New Mexico Bureau of Mines and Mineral Resources

Open File Report 340

RECHARGE AT THE CAL-WEST METALS SITE, LEMITAR, SOCORRO COUNTY, NEW MEXICO

by

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PREFACE TO REVISION

Due to an error in calculating soil-moisture content, the soil-water chloride values, and thus the recharge rate, originally reported for the Cal-West site are incorrect. The error arose when the lab assistant mistakenly calculated moisture as simply the wet weight minus the dry weight of the samples. It should have been calculated using wet weight minus dry weight, divided by dry weight minus average jar weight. Fortunately, raw data were preserved and a recalculation of the values was possible. This revised version includes 1) a new Table 2, giving corrected moisture- and chloride-content values, 2) new profiles (Figure 3) for these based on the corrected values, 3) a revised average soil-water-chloride content (Clsw) and 4) a new recharge rate recalculated from the corrected values. All changes are within the Results and Discussion sections of the report.

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INTRODUCTION

The Cal-West Metals site is a battery recycling facility located west of I-25 just north of Lemitar. More specifically, the facility is situated in NW, SW, Sec 2, T2S, R1W, 3/4 mi northwest of the Lemitar Post Office (Figure 1). Lead and various other battery components were separated and concentrated. The main production period was 1979-1981. Research and development work was carried out in 1982-1984. Lead was recovered from waste piles in 1985.

In June 1988, the facility was added to the Environmental Protection Agency's national priorities list, thus becoming a superfund site. In an effort to document background ground-water values for various constituents, an up-gradient monitoring well was installed July 14-15, 1988. Samples of the unsaturated zone taken during the drilling of this hole were used to evaluate ground-water recharge using a chloride mass-balance approach. The purpose of the recharge investigation was to characterize the average long-term rate at which water has moved downward at the site due to natural processes. This report gives the results of the Bureau's recharge study.

REGIONAL SETTING

The Cal-West facility lies in the Mexican Highlands Section of the Basin and Range physiographic province (Clemons, 1982). It is situated on the slope of an alluvial fan associated with drainage off the eastern flank of Polvadera Mountain, 4 mi to the west.

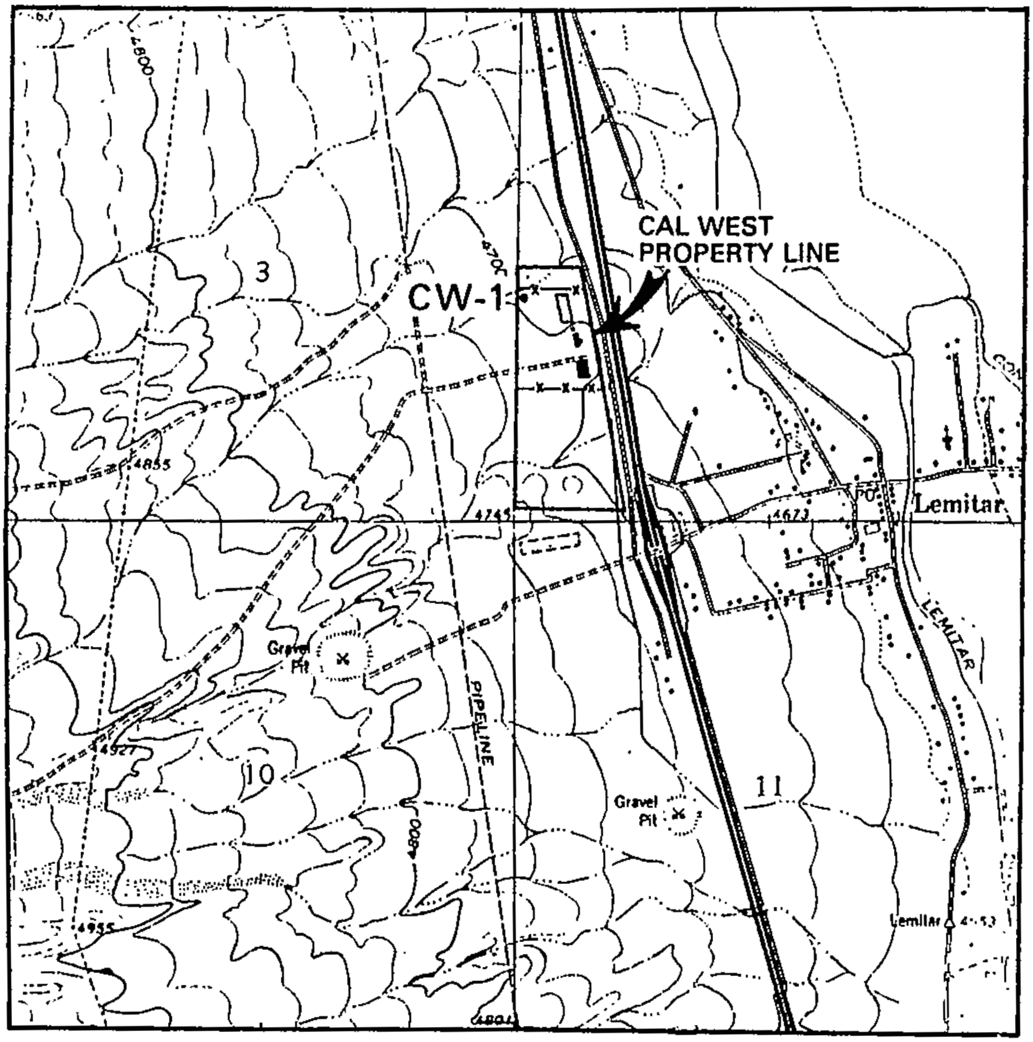

Figure 1. Location of study area (from USGS 7.5' quadrangle, Lemitar, New Mexico; 2 5/8 inch = 1 mi).

More specifically, the site occupies a position approximately 75 ft above the Rio Grande (2 mi to the east) and is drained by its tributaries. Structurally the facility lies near the western edge of the Socorro Basin portion of the Rio Grande Rift.

The area is underlain by unconsolidated sediments of the Santa Fe Formation (Tertiary). This unit consists largely of alluvium with minor amounts of lacustrine and eolian material. It is overlain by similar but younger (Quaternary) piedmont-slope deposits in basin-margin areas. Figure 2 and the Appendix show the specific character of the material penetrated at the site (hole CW-1).

Ground water lies at a depth of 80-95 ft below the surface. Regional ground-water flow is generally away from mountain recharge areas toward valley discharge areas (Stone and Summers, 1987). Locally, flow can be away from the river, as in the area to the northeast of the site (Anderholm, 1987, Plates 2 and 3).

The climate is arid with a mean annual precipitation of approximately 10 in. Nearly half this occurs in a distinct rainy season: July through September. Potential evaporation in the valley is on the order of 100 in/yr (Maker and others, 1972). Thus, net water deficits are common (Table 1).

Soils belong to the Nickel-Canutio-Rough Broken Land Association (Maker and others, 1972). This association is generally coarse textured (gravelly to sandy) and characterized by good permeability except where caliche is strong and shallow. Vegetation on these soils is sparse and dominated by creosote bush.

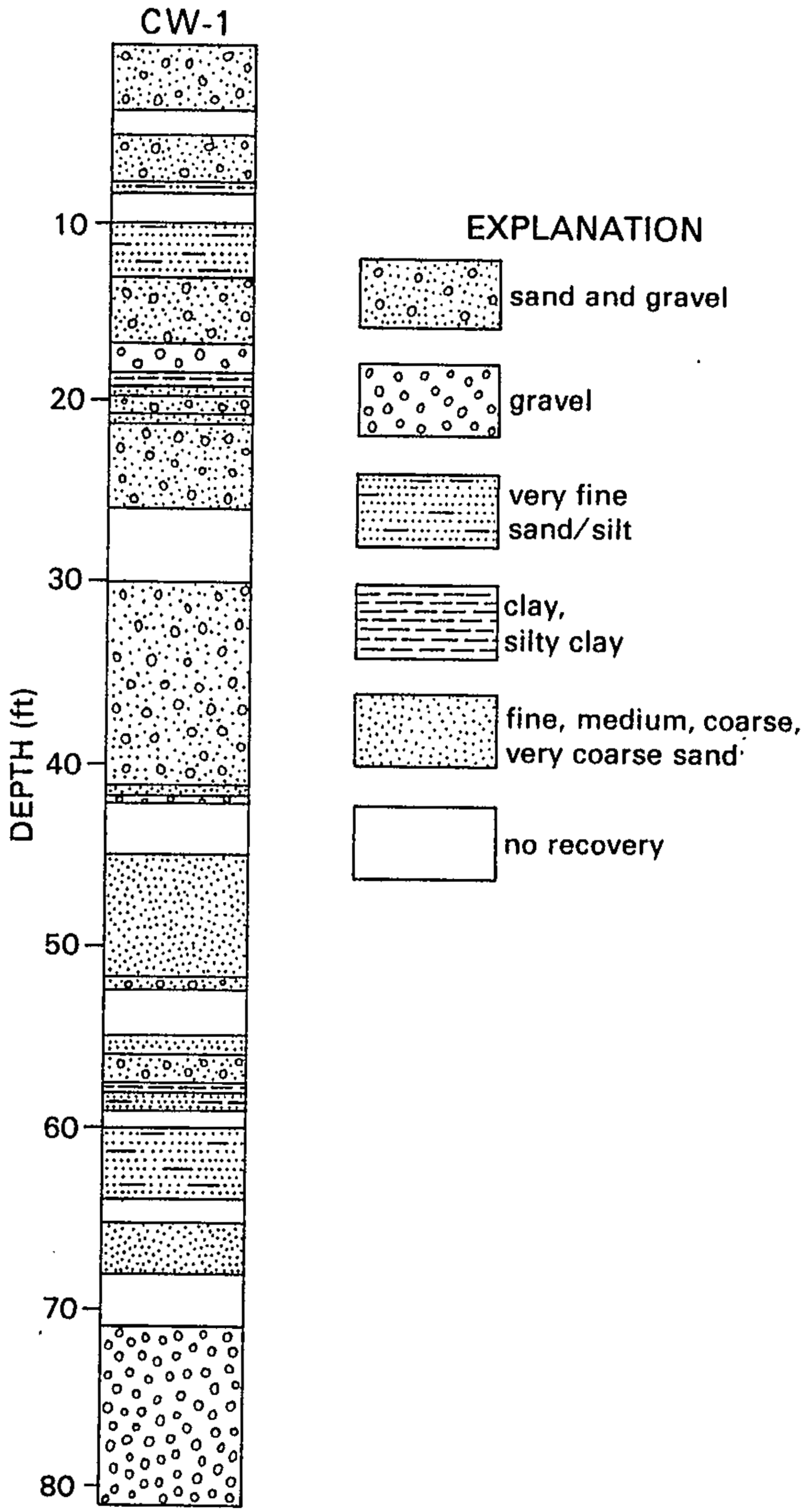

Figure 2. Lithologic log for Cal-West hole 1.

Table 1. Selected climatic data near site[1] (Gabin and Lesperance, 1977).

Station	Lat. (N)	Long. (W)	Elev. (ft)	Precip. (in.)	Yrs of Record	Water Budget (in)[2]
Bernardo	34°26'	106°49'	4727	7.5	13	-32
Kelly Ranch	34°26'	107°08'	6700	13.60	28	NA
Socorro	34°05'	106°53'	4585	9.35	76	-36

[1] site is at 34°10'N/106°55'W; elevation 4700 ft

[2] Precipitation minus potential evaporation; negative number indicates deficit.

METHODS

Recharge was determined by the chloride mass-balance method. In this relatively simple and inexpensive procedure, it is assumed that

$$P \cdot Clp = R \cdot Clsw$$ where,

P = average annual precipitation (in/yr), Clp = annual chloride input via precipitation (mg/L), R = recharge rate (in/yr), Clsw = average soil-water-chloride content below the root zone (mg/L). Rewritten for recharge this becomes

$$R = (P \cdot Clp)/Clsw.$$

P and Clp are either obtained from the literature or by measurements made on site. Clsw is determined from samples of the unsaturated zone (above the water table).

Preliminary tests suggest the general lab procedures used are valid (McGurk and Stone, 1985). The method has been widely used in arid settings (Allison and Hughes, 1978; Allison and others, 1985; Stone, 1986a).

SAMPLING

Samples of the unsaturated zone were taken by means of coring with a hollow-stem auger rig. More specifically, a CME-55 continuous sampling system with a 5-ft split barrel was hired for the work. Each 5-ft core was subsampled at 1-ft intervals for the recharge study. Samples were taken in 1-oz screw-top, plastic jars. To prevent moisture loss, these were also sealed with plastic electrical tape, placed in zip-top plastic bags, and stored out of the sun.

In the case of incomplete recovery, it was assumed for consistency that the partial core was obtained, then the barrel became plugged. Thus, the core obtained was routinely assigned to the upper part of the interval drilled. For example, if only 3 ft were recovered in the interval 10-15 ft, the core was assigned to a depth of 10-13 ft.

ANALYSIS

Before recharge can be calculated, Clsw must be determined. This involves several steps. First, moisture content of each sample is determined gravimetrically. In other words, each sample is weighed as it comes from the field, oven dried to remove moisture, then weighed again. The weight loss is attributed to moisture content. Next, samples are shaken gently with a known volume of deionized water to remobilize the salt (chloride). The resulting solution is decanted off and its chloride content measured with a pH meter and chloride electrode. The chloride content of the original soil water (Cl) in each sample is calculated using

$$Cl = (Cle \cdot W/Sd)/(Sw\text{-}Sd/Sd\text{-}J) \cdot Db$$

where, Cle = chloride content of the extract (mg/L), W = weight of water added in extraction (g), Sd = dry weight of the sample (g), Sw = wet weight of the sample (g), J = weight of the jar (g) and Db is the bulk density of the sample.

Once Cl values are calculated for each sample, they are plotted versus depth. A typical plot is characterized by a chloride peak near the surface corresponding to the root zone. Plants take up water but leave salts behind. This accumulates over time to produce the chloride peak. Ideally, for every volume of water that comes in, through precipitation/ infiltration, an equivalent volume of water moves downward by piston flow. In most storms there is rarely enough precipitation to displace any water out of the root zone. However, intense storms do result in deep percolation/displacement. This shows up as lower chloride values below the peak. Only these are used to determine Clsw.

RESULTS

A sufficient number of samples was obtained to evaluate recharge, in spite of incomplete core recovery (Figure 2). Moisture content varies with lithology of the interval, but generally hovers around 0.05 g/g (Table 2 and Figure 3). A maximum value of 0.27 g/g is associated with a sample from a depth of 59 ft. This interval is silt/clay according to the log (Appendix). The chloride profile is typical in that it shows a peak at the top and a decline of values below the peak (Figure 3). The chloride values vary, ranging from 29 mg/L (at 60 ft) to a peak of nearly 1,300 mg/L (at 26 ft). Their magnitude suggests that infiltration and recharge rates are low, as might be expected from the arid setting.

The peak in this chloride profile does not extend to the surface as expected. It seems to have been moved downward or possibly buried, based on the interval of lower values above it (Figure 3). Downward displacement could have been caused by the addition of fresh water in excess of that received from precipitation (overland runoff, channelized flow, etc.). The proximity of hole CW-1 to a small drainageway suggests a source of such flushing. The surface at CW-1 seems reworked, supporting the burial explanation as well. Both may have contributed.

In calculating recharge, published values were used for P and Clp. The value of 9.35 in/yr used for P comes from Socorro (Table 1). The value of 0.37 mg/L used for Clp also

Table 2. Results of chloride analyses, Cal-West hole 1.

Sample No.	Sample Depth (ft)	Moist. Content (g/g)	Dry Wt. Soil (g)	Wt. Wtr. Added (g)	Cl in Extract (ppm)	Cl in Soil Wtr. (mg/l)
1	1	0.11	49.12	78.60	3.30	71.7
2	2	0.06	54.03	79.03	2.40	90.7
3	3	0.05	57.02	79.94	10.20	411.1
4	6	0.04	58.43	81.27	6.40	318.1
5	7	0.04	54.68	80.12	8.00	424.2
6	8	0.14	43.11	81.12	10.60	214.0
7	11	0.15	43.50	78.80	10.30	181.0
8	12	0.08	55.64	79.70	10.00	284.2
9	13	0.06	53.52	80.19	8.20	296.2
10	14	0.06	49.18	79.19	13.00	514.2
11	16	0.06	56.78	79.43	18.00	616.8
12	17	0.05	54.83	77.26	18.00	750.0
13	18	0.07	53.03	81.47	25.00	825.1
14	19	0.04	60.71	79.53	20.50	910.2
15	21	0.06	50.82	80.70	31.00	1,143.4
16	22	0.08	53.15	80.20	40.00	1,065.9
17	23	0.04	64.07	79.88	29.00	1,217.8
18	24	0.05	56.81	79.87	31.00	1,217.7
19	26	0.06	51.15	78.67	32.00	1,284.7
20	31	0.05	58.52	82.57	28.00	1,234.2
21	36	0.04	58.22	79.27	19.00	888.1
22	41	0.07	54.53	79.71	11.00	340.2
23	42	0.05	57.05	77.69	6.00	266.2
24	46	0.04	53.24	81.88	4.00	232.2
25	47	0.03	53.31	79.60	2.60	172.3
26	48	0.03	54.88	80.00	2.40	174.7
27	51	0.03	56.34	81.39	2.10	155.1
28	52	0.09	54.81	79.42	2.90	70.3
29	56	0.08	53.98	78.34	2.00	54.1
30	57	0.04	58.27	79.95	1.90	89.4
31	58	0.15	43.30	78.62	2.10	36.1
32	59	0.27	43.60	80.35	2.80	29.1
33	61	0.12	47.33	80.82	1.80	36.9
34	62	0.08	43.67	77.98	2.10	67.6
35	63	0.07	49.43	77.75	1.50	52.5
36	64	0.12	43.92	79.33	1.70	36.7
37	66	0.02	52.12	80.45	2.40	233.4
38	67	0.03	53.51	82.55	1.40	115.2
39	68	0.03	48.79	80.10	2.70	242.7

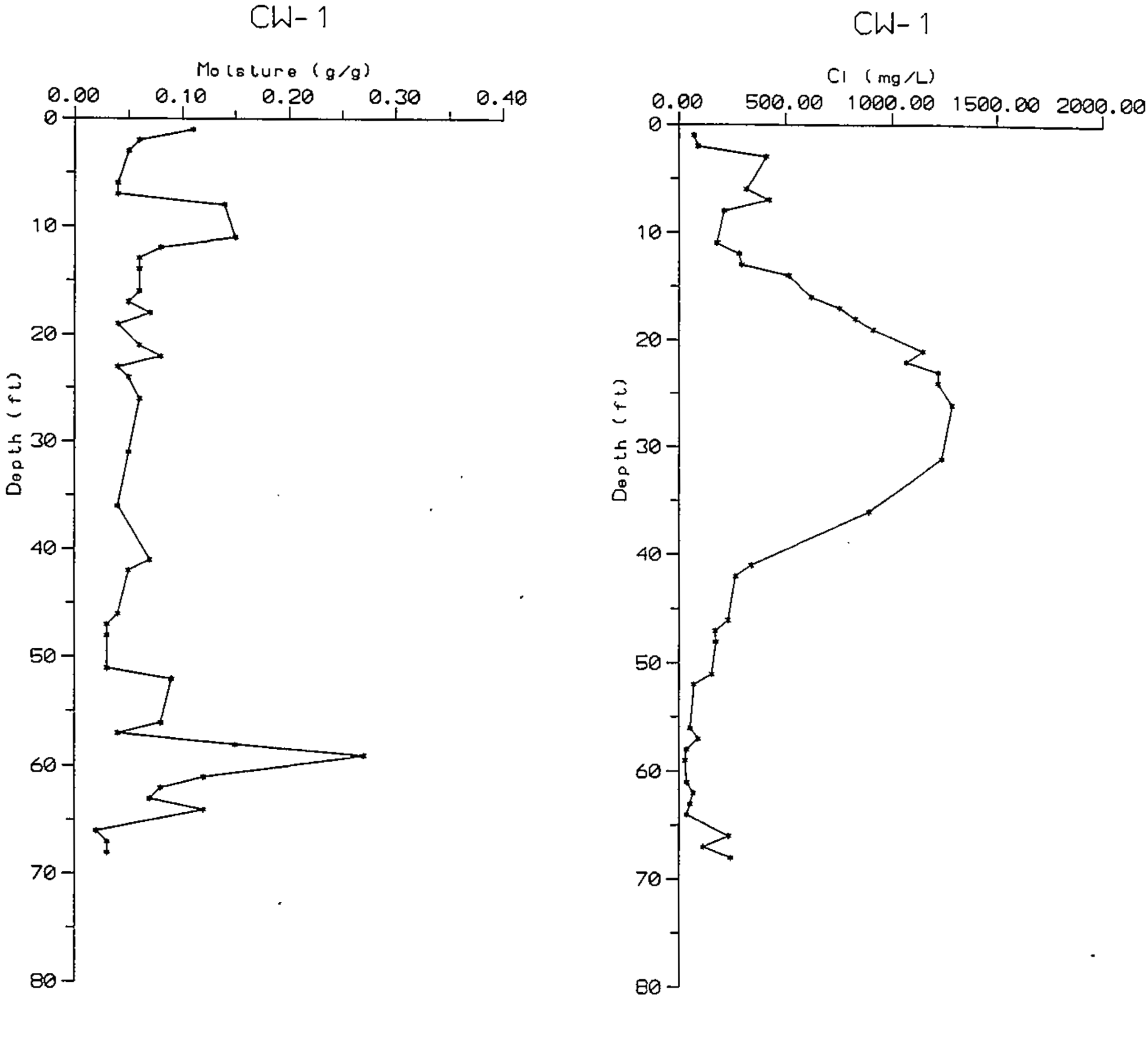

Figure 3. Results for Cal-West site.

comes from the Socorro area (Phillips and others, 1984). The value used for Clsw (88.7 mg/L) was determined over the interval 52-68 ft. Using these values in the mass-balance equation gives a long-term average recharge value of 0.04 in/yr.

DISCUSSION

The results of this study should not be taken to mean that a highly soluble material lying at the surface will migrate toward the water table at exactly a rate of 0.04 in/yr. This may serve as an ideal scenario, but is rarely attained for several reasons. First, the recharge rate calculated is a long-term average; lower (or higher) rates operate at any given time, depending on various climatic and site factors. Secondly, movement of soil water is not strictly vertical (piston flow), as would be ideal for mass-balance calculations. There is often some lateral component of movement, in response to topographic effects (McCord and Stephens, 1987) and texture of the sediments (Winograd, 1974). Additionally, the recharge rate obtained is only an estimate, because P and Clp were not available for the site. If either of these were greater than assumed, the recharge value obtained would be greater and vice versa.

However, mass-balance recharge results have compared favorably with those of other methods (Phillips and others, 1984; Stone, 1986b). The value obtained also seems reasonable in view of the geology and vegetation at the site (Figure 2), climatic data for the region (Table 1), and previous experience with the method (Allison and others, 1985; Stone, 1986a, 1988, and 1991). The recharge rate is comparable to those previously obtained in New Mexico (Stone, 1986b). It is low, representing 0.5% of the precipitation value assumed for the area.

It should be noted that the deepening of the chloride peak, whether by flushing or burial, does not alter the recharge rate calculated. Only values below the peak are used to determine Clsw.

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APPENDIX

Brief Field Description of Cores

Hole CW-1 -- NW, NW, SW, Sec 2, T2S, R1W; northwestern corner of innermost fenced area; north of old pasture fence; west and slightly north of older buildings on site.

Depth (ft)	Description
0-3.5	Gravelly, sandy, clayey alluvium with angular pebbles up to 2" in diameter; moist in upper 1.5'
3.5-5	No recovery
5-7.5	As above
7.5-8	Very fine gravel (granules); fairly well sorted
8-8.5	Very fine sand/silt, clayey, yellow
8.5-10	No recovery
10-13	As above
13-16.5	Sandy gravel with angular volcanic rock pebbles up to 3" in diameter
16.5-18.5	Pea gravel
18.5-19	Clay
19-19.5	Fine-medium sand, well sorted
19.5-20.5	Gravel and sand
20.5-21	Very coarse sand
21-22	Gravel as above
22-24	Gravelly sand, coarse-very coarse
24-26	Gravel as above
26-30	No recovery
30-41	Gravel as above

41-41.5	Fine sand, well sorted (ancient Rio Grande?)
41.5-42	Gravel as above
42-45	No recovery
45-51.5	Fine sand with occasional pebble
51.5-52.5	Sandy gravel
52.5-55	No recovery
55-56	Fine sand
56-57.5	Gravelly sand
57.5-58	Clay
58-59	Silt and clay
59-60	No recovery
60-64	Clayey, silt-very fine sand
64-65	No recovery
65-68	Fine-medium sand, yellowish gray with rusty streaks
68-100	No recovery—drilled with wooden plug; quartzite/limestone pebbles from 71-81 ft, based on material stuck in core barrel

Total depth = 100 ft
Set Schedule 40 PVC with 20 ft of slotted screen at bottom.
Water level = 95.92 ft on 28 July, 1988.
