TESTIMONY REGARDING CASE 13480
Application of Gandy Marley, Inc. to modify their existing NMOCD Rule 711 permit No. NM-01-109

Donald A. Neeper, Ph.D., on behalf of
New Mexico Citizens for Clean Air & Water, Inc.
2708 B Walnut St.
Los Alamos, N.M., 87544-2050

Outline

I. Qualification of the witness.
II. Background of the organization.
III. Reason for this appearance.
IV. Salt transport in the vadose zone.
V. Effects of salt on soil and plants.
VI. Discussion of the proposed landfill.
VII. Conclusions

I. QUALIFICATION OF THE WITNESS

I received a doctorate in low-temperature physics from the University of Wisconsin in 1964. From 1968 to 1993, I conducted research on thermal physics and engineering at the Los Alamos National Laboratory (LANL). During my last three years at LANL, I conducted research on contaminant migration and vapor extraction for the remediation of contaminated soils. I also supervised a RCRA Facility Investigation of burial sites containing radioactive and hazardous wastes, including subsurface plumes of organic vapors and tritium. Since retiring from LANL in 1993, I have continued part-time research and consulting on air motion and the transport of volatile organic compounds in the vadose zone. From 2002 through 2004, I served as a public interest representative on the national governing board of State Review of Oil and Natural Gas Environmental Regulations (STRONGER), a nonprofit corporation funded by the federal government and industry to assist states in improving their regulatory programs for wastes from exploration and production.

II. BACKGROUND OF NMCCA&W AND ITS INTEREST IN SALT POLLUTION

The New Mexico Citizens for Clean Air & Water, Inc. was founded in the late 1960's in response to air pollution from the Four Corners power plant and potential pollution from a pulp mill. The organization has continued to address pollution from smelters, regional haze, gravel mining in the Rio Grande, mine tailings, air and water quality standards, land use, and, more recently, petroleum wastes. Our organization first became interested in salt pollution in 1971, when we noticed large scale disease of pine trees due to road salting. I initiated a review of the practices and effects of road salting, both locally and nationally. One of our members obtained permission to use LANL facilities on his own time to investigate the accumulation of sodium in pine needles of living trees. Fig. 1 presents the first page of his scientific publication. Fig. 2 presents the published table of his results, showing that the sodium in the needles of the affected trees far exceeded both the background levels and the toxic limits. This documents our longstanding concern with salt pollution, a concern that has brought me to testify at this and other OCD hearings.

III. REASON FOR THIS APPEARANCE

NMCCA&W regards this case as a landmark for future permits of other landfarms and landfills. If it receives an excess of salt, a landfarm may leave a legacy of barren earth that will remain for generations. Saline wastes left in pits prior to regulatory prohibition have left many such legacy sites. Furthermore, the subsurface conditions left by a landfill may generate land that cannot be used for any purpose, even for constructed buildings. We urge that disposal sites be operated and closed in such a fashion that they do not become sacrifice areas that can be neither occupied nor adequately remediated in the decades after their use has ceased. My appearance is motivated by my previous professional work on the investigation and remediation of legacy landfills.

IV. SALT TRANSPORT IN THE VADOSE ZONE

We do not object to a landfill if the wastes can be secured and the land returned to either economic use or its natural productivity. We do object to the treatment of unlimited amounts of saline wastes at a landfarm, because the accumulating salinity would eventually render the land sterile. The OCD regulations and permit structure are generally designed to protect groundwater. However, OCD has the mandate to protect not only water, but also the environment. Even if a site has no protectable water, OCD still has the requirement and the authority to protect the land from pollution. Our concern is with the eventual movement of salt and other wastes out of the landfill,.

In less arid climates, salt pollution of the land is usually treated by flushing the salt downward, to the aquifer where it would eventually be moved by infiltrating rain to a river and then to the ocean. However, in an arid climate, most rainfall enters the ground and then emerges back into the air by evaporation or by transpiration through plants. In an arid climate, water in the vadose zone moves upward as the land surface dries. Water is held in the soil just as water is held in a sponge, by the suction of capillary action. The water moves according to the combined effect of suction and gravity. Gravity always pulls downward; suction pulls toward the direction where the soil is increasingly dry. The energy gained or lost by a volume of water in moving under the combined suction and gravity is called the moisture potential, which acts just like a pressure to move pore water in the vadose zone. Fig. 3 illustrates measurements of the moisture per unit volume in the soil, the measured suction, and resulting total potential, expressed as hydrostatic head. Water moves toward the lowest potential--that is, toward the most negative head. In Fig. 3, water both above and below the depth of 55 ft is moving toward that depth--that is, the water at depths immediately below 55 ft is moving upwards. The reason for this unique feature was never verified, but some of us who worked on this site suspected the subsurface rock at depths near 55 ft was being ventilated by the atmosphere, either by fractures or by nearby canyon walls. The point of this discussion is to illustrate that moisture in the vadose zone can move upward, carrying salt with it.

Fig. 4 is from a textbook. The figure shows the distribution of salt in the soil between ground surface and a shallow water table, where the dominant migration of water is upward. In this case, the water carries naturally occurring dilute salts, with the salinity increasing as the water evaporates during its upward journey to the surface.

Fig. 5 presents three photos I took to illustrate salts (not necessarily sodium chloride) moving upward or sideways through volcanic tuff near Los Alamos. The left photo shows salt accumulation on a boulder, sitting in the soil in an undisturbed canyon. The right two photos show salt as it was deposited on the surface of a rock at a road cut. In each of these locations, the salts are washed away with a strong rainstorm, only to reappear in another season of drying. Our concern is that sodium chloride in a landfill may likewise be continually brought to the surface, inhibiting vegetation and thereby leaving the landfill subject to erosion. Because salt is not necessarily transported downward, we assert that environmental protection must focus on the vadose zone and ground surface, not only on the groundwater.

V. EFFECTS OF SALT (SODIUM CHLORIDE) ON SOIL AND PLANTS.

Effects on soil. Sodium destroys the soil structure, in part by replacing calcium on clay particles. With increasing sodium content, the soil loses its porosity and flocculence, that is, its crumbly nature and its ability to hold water. At sufficiently high sodium content, the soil becomes "sodic," which is the powdery, hard substance of a salt pan.

Effects on plants. (Fig. 6.) The presence of sodium in the soil often reduces the availability of plant nutrients, especially calcium and potassium. Plants may also be starved of moisture, both because the soil does not transmit or hold moisture, and because the osmotic pressure of salty pore water opposed the osmotic pressure by which plants draw water from the soil. Various species of plants are more or less susceptible to chemical poisoning by either the sodium, or the chloride, or both. A common effect of such poisoning is a gradual browning of the leaves (or pine needles) starting from the tips and edges, and moving to the stem of the leaf.

Measures of salinity. I have found no single measure of salinity that completely characterizes the effect of salinity on the soil and plants. Fig. 7 lists four of the simpler measures of salinity. TDS is a measurement that includes dissolved solids other than sodium chloride. Chloride or sodium content alone do not reveal the potential impact that occurs as sodium competes with other ion species for sorption sites on the soil. Electrical conductivity correlates with the potential for plant damage, but does not reveal the impact on the soil. Sodium absorption ratio (SAR) is a single measure that correlates with plant damage and with impact on the soil, although by itself it does not necessarily reveal the movement of sodium or chloride in the soil. It would be best to use sodium and chloride concentrations, electrical conductivity, *and* SAR together to monitor the release of sodium chloride from waste facilities.

<u>SAR</u>. There are two equivalent definitions of SAR in the open literature. In the following definition, the concentrations are moles (not chemical equivalents) per mass or volume. For soil, the concentrations are often specified as moles per liter of pore water that is in saturated equilibrium with the soil.

$$SAR = \frac{Na}{\sqrt{Ca + Mg}}$$

$$= \frac{sodium(ppm/23)}{\sqrt{calcium(ppm/40) + magnesium(ppm/24.3)}}$$

If calcium carbonate is dissolved in the pore water, the SAR value should be adjusted to a larger "effective" value.

Fig. 8 lists the SAR values at which various levels of plant damage occur, depending upon the species. Because germinating seeds are most sensitive to salt, we suggest using SAR < 3 as a guideline for areas to be revegetated in arid regions.

Gandy Marley's landfarm permit, and other landfarm permits, require quarterly sampling of hydrocarbons, together with annual sampling of metals and ions at a depth not to exceed three feet. We had hoped that the data from several years of this sampling would reveal whether there is any accumulation or migration of salinity from previously treated saline wastes. Unfortunately, as shown by the X-marks in Fig. 9, records of very few sampling events exist in the OCD file. Fig. 10 illustrates what could be inferred from the sparse data. In the sampling on 1-15-02, Cells 7 and 9 showed the largest SAR values, which are approximately 6. This sampling was evidently done at the surface of the cells. The subsequent sampling, done on 12-10-04, was done at a depth of three ft. This makes it difficult to compare the two results. However, we call attention to the fact that the sodium concentrations of the sampling events are all somewhat similar, in the range of 200-300 ppm, while the SAR of the surface samples is approximately 20 times the value of the soils at the three-foot depth. This illustrates the advantage of monitoring SAR as an indicator. The SAR value of 6 suggests that the remediated soils in the Gandy Marley landfarm cells should not be used for soil that is to be vegetated, unless a lower SAR value is confirmed by sampling immediately before use.

From the absence of sampling records at OCD, it would appear that Gandy Marley is not in compliance with the sampling requirements of its existing landfarm permit. In this case, the data from several years of sampling formed a rational basis to support or to oppose Gandy Marley's original application for a permit to continue farming saline wastes. As things stand, we suggest that OCD should not issue a new or revised permit until the operator is fully in compliance for a period of two years. We do not intend this as a punitive action unique to Gandy Marley. Rather, we intend that OCD should not issue new or revised permits to any operator who is frequently out of compliance.

VI. DISCUSSION OF THE PROPOSED LANDFILL

As proposed, the landfill would become a sacrifice area, a set of hills rising above the plain, with a thin soil cap above approximately 30 feet of toxic wastes (Fig. 11). Instead, the landfill should be designed to be secure for centuries. As designed, the area could never again be used, because any traffic or disturbance would be likely to expose the wastes, which will degrade little, if at all.

Experience with closed landfills. I have personally examined two closed landfills in Los Alamos County, each of which is the approximate size of one to three Gandy Marley cells. One is a municipal landfill; the other is an industrial landfill. Both are set on mesas, in lightly welded tuff. The municipal landfill is adjacent to a canyon, so one side of its former pit is adjacent to sloping soil, rather abutting than solid rock. In each case, the wastes were buried below the original ground surface, and the landfill surfaces have been brought close to the original grade and vegetated. In each case, I saw evidence of settling, where runoff on the ground accumulated in a local depression, developed a sinkhole, and formed a channel that funneled rainwater from a larger area downward into the closed pit. At the sloping side of the municipal landfill, some of the debris is emerging from the ground. Both of these landfills are subjects of investigation and remediation.

Concerns. (Fig. 12.) The proposed landfill design offers even less apparent long-term security than the troublesome municipal and industrial landfills described above. The proposed landfill would accept solid debris, light and heavy hydrocarbons, toxic drilling wastes, and salty wastes. When a cell is closed, some of the wastes will be located above the original ground level, and covered with two feet of dirt. In effect, the resulting topography will be a mound or a series of joined mounds, rising above the level of the plain. The volatile hydrocarbons will diffuse outward into the soil and air in the vapor phase, but the heavy hydrocarbons will remain with little further attenuation. The salt will move with the moisture; therefore, some salt probably brought upward by evaporation, as discussed above. In time, the solid debris will shift, causing local depressions in the cap, forming funnels for infiltration of water. If saline soils from the landfarm are used for the cap, the surface may be difficult to revegetate. Even if the cap is covered with clean soil, the vegetation may die in the future as salt accumulates. An unprotected cap offers opportunity for erosion. I am concerned that, sometime between 10 and 200 years after closure, the wastes will be exposed and the costs of reburial will be handed to a society that no longer has the oil from which the wastes were generated.

VII. CONCLUSIONS

The petroleum industry should now ensure treatment or secure incarceration of its wastes; otherwise it merits no exemption from RCRA. Saline drilling wastes can be leached, although this is not now a common practice. Hydrocarbons, including heavy hydrocarbons, can be heat-treated. Solid debris can be incarcerated below ground level. The industry is not without options, but if the proposed landfill (and many others like it) are permitted, the industry will have no motivation to develop or to utilize the options. Thus, our concern is not simply with this landfill. We do not suggest that Gandy Marley is an unworthy operator. Rather, we see this case as setting a precedent for the future disposal of saline wastes and heavy hydrocarbons in New Mexico, so we feel compelled to oppose the proposed design of the landfill. If the landfill is permitted, we suggest that the following conditions be imposed upon the permit. (Fig. 13).

1) There should be no burial of wastes at elevations higher than 2 feet below the level of the original ground surface.

2) The landfill cap should have at least one foot of clay beneath at least two feet of soil cover. An approved RCRA cap design would be preferable.

3) Only clean soil, with SAR < 3 and TRPHC < 50 should be used for the cover.

4) Successful revegetation, not just seeding, should be required at closure of each cell.

5) The permitee should be in compliance with all regulations and permit requirements, including sampling, for at least two years prior to issuance of a new or revised permit. (We are willing to discuss revision of sampling requirements to longer intervals.)

WATER, AIR, AND SOIL POLLUTION

REPRINT

AN INTERNATIONAL JOURNAL OF ENVIRONMENTAL POLLUTION

NaCl CONTAMINATION IN PINE TREES DETERMINED BY NEUTRON ACTIVATION TECHNIQUES

H. O. MENLOVE

Nuclear Analysis Research Group, University of California, Los Alamos Scientific Laboratory, Los Alamos, N.M. 87544, U.S.A.

(Received 6 December, 1972)

Abstract. The NaCl content in samples of pine needles was measured to establish the extent of contamination from rock salt which is used for deicing roadways. Neutron activation analysis techniques were used to determine the NaCl content in the samples, and the irradiation neutrons were obtained from a portable ^{252}Cf neutron source. The average Na content in samples from the diseased trees was 50 times greater than in the control samples.

Many communities throughout this country routinely use rock salt in the winter to melt snow and ice on roadways. After the ice is melted, the salt solution is spread beyond the roadway by splashing and drainage causing ecological damage to the surrounding areas. The effects of the salt on the soil, ground water, and some types of vegetation have been reported for other areas (Staley *et al.*, 1968; Hutchinson, 1970; Davidson, 1971; Fried and Ungemach, 1971).

In recent years it has been observed that pine trees in the vicinity of roadways and drainage ditches in the Los Alamos, New Mexico, area are turning brown and dying. To help determine if salt is responsible for this problem, needles from the diseased trees were sampled at 53 different areas throughout the city. The sample areas were selected by visually observing locations with a significant number of brown or dead pine trees. One or more tree was sampled each in area where the sample consisted of about 15 needles selected from several branches. Similar control samples were obtained from healthy pine trees in nearby areas.

The NaCl content in the samples was measured using neutron activation techniques where the neutron irradiations were obtained using a portable ^{252}Cf neutron source. Prior to irradiation and weighing, all of the samples were dried in an oven to reduce their moisture content. The needles were placed in 3 dram ($\sim$11 ml) polyethylene vials giving a net weight of $\sim$4 g per sample. For the thermal neutron irradiations, a 3.3 mg ^{252}Cf source was placed in a large polyethylene moderator, and 12 sample vials were uniformly positioned at a radius of 5 cm from the source. The thermal neutron flux was calculated (Forster and Menlove, 1971) to be 7.2×10^7 n cm^{-2} s^{-1} at this radius which corresponds to the radius with the maximum number of thermal ...ons. Normally, up to 12 samples were irradiated overnight for a period of ... by means of the ^{23}Na(n, γ) ^{24}Na reaction.

... gamma-ray activity in the samples was ... 5 cm diam through-

Fig. 1

TABLE I

NaCl Concentration in Pine Needles

Sample area	Number of trees	NaCl (ppm)	Sample area	Number of trees	NaCl (ppm)
1	40	16000	28	35	7380
2	10	7340	29	80	11000
3	32	4470	30	60	19700
4	25	12000	31	65	4570
5	36	9200	32	16	8640
6	48	4810	33	30	7000
7	50	4120	34	50	11600
8	30	5010	35	15	9170
9	66	10900	36	16	7700
10	35	10700	37	90	12000
11	130	8690	38	120	12300
12	55	10700	39	65	6020
13	42	10800	40	16	7870
14	22	17800	41	30	8490
15	8	2740	42	10	6240
16	10	8200	43	55	5360
17	10	8610	44	35	8240
18	100	14700	45	12	17000
19	50	12600	46	36	6050
20	60	10900	47	36	10100
21	62	9890	48	23	9350
22	20	8440	49	10	7330
23	30	6060	50	20	7420
24	27	11200	51	28	6430
25	65	11600	52	30	10230
26	20	7540	53	8	10500
27	68	3390			
			Controls		
C-1	1	180	C-6	1	230
C-2	1	270	C-7	1	170
C-3	1	160	C-8	1	211
C-4	1	90	C-9	1	209
C-5	1	180	C-10	1	156

Fig 2

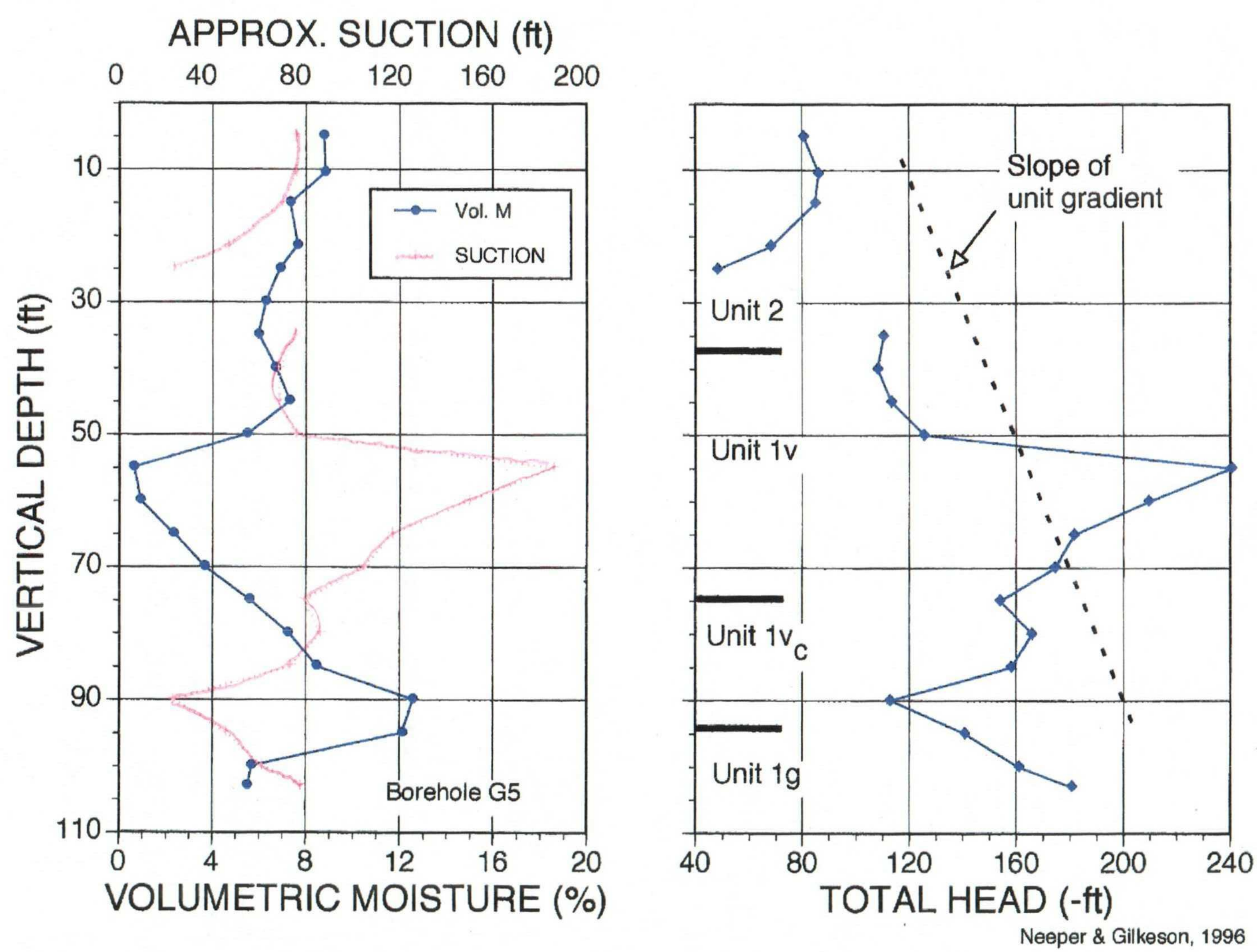


Fig. 3. Measured moisture, suction, and potential in a borehole.

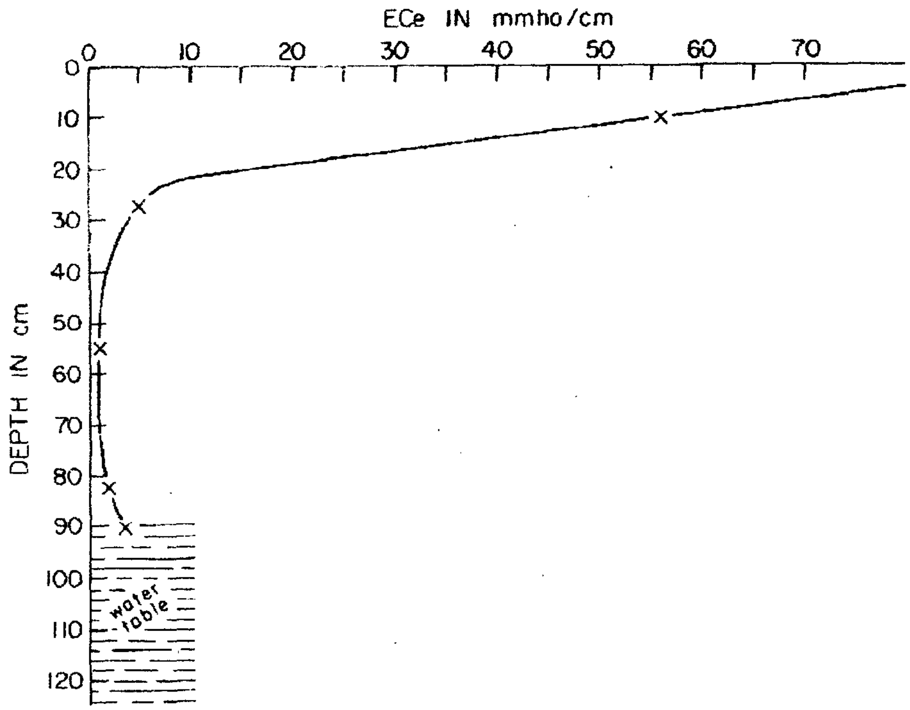
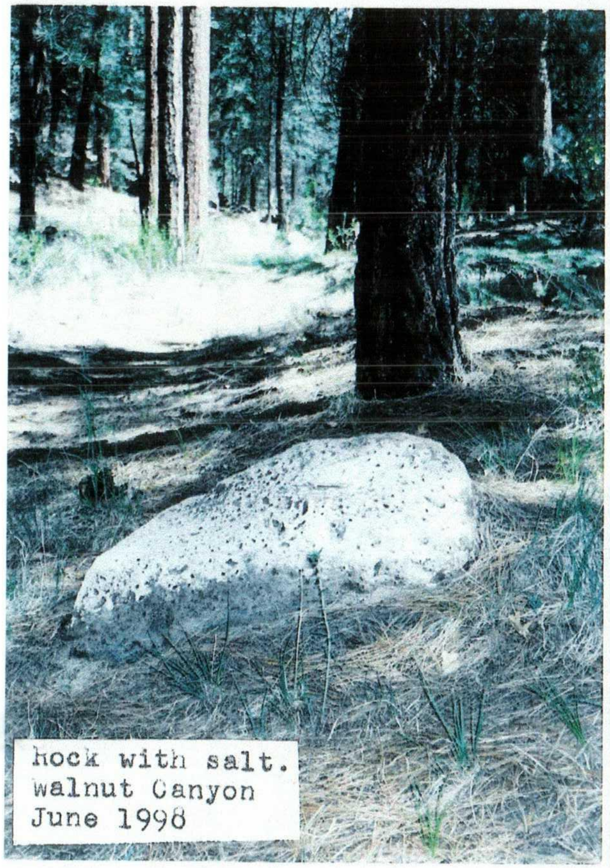
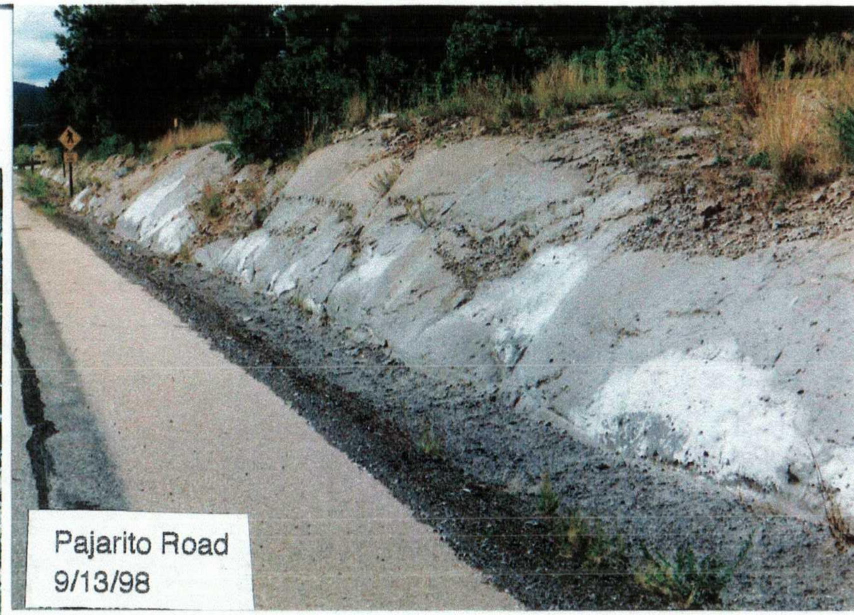


Figure 8.2 Typical salinity profile in soil exposed to a high water table. (Ayers and Westcot).

Fig. 4. Salinity profile near the ground surface.
From Bohn, McNeal, and O'Connor, Soil Chemistry;
New York: John Wiley & Sons, 1979.


Rock with salt.
Walnut Canyon
June 1998


Pajarito Road
9/13/98


Salt growing on rock
Pajarito Road 9/13/98

Fig. 5

Effects of Sodium Chloride on Soil & Plants

Salt affects the soil

- Destroys the soil structure by replacing calcium on clay particles. The soil becomes "sodic" (salt pan) at high salt content.
- Soil loses porosity and flocculence, losing its ability to hold or to transmit water.

Salt affects plants

- Reduces plant foods, especially calcium and potassium.
- Doesn't transmit moisture.
- Toxicity to sodium (varies by plant specie).
- Toxicity to chloride (varies by plant specie).
- Decreases osmotic potential, making it more difficult for the plant to draw moisture from the soil.
- ***Germinating plants are the most sensitive.***

Fig. 6

<u>Various Measures of Salinity of Soil or Water</u>

(including pore water leached from a saturated soil sample)

<u>Total dissolved solids</u> (TDS).
(chemicals other than sodium chloride may be dissolved)

<u>Chloride and sodium concentrations</u>.
(do not directly reveal soil damage or plant damage)

<u>Electrical conductivity</u> (EC).
(doesn't reveal soil damage but relates to plant damage)

<u>Sodium absorption ratio</u> (SAR)
(indicates response of soil and correlates with plant damage)

$$SAR = \frac{Na}{\sqrt{Ca + Mg}}$$

$$= \frac{sodium(ppm/23)}{\sqrt{calcium(ppm/40) + magnesium(ppm/24.3)}}$$

(ion concentrations in moles per mass or volume,
e.g. ppm/(atomic weight)

(SAR should be corrected to an effective value according to the concentration of calcium carbonate, which may increase the SAR.)

Fig. 7

SAR Ranges for Plant Damage

SAR	Problems
< 3	No sodium problem.
3-6	Few problems, except sodium sensitive plants.
6-8	Increasing problems. Flush soil with gypsum.
8-14	High sodium; not recommended for crops.
>14	Probably not growing much.

Fig. 8

Gandy Marley Quarterly Sampling

X indicates records on file

Quarter	Hydro-carbons	Metals	Ions
1Q05			
4Q04	X	X	X
3Q04			
2Q04			
1Q04			
4Q03			
3Q03			
2Q03			
1Q03			
4Q02	X	X	X
3Q02			
2Q02			
1Q02			
4Q01			
3Q01			
2Q01			
1Q01			
4Q00	X	X	
3Q00			
2Q00	X	X	
1Q00			
4Q99			
3Q99	X	Permit	Approved
2Q99	X	X	
1Q99			

Fig. 9

SAR Values from Gandy Marley Sampling

Date	Cell	Depth	Na (ppm)	SAR
12-10-04	7	3 ft	207	0.2
"	9	3 ft	218	0.4
01-15-02	7	surface	280	6.1
"	9	surface	309	6.0

Fig. 10

CLOSED DISPOSAL CELLS

with opportunities for erosion of cap, development of sink holes, accumulation of contaminated leachate, and migration through walls.

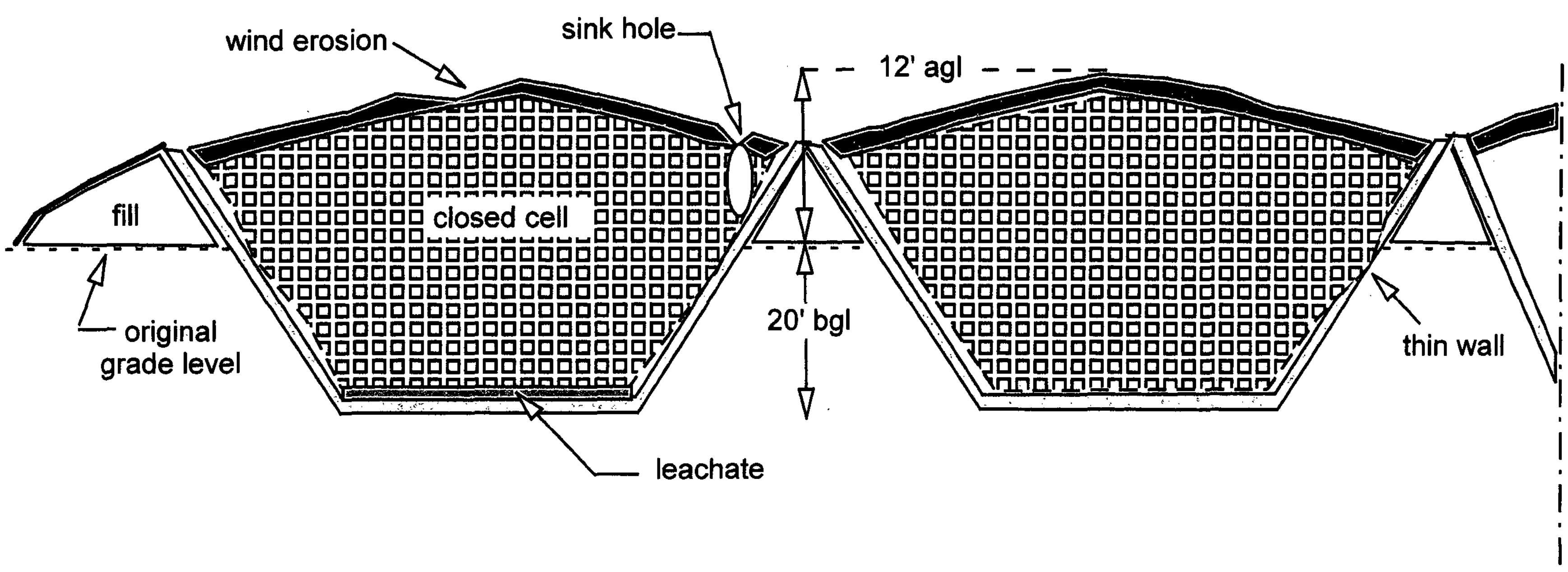


Fig. 11

CONCERNS

Biodegradation ceases upon burial. This site must be secure for centuries after closure.

Migration of salinity through the cap.

Use of remediated soils on the cap that may contain salt and/or heavy petroleum hydrocarbons.

Difficulty of revegetation, particularly if the cap soil is or becomes saline, or if it contains heavy hydrocarbons.

Wind erosion of a cap or conjoined caps that rise 12 ft above grade.

Settling, leading to sink holes and ponding in closed cells. This may occur long after official closure.

Exposure of the wastes, which may be no deeper than 2 ft below the cap surface, and as much as 10 ft above grade.

- - - -

Fig. 12

PROPOSED PERMIT CONDITIONS

1) There should be no burial of wastes at elevations higher than 2 ft below the level of the original ground surface.

2) The landfill cap should have at least one foot of clay beneath at least two feet of soil cover. An approved RCRA cap design would be preferable.

3) Only clean soil, with SAR < 3 and TRPHC < 50 should be used for the cover.

4) Successful revegetation, not just seeding, should be required at closure of each cell.

5) The permitee should be in compliance with all regulations and permit requirements, including sampling, for two years prior to issuance of a new or revised permit.

Fig. 13