pin-to-ground readings ranged from 2 to 20. Not surprisingly, the pin fields with ephemeral channels passing through them (1, 4, and 5) had the most pins recording erosion and deposition. However, many of these pins are not adjacent to the ephemeral channels. Apparently, sediment is being transported in a broad area along the main channel when runoff exceeds the capacity of the channel.

The number of pins recording erosion or deposition greater than 0.3 cm (>0.1 in) is significantly correlated with the amount of time that has passed since the last pin measurements were taken (fig. 1). This indicates that erosion and deposition can occur incrementally, and can result from many small runoff events as well as from a single large event.

HYDROLOGY

Unsaturated Zone Studies

The Texas Low-Level Waste Disposal Authority at Fort Hancock has been collecting water potential data from the two psychrometer stations since March 1990. The data are then mailed to the Bureau for analysis. The data collection and transmission process has worked very well. Some recent problems with the new psychrometer station are currently being resolved. Problems with battery corrosion will be eliminated in the future by regular servicing of the batteries.

Water potentials at the old psychrometer station have remained fairly constant throughout the monitoring period. Water potentials in the top 0.8 m of the unsaturated zone were generally outside the measurement range (0 to –8 MPa) of the psychrometers throughout most of the monitoring period. Psychrometers at 0.3-m depth had water potentials of –7 MPa in early September, which indicates that the wetting front from previous precipitation events extended to that depth.

Detailed analysis of the calibration data for the 50 psychrometers that were installed to a depth of 25 m was conducted. Multiple regression analysis was done with the statistics package SAS to develop equations of water potential versus microvolt output and temperature. These data will be used to determine the necessity for psychrometer calibration in future studies. Preliminary results from these psychrometers in the field showed that water potentials for May 1990 ranged from –1 to –8 MPa, which is similar to results from the old psychrometer station. Water potentials were lowest at the surface and increased with depth. The upward water potential gradient suggests an upward driving force for liquid water similar to that at the other psychrometer station.

Moisture content was monitored with the neutron probe on October 26, 1990, in access tubes 18 and 19 and showed no variation in moisture content with time.

Unsaturated Zone Data Analysis

The discrepancy between the upward driving forces for the liquid water suggested by the water potential data and the net downward liquid fluxes indicated by the chemical tracers could be resolved if the tracers are moving down by concentration-driven diffusion. The chloride data were examined to determine if chloride moved downward as a result of diffusion. Cubic splines were calculated for the chloride profiles, and the diffusive fluxes were estimated. The results of these analyses suggested that diffusive fluxes are 2 to 3 orders of magnitude less than advective fluxes and that the tracers are moving downward with liquid water. The results of

these analyses were submitted to the *Journal of Hydrology* in an article titled "Use of Chloride Mass Balance Data to Evaluate Moisture Flux in Desert Soils."

The relative importance of liquid and vapor transport in the shallow unsaturated zone was also examined by simulating liquid and vapor flow in response to water potential and temperature gradients using the computer code SPLASHWATR2. Data from January and June were used for the simulations because they represent the extremes in the temperature gradients. Calculated vapor flux was 4 to 10 orders of magnitude greater than liquid flux for the periods simulated. Isothermal vapor flux was upward in response to the upward water potential gradients. The net thermal vapor flux for a diurnal cycle was downward in the summer and upward in the winter. Downward vapor flux in the summer was much greater than upward vapor flux in the winter and suggests that on an annual basis there should be a net downward vapor flux that is consistent with the ^{3}H and ^{36}Cl results. These results will be submitted to *Water Resources Research* in the near future.

The contract report on hydraulic data was submitted to the Bureau for publication as a Report of Investigations. The results of the unsaturated zone studies were presented at the annual Soil Science Society of America meeting in San Antonio, at the annual Geological Society of America meeting in Dallas, and at the annual American Geophysical Union meeting in San Francisco. A lot of interest was expressed in these studies, particularly the work related to vapor transport. One of the GSA field trips included a stop at the Low-Level Waste study area, where the unsaturated zone monitoring system was described.

Ground-Water Monitoring Program

Quarterly ground-water monitoring at the Fort Hancock site was conducted in October 1990, with five water wells sampled for chemistry and stable isotopes. In addition, one aquifer test was conducted in well 72 to confirm results from previous testing. Well 98 (Camp Rice Reservoir 1 well) was not sampled during this trip because of unusually high water levels

covering the access road. Well 72 was sampled instead of well 73 because well 72 was being pumped for the aquifer test. The results from stable isotope analysis have not been received to date. The results of the aquifer test are in review and will be transmitted for review by the Authority upon completion of internal review. Results from chemical analysis are presented in table 3.

Figure 1. Relationship between erosion pin data and time since last measurement recorded at the Texas Low-Level Radioactive Waste Disposal Authority site, Hudspeth County, Texas.

Table 1. Rainfall record of gauges at the Texas Low-Level Radioactive Waste Disposal Authority site, Hudspeth County, Texas, for January 1–November 26, 1990. Only rainfall events with daily totals greater than 12.7 mm (>0.5 in) are listed.

Date	Maximum daily total (mm)	Station	Maximum 1-hr total (mm)	Station	Maximum 1/2-hr total (mm)	Station
7/14	26.0	C*	17.4	C	12.0	E*
7/15	18.4	DP*	9.4	DP	6.4	DP
7/21	21.0	W*	18.2	W	9.8	W
8/13	28.6	W	16.0	W	9.8	W
8/14	19.0	W	18.0	W	14.4	DP, W
9/14	20.2	DP	11.6	DP	11.1	DP
9/30	24.6	C	17.0	E	12.0	C, E
10/1	17.4	C, W	15.6	C	13.6	C

* C = Center; DP = Diablo Plateau; E = East; W = West

Table 2. Record of erosion and deposition in pin fields at Texas Low-Level Radioactive Waste Disposal Authority site, Hudspeth County, Texas, for March–October 1990.

Pin field	Number of pins recording >0.3-cm change on: Mar. 28	July 19	July 24	Aug. 21	Oct. 14	Total	Channel present?
0	8	1	1	3	5	18	Yes
1	2	1	1	1	0	5	No
3	6	4	2	1	1	14	No
4	3	4	2	3	4	16	Yes
5	2	5	2	6	5	20	Yes
6	1	0	0	0	1	2	No
8	0	2	0	0	2	4	No
9	2	1	3	3	0	9	No
Total	24	18	11	17	18	88	

Table 3. Chemical analyses of water samples collected from boreholes at the Texas Low-Level Radioactive Waste Disposal Authority site, Hudspeth County, Texas.

MSL ID	Well ID	Na	Mg	Ca	K	Sr	Ba	Fe	Mn
90<500	22	797	17.20	97.8	6.35	3.99	<0.02	<0.02	0.04
90<501	72	648	22.90	99.4	6.74	4.55	0.02	<0.02	0.02
90<502	126	585	8.02	73.2	4.69	8.10	0.02	<0.02	0.02
90<503	108	431	12.90	39.9	4.83	1.08	0.03	<0.02	<0.02
90<504	93	823	42.10	151.0	8.05	2.50	0.07	0.37	0.22

MSL ID	Zn	Li	B	SiO_2	HCO_3	Cl	Br	I	SO_4
90<500	0.33	0.17	1.23	9.38	58.9	462	2.48	0.08	1364
90<501	0.04	0.17	1.08	24.70	71.2	590	2.83	0.25	846
90<502	0.11	0.12	1.03	24.60	59.9	398	2.09	0.07	787
90<503	<0.04	0.14	0.61	36.90	256.0	256	0.77	0.31	456
90<504	<0.04	0.24	0.43	30.10	192.0	1200	0.75	0.34	374

MSL ID	F	NH_4	NO_3	Lab pH (units)	Field pH (units)	Field HCO_3	Eh	DO	Temp. (°C)
90<500	3.52	<0.2	23.8	7.77	8.47	80.5	+220	1.68	21.7
90<501	1.97	<0.2	16.2	7.79	8.03	87.8	+250	3.28	24.7
90<502	3.95	<0.2	19.9	7.77	8.10	58.6	+250	1.62	21.7
90<503	2.00	<0.2	5.1	8.24	7.70	253.8	+260	2.48	22.8
90<504	0.95	<0.2	<0.8	8.09	7.61	183.5	+240	1.38	19.3

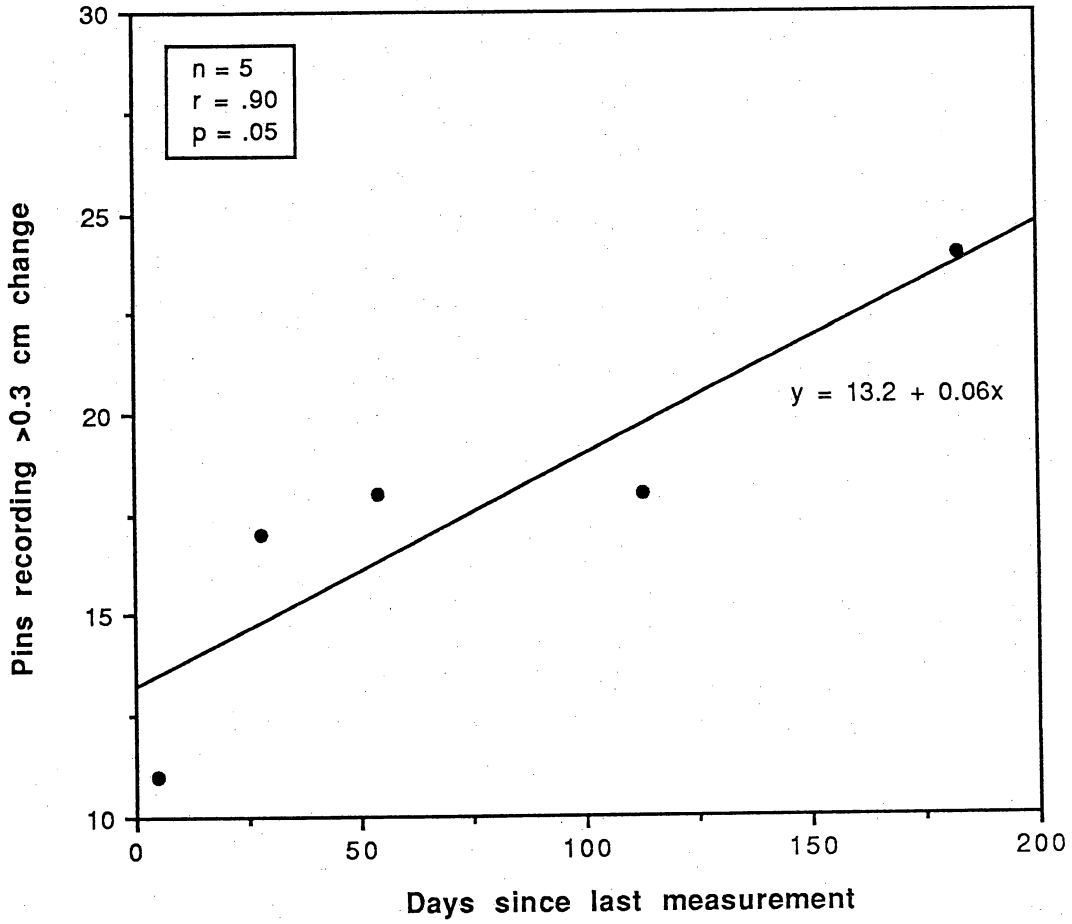

Figure 1. Relationship between erosion pin data and time since last measurement recorded at the Texas Low-Level Radioactive Waste Disposal Authority site, Hudspeth County, Texas.