1974

ENVIRONMENTAL GEOLOGY IN DEVELOPMENT OF NUCLEAR ENERGY

by Margaret Anne Rogers and LaMar J. Johnson

1974 Reference

Nuclear energy is already in use for power generation. Approximately 10% of our electrical power in the United States is generated using nuclear energy as a source. Three percent uses a hydroelectric source and 87% uses a fossil fuel source. One projection indicates by the year 2000 70% of our power will come from nuclear energy.[1]

A key factor in this development of nuclear energy as a power source is radioactive waste management. Radioactive waste is generated in the nuclear fuel cycle. While wastes are generated at the fuel fabrication plant and the reactor power plant, the greatest volume of wastes is generated at the reprocessing plant. These waste materials can be categorized as either radioactive fission product wastes e.g. cesium and strontium or heavy radioactive material wastes e.g. plutonium, uranium and americium. An example of radioactive waste material characteristics follows. Cesium 137 (^{137}Cs) emits gamma radiation and has a half-life of 30 years; strontium 90 (^{90}Sr) emits beta radiation and has a half-life of 28 years; plutonium 239 (^{239}Pu) and americium 241 (^{241}Am) emit alpha radiation and have half-lives of 24,400 years and 460 years respectively. The relative biological damage potential for these nuclides shows external radiation penetration can be stopped by a few centimeters of lead for the gamma radiation of ^{137}Cs, by 0.01 centimeters of lead for the beta radiation of ^{90}Sr and by a single sheet of paper for the alpha radiation of ^{239}Pu and ^{241}Am.

---

[1] Blomeke, J.O. et.al., "Projections of Radioactive Wastes To Be Generated by The U.S. Nuclear Power Industry", Oak Ridge National Lab. TM-3965, Feb. 1974, 112 p.

9173

LASL-ERDA-OFFICIAL

Strontium 90 has 20 times and ^{239}Pu and ^{241}Am have 30,000 times the internal aerosol radiotoxicity of ^{137}Cs. The combination of these characteristics determines the waste disposal methods used.

All radioactive wastes need to be environmentally isolated until radioactive decay has rendered them innocuous. In the case of fission products this isolation can be engineered but the long half-lives of heavy radioactive materials require the isolation to be natural. Natural isolation most favored is geologic.

The Los Alamos Scientific Laboratory (LASL) is primarily concerned with the disposal or storage of heavy radioactive materials, the transuranics, and is currently studying the natural system of isolation for these wastes prior to their permanent disposal. Wastes contaminated with less than 10 nanocuries/gram of transuranic elements are buried; those contaminated with greater than 10 manocuries/gram are stored. No liquid wastes are disposed or stored at the LASL. Any liquid waste is converted to solid.

The relief map shows the Jemez volcanic complex in north-central New Mexico (Valles Caldera; Chama, Rio Grande, Jemez Rivers; Los Alamos, Albuquerque).

The LASL is located on the Pajarito Plateau which flanks the eastern side of the Jemez Mountains. The plateau is 16-24 km wide, and more than 48 km long. Elevations from west to east across the plateau range from 2377-1890 m above mean sea level. The plateau is cut (61-122 m deep) by numerous intermittent streams tributary to the Rio Grande. The dissected eastern margin of the plateau rises 91-305 m above the Rio Grande.

The Pleistocene Bandelier Tuff, as thick as 320 m, caps the Pajarito Plateau. It is a series of welded to moderately welded, rhyolitic ashfalls and ashflows. Beneath the Bandelier Tuff are the Tertiary-Quaternary sedimentary rocks, several thousand meters thick, of the Puye and Tesuque Formations.

The main aquifer for the plateau lies in the Puye Formation

LASL-ERDA-OFFICIAL

and the Santa Fe Tesuque Formation. Perched water occurs infrequently in the alluvium of the canyons which dissect the plateau. The average annual precipitation for the plateau is 46 cm most of which falls as summer thunder showers.

The solid radioactive waste disposal area is located on Mesita del Buey, a narrow mesa which is a part of the Pajarito Plateau. The mesa top is approximately 30 m above the adjacent canyon floors which contain intermittent streams and is approximately 230 m above the aquifer. Pits, shafts and trenches for waste disposal and storage are excavated in the Bandelier Tuff which forms the mesa.

Pits are approximately 8 m deep and vary in length from 122-183 m and in width from 8-30 m. Shafts vary in depth, 8-18 m; in diameter, .6-20 m and in lining, none, asphalt or cement. Trenches are shallow, approximately 4 m wide and as long as 81 m.

Primary containment of wastes may be geologic as is the case for most pits and shafts. In the case of the trenches concrete casks are used for primary containment with secondary containment geologic.

At the LASL migration of radionuclides from the disposal site would be dependent primarily upon moisture movement. Migration is of interest whether it involves a few centimeters or hundreds of meters. The depth to the water table, lack of perched aquifers, low rainfall, and absence of surface drainage across the dispoal site greatly reduce the probablity of migration. The possibility of moisture movement in fractures and along bedding planes promoting migration is under investigation. Because of the low rainfall and the ion exchange capacity of the tuff and of the clays which fill the fractures to the depth of most disposals it is doubtful if any significant migration, i.e. beyond a few centimeters, will be found.

The migration of gaseous radionuclides from the disposal siteat the LASL is of minor concern because of the low volume of such wastes and not because all fractures are sealed or because

LASL-ERDA-OFFICIAL

the tuff has low permeability.

Another minor concern is the migration of radionuclides through erosion of wastes. The present climatic conditions make erosion remote and choice of a mesa top for the disposal site make erosion remote. All wastes are covered with a minimum of 1 m of crushed tuff. Some may then receive a cap of concrete. The crushed tuff is stabilized by selected revegetation. The possibility of faulting exposing wastes to erosion is also remote since the nearest fault is some 9 km west of the disposal site.

Under study also at the LASL is the role of plants in migration of radionuclides. At the disposal site roots of conifers extend to the depth of most disposals through fractures in the tuff. At present, species chosen for re-vegetation of the disposal site are shallow-rooted grasses. In the future some conifers will be left between excavations to monitor for any uptake of radionuclides.

At the LASL environmental geology's role in waste management is currently the investigation of migration, if any, of radionuclides by moisture movement along fractures and bedding planes.

In evaluating geologic disposal of radioactive waste (which must be isolated from the environment for geologic periods of time) environmental geology considers the following:

1. Topography - Is it well drained? Is it subject to flooding? Is the site particularly vulnerable to lateral or vertical erosion by wind or water?

2. Hydrology - What is the depth to the water table? Are there any perched aquifers above it? Is the site in an area of recharge?

3. Climatology - What is the amount and intensity of rainfall? What is the velocity and duration of winds? Is the site subject to severe wind storms?

4. Soil - Is it a barrier to rainfall

LASL-ERDA-OFFICIAL

penetration of underlying rock? What is its ion exchante capacity. What type of vegetation does it and rainfall support dense or sparse? shallow-or deep-rooted?

5. Stratigraphy - What are the lithic characteristics both physical and chemical of the units in which the disposal will be made? How much vertical or lateral variation is there in these characteristics? Of particular interest, what is the ion exchange capacity, the permeability, the number of bedding planes?

6. Structure - What is the fracture pattern? Are joints sealed or not? Where are the nearest faults? Does faulting present a seismic hazard? Increased permeability? etc.?

It is the interaction of these factors which determine the suitability of a radioactive waste disposal site.

LASL-ERDA-OFFICIAL

ENVIRONMENTAL GEOLOGY CONSIDERATIONS

WASTE DISPOSAL SITE LOCATIONS

TOPOGRAPHY

- Drainage
- Erosion

HYDROGRAPHY

- Recharged Areas
- Water Table
- Perched Aquifers

CLIMATOLOGY

- Rain Fall
- Wind

SOILS

- Thickness
- Ion Exchange Capacity
- Vegetation

STRATIGRAPHY

- Unit Lithic
  - Characteristics
    - Physical
    - Chemical

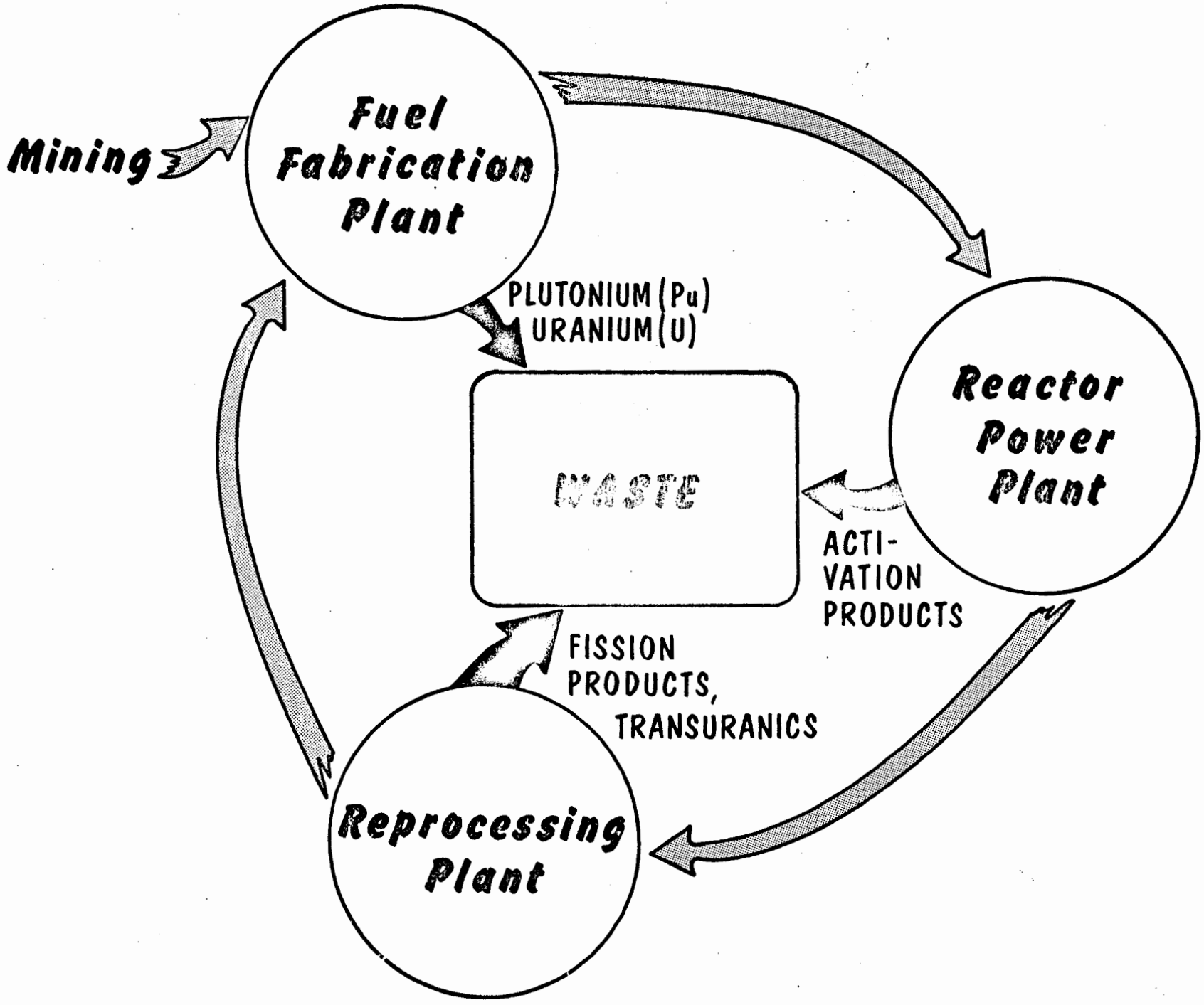
STRUCTURE

- Joint Pattern
- Faults

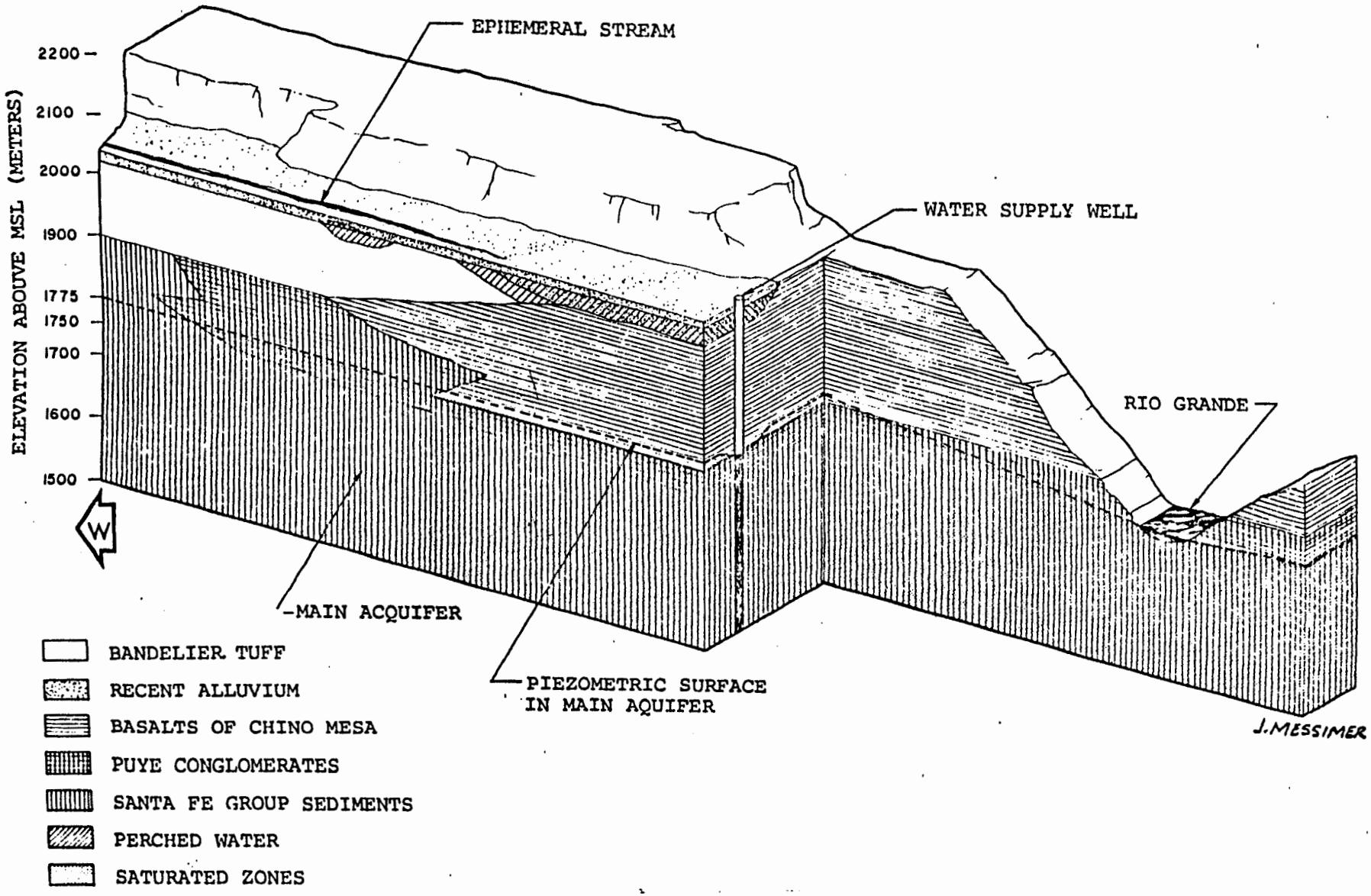
LASL-ERDA-OFFICIAL

LASL-ERDA-OFFICIAL

NUCLEAR POWER GENERATION



EXAMPLES OF RADIOACTIVE WASTE MATERIAL CHARACTERISTICS

NUCLIDE	EMISSIONS	HALF-LIFE	RELATIVE BIOLOGICAL DAMAGE POTENTIAL: EXTERNAL RADIATION PENETRATION STOPPED BY:	RELATIVE BIOLOGICAL DAMAGE POTENTIAL: INTERNAL AIRBORNE RADIOTOXICITY
^{137}Cs	γ	30 yr	n cm of lead	1
^{90}Sr	β	28 yr	0.01 cm of lead	20
^{239}Pu	α	24,400 yr	sheet of paper	30,000
^{241}Am	α	460 yr	sheet of paper	30,000

CONCEPTUAL HYDROLOGICAL CROSS SECTION OF THE LOS ALAMOS AREA