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The Los Alamos Life Sciences Division's Biomedical and Environmental Research Programs

January—December 1980

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January—December 1980

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ABSTRACT

This report summarizes research and development activities of the Los Alamos Life Sciences Division's Biomedical and Environmental Research program for the calendar year 1980. The principal features of the program have been carried out by groups in the Life Sciences Division, supported by the United States Department of Energy. Previous annual reports in this series prepared under the auspices of the United States Atomic Energy Commission, the United States Energy Research and Development Administration, and the United States Department of Energy are LA-5227-PR (1972), LA-5633-PR (1973), LA-5883-PR (1974), LA-6313-PR (1975), LA-6898-PR (1976), LA-7254-PR (1977), LA-8023-PR (1978), and LA-8577-PR (1979).

Technical reports related to the current status of projects in the major program areas of each contributing group are presented in sufficient detail to permit the informed reader to assess their scope and significance and to obtain some specific information. Further details can be obtained from the publications listed in Appendix A. Summaries useful to the casual reader desiring general information have been prepared by the Group Leaders and appear at the beginning of each section of the report. Investigators on the staff of the Life Sciences Division will be pleased to provide further information.

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INTRODUCTION

The Environmental Science Group is a multidisciplinary organization that conducts research [illegible] the identification and resolution of [illegible] issues associated with emerging energy technologies, nuclear waste management, and the Los Alamos National Environmental Research Park (LA/NERP). A primary focus of the group's activities is upon the requirements for information about air, water, and land disturbances resulting from energy developments. Such information applies directly to environmental impact and alternatives assessment, development of control technologies, facilities siting, and other decision areas in the development of new energy sources.

Current research activities include pollutant source characterization, identification of mobile contaminants, transport of pollutants in the environment, assessment of the effects of environmental pollutants, and the identification or development of methods to control environmental contaminants. Specific research programs in support of developing energy technologies include environmental assessment of geothermal systems, conditioning and stabilization of uranium mill tailings, deer population dynamics near prototype oil shale development areas, disposal and control of coal fly ash/scrubber sludges, and transport of contaminants by air- and water-borne sediments. In the area of nuclear waste management, projects include field experiments on erosion control, biobarriers, water management and advanced engineering concepts, unsaturated transport modeling, alternatives to shallow-land burial, the attenuation of radionuclides in liquid wastes by soil, and the assessment of the environmental control technologies in the US Department of Energy (DOE) nuclear waste management program. LA/NERP projects include a survey of endangered plant species, raindrop transport of contaminated soil, animal population dynamics, elk nutrition/vegetation dynamics, Ponderosa pine regeneration, and the assessment of nitrogen stress in the environment.

The Environmental Science Group consists of about 45 scientists, consultants, graduate students, and technicians. Contracts are also negotiated with regional universities for supporting research. At this time, contracts are in effect with the University of New Mexico, University of Arizona,

New Mexico State University, and Colorado State University.

A broad base of scientific disciplines is represented within the Group, including biology, botany, chemistry, ecology, archaeology, hydrology, meteorology, soil sciences, geology, and statistics.

Research support in the Environmental Science Group comes from several parts of DOE, Nuclear Regulatory Commission (NRC), and US Environmental Protection Agency (EPA). The purpose of this report is to summarize the work done for the Assistant Secretary for the Environment (ASEV).

The Mechanisms of Hydrologic Transport of Soil Contaminants in Mortandad Canyon

[T. E. Hakonson and G. C. White]

The sorting and differential transport of soil particles by rain and run-off are important mechanisms of soil erosion that influence contaminant distribution and inventory. For example, small-sized particles, generally containing much higher contaminant concentrations, are likely transported at a faster rate over longer distances than coarse-sized particles.

The initial focus of this research will be on the selective sorting and transport of soil particles as they relate to altering the distribution of contaminants in soils and sediments. Several field experiments employing radionuclide-labeled soil particle size fractions are planned to accomplish research objectives.

During the experiments in 1979, tracer-labeled soil particles were made by batch reacting different radionuclides (^{182}Ta, ^{141}Ce, ^{124}Sb, ^{46}Sc) with four soil particle size fractions. In 1980, the tracers used to label the soil particles were ^{182}Ta, ^{160}Tb, ^{181}Hf, and ^{46}Sc. The size fractions, which consisted of silt-clay (<53μm), fine sand (53-106μm), medium sand (106-495μm), and coarse sand (>495μm), were produced by mechanical sieving of several hundred kilograms of study area sediment.

Specific objectives for the initial experiments on sediment transport in Mortandad Canyon were:

- to determine the effect of particle sorting on the transport of different-sized sediment particles,
- to determine relationships between particle transport and run-off variables,
- to determine long-term effects of particle sorting on sediment distribution, and
- to develop relationships that can be used for prediction where possible, for use in surveillance, control, and mitigation of soil contaminants subject to hydrologic soil erosion processes.

The sediment transport studies conducted during the summers of 1979 and 1980 each used about 500 kg of tracer-labeled sediment particles. Labeled sediment was added to a 5 m reach of the Mortandad Canyon stream channel before the late summer rainstorm season about 20 m and 800 m upstream from two high resolution recording water gauging stations.

Careful measurements were made on a variety of watershed characteristics (e.g., slope, area, channel width), run-off volumes through time, suspended sediment loads and tracer concentrations in run-off, and tracer concentrations in channel sediments as a function of distance downstream. Tracer concentrations in samples were measured with an automated GeLi gamma ray counting system.

During 1979, three runoff events occurred in Mortandad Canyon after placement of the labeled soil in the stream channel. Two of the events (storms 1 and 2) were small and resulted in peak flows at the labeling location of 0.01 and 0.008 m^3/s. The third event (storm 3) was substantially larger, although still a relatively small flow, and resulted in a peak flow of 0.24 m^3/s. Flows in excess of 2.9 m^3/s have been recorded in Mortandad Canyon.

Our data on runoff and particle transport distance as a function of a cumulative number of runoff events (Fig. 1) clearly demonstrate that particle sorting by runoff occurs and that smaller particles are transported further downstream than larger particles during a given runoff event. For example, labeled silt-clay (<53μm) particles were transported at least ten times further downstream (Fig. 1) than were the medium to coarse sands (106-495μm and >495μm) during a given runoff event. The highly mobile nature of the silt-clay particles is further indicated by their presence in the stream channel

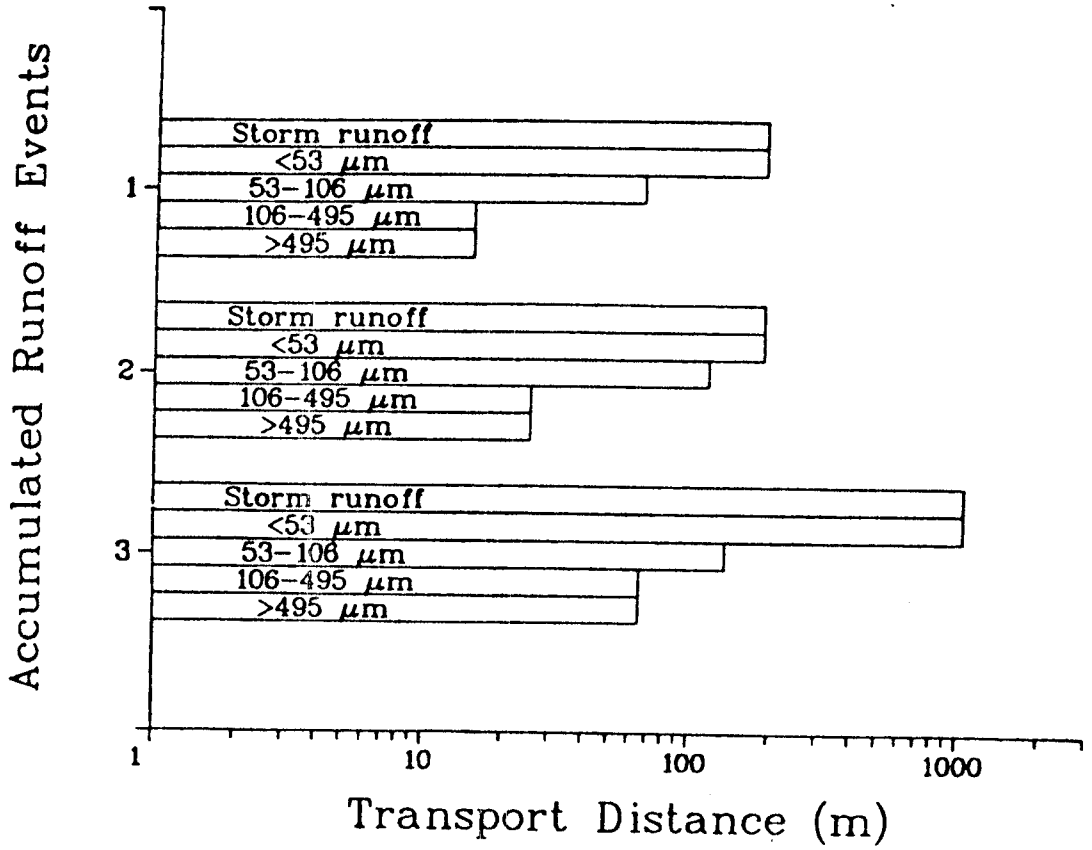


Fig. 1.

Runoff and sediment particle transport distance after three rainstorm runoff events in Mortandad Canyon during 1979.

at locations where surface water runoff from a given event ceased.

Depletion of the labeled soil from the label location was most rapid for silt-clay particles (Table I) consistent with the high mobility of this size fraction. Following the first runoff event, maximum concentrations of ^{182}Ta (<53μ m particles) in the label location were only 13% of the initial concentrations of ^{141}Ce, ^{124}Sb, and ^{46}Sc and could still be detected at the label location after the first run-off event. However, after three [illegible] events, <3% of the initial concentrations of [illegible] racers were detected at the label loca- [illegible] data imply that a point source of contamination in the intermittent stream channel in Mortandad Canyon is rapidly diluted and/or transported downstream. The rate of depletion, initially, is more rapid for the highly mobile silt-clay size fraction; however, this depletion is nearly complete for all size fractions after as few as three relatively small run-off events.

TABLE I

PER CENT OF THE INITIAL CONCENTRATION OF TRACERS IN SEDIMENT AT THE LABEL LOCATION FOLLOWING THREE RUNOFF EVENTS IN MORTANDAD CANYON IN 1979

	Runoff Event Number		
	1	2	3
^{182}Ta (<53μm)	13	13	2.4
^{141}Ce (53-106μm)	88	16	0.56
^{124}Sb (106-495μm)	100	17	0.53
^{46}Sc (>495μm)	65	28	1.2

The relationship between particle transport distance and peak runoff discharge is given for the four sediment size classes in Fig. 2. Although it is tempting to conclude that a positive relationship exists between the distance a particle moves and peak discharge, the lack of data at intermediate runoff discharges (i.e. 0.06 to 0.20 m^3/s) precludes that interpretation. Obviously, more data are needed in the intermediate runoff discharge range.

Dr. Leonard Lane, from the US Department of Agriculture (USDA) Southwest Watershed Research Center, has been retained on an inter-governmental personnel agreement to use the runoff and sediment transport data collected in Mortandad Canyon in a simple hydrologic model to estimate runoff volumes and peak rates of runoff. Additionally, the channel morphology data (slope, area, channel width) from Mortandad Canyon along with flow will be used to estimate discharge per unit width at any point in the channel. Channel morphological data, when coupled with existing total sediment bed equations, provide a means of estimating sediment transport for particles of any given size.

In summary, particle sorting by rainstorm runoff does occur and is characterized by large downstream movement of silt-clay particles with relatively smaller movement of coarser particle sizes. Furthermore, the maximum transport distance of silt-clay particles coincides with the maximum distance downstream that surface water runoff occurs. Transport of labeled soil particles from a point source is most rapid for silt-clay particles; however, after as few as three relatively small runoff events, <3% of any of

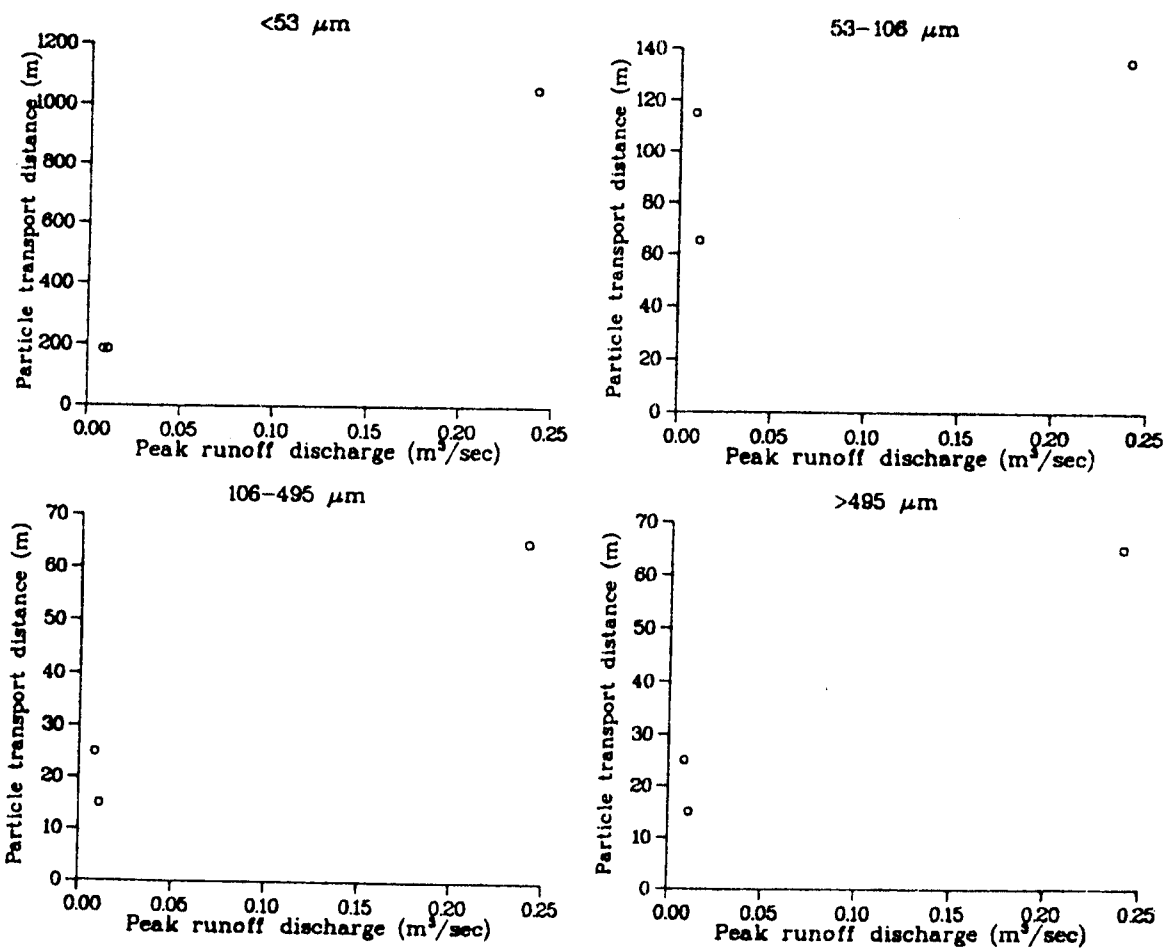


Fig. 2.

Relationship of particle transport distance to peak discharge for three runoff events in Mortandad Canyon during 1979.

the labeled particles remained at the label location. Thus, contaminants, particularly those associated with silt-clay size fractions, that are released to an intermittent stream channel would be rapidly transported downstream during rainstorm runoff events.

The Accumulation of Soil Particles on Vegetation Surfaces Resulting from Rain Splash

[T. E. Hakonson, M. Dreicer, and G. C. White]

Wind and water resuspension of soil are processes that result in surface contamination of vegetation in the environment. Observations based on our field studies of plutonium at Los Alamos and Trinity Site suggest that raindrop splash of soil is a major source of contamination on vegetation surfaces. Very little is known about the mechanisms and importance of this transport process despite the usefulness of this information in environmental surveillance, waste control, and hazard assessment activities.

The purpose of this study is to increase our understanding of the mechanisms by which surface soil particles are transferred to and retained by foliage surfaces. Specific objectives of the study are to measure the accumulation and retention of soil particles by vegetation as a function of

- soil particle size
- rainfall intensity
- height of foliage above the ground
- surface area and canopy cover of plant
- upper versus lower leaf surface
- type of particle collection surface

The study is being conducted by Colorado State University and Los Alamos National Laboratory, and it employs the radionuclide-labeled soil particle technique described for the sediment transport study. In addition, a scanning electron microscope was used to verify the labeled particle technique. Samples of leaf surfaces were visually inspected in a defined viewing field to quantify the size and number of particles present as a function of previously discussed experimental variables.

Surficial accumulation and retention are dynamic, simultaneously occurring processes, which require separate measurement for proper data interpretation. Therefore, two separate experiments were conducted, one involving accumulation of particles by foliage following ground surface application and one involving retention of particles applied directly to the foliage. These experiments were conducted simultaneously in separate but otherwise similar study plots.

An experimental plot was partitioned into four subplots to quantify the resuspension and retention of tracer-labeled soil particles exposed to rain and no-rain treatments. A roof over one-half of the plot created the no-rain, or control, treatment.

Barriers were erected around the plot to preclude wind as an experimental variable; three anemometers were located within the plot to verify the effectiveness of the wind barriers. Natural precipitation events were measured with recording tipping bucket rain gauges.

The labeled soil particles, characterized by size, density, and tracer content, were applied to the soil surface (accumulation treatment) or directly to the foliage surface (retention treatment). The ground surface in the retention plot was covered with burlap to prevent resuspension of particles that had washed off the plants.

Tomato plants, along with an artificial particle collector, were used as the particle collection surfaces. The artificial collectors consisted of glass slides covered with felt on both upper and lower surfaces. The slides were fastened to a 2.5-cm-diam dowel rod at heights ranging from 15 to 80 cm above the ground surface.

Foliage and glass slides were collected after each of four rainstorm events. A total of about 4000 samples was collected during the experiment. Analyses for the respective tracers were performed on GeLi gamma-ray counting systems.

The following discussion emphasizes the particle accumulation portion of the splashup study. The accumulation data will serve as the partial requirement of an M.S. degree for a Colorado State University graduate student. Specific objectives of this portion of the experiment were to characterize soil accumulation on tomato plant surfaces as a function of soil particle size, rainfall intensity, height of foliage above the ground and plant surface area, and canopy cover.

In order to measure the buildup, through time, of particles on plants, tomato plants were sampled after every rainstorm, as well as after exposure to several storms.

Four rainstorms occurred in the study plot following the placement of the tracer labeled soil. The results of the Analysis of Variance (ANOVA) tests for tomato plants exposed to individual storms indicated that no particles greater than 105μm were deposited on plant surfaces when compared to controls and that the differences in amounts of these larger particles with height of foliage above the ground and storm number were not significant ($p<0.05$).

Background concentrations of the two larger (>105μm) size fractions on plants averaged about 1 to 2 mg soil/g wet plant.

Conversely, concentrations of <53μm and 53-105μm soil particles on plants exposed to single storms as a function of treatment (rain vs no-rain), height of foliage above the ground, and storm number were all significantly different ($p<0.05$). Concentrations of both size fractions on plants exposed to rain averaged about 1 mg soil/g wet plant compared to about 0.2 mg soil/g wet plant for the control treatment.

Greater concentrations of soil were found on plants sampled from the 0 to 40 cm (above the ground surface) height strata than from the >40 cm strata. For silt-clay particles (<53μm), the lower strata contained about twice the soil mass per gram of plant than did the upper (>40 cm) strata. This finding is consistent with soil flux-height relationships that have been observed during wind resuspension studies.

The amounts of the two smaller soil size fractions on plants also differed significantly between storms; the average intensities of the four storms differed by nearly a factor of 10.

The differences in the amount of soil accumulated by plants as a function of plant surface area and canopy cover were not significant ($p<0.05$) for any of the particle size fractions. The uniformity of the size of the tomato plants used in this study probably contributed to this latter finding.

Attempts to relate the amount of <53μm particles on plants to rainstorm parameters (i.e. maximum intensity, average intensity, duration, etc.) were unsuccessful. However, the mean concentration of <53μm soil particles (mg soil/g wet plant) on tomato plants was highly correlated to time ($y = 0.038 + 0.0045x$, $n=4$; $r^2 = 0.94$) where y is the amount of soil and x is time from the beginning of the experiment. The significance of this observation is not immediately apparent and requires further evaluation. On the other hand, the relationships between the amount of 53 to 105μm soil particle on plants and rainfall parameters was highly significant. For example, the linear regression of mass of 53 to 105μm particles versus maximum (peak) rainfall intensity (mm/min) resulted in the equation: $y = 0.7 + 1.9x$ ($n=4$; $r^2=0.93$), where y is the amount of soil in mg/g wet plant and x is the rainfall intensity in mm/min. Thus, increasing rainfall intensity resulted in increased amounts of 53 to 105μm particles on plant surfaces.

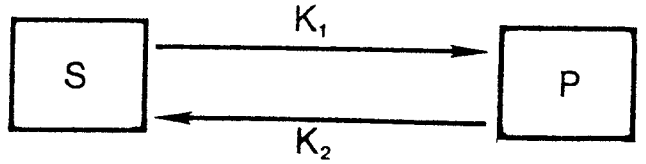
Data from plants exposed to one to four rainstorms were more revealing than the data from individual storms because of greater soil loading on the plants, which facilitated detection of the tracers. Results of the ANOVA test reveal the two smaller size fractions contributed essentially all of the soil that was deposited on tomato plants after exposure to multiple rainstorms. Concentration of the smaller size fractions on plants exposed to one to four storms was significantly ($p<0.03$) greater than controls. Coarse particles (>105μm) were either not resuspended by rainfall or, if resuspended, were not retained by the plant surfaces.

Differences in the amount of soil accumulated by plants as a function of height of foliage above the ground surface were significant ($p<0.05$) for both the <53μm and 53 to 105μm particles. In both cases, samples from the lower height strata contained as much as 10 times more soil than the upper height strata. Differences in soil accumulation between storm sequences were only significant ($p<0.05$) for silt-clay particles. In no case were significant differences found in the amount of soil detected on plants as a function of plant canopy cover and surface area.

The relationships of silt-clay particle accumulation on plants to rainstorm parameters and time were significant in most cases. For example,

the amount of silt-clay particles accumulated on tomato plants as a function of total rainfall, accumulative mean rainfall intensity, accumulative mean rainfall during the first 30 min of the storm, and time increased with increasing values of the latter parameters (Fig. 1). From this preliminary analysis of the data, it would appear that relationships using some expression of rainfall intensity have the greatest potential for predicting silt-clay soil mass on vegetation.

Curve (c) in Fig. 1 provides a basis for calculating a soil accumulation rate constant for silt-clay particles under the assumption that at the end of the fourth storm the amount of soil on the plants was approaching equilibrium. The linear model that serves as the basis for this calculation is:



where:

S = amount of soil available for resuspension, calculated as 1250 g/m^2 based on 1 mm layer over 1 m^2 with a bulk density of 1.25 g/cc

P = grams of soil/m^2 plant surface area, calculated as 0.96 g/m^2, estimating 0.0025 g soil/g wet plant at equilibrium (Fig. 1c) and 385 g/m^2 biomass

k_1 = accumulation rate constant calculated as P (equilibrium) x k_2/S

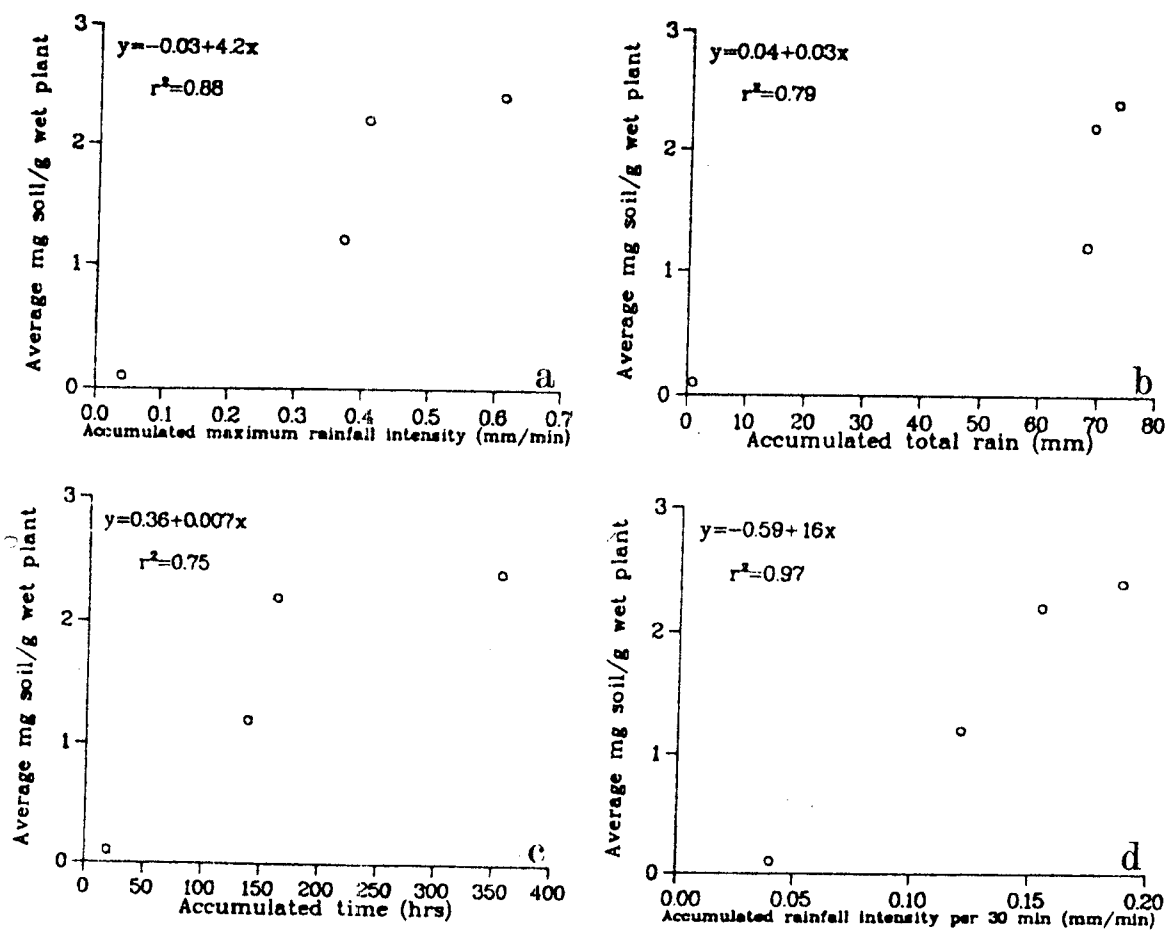


Fig. 1.

Relationship of the amount of soil accumulated by tomato plants as a function of rainstorm parameters and time.

k_2 = loss rate constant from plant surface, calculated as 0.1197/day using 5.8 d half-time (from Fig. 1).

The calculated value for k_1 was 9×10^{-5}/day. This value represents the first empirical estimate of a soil accumulation rate constant for plants under field conditions. A similar calculation for the 53 to 105μm size fraction yielded a k_1 value of 2.3×10^{-4}/day. These estimates of the accumulation rate constant have been incorporated into the DOE-funded pathway analysis for the study "Human Radiation Exposures Near the Nevada Test Site."

The results of the study using the scanning electron microscope to characterize size and number of particles accumulated and retained by tomato leaves essentially confirm the results obtained by the labeled particle technique. For example, silt-clay represented nearly 100% of the particles observed on leaf surfaces, and the lower height strata accumulated more soil than did the upper strata.

The number of particles present per unit area of leaf surface steadily increased with time (Fig. 2) in plants exposed to multiple rainstorms, whereas plant surfaces initially contaminated with soil (retention plot) lost soil through time (Fig. 2). The loss of particles from plant surfaces was likely caused by wash-off from impactin The retention and accumulation curves in appear to reach an equilibrium at about the same level, suggesting that the leaf surface had reached its soil loading capacity (i.e. loss = input). Retention (weathering) half-times roughly calculated from the data (Fig. 2) were about 7 days, based on the retention curve and 13 days based on the accumulation curve. This compares with 5.9 day half-time calculated from the data obtained by the tracer methods.

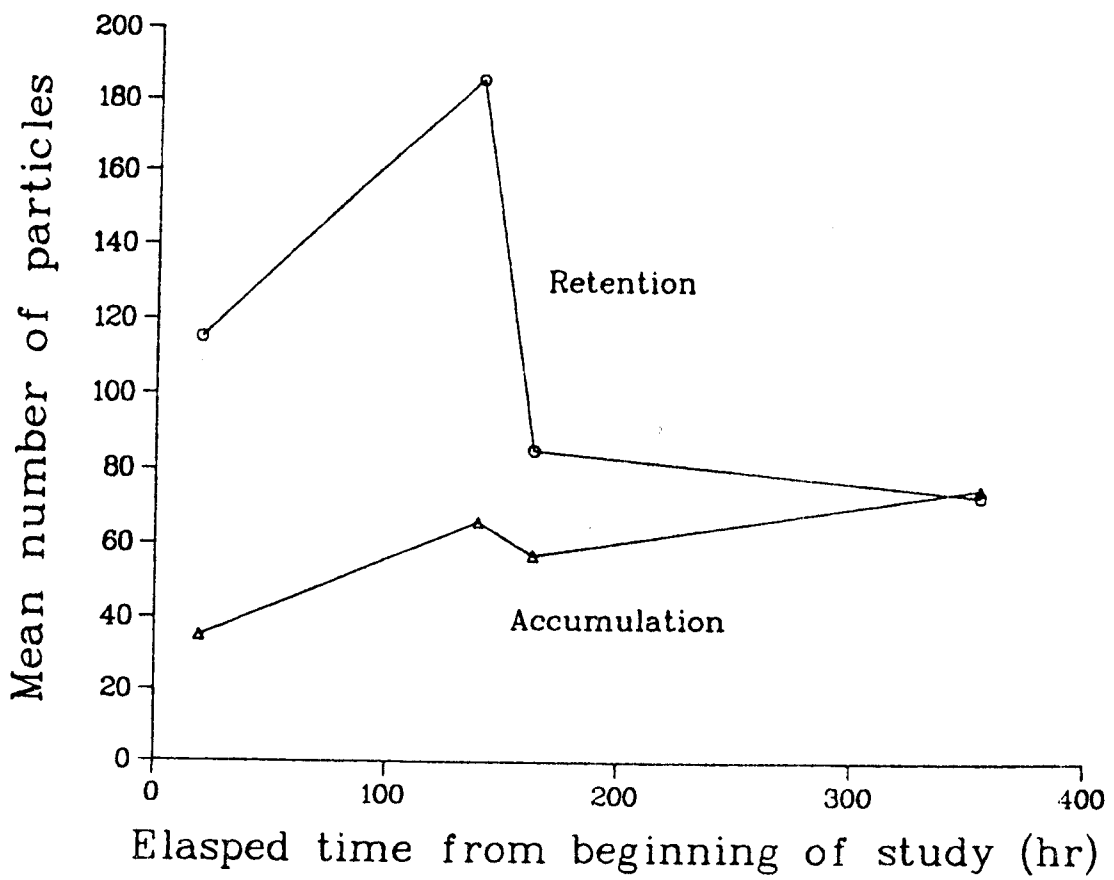


Fig. 2.

Mean number of particles accumulated and retained by tomato leaves as a function of time from the beginning of the experiment.

The particle splash-up study confirms that small, highly mobile particles are the major compo- [illegible] retained by plant surfaces. Calcula- [illegible] show that relatively small amounts of silt-clay particles, which contain as much as 10 times higher contaminant concentrations, could account for the relatively high radionuclide plant/soil concentration ratios observed in field studies.

Adsorption of Soluble Contaminants from Uranium Mill Tailings by Marine Shales

[M. L. Marple, E. T. Louderbough,* L. D. Potter,* D. R. Dreesen, and E. J. Cokal]

Leaching of contaminants from uranium mill tailings piles is an environmental concern because of potential contamination of groundwater. The adsorption of these contaminants by strata underlying the tailings piles could reduce the impacts of leaching. Many tailings piles, both inactive and active, are located in the Colorado Plateau region, which has extensive formations of Cretaceous marine shales. The Mancos shale and the equivalent Tropic shale have high levels of sodium-saturated montmorillonite clay and sodium, which increases surface sealing upon wetting. Thus, the shales could be valuable as sealants underlying tailings ponds. The purpose of this study was to evaluate the adsorptive capacities of four shales for a variety of major and trace element constituents in aqueous tailings leachates and to evaluate the potential usefulness of such shales in reducing the leaching transport of environmental pollutants.

Four shales from the Colorado Plateau, which exhibit a wide range of chemical and physical characteristics, were chosen for this study. Mancos shale samples from three sites were selected. The shales from Austin and Loma in western Colorado are dark and platy. The Austin shale has a very acidic pH of 3.5 and a 60:40 ratio of illite to montmorillonite. The Loma shale has a pH of 8.0 and a 75:25 ratio of illite to montmorillonite. The shale found near Thompson in eastern Utah has a highly alkaline pH of 9.9. It has an illite to montmorillonite ratio of 60:40. The Tropic shale was collected from an area near Kanab, Utah, and has a 10:90 ratio of illite to montmorillonite and a pH of 8.0. Soils derived from the Tropic shale are saline-sodic.

Two soils from the Grants Mineral Belt of New Mexico were used for comparison with the shales in the adsorption trials. The soil from Ambrosia Lake is a clay loam with a pH of 7.9. The Bluewater soil is a clay with a pH of 8.3.

A leaching column of each of the six substrates (shales and soils) was prepared for each of the two kinds of input tailings leachate. Fine shale material (<0.074 mm) and medium soil material (0.074 to 2 mm) were used. Each column was made of a 14-cm length of PVC pipe with a 10-cm diameter, and filled with 320 g of material (shale or soil).

Tailings from two inactive uranium mill sites were processed to produce two input leachates. The carbonate tailings from the Ambrosia Lake site in New Mexico were chosen because of their high total and leachable molybdenum and selenium contents. The acid tailings were from Mexican Hat, Utah. These tailings were slurried with distilled water, shaken daily for 25 days, and vacuum filtered.

All columns were saturated by infiltration of the leachates and were maintained at saturation. Approximately one pore volume (125 mℓ) of output leachate was collected daily from each column, as well as 125 mℓ of the input solution. The carbonate leachate study lasted 26 days, except for the Tropic shale column, which was terminated after 22 days. The acid leachate study lasted 24 days.

Both input and output leachates were analyzed daily for pH. The tailings leachates and subsequent column leachates obtained on days 1, 5, 10, 15, 20, and 25 (24 for acid tailings) were analyzed for major elements and ions at the University of New Mexico and for trace elements at the Los Alamos National Laboratory. Analyses of calcium and magnesium (using additions of lanthanum) and of sodium were performed by atomic absorption spectrophotometry. A Technicon autoanalyzer was used for analysis of sulfate and chloride. For the carbonate samples, molybdenum and selenium were analyzed using flame atomic

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absorption analysis (hydride generation). For the acid samples, cobalt, copper, iron, manganese, and nickel were determined using flame atomic absorption analyses.

Analytical results of major and trace constituents showed little variation over time. Thus, means of the six analyses over time were computed for each column and for each constituent. Mean concentrations in the input tailings leachates were tested for equality with those in the effluent leachates collected from the shale and soil columns using an approximate t-test in which the variances of the means are assumed to be unequal.[1] The equality of the mean concentrations of leachates from different shale or soil columns was also tested using the approximate t-test.

Concentrations of both calcium and sulfate in carbonate effluents were significantly greater ($p<0.1$) in shale leachates than in soil leachates. Leachates from shale columns differed significantly from one another and from soil columns. Leachates from the Tropic shale had significantly greater sodium ($p<0.001$) for both acid and carbonate leachates and significantly greater chloride ($p<0.1$) for the carbonate leachate. The pH values were significantly lower ($p<0.1$) for both acid and carbonate leachates from the Austin columns compared with all other columns.

Concentrations of trace elements and the per cent change in carbonate leachates from shale and soil columns compared to the input tailings solution are shown in Table I. The pH of the leachate was significantly lower ($p<0.001$) than the input solution only for the Austin shale column because of the acidity of the shale. Molybdenum showed the same result, a significant ($p<0.02$) change (44% reduction) only in the Austin leachate, which can be attributed to the low solubility of the element under acidic conditions.[2] Selenium content of all the shale and soil leachates was significantly ($p<0.02$) lower than that of the input solution. But the reduction in selenium content (because of adsorption) was significantly ($p<0.05$) less for the Thompson shale than for other materials.

Concentrations of trace elements and their per cent change in acid leachates are shown in Table II. Both soils showed significant ($p<0.01$) attenuation of all five elements. Three shales--Loma, Thompson, and Tropic--showed significant ($p<0.05$) attenuation for all elements, but the reductions were significantly ($p<0.01$) less than those of the soils for all elements except iron. The Austin shale differed ($p<0.01$) from the other three shales for all elements except cobalt. It showed less attenuation or even an enrichment (of

TABLE I

VALUES OF pH AND CONCENTRATIONS OF Mo AND Se (ppm) IN INPUT AND OUTPUT CARBONATE LEACHATES

		pH	Molybdenum ppm	Molybdenum %[a]	Selenium ppm	Selenium %
Input Solution		7.0 ± 0.5	0.52 ± 0.04	100	0.19 ± 0.06	100
Soil Leachate:	Ambrosia Lake	7.7 ± 0.2	0.49 ± 0.14	94	0.03 ± 0.03	14
	Bluewater	7.6 ± 0.6	0.46 ± 0.12	88	0.06 ± 0.04	32
Shale Leachate:	Austin	5.1 ± 0.8	0.29 ± 0.14	56	0.06 ± 0.05	30
	Loma	7.5 ± 0.3	0.44 ± 0.12	85	0.04 ± 0.03	21
	Thompson	7.3 ± 0.4	0.52 ± 0.05	100	0.09 ± 0.03	47
	Tropic	7.3 ± 0.6	0.52 ± 0.09	100	0.05 ± 0.01	23

[a] % = (concentration in effluent leachate/concentration in input solution) X 100.

TABLE II

VALUES OF pH AND CONCENTRATIONS OF Co, Cu, Fe, Mn, AND Ni (ppm) IN INPUT AND OUTPUT ACID LEACHATES

		Cobalt		Copper		Iron		Manganese		Nickel	
	pH	ppm	%[a]	ppm	%	ppm	%	ppm	%	ppm	%
Input Solution	4.5 ± 0.2	2.1 ± 0.02	100	7.9 ± 0.2	100	0.08 ± 0.03	100	12 ± 0.2	100	1.1 ± 0.3	100
Soil Leachate: Ambrosia Lake	7.4 ± 0.4	0.02 ± 0.01	1	0.04 ± 0.02	1	<0.01 ± 0.01	13	0.8 ± 1.0	7	0.05 ± 0.03	5
Bluewater	7.4 ± 0.2	0.1 ± 0.1	4	0.1 ± 0.1	1	<0.01 ± 0.0	13	1.3 ± 1.2	11	0.06 ± 0.08	5
Austin	4.3 ± 0.1	1.9 ± 0.5	90	3.8 ± 0.8	48	0.20 ± 0.08	250	11 ± 0.3	92	1.2 ± 0.02	106
Loma	6.7 ± 0.3	1.5 ± 0.1	70	1.6 ± 0.8	20	0.02 ± 0.01	25	9.0 ± 1.0	77	0.8 ± 0.1	72
Thompson	6.0 ± 1.3	1.1 ± 0.3	50	1.2 ± 0.7	15	0.03 ± 0.03	38	7.6 ± 1.0	65	0.6 ± 0.2	53
Tropic	6.8 ± 0.5	1.3 ± 0.3	63	1.8 ± 0.9	23	0.01 ± 0.01	13	8.1 ± 0.9	70	0.7 ± 0.1	63

[a] % = (concentration in effluent leachate/concentration in input solution) X 100.

iron and nickel) in leachates because of the acidic pH, which favors the solubility of these elements in soils.[2]

In conclusion, shales showed varying capacities to adsorb trace element contaminants from tailings solutions. The acidic shale from Austin showed large adsorption of two contaminants common in carbonate tailings solutions, but little adsorption, if any, of contaminants from acid tailings. Two other types of Mancos shale from Loma, Thompson, and Tropic shale showed moderate adsorption of contaminants from acid tailings, but fine-textured local soils had greater adsorptive capacities than the shales. These results indicate that the adsorptive capacities of shales as substrates beneath a tailings pond depend on the chemical characteristics of both the shales and the uranium mill tailings. Although such shales could be useful in reducing seepage from tailings ponds, individual assessments for apecific tailings and specific shales must be made to characterize accurately the adsorption of aqueous tailings contaminants by shales from the Colorado Plateau.

Acknowledgments

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Plant Uptake Assay of Uranium Mill Tailings

[D. R. Dreesen, M. L. Marple, and E. J. Cokal]

Previous studies at the Los Alamos National Laboratory have shown that native plant species can absorb and translocate appreciable quantities of trace elements and radionuclides from uranium mill tailings.[1-4] The levels of Mo and Se found in stems and leaves of plants grown in tailings under greenhouse conditions are much greater than the levels considered to be toxic to grazing animals.[3] High concentrations of U and ^{226}Ra have also been found in some native plants growing in tailings under field and greenhouse conditions.[3,4] The assimilation and translocation of these hazardous constituents could provide a pathway for the transport of contaminants into the environment if plant roots penetrate covers used to stabilize inactive uranium mill tailings piles. Results of previous experiments indicate that this absorption and translocation depend on the species and on the chemical characteristics of the tailings material. Thus, a technique was needed to rapidly assay the contaminant uptake potential of a wide variety of native and agronomic plants grown in a variety of tailings.

Important criteria for a successful assay technique of plant uptake are (1) the ability to perform the assays rapidly (i.e. sufficient biomass production in a time span of 2 to 3 months), (2) the need to minimize the influence of the growth media mixture on uptake, and (3) the desire to provide conditions that promote the germination and growth of native plant species of the arid western United States. The developed method was a synthesis of nutrient absorption techniques used by Stanford and DeMent[5] and a potting mixture for Western shrubs and forbs used by Ferguson and Monsen.[6] The Stanford and DeMent technique grows plants in a sand culture periodically watered with nutrient solution. When a sufficient root mass has developed, the bottom of the container is removed and the roots are placed in contact with soil containing the various nutrient treatments. We have revised this technique by substituting a potting mixture containing slow release fertilizers and calcareous (alkaline) amendments for the sand culture. Rapid plant growth is achieved with periodic irrigation using only deionized water. When an appreciable root mass has developed (Stage I of Fig. 1), the container bottom is removed and the root mass is nested into another container having a layer of tailings or a control substrate of soil or potting mixture (Stage II of Fig. 1). The roots grow into the tailings for a period of at least one month, and then the aboveground plant material is harvested.

A preliminary proof-of-concept experiment was performed with the same grass (*Sporobolus airoides*) and shrub (*Atriplex canescens*) species used in our previous uptake experiments.[3] The assayed material was fine tailings (slimes) from an inactive alkaline leach mill at Ambrosia Lake, New Mexico. These tailings have been extensively investigated in earlier uptake and mobility studies.[1-4] Several diluents of the tailings were investigated to determine whether they would promote root penetration and growth in the tailings layer. These diluents included the peat moss/vermiculite potting mix and fine vermiculite. Two potting mixtures were evaluated: the peat moss/vermiculite mix of Ferguson and Monsen[6] and the same mix minus peat moss with fine vermiculite replacing the coarse vermiculite. The water soluble organics leached from the peat moss could affect the uptake of contaminants; therefore, peat moss was eliminated from one of the potting mixtures.

One month following germination, the plant roots were placed on the tailings treatments or the control substrates. After growing for another month, the aboveground plant material was harvested, air dried, acid digested, and analyzed for Mo by flame atomic absorption spectrophotometry. Molybdenum was chosen as the indicator element because of its bioavailability in the tailings material, as shown in earlier studies.[3]

The Mo content of the aboveground plant material is reported in Table I for the two species, the two potting mixes (controls), and the three tailings treatments. Concentration ratios have been included comparing the Mo concentration of the plants grown in tailings versus the plants grown in the controls. In addition, Mo concentrations and concentration ratios from an earlier experiment[3] are presented.

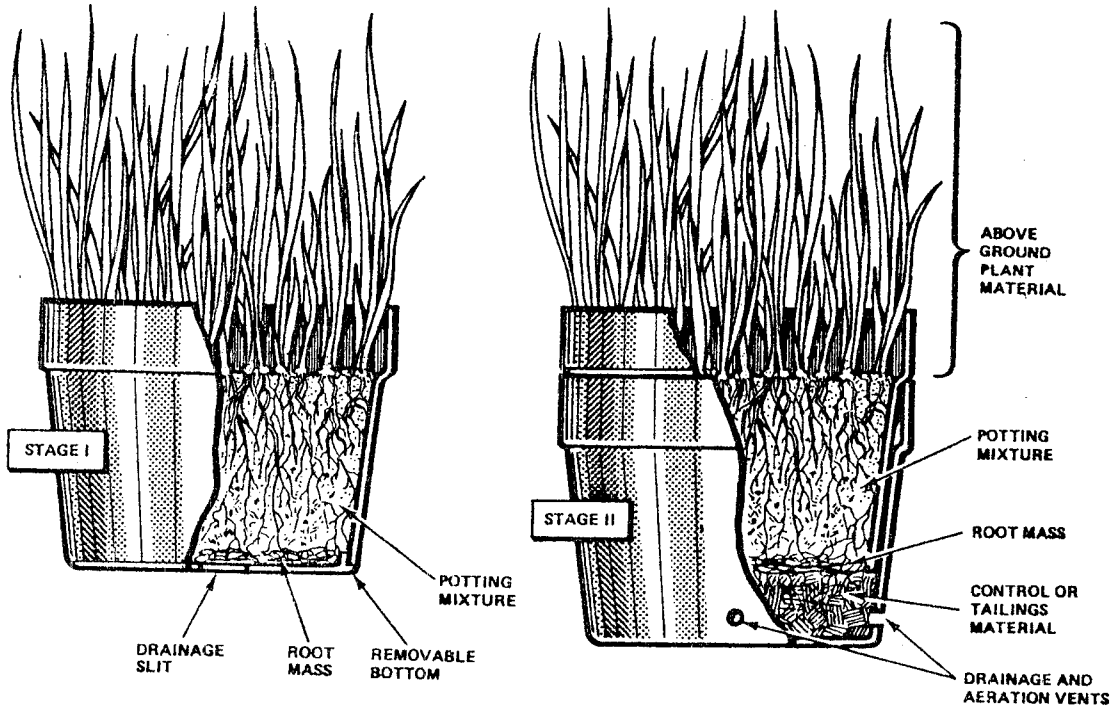

Fig. 1.
Configuration of two stages of the assay technique for plant uptake.

ser Mo concentrations in vegetation
ke assay compared with our earlier
experiment are readily apparent. The most probable reason is the difference in longevity of growth (one month for assay vegetation and six months for greenhouse vegetation). The concentration of assimilated elements is expected to increase with plant age or over the course of a growing season.[7] Even though the absolute Mo concentrations differ between the two experiments, the concentration ratios cover a similar range of values. If appropriate control materials are assayed for all experimental designs, concentration ratios can be calculated to provide the best measure of bioavailability. The next set of experiments will use the vermiculite potting mixture, because of the apparent difference with peat moss, and undiluted tailings to simplify the assay system. Future attempts will be made to harvest clean roots from only the potting mixture layer. By analyzing the roots, we may be able to ascertain if certain elements are absorbed by the roots but not translocated to stems and leaves. These experiments will assess concentration as a function of age (i.e., time grown in assay material) and will evaluate the uptake of contaminants from tailings from three inactive mill sites (Salt Lake City, Utah; Shiprock, New Mexico; and Durango, Colorado).

The plant uptake assay technique holds promise as a generic method to assess contaminant uptake from solid wastes and will provide a rapid means to evaluate uptake potential of tailings contaminants by important plant species of the arid western United States.

TABLE I

MOLYBDENUM CONTENT OF ABOVEGROUND PLANT MATERIAL FROM THE UPTAKE ASSAY AND THE GREENHOUSE EXPERIMENT[a]
(in μg/g dry weight basis)

PLANT UPTAKE ASSAY

	Sporobolus airoides (Alkali Sacaton)		*Atriplex canescens* (Four-Wing Saltbush)	
Potting Mixture	Vermiculite	Peat Moss/ Vermiculite	Vermiculite	Peat Moss/ Vermiculite
Control	0.21	0.61	0.36	0.36
Tailings	5.8 (28)	9.4 (15)	11.0 (31)	39.5 (110)
Tailings + Peat Moss/Vermiculite		4.9 (8)		29.1 (81)
Tailings + Vermiculite	3.7 (18)	4.8 (8)	12.3 (34)	9.3 (26)

GREENHOUSE EXPERIMENT[b]

	Sporobolus airoides (Alkali Sacaton			*Atriplex canescens* (Four-Wing Saltbush)		
	Sand	Loam	Clay	Sand	Loam	Clay
Control	6	8	13	10	12	2
Mean		9			8	
Tailings	147 (25)	173 (22)	78 (6)	273 (27)	181 (15)	147 (73)
Mean		133 (15)			200 (25)	

[a]Concentration ratio of plant conc. (tailings)/plant conc. (control) in ().

[b]Ref. 3.

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Thermal Water Supplies to Surface Waters as Related to Hydrothermal Energy Development in the Jemez Mountains

[J. M. Williams, L. E. Hersman, and G. J. Langhorst]

The Jemez caldera provides an excellent source for the production of energy by thermally heated water. Two technologies are currently being developed there: hot dry rock or HDR (by DOE/Los Alamos National Laboratory) and hydrothermal (by Union Geothermal, Public Service Company of New Mexico and DOE). HDR will use a closed, recycled water system in a hot but dry underground zone. The hydrothermal process, on the other hand, will pump water from a hot underground aquifer. Most of the water will be pumped back into the ground, but about 27% will be lost to the atmosphere, primarily through cooling tower vapors. Interested groups have raised questions about the impact that such a water loss, at flow rates needed for power generation, will have on the supply of surface water for agriculture and recreation in the Jemez Mountain area.

The principal, observable, thermal releases to surface waters in the Jemez Mountains are in the Soda Dam-Jemez Springs area (Fig. 1). This is downstream from the Redondo Creek/Sulfur Creek area where hydrothermal energy development will occur. Because the prime source of certain chemical ions in the surface waters of the region is thermal water, the amount of thermal water flow can be evaluated from the concentration of these indicator ions. Purtymun et al.[1] have been monitoring water quality in this area for a number of years. Their data provide an excellent source for determining thermal flow to the Jemez Pueblo (Position 6 in Fig. 1). Water Resources Associates, Inc. used arsenic to determine that 0.0103 m^3/s (0.365 cfs) of thermal water is flowing into

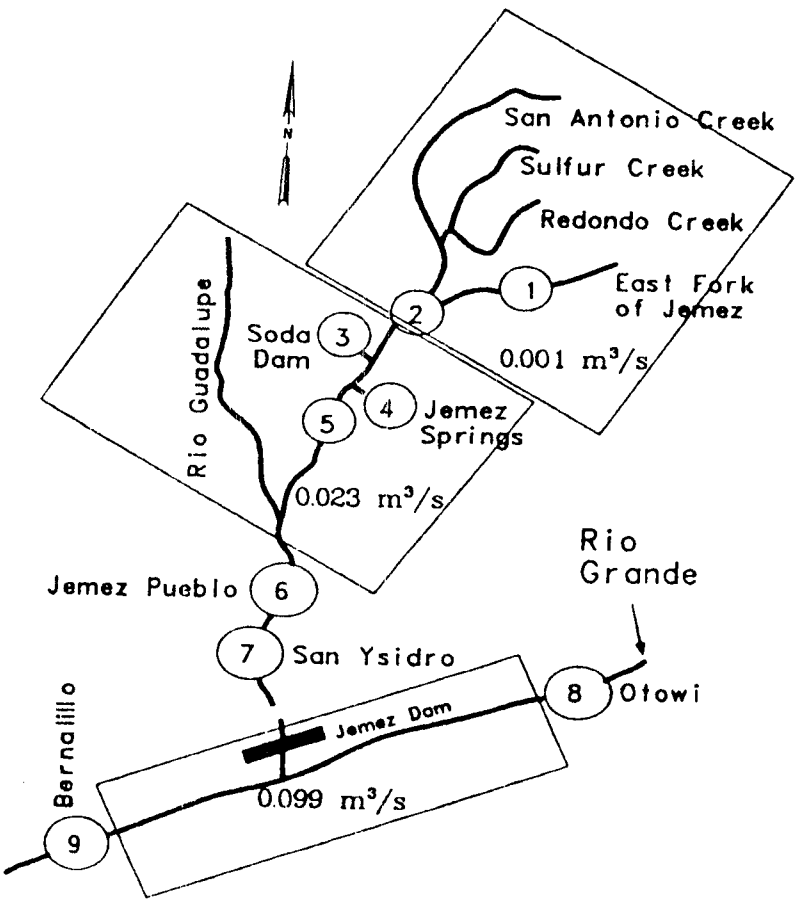

Fig. 1.
Jemez River thermal supplies.

the Jemez River from sources above Jemez Pueblo.* W. P. Balleau used 5 ions and obtained a value of 0.023 m^3/s (0.81 cfs).** Our analysis using 6 ions is shown in Fig. 1. The thermal water supply from the hydrothermal development area above Soda Dam is minor [0.00105 m^3/s (0.037±0.04 cfs or 26±29 acre ft/y)]. Thermal inputs to the Jemez River above Jemez Pueblo, including those from Soda Dam and Jemez Springs (major contributors) and Rio Guadalupe, amount to 0.023 m^3/s (0.81±0.34 cfs). The thermal water supplies in this region appear to be defined reasonably well.

Thermal water flows from most of the other Jemez Mountain areas are poorly defined. Water quality data are less abundant than for the upper Jemez River, and the flow systems are complexed by dams, which can serve as evaporating points and thus as ion concentrators. An attempt has been made by Balleau, however, to apply the ion concentration method described above.** His analysis shows that no thermal flow is being produced from the east quadrant of the Jemez Mountains, but that 0.14 m^3/s (5 cfs) is being produced in the half quadrant between this quadrant and the Jemez Springs area discussed above. The lack of appreciable water flow of any kind through the latter area makes this analysis suspect. We believe that a better approach is provided by the following method, which treats the Jemez Mountain drainage system as a set of proportionate sectors.

The drainage fields from the Jemez Mountains can be divided into four sectors based on ground water flow directions (see Fig. 2). In this manner, the hydrothermal development area and the upper portion of the Jemez River (that including the Jemez Pueblo) form one sector and account for 35.8% of the flow area. Using the thermal supply value [0.024 m^3/s (0.85 cfs)] of this sector and assuming that the thermal supply in each sector is proportional to its share of the total area, the thermal water supplied by each sector can be estimated (see Table I).

The total thermal flow from the Jemez Mountains, based on proportionate sectors, is

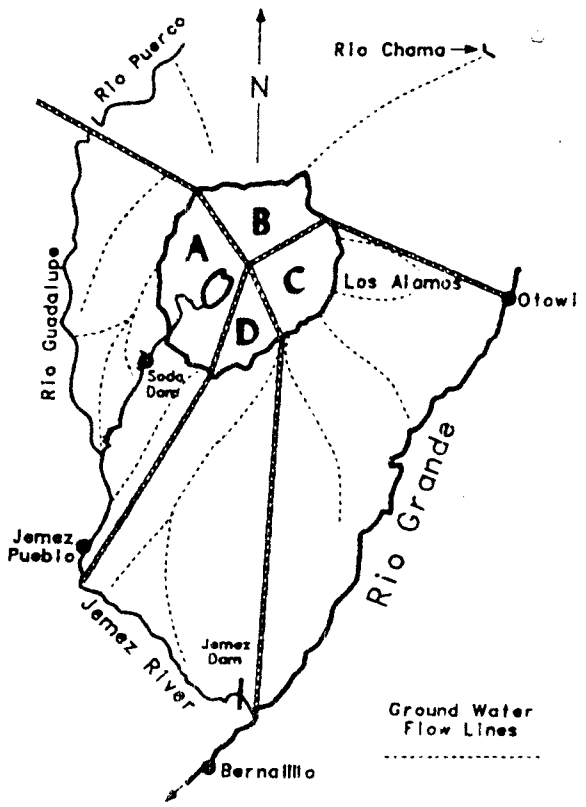

Fig. 2.

Thermal water supplies to surface waters in the Jemez Mountains.

TABLE I

THERMAL WATER SUPPLIES TO SURFACE WATERS IN THE JEMEZ MOUNTAINS

Sector	Fraction of Total Area (%)	Thermal Water Supply m^3/s (cfs)
A	35.8	0.024 (0.85)
B	26.7	0.018 (0.63[a])
C	25.3	0.017 (0.60[a])
D	12.2	0.0082 (0.29[a])
A to D		0.067 (2.37)

[a]Value based on proportionality of area to Sector A.

*J. R. Erickson, "Hydrology--Jemez Mountains, New Mexico," Report by Water Resources Associates for Union Geothermal Division of Union Oil Company (March, 1977).

**W. P. Balleau, "Geothermal Hydrology at Jemez Mountains--Ion Balance and Flow Depletion," report for Department of Interior/Bureau of Indian Affairs (March, 1980).

approximately 0.068 m^3/s (2.4 cfs) with about half [0.031 m^3/s (1.1 cfs)] flowing down the Jemez River system (sectors A and D). The total is somewhat lower than the 0.215 m^3/s (7.6 cfs) estimated by Purtymun and Johansen in 1974.[2] The flow down the Jemez River system appears fairly reliable, however, and places an upper limit on the extent to which a hydrothermal development can influence water flow in that system. Thus, complete stoppage of thermal water supplies to the Jemez River would reduce the mean flow rate of 0.77 m^3/s (27 cfs--Erickson, 1977) by 0.031 m^3/s (1.1 cfs) or about 4%.

A complete stoppage of thermal water supplies is probably unlikely. A significant reduction, however, could cause mineral spas to close and take croplands out of production in this water-limited land. Further work will be performed to evaluate the extent to which various levels of reduction will influence crop irrigation and to address the complex problem of just how much thermal water flows will be reduced by hydrothermal development in the Jemez Mountains.

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Activities of the Los Alamos National Environmental Research Park, 1980

[K. V. Bostick]

The Los Alamos National Environmental Research Park (LA/NERP) was dedicated in 1976 as a field laboratory set aside for ecological research, for study of the environmental impacts of energy development, and as a source of public information on environmental issues. The emphasis of research on the park is to develop criteria that facilitate energy development in ways that are least harmful to the environment.

The philosophy of the LA/NERP is also guided by the Charter For The Life Sciences at Los Alamos National Laboratory. Part of this charter is:

> " As a necessary basis for effective long-term performance in meeting the obligations and commitments associated with its primary goal, develop life sciences and environmental research at Los Alamos National Laboratory to a status of national and international recognition as a center of excellence with emphasis on the need for a continuing program of sound supporting research.
>
> Develop close relationships with universities and research institutions, especially with the University of California, on a scientific and academic level."

The LA/NERP encompasses approximately 111 km^2 of DOE land at Los Alamos. The steep elevation gradient (1500 m in 25 km) and Canyon/Mesa terrain give the research park a wide spectrum of Southwestern habitat types in a compact area. Another unique feature of the LA/NERP is that some areas within the park have been protected from activities such as agriculture and lumbering for nearly 40 years. Pre-Columbian Indian ruins are in better condition than similar ruins on adjoining U. S. Forest Service lands because of this history of restricted access.

Studies conducted on the LA/NERP primarily involve Laboratory staff and graduate and undergraduate students from regional universities contracted to conduct specific studies. Some of the work is conducted in cooperation with Federal and state agencies, such as the National Park Service and the New Mexico Department of Game and Fish.

Research projects are selected by the LA/NERP Advisory Committee from proposals solicited within the Laboratory and at regional universities. Members of the Advisory Committee are E. M. Wewerka, LS-6; W. R. Hansen, H-8; R. F. Crombie, ENG-11; and G. J. Nunz, G-DO. Wewerka and Hansen are the LA/NERP Co-coordinators. K. V. Bostick is the Assistant Coordinator.

The La Mesa fire in June, 1977 burned over 60 km^2 on Department of Energy, National Park Service, and US Forest Service land. Many

of the studies conducted by the LA/NERP are related to this fire. These studies and other LA/NERP sponsored studies conducted in 1980 are described below.

Natural Regeneration of Ponderosa Pine as Related to Fire History and Land Use

[L. D. Potter, T. S. Foxx, and F. Barnes]

Natural regeneration of ponderosa pine is dependent on a number or environmental factors such as species competition, canopy cover, soil types, and climatic conditions. In general, ponderosa pine forests of the Southwest are slow to recover after wildfire. Artificial restocking is routinely carried out.

Because of differing philosophies in land use management, lands under jurisdiction of each agency were treated somewhat differently after the La Mesa fire. Lands controlled by the National Park Service were not logged after the fire, and no artificial restocking is anticipated. Lands under jurisdiction of the United States Forest Service were logged and restocking is scheduled for 1981. All lands, with the exception of 0.7 km^2 on the LA/NERP, were seeded with six native grasses soon after the fire to prevent severe soil loss.

Two of the six seeded grasses became well established. They included sheep fescue (*Festuca ovina*) and slender wheatgrass (*Agropyron trachycaulum*). There is evidence that these grasses will severely suppress natural pine regeneration by competing for water, sunlight, and nutrients. It was therefore decided to look at natural pine regeneration as related to various land management practices on the Pajarito Plateau and to determine the microsite conditions that favor pine establishment. To further understand the grass-pine seedling competition, the water status of sheep fescur, slender wheatgrass, and mountain muhly (*muhlenbergia montana*) was studied during the growing season and compared with soil water at several depths.

The following treatment areas were surveyed for the presence or lack of presence of ponderosa pine seedlings.

(1) Areas seeded with grasses and not logged post-fire,

(2) areas with native grasses not logged post-fire,

(3) areas seeded and logged post-fire,

(4) areas thinned post-fire and not seeded,

(5) areas not logged post-fire and not seeded, and

(6) areas with known fire history, which burned before 1977 and which have had ample time for natural succession.

In addition to determining the numbers of seedlings per km^2, site specific information was gathered for individual seedlings. Thus far, such information has been tabulated for 1385 seedlings. Presently, field surveys have been completed, and data tabulation and correlation are in progress.

Niche separation of sheep fescue, slender wheatgrass and mountain muhly were studied during the 1980 growing season by periodic measurements of leaf water potential, per cent soil water and root structure.

The relationship between leaf water potential and soil water at different depths is currently being studied for each species. Small ponderosa pine seedlings (1 to 2 years) will be excavated to determine their root structure and comparisons made with grass root structure and water usage.

Biotelemetry Studies on Elk

[G. C. White]

The movements of Rocky Mountain elk (*Cervus elaphus nelsoni*) in the eastern Jemez Mountains in north-central New Mexico were studied from 1978 to 1980. Thirty-six elk were trapped, marked, and released, and thirty of these animals were radio-collared.

The La Mesa fire created a wintering habitat that was used heavily by the radio-col[illegible] The 10-year-old clear cuts on Cerro de[illegible] Baca Land and Cattle Company property were [illegible] for calving and nursing areas. In general, radio-collared elk used areas in an early successional state, and they did not use areas at Los Alamos National Laboratory where there was human activity.

Results of the study through 1980 are published in "Biotelemetry Studies on Elk" (Los Alamos National Laboratory report, LA-8529-NERP, 1981). A motion picture, "Elk Biotelemetry at the Los Alamos Environmental Research Park" (Y-355) was also produced based on this study.

Comparative Winter Nutrition of Elk in the Jemez Mountains, New Mexico

[M. M. Rowland, A. W. Alldredge, J. E. Ellis, and G. C. White]

Studies of winter diet quality and nutritional status of elk were conducted in the Jemez Mountains in 1979-1980. A recently burned montane area, including LA/NERP lands, and an unburned area were selected for winter range comparisons. Composition of elk diets in the two areas, determined by fecal analysis, was markedly different. Elk consumed significantly more grass in the burned area, while consumption of browse was significantly greater in the unburned area. *In vitro* organic matter digestibility of grass forages was greater in the burned area, but other forage quality comparisons revealed no differences between areas. Although dietary protein was similar between locations, digestibility on the burn was significantly greater than in the unburned area. Observed differences, between areas, in diet quality were attributed, in part, to changes in forage availability following the fire in Bandelier National Monument, rather than increases in forage quality. A simulation model of ruminant energy and nitrogen balance was used to predict effects of diet quality on elk nutritional status. Greater energy deficits were predicted for elk in the unburned area, effecting greater losses of fat and lean body in this area. Superior dietary nitrogen was insufficient to compensate for these losses.

Fire plays an important role in maintaining quality habitat for elk in the Jemez Mountains. Other winter ranges for the Jemez Mountain elk include proposed geothermal sites. Knowledge of winter range qualities associated with good winter range for elk may assist in mitigation of potential losses of habitat caused by energy development in the Jemez Mountains.

The Influence of Winter Range Quality on Elk Condition

[B. J. Weber and G. C. White]

Condition of elk utilizing portions of the area burned by the La Mesa fire was established from animals live-trapped at Bandelier National Monument (BURN, N=20) during winter, 1980. Values obtained from elk at the BURN were compared to those of elk trapped at a similar, but unburned habitat (BACA, N=16) during the same time period. Animal condition was evaluated on the basis of weight, depth of back fat (DBF), and several blood parameters. Pregnancy rates were determined by rectal palpation. Observed age and sex ratios did not differ significantly between areas ($P>0.73$). Differences between locations for weight, DBF, and blood values were analyzed using an analysis of variance. Elk sampled at the BURN weighed significantly more than elk at the BACA ($P<0.01$). DBF was greatest at the BURN, and back fat was detected in only one BACA elk. Blood variables indicative of nutritional status (alkaline phosphates, triglycerides, albumin, mean corpuscular volume) were all significantly higher at the BURN ($P<0.05$). Significantly higher ($P<0.05$) serum levels of CO_2 and total bilirubin found in the BACA elk suggest that these animals were under greater stress. Pregnancy rates were 100% for adult female elk at both locations. No yearling elk were captured at the BACA, and only one of four trapped at the BURN was pregnant.

Piñon-Juniper Habitat Types

[F. J. Barnes]

The aim of the piñon-juniper habitat study is to determine a graded series of habitat types in the piñon-juniper woodland of the LA/NERP and adjacent lands. These studies will provide the basis for an eco-physiological investigation into the distribution of *Pinus edulis* and *Juniperus monosperma*, the dominant tree species of the woodland. The final study will provide information for developing a management tool to determine production potential of the various habitat types of pinon-juniper woodland of the Southwest.

Extensive reconnaissance of the LA/NERP lands has been completed, while reconnaissance of the Bandelier National Monument woodland is still underway. Sample stands of woodland are being selected and study plots (25 by 15 m) are being established. To date, 15 plots have been staked. The density and cover of pinons and junipers are being recorded by basal diameter classes. Because junipers branch extensively from the base, all basal branches are recorded by diameter classes,

and an equivalent basal diameter is calculated using the formula

$$DAB = \sqrt{d_1^2 + d_2^2 + \ldots + d_n^2} \ ,$$

where DAB is the equivalent diameter at base, and d_n is the diameter of the nth branch. Representative trees on each plot are cored for age determination and their heights recorded. Over 150 specimens of grasses and forbs have been collected and pressed, and identification of these specimens is under way.

Status of the Flora of the Los Alamos National Environmental Research Park

[T. S. Foxx and G. D. Tierney]

Results of the survey of the LA/NERP for endangered, threatened and rare plant species have been published in LA-8050-NERP, Vol. 1 "Status of the Flora of the Los Alamos National Environmental Research Park" 1980.

Under the Endangered Species Act of 1973, it became necessary to locate critical habitats of plant species in danger of extinction on State and Federal lands. A study to provide information regarding locations of possible endangered, threatened, protected, and rare plant species within the LA/NERP was initiated in August, 1977.

Only one species, grama grass cactus (*Pediocactus papyracanthus*), presently on proposed Federal endangered and threatened species lists (1975, 1978), was found in the area adjacent to the LA/NERP. The population was not large, and various human activities are contributing to the deterioration of its habitat.

Fourteen plants on the New Mexico State protected list were located. Only one, larkspur violet (*Viola pedatifida*) appears to be of any significance. It is a rare peripheral, which has been collected infrequently in New Mexico. It was found in a small population, and its habitat could be damaged by logging, herbicides, or surface water depletion. All other species present in the area that are on the protected list are enumerated for information purposes. None of those plants were considered rare or in need of protection from Laboratory activities other than to help preserve the natural flora of the area.

During the survey, 322 species representing 64 taxonomic families were collected or noted in Mortandad, Effluent, and Water Canyons. Many of these species have not previously been reported for the area.

Much of the area surveyed was heavily disturbed because of activites before and after the establishment of the Laboratory. Various stages in plant succession were noted.

The upper portion of Water Canyon was subjected to the La Mesa fire. Post-fire plant succession showed increased size in many plant species. Heavy browsing of most shrubs, some trees, and many forbs was observed.

Assessing Nitrogen Stress in Local Ecosystems

[V. P. Gutschick]

Ammonia transferred in air at normal parts-per-billion levels may have a large impact on long-term nitrogen balances of ecosystems. The transfer itself has proved difficult to assess because accurate field measurements are both cumbersome and lengthy, hence few in number. Thus, a small and rapid detector was designed, in which selective absorption of ammonia should occur from an air flow onto a quartz oscillator crystal. The change in oscillator frequency by mass-loading will quantify the ammonia le the air, upon equilibration for several m Fabrication of the electrical and mechanical assemblies is now complete, and evaluation of crystal coatings for sensitivity and ammonia selectivity has begun.

The ecological studies in discerning broad principles behind nitrogen-acquisition activities of plants have progressed considerably. A number of concepts have been developed and are ready for quantitative testing in the laboratory and in the field.

Other Activities

One other LA/NERP-funded study, "Rainfall as a Mechanism for Soil Contamination of Plant Surfaces," is described above. In addition to these studies, the LA/NERP also provided support to James N. Hill, UCLA, conducting archaeological surveys on the Pajarito Plateau and to LeRoy D. Hacker of the US Soil Conservation Service, com-

pleting verification and followup work on a soil-type map of Los Alamos County.

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Overview Assessment of Nuclear Waste Management

[B. W. Burton, B. A. Perkins, and J. G. Steger]

In October 1979, at the request of the Environmental Safety and Engineering (ESE) Division, Los Alamos National Laboratory began an evaluation of the effectiveness of environmental control practices in the DOE waste management program. Our role in this activity is to assist ESE to conduct an independent evaluation of the environmental control technologies applied to nuclear waste management, and to advise ESE where these controls seem to be inadequate, or where further studies are needed to determine adequacy.

After reviewing the environmental control technologies associated with nuclear waste management programs, we have identified the most urgent problems requiring further action or follow-up. They are listed, in order of decreasing importance.

Shallow-Land Disposal Technology Development. There is insufficient understanding of radionuclide release and transport mechanisms, which is compounded by the location of many burial sites in areas of complex geology. Regulatory standards and criteria seem to be conflicting and, in any case, may not be adequate to provide safe disposal. In addition, there seems to be no coherent plan for ensuring site integrity after closure. We recommend further research in the areas of hydrogeologic conditions at existing sites and radionuclide release and transport mechanisms. A close evaluation of limiting concentrations in burial grounds (maximum and minimum allowable concentrations) is needed. Also needed are programs to address waste treatment and volume reduction. Land use evaluation schemes to be used in new facility siting should be developed.

Active Uranium Mill Tailings Piles. Remedial action and the NRC licensing requirements addressing old and new tailings piles are promising, but their long-term effectiveness has yet to be proven. Environmental controls for currently active piles are not adequate, but these facilities are already licensed. It is reasonable to assume that successful developments in remedial action programs and NRC regulations regarding stabilization/rehabilitation at the close of operations will be applied to these active piles. However, currently active milling operations, which were not subject to the new NRC requirements at the time they were licensed, should be comprehensively studied to determine the extent to which their current practices are affecting the environment and to determine the cost/feasibility of ameliorative action.

Uranium Mine Dewatering. Pumpage of uranium mine water results in changes in the aquifer, dispersal of contaminants (both radioactive and toxic), and loss of water, itself a valuable resource. Mine water control is not very effective, and these activities are poorly documented. Environmental health and safety regulations and division of authority are not clear. Carefully coordinated field studies to determine the overall potential health and environmental impact of current uranium mining practices with particular attention to implications of gaps in regulatory authority and enforcement capacity of both state and federal authorities should be undertaken.

Site Decommissioning. Some of the decontamination and site decommissioning activities scheduled for the near future are potentially hazardous. They will involve large quantities of radionuclides, will take place in populated areas, and are novel. Relevant documents do not address methods of establishing priorities, development of cleanup criteria, or methods for the disposal of the waste. These issues must be addressed before operations are allowed to begin.

INEL TRU Exhumation/Treatment. This activity is discussed in some documents but not in others, so the current status of the project is not clear. The operations will be innovative, the quantity of radionuclides involved is large, and the environmental controls are not known. This activity is potentially hazardous and, if it is still scheduled, DOE should ensure that careful plans are made and the environmental controls are adequate before exhumation is allowed to begin.

Uranium Mine Spoils. Mine spoils piles are a potential source of wind- and water-borne contamination (both radioactive and toxic). There are very little data available regarding mine spoils. Although spoils piles are poorly regulated, an effective reclamation program can probably be developed under RCRA. These spoils piles are outside DOE jurisdiction, but ESE should pay close attention to developments in this area.

Medical/Institutional Wastes. Large volumes of very low activity wastes are produced by the medical/institutional community. Enforcement of environmental controls has been ineffective, and much of the waste is disposed to municipal sewer and refuse systems. Because of the low activities involved, the hazards of institutional wastes are biological and chemical rather than radiological. Large volumes of toxic and organic liquids are buried in commercial low-level burial grounds, presenting the potential hazard of chelating and mobilizing radionuclides. Although these waste generators are not under DOE jurisdiction, there is a real need for increased development of waste treatment and volume reduction systems.

The Nuclear Regulatory Commission (NRC) has recently proposed a rulemaking to deregulate some biomedical wastes.* If adopted, the new rule would exempt liquid scintillation media and animal carcasses from NRC regulation and increase the amount of uncontrolled release of tritium and carbon-14. The ultimate effects of this decision are not entirely clear at the present time.

We feel that the following areas need not be of immediate concern.

*Federal Register, Vol. 45, No. 197, pp. 67018-67020 (October 8, 1980).

Conversion/Enrichment/Fabrication. Because of the small amounts of waste produced by these facilities, we feel they should receive a low priority. These facilities have been in operation for some time, and no environmental releases of any consequence have been reported. We perceive the major problem to be onsite holding ponds, but these will not become a concern until the facilities are decommissioned.

Reactors/Fuel Storage Operations. These operations have been under licensed supervision for many years and we feel there is no immediate problem in these areas other than the need for more efficient waste volume reduction practices at reactors.

Terminal Isolation. These programs are relatively new, and it is probably too early to assess the potential control technologies at this time. We have noted that post operational monitoring and accident recovery are not adequately covered. Also, there may be conflicts in the guidelines. We are somewhat concerned about the potential misuse of probability estimates of future geological and climatological events.