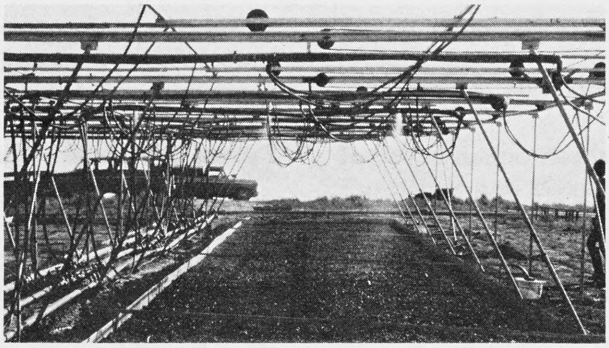

Figure 1. The Rainulator.

Water Infiltration at Surface-Mined Sites in Western North Dakota

J. E. Gilley, G. W. Gee, A. Bauer, W. O. Willis and R. A. Young

Soil water content changes resulting from simulated rainfall events were determined on undisturbed native rangeland, on cultivated and noncultivated levelled spoil and from cultivated and noncultivated spoil with "topsoil." Water movement into the rangeland site was considered to be unrestricted. Water movement into noncultivated spoil was minimal. Water flow into cultivated spoil material was restricted to less than a 6-inch depth. Water storage on the topsoiled sites was limited to the topsoil materials. Disking of the topsoil-spoil interface had no apparent effect on water movement into the spoil medium.

Increased utilization of coal reserves in the Northern Great Plains is expected as a result of growing national energy needs. An estimated 91.6 million acres in the states of North and South Dakota, Montana and Wyoming are underlain by surface mineable deposits of coal (2) with a projected recoverable coal reserve base of 64.2 billion tons. By the year 2000, more than 100,000 acres of productive agricultural lands are expected to have been committed to energy development. The need for reclamation research directed toward restoring the productivity of surface-mined lands is readily apparent.

Inherent in the concept of reclamation is the idea of establishing an environment suitable for sustained vegetative growth. Essential considerations include land stability, suitable plant growth medium of adequate thickness, proper fertility and water supply. Vegetative growth in this semiarid region is frequently limited by lack of water even where infiltration is not restricted and no runoff occurs. Where water movement into the surface is limited, the water supply in the rooting zone of plants can be affected. Information about water movement is needed for typical surface-mined materials to aid in establishment of efficient soil and water management procedures required for reclamation.

Procedure

A portable rainfall simulator or rainulator which combines features of standard runoff plot size, rainfall drop characteristics, minimized wind distortion and complete portability was used during the summer of 1975 (1) to investigate water content changes in rangeland, spoil and topsoil materials. The studies were conducted at the North American Coal Corporation Indian Head Mine near Zap, North Dakota (see Figure 1).

Operating procedure consisted of imposing a simulated rainstorm of 1-hour duration at a constant intensity of approximately 2.5 inches per hour. A second, or wet run, was conducted under identical conditions approximately 24 hours later. Water content changes were determined from soil samples collected immediately before and approximately 24 hours after each simulated rainfall event. Individual plots were 13.3 feet across the slope by 72.6 feet long, separated by a 6.7-foot border area.

Gilley was research associate, Department of Agricultural Engineering; Dr. Gee was research scientist and Dr. Bauer was professor, Department of Soils; Dr. Willis is research leader, USDA-ARS, Mandan, North Dakota; and Dr. Young is agricultural engineer, USDA-ARS, Morris, Minnesota.

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The native rangeland site was located within the mine complex. This site served as a pre-mined condition for comparison with mining conditions. The soil at the rangeland site was sandy loam in texture with sodium adsorption ratio (SAR) in the upper foot of less than 1 (Table 1). Rainulator tests on replicated plots were run in October, 1975. The grass cover was last cut and harvested in September, 1974.

Table 1. Individual site identification.

Surface material	Texture*	Slope, %	SAR**	Per cent sand	silt	clay
Rangeland	sl	9	1	63	23	14
Spoil	scl	17	37	58	19	32
	cl	10	31	31	38	31
	sicl	13	33	12	49	39
Topsoil***						
Non-cultivated	sl	8.5	3	55	26	19
Cultivated	sl	10.4	3	54	26	20

**sl - sandy loam, scl - sandy clay loam, cl - clay loam sicl - silty clay loam.*

***When concentrations are expressed in milliequivalents per liter,* $SAR = Na/\sqrt{0.5\,(Ca + Mg)}$

****Treatments include a topsoil-spoil interface that was not cultivated and cultivated.*

Non-replicated plots were established on bare spoils representing three textures. The spoil material at each of the sites was considered to have a high SAR (Table 1). Each of the spoil textures included a cultivated and a noncultivated treatment. The cultivated plots were roto-tilled with a small garden tractor to a depth of 2 to 3 inches immediately before the initial water application. The sparse vegetative growth on the noncultivated plots was clipped prior to testing. The cultivated plot borders were installed in July, 1975, and the borders of the noncultivated plots in November, 1974. Field evaluation of both surface conditions was conducted in August and September, 1975.

A third set of plots consisted of two treatments of Flaxton sandy loam topsoil, approximately 10 inches thick, placed on spoil of clay loam texture. These plots were established in July, 1975, and were replicated twice. The SAR of the topsoil was 3 (Table 1). The spoil material over which the topsoil was placed was disked to a depth of 4 to 5 inches on the cultivated treatment, and left undisturbed on the noncultivated treatment. Approximately 2.5 inches of precipitation occurred prior to field testing in late September and October, 1975. The area on which both the spoil and topsoil plots were located was mined in 1971 and reshaped in 1973.

Samples were obtained from six points from each of the plots to evaluate water content. Samples were collected in 6-inch increments to a depth of 24 and 12 inches on the rangeland and spoil sites, respectively. A single topsoil sample and a spoil sample to a depth of approximately 4 inches was obtained from each of the six points on the topsoil plots.

Results and Discussion

The water content data resulting from each of the simulated rainfall events are summarized in Tables 2, 3 and 4. Averages of two replications on the rangeland and topsoil plots are shown; other listed values describe nonreplicated plots. Data from each of the three sets of surface conditions will be examined separately.

Rangeland

The predominant land use for much of the area designated for energy development in the Northern Great Plains is range. Water content information on the sandy loam range site is shown in Table 2. A substantial change in water content as a result of the two rainulator applications is apparent at the 18 to 24-inch depth. Similar water contents were determined between sampling sets 2 and 3 on the 0 to 6 and 6 to 12-inch depths. The upper foot of the root zone appeared to be near field capacity after the initial water application. Water moved into the lower depths as a result of the second rainulator event.

Table 2. Water content changes after water application on rangeland site.

Depth, inches	Water content, % by weight* sampling set 1	2	3
0-6	16	21	21
6-12	10	13	14
12-18	5	11	13
18-24	4	10	13

**1 - before initial run, 2 - 24 hours after initial run, 3 - 24 hours after wet run.*

Relatively unrestricted vertical water movement apparently exists at this location. The native grasses at the site likely draw from a water reservoir extending vertically for several feet. This extensive rooting zone can provide a substantial supply of available water.

Spoil

Table 3 lists water content data collected from three spoil textures. Sampling variations in water content of 1 to 2 per cent resulted from the heterogeneous nature of the material. The plots which

Table 3. Water content changes after water application on spoil sites.

			Water content, % by weight*** sampling set		
Texture*	Surface treatment**	Depth, inches	1	2	3
scl	N	0-6	10	10	11
		6-12	16	17	17
	C	0-6	12	12	12
		6-12	15	15	15
cl	N	0-6	11	11	10
		6-12	18	19	17
	C	0-6	10	11	16
		6-12	17	16	17
sicl	N	0-6	11	11	11
		6-12	16	16	18
	C	0-6	10	17	18
		6-12	17	15	17

**scl - sandy clay loam, cl - clay loam, sicl - silty clay loam.*

***N - Noncultivated, C - Cultivated.*

****1 - before initial run, 2 - 24 hours after initial run, 3 - 24 hours after wet run.*

were not cultivated correspond closely to conditions existing after the reshaping process is completed.

Changes in water content in the noncultivated plots was minimal for each of the three textures investigated. Similar results appeared on the cultivated sandy clay loam plot. However, an increase in water content occurred in the upper increment of the cultivated clay loam and silty clay loam plots. No change in water content was apparent at the 6 to 12-inch depth for any texture or tillage treatment.

The limited change in water content of the spoil treatments is attributed to dispersed surface conditions. This dispersed condition is typical of materials with high SAR, particularly when coupled with fine textured materials. A different response would be expected on sites with much lower SAR values. When water movement into soils is limited, water storage is correspondingly diminished and productivity may be restricted.

Topsoil

Prior to mining, the soil material considered most suitable for plant growth, "topsoil," is removed and stockpiled. After the area is mined and the spoil reshaped, the topsoil is then replaced. Water content data on the topsoiled sites are presented in Table 4.

Water content at field capacity of the sandy loam soil was determined to be approximately 14 to 16 per cent by weight. A substantial increase in water storage of the topsoil material appeared between sampling sets 1 and 3 on the noncultivated and cultivated treatments. The topsoil at both sites appeared above field capacity, but no significant change in water content of the underlying spoil occurred.

Table 4. Water content changes after water application on topsoiled sites.

		Water content, % by weight** sampling set		
Treatment*	Material	1	2	3
Noncultivated				
	topsoil	7	16	17
	spoil	13	14	14
Cultivated				
	topsoil	11	15	19
	spoil	14	13	15

**Treatments include a topsoil-spoil interface which was not cultivated and cultivated.*

***1 - before initial run, 2 - 24 hours after initial run, 3 - 24 hours after wet run.*

If vertical water movement is restricted by buried, high SAR spoil, water storage for plant needs is limited to that provided by the topsoil material. The amount of storage will be affected by topsoil thickness and topsoil texture. Research data are presently not available to define the exact topsoil depth that should be returned for optimum productivity.

When the movement of gravitational water through the root zone is impeded by an impermeable layer, soil aeration may become a problem and may inhibit plant growth. Greater topsoil depths above the restrictive layer would lessen possible difficulties resulting from an elevated water table.

Summary

Changes in water content, following application of water with a rainulator, were determined at sites representing typical pre-mined and mined conditions. Water movement into sandy loam soil at a native range site was considered to be unrestricted. Infiltration was minimal on spoil plots left in an undisturbed state. Roto-tilling did not affect water movement into a sandy clay loam spoil, but it did on clay loam and silty clay loam spoil materials. However, water movement into these materials was restricted to a depth of less than 6 inches. Water storage on the topsoil sites was limited to the topsoil material. Disking of the topsoil-spoil interface had no effect on water movement into the spoil medium.

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