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ORNL/EIS-133/VI

**SHALLOW LAND BURIAL
OF
LOW-LEVEL RADIOACTIVE WASTES**

A Selected, Annotated Bibliography

Vol. 1

**Sponsored by the
DEPARTMENT OF ENERGY
ENERGY TECHNOLOGY
OFFICE OF NUCLEAR WASTE MANAGEMENT**

OAK RIDGE NATIONAL LABORATORY
OPERATED BY UNION CARBIDE CORPORATION FOR THE DEPARTMENT OF ENERGY

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SHALLOW LAND BURIAL OF
LOW-LEVEL RADIOACTIVE WASTES

A Selected, Annotated Bibliography

Vol. 1

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Prepared by the
OAK RIDGE NATIONAL LABORATORY
Oak Ridge, Tennessee 37830
operated by
UNION CARBIDE CORPORATION
for the
DEPARTMENT OF ENERGY

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ABSTRACT

This publication is the first in a series of annotated bibliographies jointly compiled by the staffs of the Ecological Sciences Information Center of the Information Center Complex at Oak Ridge National Laboratory and of Dames & Moore, White Plains, New York. The data file was built to provide information support to Department of Energy researchers in the field of low-level radioactive waste disposal and management. The scope of the data base emphasizes studies which deal with the "old" Manhattan sites, commercial disposal sites, and the specific parameters which affect the soil and geologic migration of radionuclides. Specialized data fields have been incorporated into the data base to improve the ease and accuracy of locating pertinent references. Specific radionuclides for which data are presented are listed in the "Measured Radionuclides" field, and specific parameters which affect the migration of these radionuclides are presented in the "Measured Parameters" field. In addition, each document referenced in this bibliography has been assigned a "relevance" number to facilitate sorting the documents according to their pertinence to shallow land burial technology. The documents are rated 1, 2, 3, or 4, with 1 indicating direct applicability to shallow land burial technology and 4 indicating that a considerable amount of interpretation is required for the information presented to be applied. The references are arranged by the representing affiliation (i.e., government, industry, academic, or foreign). Subheadings are also included where two or more contributing organizations are listed. Within each of the affiliation sections, the references are arranged alphabetically by the organization responsible for the research (corporate author). Indexes are provided for author, geographic location, title, measured parameters, measured radionuclides, keywords, subject categories, and publication description.

INTRODUCTION

This publication of 504 abstracted references is the first in a series of annotated bibliographies concerning information relevant to the disposal and management of low-level radioactive wastes. An introductory bibliography (ORNL/EIS-115), published in February 1978, was made available for review to principal investigators of research projects in the field of low-level radioactive waste management. The contents of the introductory publication and the review comments are included in this bibliography.

This compilation of literature is the result of a joint project carried out by the staffs of the Ecological Sciences Information Center, Information Center Complex, Oak Ridge National Laboratory, and of Dames & Moore, White Plains, New York, for the purpose of providing information support to the Department of Energy/Energy Technology, Office of Nuclear Waste Management and its contractors. The scope of the project centers on studies which deal with the "old" Manhattan sites, commercial disposal sites, and the specific parameters which affect the soil and geologic migration of radionuclides. Additional literature selected for inclusion in the data base deals with container design and performance, waste production and processing, legal and political aspects, and nonnuclear waste disposal. Current and pre-1970 domestic literature, as well as foreign literature, is included.

The references to the literature are stored in a computer-retrievable data file. Each reference in the data base contains a complete bibliographic citation, an informative abstract emphasizing the important findings, subject categories describing the general subject area, keywords identifying specific topics in the document, and date and location of data-taking activities. Specialized data fields have been added to improve the ease and accuracy of identifying pertinent references. Specific radionuclides for which data are presented are listed in a field called "Measured Radionuclides." When information is presented on parameters which affect the migration of these radionuclides through the soil and geological formations, the parameters discussed are listed in a field entitled "Measured Parameters." The parameters are also discussed in the abstract along with numeric values, where possible. These fields enable the user to review only those references to documents concerned with the radionuclides and parameters of interest.

Each referenced document is assigned a "relevance" number to facilitate sorting documents according to their pertinence to shallow land burial technology. Documents are rated 1, 2, 3, or 4, with 1 indicating direct applicability to shallow land burial technology and 4 indicating that a considerable amount of interpretation is required for the information presented to be applied. The "relevance" number does not reflect the quality of the document, only its applicability to shallow land burial technology.

Measured Parameters

The following is a list of specific parameters which have been selected for inclusion in the Shallow Land Burial Data Base. Data on these parameters are extracted from the literature and included in the abstract. These data are flagged in a separate field, labeled "Measured Parameters," to increase precision in locating pertinent references.

Calcium Carbonate Content	Cation Exchange Capacity
Clay Content	Density
Depth to Water Table	Dispersion Coefficient, Longitudinal
Dispersion Coefficient, Transverse	Distribution Coefficient
Drawdown	Effective Porosity
Emission Rate	Erosion Rate
Evaporation Rate	Exhalation Rate
Grain Size Distribution	Head
Horizontal Flow Rate	Hydraulic Conductivity
Hydraulic Diffusivity	Hydraulic Gradient
Hydraulic Velocity	Infiltration Rate
Initial Injection Pressure	Intrinsic Permeability
Ion Exchange Capacity	Leaching Rate
Leakage Coefficient	Leakage Factor
Leaking Rate	Mean Precipitation
Migration Rate	Moisture Content
Permeability Coefficient	Percolation Rate
pH	Plasticity
River Flow	Saturation Capacity
Selectivity Coefficient	Specific Yield
Stack Height	Storage Coefficient
Stratigraphic Unit Thickness	Temperature
Thickness of Upper Aquifer	Total Cation Concentration
Total Organic Carbon Content	Total Porosity
Transmissivity	Volumetric Water Content
Waste Volume	

Citation Form

The references are arranged by affiliation (i.e., government, industry, academic, or foreign). Some of these four organizational headings have subheadings when additional contributing organizations are given. Within each of the affiliation sections, the references are arranged alphabetically by the organization responsible for the research (corporate author).

As a result of computer limitations in indicating superscripts and subscripts in the standard manner, certain conventions have been established in this bibliography:

1. X sub t (X being a variable) means X_t or X subscript t .
2. In chemical compounds and elements, NaIO3 (for example) means NaIO^3 .
3. $10 (E+3)$ or $X (E-3)$ (E denoting exponent) means 10^3 or X^{-3} .
4. For units of measurement, such as centimeters, meters, and feet, $X3$ means X^3 .

Indexes are provided for author, geographic location, title, keywords, measured parameters, measured radionuclides, subject categories, and publication description.

Sample Reference

The following reference is an example of the format for the descriptive fields used in this bibliography.

1 - Affiliation	7 - Publication Description
2 - Record Number
(sequential number of reference)	8 - Document Title
3 - Corporate Author	9 - Abstract
4 - Relevance Number	10 - Abstractor's or editor's initials
5 - Author(s)	11 - Comments
6 - Publication Date	12 - Measured Parameters

¹ GOVERNMENT

² <000>

³ Los Alamos Scientific Laboratory, Los Alamos, NM

⁵ Purtymun, W.D. and W.R. Kennedy. ⁶ 1971, May. ⁷ LA-4660; 12 pp.

⁸ Geology and Hydrology of Mesita del Buey ⁴ (1)

⁹ Mesita del Buey is used for the disposal of wastes contaminated by radionuclides, of toxic or explosive chemicals, and of classified materials. These are buried in pits or shafts dug into the mesa surface. The mesa, covered by a clay-like soil, is underlain by a series of ashfalls of rhyolite tuffs from 240 to 590 ft thick. The tuffs are above the main aquifer of the Los Alamos area which lies at a depth of about 1,050 ft along the western margin of Mesita del Buey and at 850 ft at the eastern margin. Total porosity of the tuffs range from 15-60% in volume. Stream flow in adjacent canyons is intermittent. Water in the alluvium of the stream-connected aquifer in the canyon south of the mesa is recharged by storm runoff. The hydrologic characteristics and conditions of the soil, tuff, and seal material used to cover the waste indicate no recharge to the stream-connected aquifer or main aquifer through the soil, buried waste, or tuff at Mesita del Buey. Where the soil cover has been disturbed, the moisture content of the tuff indicates that precipitation may have infiltrated to a depth of 10 ft. The moisture ranges from 2.0 to 8.0% by weight, decreasing with depth. Below 10 ft, the moisture content ranges from 0.5 to 2.0% by weight. Vertical and horizontal erosion rates of the tuff surrounding the waste in pits or shafts indicate that under present climatic conditions the estimated life of the pits will be about 27,000 years. The erosion rate for the past 1.1 million years is about 7.2×10^{-5} ft/yr. Routine maintenance to control erosion of the seal material will extend this life. ¹⁰ (JK) (CSF)

¹¹ The data and discussions presented in this report are relevant to the geology and hydrology of Mesita del Buey, the topographic feature utilized for the disposal of radioactive wastes. ¹⁰ (ESIC/CSF)

¹² Depth to Water Table; Volumetric Water Content; Erosion Rate; Total Porosity; Thickness of Upper Aquifer

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The Ecological Sciences Information Center (ESIC) provides a number of specialized services to government, industrial, academic, and foreign requestors. These services include identifying, acquiring, organizing, indexing, abstracting, processing, storing, and maintaining information. Customized searches as well as copies of specific published documents referenced in the bibliography are provided upon submission of requests. Annotated and indexed bibliographies are published whenever a particular need is shown. Specialized data bases can also be created if a specific subject area has not previously been covered.

The services of ESIC are free to DOE-funded researchers. Others will be assessed a minimum fee of \$30, which covers the charges for most searches. Fees will be charged through the National Technical Information Service in Springfield, Virginia. All inquiries for information services should be addressed to:

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Argonne National Laboratory, Argonne, IL

Fried, S., A.H. Friedman, J.J. Niles, F.V. Atcher, L.A. Quarterman, and A. Volesky. 1976. December. ANL-76-127; ACS Symposium Series No. 35: Actinides in the Environment, A.H. Friedman (Ed.), Proceedings of a Symposium held in New York, New York, (pp. 19-66), 107 pp.

Annual Report for Fiscal Year 1976 on Project 450175A: The Migration of Plutonium and Americium in the Lithosphere (2)

Experiments were carried out concerning surface contamination and the transportation and migration of plutonium and americium into the lithosphere through the agency of water. Airborne contamination was not considered. Three lithological units were used in the testing to examine the properties of rocks in acting as a retarding agent in the migration of the radionuclides. These rock units were the Los Alamos Tuff, the Niagara limestone, and a basalt found in the area of the Idaho National Engineering Laboratory. It was found that the bulk of the Pu and Am were held very tenaciously by the stony materials studied (tuff, basalt, and limestone). The migration rate in the dense stone samples was discovered to be 30 plus or minus 10 micrometers/meter of waterflow for the limestone, and 61 plus or minus 8 micrometers/meters of waterflow for the basalt. The average value of the relative migration coefficient is 10^{-10} of waterflow and a water-flow velocity of 0.16 km/year. At such rates, the bulk of Pu 239 would decay long before it could migrate 1 kilometer. Some amount, less than 35% of the plutonium in these experiments, appears to migrate about ten times as fast as the bulk of the plutonium. The amount of the more rapidly migrating species appears to vary widely and is undoubtedly affected by the chemical environment and kinetics. The rapidly migrating species may be a polymeric form of plutonium, either by itself, or absorbed on fine mineral particles. Some small fraction of the plutonium and americium migrates more rapidly (either vertically or radially) than the bulk of these species and appears to give an "exponential leading edge". Once fixed, however, this fraction becomes much less mobile. This rapid migration may be due to plutonium solute being carried through the pores by high-velocity, unobstructed flow of solution, which may not have had sufficient time to absorb on the pore surfaces. The chemical environment can drastically increase the migration rate of Pu and Am. Surface absorption coefficients are affected by the types and concentrations of other salts. Even solutions as dilute as 10^{-10} of highly charged ions can effect a substantial desorption of Pu and Am, and concentrated solutions of lesser charged species, such as NaCl can cause small, but still appreciable desorption. It is therefore important to consider not only the geological quiescence of a storage site but also the chemical and migrational behavior in the case of an accidental influx of water. (JMT)

Infiltration Rate; Migration Rate

(C2)

Argonne National Laboratory, Argonne, IL

Verigori, R.S., and P.B. Yarikos. 1976. ANL-76-60 (Part 1); Radiological and Environmental Research Division Annual Report,

January through December 1975, (pp. 9-11) (ANL-75-60, Part 1).

Leaching Rates of Several Cations from Soils by Simulated Rainwater (3)

Laboratory experiments were conducted in which leaching of major cations from natural soils was studied. The soils were subjected to simulated acid rainfall at various pH values and leachates or filtrates were collected and analyzed. It was found that Ca and Mg accounted for 90% of exchangeable cations in the two soils tested and that the rate of displacement of the major ions increased sharply when soil pH was lowered below 5. Thus precipitation with a pH of less than 5 strongly lowers soil pH below the critical value (pH 5) and increases the rate of removal of major ions. A warning is given that such an eventuality could affect the growth of plants. (CAB)

Deals only with leaching of non-radioactive major ion leaching. (DB/CAB)

PH

(C3)

Argonne National Laboratory, Argonne, IL

Friedman, A.H. (Ed.). 1976, August. ACS Symposium Series No. 35; Proceedings of a Symposium held in New York, New York, April 9, 1976, 107 pp.

Actinides in the Environment (2)

Six papers are presented which discuss the behavior of actinides in the environment, especially plutonium and americium. Among the specific topics discussed are chemical behavior, biological pathways, and transport of actinides in the environment. The contained information is useful both in the field of low and high level radioactive waste disposal. (WT)

Information pertinent to the migration of actinides from actinide-bearing shallow radioactive waste is presented. (DB/WT)

(C4)

Argonne National Laboratory, Chemistry Division, Argonne, IL

Fried, S., A.H. Friedman, and B. Veeber. 1976, April. ANL-8069; Chemistry Division Annual Report, July 1972 through June 1973, (pp. 10-12), 176 pp. (ANL-8069).

Studies of the Behavior of Plutonium and Americium in the Lithosphere (2)

Absorption coefficients for plutonium in porous rock media under groundwater flow conditions were determined. In the experiment, a pressurized reservoir of solution was set up to force fluid through the interstices in a porous media in order to simulate natural groundwater flow. A plutonium 238 tracer was deposited onto the surface of a slab of Niagara limestone and the L sub I and L sub III x-rays of Pu 238 were measured relative to the L sub II x-ray as a function of rock thickness by counting with a silicon-lithium detector. The migration

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coefficient for Niagara limestone with pure water was shown to be 0.1 m/s at 25°C. The experiments were carried out in a solution and on the rock surface. The results are presented in graphical form. The results are presented in graphical form. The results are presented in graphical form.

Presented at the Symposium on the Chemistry of the Environment, 1976, San Francisco, CA. (65/20)

Distribution Coefficient

Atomic National Laboratory, Chemistry Division, San Francisco, CA.

Presented at the Symposium on the Chemistry of the Environment, 1976, San Francisco, CA. (65/20)

A study was done on the migration of Pu-239 in limestone and basalt. The results show that the migration of Pu-239 is much slower in limestone than in basalt. The results show that the migration of Pu-239 is much slower in limestone than in basalt.

This study is applicable to research on shallow burial of low-level plutonium liquid wastes. (65/20)

Atlantic Richfield Hanford Company, Chemical Technology Laboratory, Richland, WA.

Presented at the Symposium on the Chemistry of the Environment, 1976, San Francisco, CA. (65/20)

Migration of Radioactive Wastes by Hydrothermal Reactions with Clays (6)

A means of converting high-level radioactive waste containing sodium salts to solid, relatively insoluble aluminosilicate minerals is described. Powdered aluminosilicate clays such as kaolin or bentonite are allowed to react with caustic, aqueous solutions of the waste at temperatures in the range of 70 degrees to 100 degrees C. The reaction product from nitrate-containing wastes is a

sub-filled, sodium aluminosilicate with the framework structure of cancrinite. The radioactive cesium and strontium are trapped in cancrinite along with sodium salts. The cancrinite crystals are clustered, there is a large temperature effect on the reaction rate. Leaching of the powdered product with distilled water at 30 degrees C gives low bulk leach rates which are in the range of 10 (E-7) to 10 (E-9) g of sample/24 hr based on BET surface areas. The melting range of cancrinite products is between 900 degrees-1200 degrees C and the thermal conductivity ranges from 0.11 to 0.67 Btu/(ft-hr-in) (deg F/ft-in). Hardeners or binders can be added to improve the mechanical strength of the product. The volumes of the clear and waste solutions are nearly additive. (auth) (77)

This report is applicable to the processing of wastes prior to shallow waste burial. (65/20)

Atlantic Richfield Hanford Company, Hanford, WA. (65/20)

Presented at the Symposium on the Chemistry of the Environment, 1976, San Francisco, CA. (65/20)

Solidification and Improved Treatment of Low- and Intermediate-Level Radioactive Wastes at Hanford (2)

Operational experience in large-scale production techniques used to solidify intermediate-level radioactive liquid wastes and to improve the treatment of low- and intermediate-level radioactive wastes at Hanford is discussed. Three types of evaporation units are used to concentrate intermediate-level wastes to solids: a 650 degree C in-tank air sparger; a thermosiphon electric immersion heater; and a thermosiphon evaporator. The hot air sparger feeds to a semi-continuously to a specific gravity for high viscosity and specific gravity is required blending with feed to the electric immersion heater. Special off-gas treatment is required due to the large heated air flow. The electric immersion heater and the thermosiphon evaporator operate on a continuous recycle system, utilizing several 2.0 x 17 (76)-litre storage tanks in series for air cooling and salt accumulation. Salts are deposited from the cooled mother liquors and the supernatant solutions are sized with fresh feed for recycle to the evaporators. When a cooled tank is filled with solids the residual liquid is removed leaving an insoluble salt cake. In past practice at Hanford, cooling-water effluents have been routed to artificial ponds to underground tile fields where the soil's active ion-exchange capacity. Several of the latter streams are being treated as part of a program to reduce the radioactivity content of the ground to the lowest practicable quantity. Monitoring systems have been installed for some liquid effluents, such as process cooling water and steam condensates which activate diversion to intermediate-level disposal in case of an increase in radioactivity owing to equipment failure or an accident. Intermediate-level liquid wastes from

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Laboratory facilities, nuclear reactor facilities and decontamination of nuclear fuel processing equipment are evaporated to remove radioactivity before discharge to the soil. The more radioactive process condensates in the Purex nuclear fuels processing plant are recycled to the process. Condensates from high-level waste, self-boiling storage tanks and the in-tank solidification units are recycled or treated by ion exchange to remove cesium 137. (Auth) (CIS)

<8>

Atlantic Richfield Hanford Company, Research and Engineering Division, Research Department, Richland, WA

Veatch, F.R., G.V. Last, and R.R. Price. 1977. Jom. AHW-SI-156 (Vols. 1-3); 496 pp.

Evaluation of Scintillation Probe Profiles from 200 Area Crib Monitoring Wells (1)

A study was done at the Hanford Reservation, Washington to measure qualitatively the distribution, redistribution, and decay of radionuclides beneath the crib facilities. The crib facilities were used to dispose of liquid radwaste from the separations plants. Disposal was started in 1945 on a limited basis. After a brief study indicated the ground could take care of more radwaste, the discharge was greatly increased, reaching a peak in 1955 of 8.34×10^{10} curies. Thereafter, the volume and quantity disposed of decreased as the plants were shut down to 16 curies in 1976. The area is underlain by three major stratigraphic units: Yakima Basalt of the Columbia River Basalt Group; unconsolidated sediments of the Pingoli Formation; and unconsolidated sands, silts, and gravels (glaciofluvial deposits). The upper Pingoli contains the water table at about 56 to 107 meters below the surface. Wastes discharged into the vadose zone infiltrate laterally by capillary transport and downward by both capillary and gravitational transport. The movement of the water through the vadose zone is controlled by the stratification and the variation between well-sorted and poorly-sorted sediments. Movement occurs along the bedding planes and across the planes by capillary pressure. The scintillation probe data indicate that most radioactive contaminants are retained immediately beneath the crib facilities, well above the water table. However, 2% of the crib sites radwastes were found with in a meter of the groundwater surface and breakthrough occurred at 20 sites. The one crib that had been removed from service showed no evidence of redistribution downward of the contaminants. Hence, the radioactive contaminants stayed essentially fixed to the surface in. (SPV)

Volume 2 (Appendix A) and Volume 3 (Appendix B) contain selected scintillation probe profiles, background information, evaluation of radionuclides in the ground. (ESIC/SPV)

<9>

Atlantic Richfield Hanford Company, Research and Engineering Division, Research Department, Physical and Life Science Technology, Richland, WA

Isaacson, S.E., L.V. Brownell, and J.C. Hanson. 1974. October. AHW-1943; 46 pp.

Soil Moisture Transport in Arid Site Vadose Zones (2)

Soil moisture transport processes in arid soils at the Hanford site are evaluated in this report. The soil of the Hanford location is relatively uniform sand to loamy sand throughout the soil profile with the water table approximately 5 m below the surface. Four wells, located southeast of the 200 East Area (Coordinates 32-49), were used in the study of soil-moisture relations. The particle size analysis showed that the sand content ranged from 61.5% to 111.3%. Silt content varied from 0.8% to 11.4% and the clay content was from 0.0% to 6.6%. The depth of meteoric water penetration has been determined by the profiling and has revealed that meteoric water during the wet season percolates only several meters out of the ninety meters lying between the ground surface and the water table. "In situ" temperatures and water potentials were measured utilizing temperature transducers and thermocouple psychrometers down a borehole. These data were compiled to establish the thermodynamic conditions affecting soil moisture changes. Two lysimeters, one with an open bottom and another closed, were constructed complete with neutron probes, temperature transducers, and thermocouple psychrometers. These lysimeter experiments allow the study of sociothermal soil moisture transport processes. In the upper nine meters of soil column, a thermal pump which moves moisture towards the ground surface has been observed. Additionally, a desiccation zone from nine to sixteen meters has been delineated. This experimental set-up will be maintained for future data gathering. (Auth) (JC) (CSF)

A slightly more thorough presentation of the Hanford site unsaturated zone studies. More recent reports consisting mostly of raw data exist. See also AHW-SA-169. (JM/JC, ESIC/CSF)

Clay Content; Depth to Water Table; Grain Size Distribution

<10>

Atlantic Richfield Hanford Company, Research Department, Richland, WA

Smith, A.E., D.J. Brown, and S.E. Isaacson. 1975. AHW-SA-0192; CONF-747634; Waste Management, Proceedings of a Symposium held in Tucson, Arizona, April 21-24, 1974, (10 pp.) (AWH-SA-0192, CONF-740313).

Chemical Behavior and Ground Movement (3)

A general discussion of radionuclide retardation in groundwater flow as it relates to fluid leaks from the tank farms at Hanford is presented. The rate of radionuclide movement is discussed in terms of fractions of the groundwater velocity. The low mobility of plutonium, strontium, and cesium is attributed to the alkaline nature of both the neutralized waste and the substrate. The observed migration of radionuclides following the '973 tank leak is briefly discussed. (JC)

This report is a simplified discussion of radionuclide retardation in groundwater flow probably written for reading by the public. The discussion is aimed at dispelling concern over leaks from the tank farms at the Hanford Facility.

SCS-700000

<10> 2000

(20/21)

<11>

Atlantic Richfield Hanford Company, Richland, WA

Wasson, J.E. 1976, August. ARH-CD-767; 1 pp.

Design Criteria Borial Containers for
Non-Transuranic Solid Waste (2)

The report provides criteria for the design, fabrication, inspection, and testing of borial containers for solid non-transuranic radioactive waste. The guidelines apply specifically to containment of beta-gamma contaminated wastes removed from a controlled area, transportation across an uncontrolled area where there is risk of release to the environment, and burial in an approved burial ground. Before containers will be accepted for use for burial, information is required concerning: container design; gross total weight of the containers and contents; proposed method of transportation; estimated radiation dose rates at the surface, 10, 20, and 30 feet from the containers; and the estimated delivery date. (P10)

<12>

Atlantic Richfield Hanford Company, Richland, WA

Wasson, J.E. 1975, August. ARH-CD-353 (Rev); 2 pp.

Design Criteria Transuranic Dry Waste Borial Containers (Steel and Reinforced Concrete) (7)

A description of criteria which establish guidelines for the design, design loading, fabrication, inspection and quality assurance of transuranic dry waste containers is given. Container skin must be 0.109 inch or thicker. Gasket material shall be selected for 20 years life in the burial trench. Containment skin materials must not fail at 125% of permanent earth loading (earth weighing 110 lbs/cubic ft and 16 feet deep). The container will be filled with water and tested at 5 feet of water hydrostatic head with no leakage in one hour. (P10)

<13>

Atlantic Richfield Hanford Company, Richland, WA

Brown, D.J., and J.R. Warren. 1970. COU-700905; IAEA-SR-137/68; Developments in the Management of Low- and Intermediate-Level Radioactive Wastes, Proceedings of a Symposium held in Aix-en-Provence, France, September 7-11, 1970, (pp. 525-536) (COU-700905, IAEA-SR-137/68).

Land Requirements and Waste Management Policy at Hanford (9)

A review of the special minimum specific land requirements for the support of all 200 Areas operation. The study considered all effluent streams, solid refuse volumes and projected land requirements for normal operating conditions, abnormal plant operations (see 11

quantities of high-level waste released) and various credible accident conditions. Land requirements guides were designed to provide a basis upon which to assess the land requirements. These guides include the limitation of general public exposure to less than 10% of the allowable annual radiation dose as a result of inhalation, ingestion, or external exposures. Waste reduction methods reviewed include (a) installation of new processing equipment, (b) evaporation and/or segregation of waste effluents, (c) use of ion-exchange materials, (d) recycling of selected waste streams, and (e) stream stripping of organic wastes.

A general review of the land requirements and waste management policies at Hanford, no significant data presented. (10/37)

<14>

Atlantic Richfield Hanford Company, Richland, WA

Isaacson, B.E., and L.E. Brownell. 1972, August 19. ARH-SA-126; COU-721107; Management of Radioactive Wastes from Fuel Reprocessing, Proceedings of a Symposium held in Paris, France, November 21-December 1, 1972, (33 pp.) (ARH-SA-126, COU-721107).

Ultimate Storage of Radioactive Wastes in Terrestrial Environments (10)

New avenues are opened for the ultimate storage of radioactive wastes via the "STOPPER" and "Thermalt" processes. STOPPER is the Stone Process for Permanent Encapsulation of Radionuclides, a hydrothermal process. Thermalt is a pyrochemical process for fixing radionuclides in a basalt-like product. The products contain analogs of silicate and aluminosilicate minerals such as pollucite, strontian feldspar and "plutonite"--a structural analog of zircon. Ultimate storage will have been effected if these product forms are secured in geochemically compatible media where the authigenic precipitation of cation aluminosilicates will provide additional protection from transport by groundwater movements. (Auth) (J1)

Primarily concerned with the subsurface disposal of high level wastes. Some data is pertinent to shallow land burial. (10/37)

<15>

Atlantic Richfield Hanford Company, Richland, WA

Toulinson, B.E., and S.L. Bittor. COU-700905; IAEA-SR-137/69; STI/PUB/266; Developments in the Management of Low- and Intermediate-Level Radioactive Wastes, Proceedings of a Symposium held in Aix-en-Provence, France, September 7-11, 1970, (pp. 515-520) (COU-700905, IAEA-SR-137/69, STI/PUB/266).

Treatment and Storage of Hanford's High Salt, Intermediate-Level Liquid Wastes (2)

A review of the in-tank surveillance program (ITS) to be conducted at Hanford to solidify between 1.9×10^{16} to 3.8×10^{16} liters of intermediate-level, liquid radioactive wastes (specific activity 0.1 to 10 Ci/l). During the first phase of the program, (started in 1965), water was removed by

evaporation and salts were formed from the cooling of the concentrate. The salts were monitored for temperature, salt stability and radiolytic gas concentration during the second stage. The third phase entails the long-term storage and surveillance. The type and frequency of the surveillance required is a function of the geohydrologic characteristics of the site. Annual rainfall averages 15.5 in. Moisture infiltration is limited to the first 6 meters beneath the ground surface (based on tritium migration studies). The Hanford area is underlain by a series of sand and unconsolidated sediments, primarily sands, gravels, and silts. These sedimentary deposits are underlain by recent basalt flows which are interspersed with volcanic ash, tuffs, sands and silts. (17)

Primary emphasis is on the solidification programs planned for the intermediate-level wastes Hanford. Geohydrologic information provided is of a summary nature. (18/19)

Atlantic Richfield Hanford Company, Richland, WA
1970. AHC-220; 48 pp.

Radiation Protection Standard (3)

The radiation protection standards to be followed at the Hanford Reservation are outlined. Definitions of radiation zones, barriers, marking of radiation zones, radiation symbol, radiation work procedures, radiation work practices, non-occupational exposure standards, occupational exposure standards, occupational exposure controls, emergency exposure controls, radiation exposure measurement, visitor exposure control, airborne contamination, highly toxic materials, surface contamination, and internal deposition measurement are discussed in detail. The procedures to be followed are explicitly outlined. The Hanford Reservation is the site of waste disposal and criteria have been set forth to control such activity. The site will include topological and geological considerations, proximity to paved roads, railroads, power and telephone lines, projected or past conflicting uses of the site and associated hazards. Boundaries and markers are to be provided. Solid wastes are to be disposed of in sites specifically designed for solid wastes with the waste volume at a minimum. Liquid wastes are categorized as: low-level, less than 5 x 10⁶ (E-5) dCi/ml; intermediate-level, from 5 x 10⁶ (E-5) to 100 dCi/ml; and high-level, greater than 100 dCi/ml. Termination of a site will occur when 3 x 10⁶ (E-5) Co 60, 3 x 10⁶ (E-7) 40, 2 x 10⁶ (E-5) Cs 137, 5 x 10⁶ (E-6) Pu 239, or 6 x 10⁶ (E-6) Am 241 are detected in the ground water beneath the site. High-level wastes are not to be expected to be disposed of in such sites. Gaseous wastes are to be kept as small as practical and average weekly amounts should not be exceeded for Sr 90, I 131, total plutonium, and total of all others. The values for these are: 0.1, 3.0, 1 x 10⁶ (E-3), 6 x 10⁶ (E-3), 2.0 curies, respectively. Also listed are the release levels for beta emitters and alpha emitters. (20)

An extensive list of radioisotopes and their release limits are included in an appendix. (21/22)

Battelle Columbus Laboratories, Columbus, OH
Reel, L.F., E.C. Beeks, S.E. Poweroy, and V.G. Hale. 1976. December. EPA-600/7-76-036; 51 pp.
Assessment of Environmental Aspects of Uranium Mining and Milling (2)

This recent program was initiated with the basic objective of making a preliminary assessment of the potential environmental impacts associated with the mining and milling of domestic uranium ores. All forms of pollution are considered except radiation. Liquid discharges for acid and alkaline leach systems are approximately 0.2 and 1.05 cubic meters (1000 and 250 gallons) per metric ton of ore processed, respectively. The recycling of liquids considerably reduces the requirements for water and chemicals, but wastes must eventually be disposed. Liquid wastes from mills are aqueous solutions containing various elements, leached elements and suspended fine particles. These solutions, such as U3O8, H₂O, Ca, Fe, Zn, Cu, Pb, K²CO₃, Na₂CO₃, and Na₂SO₄. The waste solutions from the acid and alkaline leaching processes have pH's of 1.5 to 2.0 and 9.5 to 10.0, respectively. Ordinarily these liquid wastes from milling or refining are discharged into tailing lakes and tailing ponds, but the quantities of seepage from these ponds varies, depending on the pond design. Surface water may become contaminated through ground water discharge into ponds or streams by discharges from mill operations. Tailings ponds support little if any aquatic life because of their pH and toxic substances. However their effects on birds, particularly waterfowl, and other wildlife that may inadvertently use the ponds are not known. Large quantities of solid wastes must be disposed of at milling sites due to the fact that ore normally contains on the order of 0.2 to 0.3% uranium. Several types of environmental problems may result from tailings solids. Substances (e.g., selenium and strontium) may leach from the tailings and enter the ground and surface water when the tailings basin is permeable. Tailings must be kept moist to prevent wind erosion. Otherwise tailings particles will be transported to adjacent lands and waters where contaminants may be taken up by crops and ingested by livestock. Abandoned tailings are biologically unproductive due to their high acidity or alkalinity, lack of soil and moisture. If tailings ponds are to be covered with soil, when operations cease, additional areas must be disturbed to obtain this soil, and thus, increasing the area to be reclaimed. (23)

Battelle-Pacific Northwest Laboratories,
Chemistry Department, Richland, WA
Hajek, B.F. 1967. BNWL-CC-208; 20 pp.
Adsorption, Migration, and Dispersion of Strontium and Cesium in an A-Horiz Soil (7)

Experiments were run to determine the potential for disposal of emergency liquid waste water to the ground as a safe and

(18) COST

economic alternative to tank storage. This alternative would only be used in the event of a reactor primary loop failure. A preliminary study was also included in the investigation. Adsorption, migration, and dispersion in the soil with respect to strontium and cesium was studied. The grain size of the soil is 60% less than 2 mm. The distribution coefficients were found to be 220 and 21 m²/g for cesium and strontium, respectively. Calculations based on theoretical equations and equilibrium distribution coefficients indicated that the average migration rate of cesium through a soil column should be 1/10 the rate of strontium. The actual migration rate of cesium through the column was 1/11 of the strontium rate. Migration rates for strontium and cesium were 1/100 and 1/1000 the rate of ground water movement, respectively. The average infiltration rate was determined to be 170 cm/day. The diffusion coefficients were also found to be 1.5×10^{-11} m²/sec and 2.1×10^{-12} m²/sec for strontium and cesium, respectively. It was found that the diffusion coefficients indicate spreading by diffusion is negligible. From the experimental and mathematical results the soil appears to be able to handle any accidental release. (197)

Distribution Coefficient; Dispersion Coefficient; Infiltration Rate; Grain Size Distribution

(19)

Battelle-Pacific Northwest Laboratories, Earth Sciences Section, Environmental and Radiological Sciences, Richland, WA

Wies, L.L., Jr., and R.F. Hajek. 1966, March 8. BWL-CF-539; 10 pp.

Statistical Analysis of Cesium and Strontium Sorption on Soils (3)

The distribution coefficient is a useful concept in studying radionuclide sorption processes, but is dependent on the laboratory working conditions. To circumvent this drawback, a study was undertaken to establish the feasibility of statistically evaluating radionuclide sorption data, and obtaining regression equations that would permit the calculation of radionuclide distribution as a function of several influencing factors. The statistical design used was a simple two-level factorial, which provided 16 factor combinations. The four factors involved were NaOH, NaOH, NaOH, and Ca(NO₃)₂ at two concentration levels. Each design table was used for Ca 130 and Sr 85, which were the dependent variables. For both cases comparison between the original and final solution or column counts of equal volume were made. The Yates method of factorial analysis was used to determine the effects of factor variation on the dependent variable. For Ca 130, NaOH, NaOH, Ca(NO₃)₂, and NaOH concentrations were all statistically significant at the 5% level. Regression coefficients were obtained and a regression equation derived. At the 5% level there were no significant effects of the independent variables on Sr 85 for the concentrations used. Further work indicated significance was achieved when the concentration range of NaOH was lower. It was found that several replicates may be necessary to improve precision and lower the errors involved in the resulting regression equation. The study

showed the importance of an accurate number and value for the independent variable ranges of the actual radionuclide wastes. Future work should include soil characteristics and use of high and low concentrations of actual waste chemical constituents along with radionuclides of interest. (197)

Distribution Coefficient

(20)

Battelle-Pacific Northwest Laboratories, Environmental and Life Sciences Division, Water and Land Resources Department, Richland, WA

Cearlock, D.B., and R.B. Hertz. 1970, November. BWL-1503; 33 pp.

Analysis of Hydrological Factors Influencing the Operation of the 100-B Emergency Waste Disposal Crib (7)

An analysis of the transport of radionuclides through the soils was done at the Hanford Reservation. It was to determine the nuclear safety of an emergency waste disposal (EW) crib for both emergency and fuel element ruptures. Also the analysis was done considering another crib in conjunction with the EW crib. Features in this report are the hydrological factors affecting the operation of the crib. A mathematical simulation model was used to predict the groundwater flow system. It was a two-phase analysis at the horizontal plane which allowed for the consideration of more than one source, neglected the vertical flow component, (assumed) inflow and outflow surfaces to penetrate the entire system, (assumed) equal thickness constant, and (assumed) permeability constant with respect to depth. These assumptions were reasonable due to the close proximity of the Columbia River. The ground water potentials were measured periodically and the effective porosity was taken to be 2 to 12% for the worst and best conditions. From the analysis, there is a significant advantage in operating the EW crib with 1301-B crib. With the two of them in operation a 99.8% and 90% reduction in maximum total iodine and tritium, respectively, entering the Columbia River over that obtained through use of the 1301-B crib. If only the EW crib is used the reduction in maximum total iodine and tritium was 55% and 6%, respectively. The reduction in iodine occurred due to both decay and flow geometry but only the flow geometry reduces the amount of tritium entering the river because of the short travel time (5 to 12 days). A major result of this study is 12 to 13 day travel time is more realistic than the present field estimate of 5 days. This is with both cribs in operation. (197)

Transmissivity; Effective Porosity; Hydraulic Gradient; Hydraulic Velocity; Depth to Water Table

(21)

Battelle-Pacific Northwest Laboratories, Environmental and Life Sciences Division, Water and Waste Management Department, Richland, WA

Knoll, R.C. 1969, January. BWL-860; 13 pp.

Reactions of Organic Wastes and Soils (9)

(21) CONT.

The results of laboratory experiments to determine the effects of organic matter from a nuclear facility on the ion exchange and permeability of the soil through which it passes are presented in this report. The objectives of this study were to determine the movement of organics through the soil, to measure the effect of organics on permeability as well as ion exchange properties of the soil, the removal of radionuclides reversibly adsorbed and the adsorption of radionuclides from the organic solutions. The experiments were performed in 5 cubic centimeter (0.6 x 1.9 x 1.9) glass tubing into which 0.5 cc of soil was packed. Permeabilities were determined by a falling head permeometer. Ion exchange phenomena were established by careful monitoring of column influent and effluent. Each type property results are presented in terms of percent activity removed per column volume of fluid passed through the tubing. The results showed little effect of the presence of organics on permeability or on ion exchange. The soil was shown to remove some of the plutonium and americium from the organic wastes. A mixture of 0.5 M diethylamyl phosphoric acid and 0.2 M triethyl phosphate in carbon tetrachloride and hydrocarbon acid were shown to appreciably remove Pu 239 and Pu 241 and to a lesser extent Pu 238. (Bath) (JC)

The data presented in this paper offer insight into the effect of organic substances such as tributylphosphate on radionuclide migration from burial trenches. These substances have been reported in trench leachate analyses from Laxar trenches. (Bath) (JC)

Hydraulic Conductivity

(22)

Battelle-Pacific Northwest Laboratories, Environmental Evaluation Section, Occupational and Environmental Safety Department, Richland, WA

Soehnlein, J.W. 1979, December. BNWL-1779; 9 pp.

Hanford Waste Disposal Summary, 1972 (1)

An inventory of the radioactive wastes released to the environs at Hanford. Releases to the Columbia River by direct discharge from the B-reactor and indirectly from the 100-A Area crib totaled 1300 Ci and 7000 Ci respectively. The total volume of liquid radioactive wastes discharged to the cribs from the various area cribs totaled 2.5 x 10¹⁰ liters. Radioactive gaseous discharge to the atmosphere averaged 1.0 x 10¹⁰ Ci, primarily Argon 41. Solid wastes totaled more than 1.8 x 10¹⁰ Ci. Routine surveillance of the environment indicated radioactivity as less than 10% of the Concentration Guides. (JF)

Major emphasis is on liquid radioactive wastes released into the ground. A general inventory of the radionuclides released to the ground is provided. Minimal data are presented on the solid waste inventory. (Bath) (JC)

(23)

Battelle-Pacific Northwest Laboratories, Nuclear Waste Technology Program, Richland, WA

Sarason, R.W.C. (Project Manager). 1975, September. BNWL-1736; Nuclear Waste Management and Transportation Quarterly Progress Report, April through June, 1975, (pp. 51-66) (BNWL-1736).

Disposition of Retired, Contaminated Facilities at Hanford (3)

This chapter assesses the progress that has been made towards the disposition of retired facilities. It reviews the collection of bibliographies, the technical progress that is made in terms of site characterization, disposition of the waste, and the removal and development which is needed for decontamination. (JF)

A review of the progress reports will cover the retiring of the contaminated facilities. (Bath) (JC)

(24)

Battelle-Pacific Northwest Laboratories, Nuclear Waste Technology Program, Richland, WA

Ellison, J.W. (Project Manager). 1975, September. BNWL-1736; Nuclear Waste Management and Transportation Quarterly Progress Report, April through June, 1975, (pp. 57-62) (BNWL-1736).

Characterization of 300 Area and Wye Burial Grounds (1)

The paper is a summary of the progress made to date on the characterization of the 300 Area and Wye burial grounds. The following topics were reported on, each by the principal investigator in the work. 1) Waste detection and mapping - concerning geophysical methods and computer codes used to locate buried waste material; 2) Drill sampling, wells and analysis - involves interpreting drillers logs in terms of lithologic boundaries; 3) instrumented wells and soil characterization - monitoring fluid transport through the 300 North burial grounds. Bulk density, fluid content, temperature, depth and matrix potential are related and viewed seasonally; 4) evaluation of moisture movement mechanisms and modeling - looks at the factors controlling fluid movement; and 5) evaluation of biological transport mechanisms - looks at the effects of burrowing animals on contamination potential. (JF)

A summary of the work done to date on various aspects of the 300 Area and Wye burial grounds with respect to the local physical parameters. (Bath) (JC)

Moisture Potential; Temperature

(25)

Battelle-Pacific Northwest Laboratories, Nuclear Waste Technology Department, Richland, WA

Randel, J.E. 1973, July. BNWL-1745; 66 pp.

A Review of Leaching Test Methods and the Leachability of Various Solid Wastes Containing Radioactive Wastes (1)

A review of leachability experimental techniques and measurements from thirty-five published reports from ten different countries spanning the period of 1954 through 1972 is presented. Factors which affect leachability

with as release state of radioactive investigated, crystalline composition, crystalline structure, and test conditions are described. Primary emphasis is placed on studies of isotropic solid media suitable for the high temperatures and radiation fields associated with the solidification of high-level waste, however, several studies of other solidification media such as cement, bitumen, and polyethylene for the incorporation of low and intermediate-level wastes are also presented. The need for two different types of leach tests is emphasized, 1.) a rapid comparative test, and 2.) a more comprehensive performance test which attempts to closely simulate actual field conditions. (Auth) (P7)

Excellent review of the leachability of solidification media data. (P5/P7)

(26)

Battelle-Pacific Northwest Laboratories, Richland, WA

Barlett, J.W., R.C. Bartholmer, C. DeGish-Price, and V.S. Eymann. 1976, March. 1981-1978; Nuclear Waste Management and Transportation Quarterly Progress Report, October through December, 1975, A.E. Platt (Comp.), (pp. 1-15), 42 pp. (1981-1978).

Advanced Methods for Management and Disposal of Radioactive Wastes (7)

Report covers development of radioactive migration models for faulted media and homogeneous media; model differences being in coefficients used for different media types. Results of sampling public attitudes toward nuclear waste management reflect high priority of long term safety, followed by short term safety and accident detection. The lowest priority was cost factor. (P20)

(27)

Battelle-Pacific Northwest Laboratories, Richland, WA

Burton, L.L., J.A. Franz, and P.D. Schoele. 1976, March. 1981-1978; Nuclear Waste Management and Transportation Quarterly Progress Report, October through December, 1975, A.E. Platt (Comp.), (pp. 27-33), 63 pp. (1981-1978).

Tritium Separation and Fixation (3)

The goals of the program are to investigate isotopic separation as a means of concentrating tritiated aqueous wastes, to consider alternative procedures such as increased recycle of water, and to examine methods of fixing tritiated water for permanent storage. Thermal stabilization of polymers for tritium fixation were studied using thermogravimetric analysis (TGA). The development of a process for the fixation of T_2O in a polymer within minutes at room temperature, allowing optimization of the polymer for loading and leach testing of tritiated samples, was completed. Development of a procedure for T_2 fixation in styrene was delayed by difficulties with air oxidation of the homogeneous catalyst system. Several hydride samples have been prepared

reacting with zircalloy metal. High reactivity levels, notably appreciable amounts of oxygen, nitrogen, and carbon, and slow reaction rates have been consistent problems. Further changes in techniques have been made to initiate the reaction. (Auth) (P7)

(28)

Battelle-Pacific Northwest Laboratories, Richland, WA

Baron, L.R. 1976, March. 1981-1978; Nuclear Waste Management and Transportation Quarterly Progress Report, October through December, 1975, A.E. Platt (Comp.), (pp. 33-41), 63 pp. (1981-1978).

Disposition (B and D) of Retired Contaminated Facilities at Hanford (2)

The program has the following objectives for FY 1975-1976: to establish authority, costs and priorities for the disposition of retired (excessed) Hanford facilities; to formulate plans and specifications for a contract to accomplish permanent disposition of a retired Hanford facility; and to identify required facility disposition BDO. Radiochemical criteria governing the release and use of a reactor retention basin system and the Bldg Plant plutonium concentration (211-5) building were developed, for four different use restriction categories. A computer-based management information system for the contaminated facilities at Hanford was developed and input provided for the liquid (1) pool sites, burial grounds, and reactor retention basin systems. This system, to be used for serving BDO priorities for retired contaminated Hanford facilities, was used to derive preliminary priorities among the various retention basin systems. Planning for the 211-5 BDO demonstration continued. The demonstration trench to be used in a test of a proposed technique for stabilizing contaminated ground sites was installed as planned. (Auth) (P70)

(29)

Battelle-Pacific Northwest Laboratories, Richland, WA

Williams, L.D. 1976, March. 1981-1978; Nuclear Waste Management and Transportation Quarterly Progress Report, October through December, 1975, A.E. Platt (Comp.), (pp. 51-55), 63 pp. (1981-1978).

Transportation Safety Studies (1)

The objective of the Transportation Safety Studies Program is to develop and use a model for calculating the risks associated with the shipping of radioactive materials. An assessment of the risk in transporting plutonium by train has been completed and is under internal review. The results indicate that the risk spectrum for the shipment of PuO_2 by train is similar to that previously calculated for truck shipment. The risk spectrum for the plutonium nitrate solution shipment by rail appears to be about an order of magnitude greater than that previously found for plutonium nitrate shipment by truck. An assessment of the risk in shipment of chlorine by rail has been initiated. A fault tree indicating the various ways that chlorine

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can be released during transport has been given in other system description information has been gathered, work on an assessment of the risk to transporting WPA continued. The work's description has been completed. Fault trees have been drawn, and a survey questionnaire to obtain human factor data has been completed. Efforts to develop transportation accident environment information for the large WPA containers were started. Work also continued on developing an assessment of the risk to the shipment of low-level beta-gamma wastes. The dose conversion factors and waste dispersion fractions have been defined for the beta-gamma wastes. (NATH) (PIO)

(30)

Pattelle-Pacific Northwest Laboratories,
Richland, WA

Phillips, J., and J. J. Raymond. 1975. SW-54-S49 (part 2); CONF-750967; Environmental Protection, Proceedings of the 3rd WPA Conference, held in Chicago, Illinois, September 23-26, 1975. (52 pp.) CONF-750967, SW-54-S49a).

Monitoring and Characterization of Radionuclide Transport in the Hydrogeologic System. (P)

Site determination and decontamination plans are needed on the Hanford Reservation since plutonium protection there has been curtailed. Each contaminated site will be relocated or placed in a stable condition with the minimum possibility of affecting the local environment. During operations at Hanford radioactive or contaminated materials were placed in locations which would minimize exposure to personnel. Specific conditions for disposal of these radioactive wastes were: 1) that the waste would not migrate in quantities sufficient enough to threaten personnel and 2) the locations of the radioactive material would be positively identified and records would be kept as long as significant quantities of contaminated materials remained. The 100 North and 100 South Grounds contain volumes of approximately 5000 m³ and 300 m³, respectively, of buried waste. Low-level wastes were collected in square cardboard cartons which were placed in open trenches in a controlled burial ground. Intermediate level wastes were placed in some aluminum cylinders which were sealed, then transported in lead casks to a burial ground into which they were loaded, through a chute, into a buried vertical cask. In many instances the casks were sealed with concrete. High-level wastes were sealed in 11 commercial cans and disposed of in special revolving Pb casks. They were buried in the same manner as intermediate-level wastes. New techniques have been employed to detect buried waste. These include: 1) a metal detector, 2) a magnetometer, 3) acoustic, 4) ground penetrating radar and 5) infrared imaging studies. Sediment-fluid interaction and fluid migration were characterized. A study to determine biological transport of radionuclides was initiated. In future work drilling techniques will be developed and utilized in order to determine amount of waste migration as well as for recovering and characterizing sediments and contaminated material. (P)

Begin with monitoring and characterizing disposed high-, intermediate- and low-level waste. Tables

and 2 provide data on bulk density, saturated water content, and hydraulic conductivity. (P/JM)

Hydraulic Conductivity; Volumetric Water Content; Waste Volume; Density

(31)

Pattelle-Pacific Northwest Laboratories,
Richland, WA

Price, E. S. 1977, December. SW-54-S49; 67 pp.

A Critical Review of Biological Accumulation, Discrimination, and Uptake of Radionuclides Important to Waste Management Practices, 1963-1977. (P)

Plutonium from fallout has been considered a minimal hazard to man as long as particles deposited on vegetation and soil remain deposited. However, a slight downward movement into undisturbed soil profiles at the Nevada Test Site during the 10 years following deposition was observed. While solubility of plutonium in the presence of soil is poorly understood, an infiltration depth of 12 cm was attributed to the downward movement of the high density particles and solubilization. Other studies have shown plutonium particles having a similar number and associated with greater than 10⁶ particles. Horticultural soils from Denver showed 5% wt of the plutonium to be below 5 cm in the first 10 cm of the soil profile. However, other samples taken in the Rocky-Plains area showed 60% of the plutonium to be in the upper 5 cm, and the deep penetration in Denver was attributed to horticultural techniques. Sorption from soil was found to be greater than 97% when the pH was between 2 and 4. Sorption is also dependent on oxidation state. If a Ca-bentonite clay is used the release may be successful in 1), followed by 2) and 3). In water environments the hydrolysis products exhibit colloidal behavior, and may form noncolloids when sorbed. The most common form in natural waters is plutonium (IV) (Pu(IV)). This state changes particle charge depending upon the concentration and pH and hence confirms the suggestion that radionuclides are positively charged up to about pH 9 and negatively charged at higher pH's. The behavior of the cation would partially explain the soil sorption phenomenon. However, when leaching tests are performed only 0.1 to 1.5% Pu is released indicating that solubility is more important than soil exchange mechanisms to the movement of plutonium in the soil. Plutonium movement through the Los Alamos Tuff was explained by water movement through fissures although the possibility existed for organic complexes to be present. In leaching studies plutonium was observed to be tightly held by soils when leached by 100 ppm solutions of nitric, carbonic, or acetic acid as well as a 10% saturated water. However, any complexes formed would not be easily removed from solution but would be from the soil. The solubility of plutonium in the soil was demonstrated with extracting solution using an equilibrium technique. Other transuranic elements such as americium, cerium, and neptunium have received very little attention. The leachability of americium is greater probably due to soil exchange. It is also much as easy to remove americium from soil by organic solvents than was plutonium. Current in respect of forming colloids and behavior similarly to plutonium. Behavior of neptunium in soils is unknown. (P/P)

<10> CONT.

Geologic history of the geotectonic
periods from 1941 to 1971 is given. (ESIC/CSM)

<11>

Battelle-Pacific Northwest Laboratories,
Richland, WA

Paymont, J.P., P.A. Burns, J.J. Pitt, V.L. McKen,
and P.P. Schroeder. 1976. March. ENEC-1976: 69
pp.

Environmental Monitoring Report on Radiological
Status of the Ground Water Beneath the Hanford
Site, January-December 1976 (1)

Low- and intermediate-level radioactive wastes
have been disposed to the ground at the
Hanford site since 1949. Liquid wastes
percolate laterally and downward through up to
100 ft of unconsolidated sediments overlying
the water table. Some of the longer lived and
more hazardous radionuclides are effectively
removed from the water because of favorable
ion-exchange characteristics whereas others
eventually enter the ground water. The
contaminants which enter the water table are
transported with the groundwater and their
concentration is reduced by radioactive decay,
ion exchange, diffusion, and hydrodynamic
dispersion. More than 700 monitoring wells,
used for obtaining geologic, hydrologic and
water quality data, have been drilled to water
since the beginning of operations at Hanford.
Some penetrate basalt bedrock, others pierce
the first impervious layer below the water
table and still others have just been drilled
only a few tens of feet below the water table
in the unconfined aquifer. Two hundred fifty
of these wells were used in the 1976
Groundwater Monitoring Program. From these
wells, 655 samples were taken and these
provided nearly 2000 analytical results. Most
groundwater samples are collected near the
water surface of the unconfined aquifer
because that is where the highest
concentration of contaminants occurs. A study
to define vertical stratification of
contaminants is underway. Radionuclides
represented by beta- γ , α and β analysis
are easily and cost effectively detected in
low concentrations and since they appear in
the highest concentrations in the groundwater
they are utilized as tracers in assessing
groundwater contamination. The map
configurations of beta- γ , α and β
contamination in the unconfined groundwater
show essentially no changes over the previous
reporting period. Besides the primary tracers
analyses were made for Pu 239, Pu 240, Co 60,
I 131, I 135, Sr 90, Sb 125 and Cs 137.
Several of these nuclides occur at relatively
low levels in the ground water beneath the
Hanford site and their relative concentration
and distribution generally follow the pattern
of the primary tracers. In summary there is
presently no observable effect of ground water
transport of contaminants from the chemical
separation as on the Columbia River. (2)

Tracers derived from low- and intermediate-level
waste used to track ground water from beneath
Hanford Site are of direct relevance. (28/30)

<12>

Battelle-Pacific Northwest Laboratories,

Richland, WA

1976. Pay. ENEC-76-47: Alternatives for Managing
Wastes from Reactors and Post-Fission Operations
in the LWR Fuel Cycle, Vol. 4, (No. 24-1-76-47)
(ENE-76-47).

Geologic Storage Alternatives. Serial Grounds
(1)

Current disposal practices at the 6 commercial
facilities and 5 ENEC sites for burial of
wastes are briefly discussed. Burial in this
instance is understood to mean "placement of
waste at relatively shallow depths in earth
materials, with no intent or provision for
ready retrievability at a later date.
Chem-Nuclear Systems, Inc. operates a
commercial site at Barnwell, SC while Nuclear
Fuel Services operates one at West Valley, NY.
The rest of the commercial sites are run by
Nuclear Engineering Company at Sheffield, IL;
Beatty, W; Richland, WA; and Trenchard, NY.
The wastes generally accepted at these sites
are low-level and come from the nuclear fuel
cycle, educational institutions, hospitals,
government installations, industrial research
and production facilities, pharmaceutical
manufacturers and waste disposal and
decontamination companies. The exact wastes
accepted, waste packaging required, waste
treatment, burial procedures, special burial
techniques, disposal location markings and
records, burial site inventory, burial
charges, licensing, and hydrologic
characteristics are outlined in detail. A
similar discussion of the wastes disposed of
in the 5 ENEC sites is also presented. The
ENEAC sites are: Savannah River Laboratory,
SC; Idaho National Engineering Laboratory, ID;
Oak Ridge National Laboratory, TN; Hanford,
WA; and Los Alamos Scientific Laboratory, NM.
Decontamination, physical case, and resource
commitments are also included in the topic
lists. Although no hazards have been found as
a result of leakage from the above burial
grounds better retention can be had by
improved engineered containment,
administrative measures and decontamination.
Finally, increased containment of radionuclides by
a burial site may be had by a better
understanding of the geology and hydrology of
the area and in what region the site is to be
located. (28/3)

Tables containing commercial burial ground
operations, waste inventories, licensing of
commercial sites, site characteristics; ENEAC
burial ground operations, waste inventories, and
site characteristics are included. Monitoring
programs are also tabulated. (ESIC/NDV)

<13>

Battelle-Pacific Northwest Laboratories,
Richland, WA

Pai, D., and P.J. Searcy. 1977. January-March.
Journal of Environmental Quality, 6(1), 69-75.

Plutonium Activities in Soil Solutions and the
Stability and Formation of Selected Plutonium
Materials (2)

Selected thermodynamic data was used to
develop solid phase-soil solution equilibria
diagrams which are used to predict and
understand plutonium behavior in terrestrial
environments. The plutonium mineral
transformations in soils are highly dependent
upon the pH, Eh, and the soil solution
composition. The predictions of weathering and
formation sequences of various plutonium

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minerals at pH values from 3 to 11 at pO₂ from 9.69 to 96, and in an assumed weathering environment are given. The study shows that FeO₂ is the most stable mineral in the pH and pO₂ ranges found in terrestrial environments. Also, the nature and activity of ions and ion-complexes and, hence, the total plutonium in solution is a function of the stable phase, Fe, Pb, and complexing ions. (Roth)(GM)

Solid phase-soil solution equilibria diagrams and thermodynamic data can be used to predict plutonium behavior, such as migration, in terrestrial environments. (DZ/GM)

<35>

Battelle-Pacific Northwest Laboratories, Richland, WA

Bartlett, J.V. 1976, August. ACS Symposium Series No. 35: Actinides in the Environment, R.H. Friedman (Ed.), Proceedings of a Symposium held in New York, New York, April 9, 1976, pp. 1-7, 107 pp.

The Role of Actinide Behavior in Waste Management (3)

A brief but accurate description of the problems encountered in the field of waste management. The topics reviewed include: repository system, repository degradation, geosphere transport, geosphere-biosphere interface, biosphere transport and biosphere consequences. The lack of data in many of these areas is discussed. (LS)

Brief introductory paper describing in general terms the concept of waste disposal and its ramifications. (DM/LS)

<36>

Battelle-Pacific Northwest Laboratories, Richland, WA

Onishi, T., P.A. Johanson, P.C. Dace, and P.L. Willy. 1976, January. BNWL-B-052; 41 pp.

Studies of Columbia River Water Quality (3)

A quasi-two dimensional mathematical simulation model has been developed for determining radionuclide inventories, their variations with time, and movement of sediments and individual radionuclides in the freshwater region of the Columbia River below Priest Rapids Dam. Numerical examples are given. River temperature data accumulated by WSSS is also employed. (HWM)(JT)

A general review of the quasi-two dimensional models developed for determining the movement of radionuclides in fresh water.

<37>

Battelle-Pacific Northwest Laboratories, Richland, WA

Wilson, B.V. 1965, January. BNWL-16 (Part 0); Hanford Radiological Sciences Research and Development Annual Report for 1964, B.V. Pearce and J.E. Green (Eds.), (pp. 0.1-0.0), 571 pp. (BNWL-16, Part 0).

Development Annual Report for 1964, B.V. Pearce and J.E. Green (Eds.), (pp. 0.16-0.26), 571 pp. (BNWL-16, Part 0).

A Sequence for Predicting Waste Transport by Ground Water (3)

A sequence of steps for analyzing ground water flow and predicting rates and paths of movement is described. Three computer programs are used to yield data in forms useful for subsequent steps and definitive of the ground water behavior with respect to outflow paths and rates. Input data required for the computations include the distribution of potentials (fluid heads) throughout the region of interest, boundary permeability data, representative data on relative capillary conductivity versus capillary pressure head of the soils, and the configuration of flow system boundaries. Independent fitting functions are also required to supplement the derived mathematical computation and program. (Roth)

<38>

Battelle-Pacific Northwest Laboratories, Richland, WA

Payson, J.B. 1965, January. BNWL-16 (Part 0); Hanford Radiological Sciences Research and Development Annual Report for 1964, B.V. Pearce and J.E. Green (Eds.), (pp. 0.27-0.35), 571 pp. (BNWL-16, Part 0).

Earth Material Sampling by Coring Techniques (9)

Methods and techniques are described and equipment shown for small diameter hole core sampling of consolidated and unconsolidated materials. Cores are taken by the bit displacing the material into a hollow barrel or tube. The core barrel is advanced into the material by rotational and/or compressive and impact forces applied through a drill rod to a bit (drive shoe). One method of coring is to use drive sampling equipment. The sampler consists of a bit, core lifter, sample barrel, and sampler head. The sampler is driven into the ground by a drive hammer, which is a heavy steel weight. This technique is useful only with soft or unconsolidated porous media where the bit can compress or displace material as in crib bottoms and shallow wells. The equipment for rotary coring consists of: drill bit screwed on the end of a core retaining barrel, drill rods attached to the upper end of the core barrel, and a power source to rotate the rods and apply compressive pressure on the bit. Drilling fluid is used to flush the hole of cuttings. Any material may be cored with this technique provided proper methods and equipment are used. Factors that affect coring are: bit, core lifter and core barrel design, rotary speed, bit pressure, and drilling fluid type, viscosity, flow rate, and pressure. (HWT)

<39>

Battelle-Pacific Northwest Laboratories, Richland, WA

Wajot, B.V. 1965, January. BNWL-16 (Part 0); Hanford Radiological Sciences Research and Development Annual Report for 1964, B.V. Pearce and J.E. Green (Eds.), (pp. 0.1-0.0), 571 pp. (BNWL-16, Part 0).

(19) CONT.

Case Absorption, Diffusion, and Dispersion Characteristics of Ions in Soils (19)

Absorption and diffusion characteristics of Cl^- , $(\text{NO}_3)^-$, $(\text{SO}_4)^{2-}$, $(\text{CrO}_4)^{2-}$, and $(\text{Cr}_2\text{O}_7)^{2-}$ were determined in a Hanford soil. The equilibrium distribution coefficients for phosphate, arsenate, and chromate ions in tap water are 10.86, 12.97, and 36.37 ml/g, respectively. The coefficients were also determined for distilled water and at concentrations of 10, 25, 50, 100 ppm. Adsorption selectivity is $(\text{Cr}_2\text{O}_7)^{2-}$, $(\text{SO}_4)^{2-}$, $(\text{NO}_3)^-$, and Cl^- in descending order. It was found that any small change in pH, ionic strength, accompanying ions, and equilibrium time will greatly change the amount of sorption. The diffusion coefficients ranged from 0.21×10^{-6} to 1.2×10^{-6} cm^2/sec . Verification was also presented of the need to separate the diffusion and hydraulic dispersion coefficients in the dispersion equations. The breakthrough curves for phosphate, chloride, and chromate were shown. (SDV)

Distribution Coefficient: pH: Diff. Coefficient

(20)

Pattelle-Pacific Northwest Laboratories, Richland, WA

King, L.G. 1965, January. BNWL-36 (Part 4); Hanford Radiological Sciences Research and Development Annual Report for 1964, D.W. Pearce and J.K. Green (Eds.), (pp. 4.47-4.50), 571 pp. (BNWL-36, Part 4).

Measurement of Soil Characteristics for Partially Saturated Flow. (2)

Methods are described for obtaining and analyzing data for simultaneous laboratory measurement of liquid permeability, saturation, and capillary pressure of partially saturated porous media. The attenuation of gamma rays from an Am^{241} source was used to measure saturation of a column of soil. A typical set of results is shown. Results of this type are needed as input data for solution of partially saturated flow problems related to waste disposal analysis. (Both)

(21)

Pattelle-Pacific Northwest Laboratories, Richland, WA

Ames, L.L., Jr. 1965, January. BNWL-36 (Part 4); Hanford Radiological Sciences Research and Development Annual Report for 1964, D.W. Pearce and J.K. Green (Eds.), (pp. 4.8-4.12), 571 pp. (BNWL-36, Part 4).

Linde 13X Equilibria with Trivalent Cerium and Yttrium Cations (1)

Cation exchange equilibria of zeolite Linde 13X in a sodium-cerium, sodium-yttrium, and strontium-cerium systems were studied. It was found that the zeolite has an ion capacity for cerium of 3.6 meq/g. A selectivity coefficient was determined at equilibrium and corrected for nonideal behavior of the cations

in the solution and on the zeolite. The method is outlined in the appendix. The zeolite is highly selective for cerium in the presence of sodium but prefers strontium to both cerium and sodium. (SDV)

Cation Exchange Capacity

(22)

Pattelle-Pacific Northwest Laboratories, Richland, WA

Beisenauer, A.E. 1965, January. BNWL-36 (Part 4); Hanford Radiological Sciences Research and Development Annual Report for 1964, D.W. Pearce and J.K. Green (Eds.), (pp. 4.53-4.55), 571 pp. (BNWL-36, Part 4).

Iterative Calculation of One-Dimensional Transient, Partially Saturated Flow (2)

Horizontal, one-dimensional, transient, partially saturated flow in porous media can be solved numerically by an iterative procedure based on Philip's method. The equation takes into account saturation, time, horizontal distance, diffusivity, permeability, liquid viscosity, soil porosity, and capillary pressure. Substitution in the original equation reduces it to simpler terms and simpler boundary conditions, which can be handled easily in a computer program. Saturation and permeability at capillary pressure are used as input to determine the diffusivity. An average diffusivity value is calculated with 100 increments of saturation. By using 1000 increments diffusivity for initial estimates is calculated. Parameters required for input are: initial saturation, the final saturation, porosity, and the column area as well as parameters needed for the diffusivity calculation. The results listed in the output are: diffusivity and phi values as a function saturation for each iteration and the moisture profile. The profiles are integrated to give the accumulated volume inflow for each time. An error function is also included. An immediate application of this method is the prediction of transient development of flow pattern beneath a waste storage tank or pipeline. (SDV)

(23)

Pattelle-Pacific Northwest Laboratories, Richland, WA

Ames, L.L., Jr. 1965, January. BNWL-36 (Part 4); Hanford Radiological Sciences Research and Development Annual Report for 1964, D.W. Pearce and J.K. Green (Eds.), (pp. 4.6-4.7), 571 pp. (BNWL-36, Part 4).

Self-Diffusion Coefficients of Some Cations in Open Zeolites (1)

Sodium, strontium, and cesium self-diffusion coefficients were determined in the natural zeolites erionite, phillipsite, and clinoptilolite and synthetic zeolites Linde 4A and 13X. The method used was that of Wolfenrich and it involves loading a shallow bed with a nontracer solution then adding a tracer after equilibrium is reached. When two different grain sizes are used there is no difference in the self-diff. coefficients. With a solution of 0.2 M at 50 degree C the average self-diffusion coefficients range from

(33) 1967.

2.30×10^{12} to 1.43×10^{12} cm/sec.
At 70 degrees C the average self-diffusion coefficients range from 3.02×10^{12} to 1.43×10^{12} cm/sec. In general, the higher valence cations were the slower to diffuse, and the univalent were the most rapid. However, the rates seen in zeolites are rapid when compared to a highly cross-linked organic resin. (BIV)

Dispersion Coefficient

(34)

Battelle-Pacific Northwest Laboratories,
Richland, WA

Hajek, R.F. 1965, January. BNWL-36 (Part 4):
Hanford Radiological Sciences Research and
Development Annual Report for 1964, D.W. Pearce
and J.K. Green (Eds.), (pp. 6-5-6.6), 571 pp.
(BNWL-36, Part 4).

Clay Mineral Composition of Two Hanford Soils (2)

Two soils from the Hanford Reservation were analyzed by x-ray diffraction to determine the mineralogical composition. One soil came from a valley south of Cable Mountain and the other was collected from near the Columbia River in the vicinity of F-Reactor. During the fractionation all the exchangeable divalent cations, free carbonates, iron oxides and organic matter were removed. Within all size fractions except the 2-0.2 μ fraction of the F-Reactor soil, montmorillonite is the most abundant clay mineral. In all size fractions of the Valley soil, montmorillonite is the most abundant clay mineral. Vermiculite, mica, chlorite, and traces of kaolinite were found in both soils. It is essential to have a qualitative knowledge of mineralogy of the soils because the clay minerals contribute most to the active portion of the soils and the basic knowledge of radioactive-clay mineral system can be applied when the mineralogy is known. (BIV)

(35)

Battelle-Pacific Northwest Laboratories,
Richland, WA

Brown, P.L. 1965, January. BNWL-36 (Part 4):
Hanford Radiological Sciences Research and
Development Annual Report for 1964, D.W. Pearce
and J.K. Green (Eds.), (pp. 6-10-6.16), 571 pp.
(BNWL-36, Part 4).

The Movement of Ground Waters in Confined
Aquifers Beneath the Hanford Project (1)

In 1960, it was found that the existence of gentle but progressively greater folding with depth of the Ringold Formation allowed identification of aquifers which low-level radionuclides could move to depth. In 1962, traces of radon were detected in a highly confined aquifer in the upper part of a basalt series several hundred feet below the Columbia River. Studies showed the radon was entering the aquifer through an erosional window which exposed the upper Beverly Member of the basalt series. The Beverly Member is confined by the Ringold Formation silts and clays and by the Elephant Mountain basalt flow. Hence, there is no ready entry into the

Columbia River for water in this Member. Geophysical seismic work confirmed the stratigraphy in the Columbia River area in 1963. Piezometric gradients in the upper Beverly aquifer indicate seven recharge areas from all sides except the southeast. Piezometric head studies in wells confirm the above. Hydraulic gradient directions suggest that movement of ground waters in the aquifer are to the southeast toward Wallula Gap. The Priest Rapids Dam pool to the northwest recharges the upper Beverly Member aquifer, as do the Columbia Basin Irrigation Project and the contain its from the 200-Fast Area. These are in addition to the natural sources of recharge. Other studies have suggested that small anomalies in the unconfined water table gradients may be caused by local discharge of water from the upper Beverly Member aquifer into the water table aquifer. From this study the importance of a full awareness of ground water table flow in 3-dimensions, particularly between different aquifers is clearly shown. (BIV)

(36)

Battelle-Pacific Northwest Laboratories,
Richland, WA

King, L.C. 1965, January. BNWL-36 (Part 4):
Hanford Radiological Sciences Research and
Development Annual Report for 1964, D.W. Pearce
and J.K. Green (Eds.), (pp. 6-37-6.45), 571 pp.
(BNWL-36, Part 4).

Analytical Description of Soil Characteristics
for Partially Saturated Flow (1)

Two empirical equations are described for relating relative permeability to capillary pressure. Of the two, Carman's equation appears to fit the experimental data better and is certainly easier to use because of its simple form. An equation is also presented for representing saturation as a function of capillary pressure. This equation can be differentiated. Hence, the equation can be used to calculate relative permeability and diffusivity as functions of saturation in computer programs for solution of both steady and transient partially saturated flow problems involving radioactive liquid waste. The main utility of the equations appears to be in simplifying the handling of input data and programming for digital computers. They may also prove useful in studying wide ranges of possible soils in that a wide range is covered by Carman's small number of parameters. (BIV)

(37)

Battelle-Pacific Northwest Laboratories,
Richland, WA

Raymond, J.V. 1965, January. BNWL-36 (Part 4):
Hanford Radiological Sciences Research and
Development Annual Report for 1964, D.W. Pearce
and J.K. Green (Eds.), (pp. 6-36-6.39), 571 pp.
(BNWL-36, Part 4).

Use of A Neutron Well Probe (2)

The neutron well probe is used to describe subsurface stratigraphic breaks. The probe works on the basis of the more soil moisture present the higher the reading. Silts and shales give the higher readings because the

CST) CONT.

small pore size allows more water to be held than do the coarse-grained sediments, such as sandstones. The probe also aids in studying the subsurface moisture in the aeration zone above the water table and in determining the degree of saturation in the capillary fringe. The probe will determine the total porosity so an estimate can be made of ground water flow rates. Examples are given of the ability to determine position of the release formation, which is a fine sandy-silt zone. In one of the logs a perched water zone is noted. The water table on both logs is clearly evident. The neutron probe was originally designed for measuring moisture content of the soil adjacent to buried high-level, radioactive waste storage tanks. (PWT)

C68)

Battelle-Pacific Northwest Laboratories,
Richland, WA

Jacks, R. 1969. Industrial Water Engineering.
61721. 88-89.

Groundwater Flow Simulated on Computer Aids
Nuclear Plant Radioactive Waste Study (3)

A computer program which simulates the flow of groundwater has been developed for the Hanford nuclear plant. The patterns are displayed on a cathode-ray screen. Since the display screen allows for many patterns to be done it is extremely useful for limiting the flow of contaminated water and for other technologies. The figures that are included show the effect of adding points of withdrawal or injection to the original flow pattern. While this method is much better than drilling a well, it does require information which is computer oriented or laborious keypunching of cases of input information from hand-drawn plots. (PWT)

Examples of the system's capability are included.
(ESIC/PWT)

C69)

Battelle-Pacific Northwest Laboratories,
Richland, WA

Velson, R.V. 1965, January. BWL-36 (Part 4):
Hanford Radiological Sciences Research and
Development Annual Report for 1964. D.V. Pearce
and J.K. Green (Eds.), (pp. 8.27-8.29), 571 pp.
(BWL-36, Part 4).

The Permeability Integral: A Key to Measurement
in Heterogeneous Porous Media (2)

An analysis is provided of the efficient solution of the partial differential equation defining permeability distributions for heterogeneous porous media. The three results necessary for the solution of the problem are the permeability integral, the recently derived stream functions for heterogeneous media, and the complete differential of the potential. The manipulations of these three results are briefly outlined and the final result, permeability distribution, is noted. Simultaneous solution of a pair of ordinary differential equations, followed by integration of the derived permeability integral is the solution method. The procedure is accurate as well as efficient.

C70)

C71)

Battelle-Pacific Northwest Laboratories,
Technical Services Division, Radiation Protection
Department, Richland, WA

Wilson, C.B. (Ed.). 1970. May. BWL-13K1: 73 pp.

Evaluation of Radiological Conditions in the
Vicinity of Hanford for 1968 (4)

Combined effects of radioactive waste management practices of all Hanford contractors during 1968 were evaluated. The three important sources of contamination are: (1) disposal of reactor cooling water to Columbia River; (2) stack releases at the chemical separations area and laboratory areas; and (3) disposal of radioactive waste to ground. Disposal of cooling water to the Columbia River is the most significant contribution. The radioactive nuclides present in the reactor effluent are short-lived and disappear quickly through decay. So, the radiological contribution is extremely small. Seasonal fluctuations in river discharge cause corresponding changes in the radionuclide concentrations. Also, river bank covering releases some of the longer-lived nuclides, Sr 90 and Cs 137, to the water occasionally. For the study period, radionuclide concentrations decreased due to fewer production reactors remaining in operation. Phosphorus 32 concentration decreased from 260 pCi/l to 100 pCi/l due to the lower river transport. Airborne concentrations of I 131 were less than the analytical limit of 0.2 pCi/m³. Also noted was an increase in the first half of 1968 due to foreign nuclear testing. The doses of radiation were considered for the whole body, gastrointestinal tract bone, and thyroid (infant) in the average individual, typical Richland resident and average Richland resident. In the average individual 20 (5% of standard), 62 (8%), 250 (17%), 1700 (7%), respectively were found percent. For the typical Richland resident 3 (2%), 20 (5%), 0 (2%), 550 (11%), respectively were detected. In the average Richland resident 3 (2%), 25 (5%), 13 (10%), 390 (11%), respectively were found. The amounts of radionuclides introduced into the environment by the activities at Hanford were within accepted standards. Bare earth and ythion were also considered in the waste. (PWT)

Numerous graphs and charts used for presentation and comparison of data. Emphasis is on dose rate to the population in the vicinity. (ESIC/PWT)

C72)

Battelle-Pacific Northwest Laboratories, Water
and Land Resources Department, Richland, WA

Ahlstrom, S.W., and R.F. Foote. 1976.
CONF-760607; Environmental Modeling and
Simulation, Proceedings of a Conference held in
Cincinnati, Ohio, April 20, 1976, (5 pp.)
(CONF-760607).

Transport Modeling in the Environment Using the
Discrete-Parcel-Random-Walk Approach (2)

When formulating a mathematical model for
simulating transport processes in the

(51) 205.

environment, the system of interest can be viewed as a continuous of matter and energy or as a large set of small discrete parcels of mass and energy. The latter approach is used in the formulation of the Discrete-Parcel-Random Walk (DPRW) Transport Model. Each parcel has associated with it a set of spatial coordinates as well as a set of discrete quantities of mass and energy. A parcel's movement is assumed to be independent of any other parcel in the system. A Lagrangian scheme is used for computing the parcel advection and a random random walk concept is used for simulating the parcel diffusion and dispersion. The DPRW technique is not subject to numerical dispersion and it can be applied to three-dimensional cases with only a linear increase in computation time. A wide variety of complex source/sink terms can be included in the model with relative ease. Examples of the model's application in the areas of oil spill drift forecasting, coastal power plant effluent analysis, and solute transport in groundwater systems are presented. (auth) (M)

(52)

Battelle-Pacific Northwest Laboratories, Water and Land Resources Department, Richland, WA

Lee'son, R.C. 1973, Nat. A. DPWL-196-7; 59 pp.

A Review of Studies on Soil-Waste Relationships on the Hanford Reservation from 1945 to 1967. (M)

The literature regarding effects of the liquid waste disposal operations at Hanford on the soil environment was summarized and divided into studies pertaining to: 1) the vadose zone below a depth of twenty feet (lower vadose zone); 2) the saturated zone; 3) the vadose zone above twenty feet (upper vadose zone). The division is based upon the relative desirability of these zones for nuclear waste disposal (storage). Liquid nuclear wastes have been safely discharged to the lower vadose zone for over twenty years. It has been concluded that: 1) little movement of sorbed radionuclides by diffusion, leaching, and for particulate transport within ten half-lives of even the long-lived radionuclides occurs; 2) the sorbed radionuclides can only be removed from this zone by a cataclysmic occurrence in which the sediment in the lower vadose zone and the entrained wastes are both physically removed. The saturated zone is the second most desirable zone for radioactive waste disposal because water disposal to the saturated zone takes several years to travel from the disposal areas to the Columbia River. A finite time period for radioactive decay thus exists. Travel times considerably longer than that of the water itself can be anticipated for radionuclides which are sediment-sorbed such as Sr 90 and Cs 137. The saturated zone is a less desirable zone for waste disposal than the lower vadose zone because finite travel times for each nuclide do exist therein. Radioactive wastes accidentally released to the vadose zone above twenty feet (upper vadose zone) are carefully monitored and controlled, since this is the zone where possible organism contact is most probable. Radionuclides are not normally discharged to the sediments of this zone. The expectation is disposal of radioactive wastes containing sized fission products having an activity of 1.5×10^{-5} Ci of gross β per milliliter. It may be necessary to implement a monitoring program to determine

the level of sediment radioactivity as a guide to future management practices. It is concluded that the suitable climate, deep permeable sediments with adequate sorption capacities, and great depth to the water table render Hanford a nearly ideal environment for ground disposal of radioactive wastes. (auth) (M)

Ground disposal of radioactive wastes into the vadose and saturated zones at Hanford is discussed. (auth) (M)

(53)

Battelle-Pacific Northwest Laboratories, Water and Land Resources Department, Richland, WA

Abstract: S.V., R.C. Lee, and R.J. Gorman. 1973. DPWL-195; 70 pp.

Transport Model: Theory and Computer Implementation. (M)

A transport model was developed to predict the movement of radionuclides in the saturated and unsaturated sediments of the Hanford Reservation. The model is designed to work in conjunction with either the unsaturated hydraulic flow model or the saturated aquifer model developed at DPWL. Transport model utilizes hydraulic velocities generated by these models together with soil waste reactions to predict contaminant movement. In the report, the fundamental model equations are first formulated, then specific forms of the model are derived for predicting the distribution and movement of dissolved minerals and radioactive elements present in trace quantities. Mathematical model is based on the two dimensional form of the general diffusion convection equation which considers variable dispersion coefficients and variable media thickness, as well as all possible source and sink terms. The numerical algorithm used is based on particle in a cell technique (method of characteristics). The program has been tested and verified on both one dimensional and two dimensional test problems, in addition to a large-scale test using field data gathered by sampling numerous wells in the Hanford Area. (auth) (M)

A working transport model was developed. The major difficulty apparently was obtaining all the detailed and accurate space-dependent hydrogeological parameters required by the model in order to be accurate. Methodology is one of several accepted numerical algorithms for the dispersion convection equations. (auth) (M)

(54)

Battelle-Pacific Northwest Laboratories, Water and Land Resources Department, Richland, WA

Abstract: L.E., D.H. Friess, and R.L. Kipp. 1973. DPWL-196-7; 39 pp.

The Transmissivity Iterative Program on the PDP-9 Computer, A Man-Machine Interactive System. (M)

A system of computer programs, the Transmissivity Iterative Sequence, has been written with the purpose of providing an analytical aid in the simulation of groundwater flow. This man-machine interactive system directly involves the user

<53> 1087.

making decisions in the analysis loop. Because of the limited amount of data available, this analysis loop is highly iterative in nature and its success depends on the ability to rapidly input and output information in a form directly related to the groundwater system being analyzed. The iterative sequence provides these analytical capabilities in a self-contained computer package which constitutes a useful tool for modeling a ground water system. (Ruth)

Detailed explanation of the transmissivity calculation programs from the given water level potential contours and some well measured transmissivities. Places where decisions during execution of the program are detailed. Useful though somewhat academic methodology. (DN/72)

<55>

Battelle-Pacific Northwest Laboratories, Water and Land Resources Department, Richland, WA

Cearlock, D.R., K.L. Kipp, and R.P. Friedrichs. 1975. May. BNWL-1706; 78 pp.

The Transmissivity Iterative Calculation Routine: Theory and Numerical Representation (3)

A computer routine is developed to determine two dimensional space dependent transmissivity or hydraulic conductivity values using numerical integration of appropriate transport equation along streamlines, with input values of water table potential surface and some field measured transmissivities or hydraulic conductivities. The computer code is applied to the water table aquifer of Hanford Reservation and the results are utilized in a water transport model. (00)

Methodology is developed to calculate transmissivity or hydraulic conductivities from water level contours and some known values of transmissivities, method is straightforward and useful. Only drawback being it requires considerable information in order to be reliable. Data on BNWL is included.

<56>

Battelle-Pacific Northwest Laboratories, Water and Land Resources Department, Richland, WA

Pearson, P.C., and P.J. Serne. 1972. BNWL-1718; 44 pp.

One Dimensional Model of the Movement of Trace Radioactive Solute through the Soil Column: The Percol Model (1)

A one dimensional mathematical model, PERCOL, has been developed to predict the movement of radionuclides through porous media as a function of measurable chemical parameters of the media. Laboratory column studies were conducted to verify the model (BNWL-1719). System parameters considered include soil type, radionuclide type, waste composition, flow rate, column length, and soil saturation. The agreement between measured radionuclide movement and that predicted by the model is considered good. (Ruth)

A valuable reference on simulation of the chemical interactions within a porous medium.

Functions and results appear logical and adequate. Only drawback may be the amount of preliminary information required to run the model. (DN/72)

<57>

Battelle-Pacific Northwest Laboratories, Water Resources Systems Section, Richland, WA

Kipp, K.L., W.L. McGhan, and D.W. Damschen. 1973, June. BNWL-1739; 111 pp.

Hanford Wells (4)

More than 1600 wells were constructed in the Hanford Reservation area; as of June, 1973, 1307 still existed. Seven hundred fifty of these wells were drilled to the groundwater table with 640 still containing water. The others have become dry through infiltration of sediments or a general lowering of the water table in their vicinity. Some wells were constructed as sources of water, others as study groundwater in the vicinity of waste disposal facilities and still others to aid in obtaining regional geologic data. A tabulation of existing wells and others for which data are recorded is given. The information provided well designation, coordination, elevation of casing, drilled depth, depth to water, casing diameter, elevation of the bottom of the well, status and maximum depth to perforations, data completed, former designations, well identification number, and comments. These data can provide essential input in the design and the implementation of any ground water monitoring program. (JW) (CSF)

This report provides a complete documentation of wells in and adjacent to the Hanford Reservation. Data can be used in implementation of monitoring programs. (DN/JW)

Depth to Water Table

<58>

Battelle-Pacific Northwest Laboratories, Water Resources Systems Section, Richland, WA

Kipp, K.L. 1973, August. BNWL-1742; 27 pp.

Biological Status of the Groundwater Beneath the Hanford Project, July-December 1972 (1)

A summary of the status of groundwater contamination which resulted in the disposal of radioactive effluents from Hanford Plant operations. Several groundwater samples, collected from wells within or near the zone to which 200 Area effluents have been released, indicate the presence of tritium, strontium 90, cesium 137, cobalt 60, ruthenium 106, and nitrate ions. Concentration guide limits were exceeded in four wells, ruthenium 106 in two wells, strontium 90 in one well, and nitrate ions in fourteen wells. Samples collected in 100 Area and 300 Area wells and their associated 600 Area wells, indicate that only nitrate ion the concentration guide limit, 85 mg per liter was exceeded. (JT)

The report presents excellent data on the concentration of certain radionuclides in groundwater beneath the disposal areas at Hanford. (DN/JT)

<59>

Brookhaven National Laboratory, Department of Applied Science, Process Technology Division, Associated Universities, Inc., Upton, Long Island, NY

Colombo, P., and P.N. Neilson. 1976, December. BNL-50559; 53 pp.

Critical Review of the Properties of Solidified Radioactive Waste Packages Generated at Nuclear Power Reactors (1)

The report is a review of the existing information on the properties of various solidified wastes and waste packages currently being generated at commercial nuclear power reactors. The sources of radioactive waste, their character, and generation rates are discussed. Cement, urea formaldehyde and bitumen solidification techniques are described. Containerization, interim storage, transportation, and burial procedures are outlined in detail. Container properties of 55 gallon drums and 50-200 cubic foot metal or concrete vaults are discussed in terms of physical strength, thermal behavior, and corrosion properties. The three important solidification techniques are reviewed on the basis of leach rates, mechanical strength, chemical compatibility with wastes, generation of gas and free water, and glass stability. Conclusions on the current state of knowledge of solidified waste properties are presented and recommendations for future studies are offered. (Auth)(JC)

A comprehensive review of the solidified radioactive waste and waste package is presented. The references cited form an excellent data base on solid and liquid waste processing. (DB/JC)

<60>

Brookhaven National Laboratory, Department of Applied Science, Upton, Long Island, NY

Colombo, P., and P.N. Neilson, Jr. 1977, January. Nuclear Technology, 32, 30-38.

Some Techniques for the Solidification of Radioactive Wastes in Concrete (2)

Descriptions of packaging and solidification methodology for the preparation of radioactive waste generated at the Brookhaven National Laboratory facility are presented. The wastes prepared for disposal include sludges from the Brookhaven Graphite Research Reactor, the Hot Laboratory complex and the High Flux Beam Reactor. The onsite storage and treatment facilities are also described. The techniques developed for solidification and volume reduction are outlined. The sludges are solidified in concrete and polymer impregnated concrete and placed into three different sized concrete casks designed for various waste types. Experimental studies were performed which incorporated Savannah River Laboratory wastes into concrete and appropriate leachability tests were performed. The results of these leachability tests are presented in tabular form. (JC)

This report presents some valuable leachability data for concrete and polymer impregnated concrete. (DB/JC)

<61>

Brookhaven National Laboratory, Health Physics Division, Upton, Long Island, NY

Gessell, L., and S.G. Pearsall. 1963. Retention and Migration of Radioactive Ions in Soils. Proceedings of an International Colloquium held in Saclay, France, October 16-18, 1962. (pp. 199-206).

Transport of Fission Products through the Soil Following Injection from a Well and Methods Used for Removal (2)

A well on the Brookhaven National Laboratory site was accidentally contaminated with about 5 curies of fission products when 8 inches of cement and slurry had been pumped down it. It was decided to use the incident to study the movement of radionuclides in the soil beneath the Laboratory. Forty wells were drilled on an arc along the lower stream pattern of ground water flow. Brookhaven is located on 1400 feet of sand, clay and gravel of glacial origin. The ion exchange capacity of the soil ranges from 0.4 to 1.8 meq and the ground water flows at a rate of 8 to 12 inches/day depending on the season. From the well study it was found that the contaminants were moving with the same rate as the ground water. The peak of activity was found at the 21 foot level and at no point did the area of contamination appear to be more than 5 feet high and 10 feet wide. The soil was sampled according to the Chalk River method. The soil samples in the well closest to the contamination showed the highest concentration to be between 18 and 24 feet. Wells farther away showed rather low activity in the soils. In the closest well the activity was due to Cs 137, while farther from the source Sr 90 becomes more prominent. The wells were contaminated by pumping the water through anion exchange resin. Pumping yielded 227,070 gallons of water and about 85 mc of activity. (DBT)

Stratigraphic Unit Thickness; Ion Exchange Capacity; Hydraulic Velocity

<62>

Brookhaven National Laboratory, Process Technology Division, Department of Applied Science, Upton, Long Island, NY

Colombo, P., and P.N. Neilson. 1976, October. BNL-50557; 41 pp.

Properties of Radioactive Wastes and Waste Containers, Quarterly Progress Report, April-June 1976 (1)

The physical and chemical integrity of solidified radioactive waste packages must be maintained at a sufficient level to prevent significant radionuclide migration offsite and onto pathways to man. The results of extensive laboratory work and literature review on this subject are presented in quarterly reports from the BNL Nuclear Waste Research group. The results from a portion of the work completed are presented. The objectives of the radioactive waste package program include surveying the literature for solidification and encapsulation process methodologies; identification of regulations and specifications governing transportation, storage, and disposal of solidified waste packages; establishment of testing procedures for evaluation of waste packages; determination of the physical and chemical

<62> CONT.

properties of the solidified wastes and waste containers; the confirmation of the adequacy of the available solidification methods; and the establishment of the technical basis for criteria development for which standards and specifications for storage, disposal, and transportation can be formulated. The tentative program schedule is presented in detail. The general conceptual information is presented in text form. The results of experimental radwaste formulations are presented in tabular form. The physical properties of Portland Type II cement and urea formaldehyde are reviewed. The results of tests on the leachability of strontium from Portland cement are presented graphically as cumulative fraction release times (V/S) versus leach time. The results of the hydrostatic testing of 55 gallon drums are also presented. (Ruth)(JC)

Some of the very useful early results of a program designed to be quite comprehensive and valuable to radioactive waste management. (DN/JC)

<63>

Brookhaven National Laboratory, Process Technology Division, Department of Applied Science, Upton, Long Island, NY

Colombo, P., and L.H. Weiss. 1977, January. NSL-50875-50617: 30 pp.

Properties of Radioactive Wastes and Waste Containers, Quarterly Progress Report, July-September 1976 (2)

The report is the second in a series of quarterly reports which presents the results of a research program investigating the properties of radioactive waste and waste packaging as it applies to isolation of these materials from the environment. The results of experiments discussed in this report include waste formulations with urea formaldehyde and Portland cement; the leachability of cesium and strontium from bead and powdered resins; Co 60 radiolysis gas release from Portland cement; urea formaldehyde, and asphalt, and isod isopropyl, strength, and flammability of urea formaldehyde (UF), cement, and asphalt samples. The waste formulation tests were established to define the maximum waste to solidification agent ratios which result in an acceptable solidified product. Successful products were obtained for all waste types except for sulfate wastes in UF and boric acid concentrates in Portland cement. Adjustment of mixture pH to 1.5 in UF formulations was shown to lessen quantities of free standing water. The fractional release rates for cesium and strontium from the bead resin (Huberlite 198-77) was 3.2×10^{-5} and 1.2×10^{-5} per day respectively and for the powdered resin 9.6×10^{-5} and 1.1×10^{-5} per day respectively. (JC)

Very thorough experimental data presentation. (DN/JC)

Leaching Rate

<64>

Brookhaven National Laboratory, Process

Technology Division, Department of Applied Science, Upton, Long Island, NY

Colombo, P., A.J. Weiss, and A.J. Francis. 1977, March. NSL-50875-50623: 26 pp.

Evaluation of Isotope Migration--Land Burial, Water Chemistry at Commercially Operated Low-Level Radioactive Waste Disposal Sites, Quarterly Progress Report, April-June 1976 (3)

This report represents the first quarterly progress report from a program which is part of a joint investigation undertaken by the U.S. Nuclear Regulatory Commission and the U.S. Geological Survey. The purpose of the joint program is the collection and analysis of soil and water samples from the environs of the existing commercial low-level radioactive waste burial grounds. A description of the field effort for sample collection at the Harey Flats low-level radioactive waste burial site is presented. Details on sample collection, processing and analysis are also presented. The inorganic analyses were performed following plastic membrane filtration through 0.45 micron filters. Fractions saved for dissolved cations and radionuclides were acidified. Inorganic chemical data includes pH, temperature and specific conductance gathered in the field. Laboratory analysis provided data on calcium, iron, lithium, magnesium, manganese, potassium, sodium, alkalinity, chloride, nitrate, nitrite, silica, and sulfate. Organic analyses was performed following silver-silver-sulfate steel filtration through a 0.45 micron membrane. Total carbon, inorganic carbon and organic carbon determinations were made. Gas chromatograph mass spectrometer analysis were performed to make tentative organic compound identification. Preliminary results were derived from these analysis. Radiochemical data from six trenches and two onsite wells are presented. (JC)

Represents some of the only directly measured source term information. (DN/JC)

Total Cation Concentration

<65>

Comptroller General of the United States, Washington, DC

1977, March 6. EMP-77-27; Report to the Conservation, Energy, and National Resources Subcommittee, House Committee on Government Operations: 34 pp.

Issues Related to the Closing of the Nuclear Fuel Services, Incorporated, Reprocessing Plant at West Valley, New York (3)

When the Nuclear Fuel Services Reprocessing Plant at West Valley, NY was shut down for enlargement and reduction of radiation exposure by the employees a number of questions was raised about the operation of such a plant. The site consists of 7 high-level storage tanks containing 612,000 gallons of waste, a high-level burial ground containing about 100,000 cu ft and a low-level burial ground containing about 2 million cu ft of solid radwaste. The tank integrity is in doubt, and before the wastes can be extracted and solidified the tank condition must be verified. There is also a question as to whether or not the tanks could withstand an earthquake. Since there has been a flotation problem below the tanks and vent system, the

<65> CONT.

soil characteristics should be determined in case of a tank rupture. A priority item is the characterization of the physical and chemical properties of the high-level waste sludges for satisfactory extraction. No solidification process has been developed for managing the wastes. The government will have to provide technical assistance to EPC and New York for studying and correcting many of the site problems. Also the government will have to establish guidelines and plans for 1) handling the spent fuel stored and buried and decommissioning the re-processing plant and 2) long term care requirements for the high and low-level waste burial sites. A policy of assistance to New York State should be developed with the Federal government. (SDV)

<66>

Comptroller General of the United States, Washington, DC

Comptroller General of the United States. 1976. REP-N-58: 57 pp.

Improvements Needed in the Land Disposal of Radioactive Wastes--A Problem of Centuries. (1)

More comprehensive studies of existing disposal sites are called for in this report because after 30 years it is not clear as to what mix of hydrogeologic characteristics and not engineering features offers the greatest assurance that disposed radwastes will not be a public hazard. Six licensed commercial and five principal Federal sites are in operation and through 1973 about 9.1 x 10¹⁶ cu ft of solid wastes have been buried at the commercial sites. At Federal facilities, 82 million cubic feet have been deposited through 1970. Before such sites are used, the geology and hydrology should be well-defined and compared against set criteria. However, the study found that site selection criteria have not been established, important geological and hydrological characteristics have not been defined, and some disposal sites are releasing radwastes to the environment. Also long-term-care requirements should be identified before terminating and decommissioning disposal sites. These requirements have yet to be established by the Nuclear Regulatory Commission and agreement states. A policy should be developed by EPC and EPC in correcting migration problems at commercial disposal sites. While the report calls for EPC and EPC to work together, there is reluctance because of their separate missions. However, a committee of experts in the relevant technical areas should be formed to advise and guide a joint EPC and state study of commercial waste disposal sites. (SDV)

<67>

Connecticut Agricultural Experiment Station, New Haven, CT

Savhney, R.L. 1969. Soil Science Society of America, Proceedings, 28, 103-106.

Sorption and Fixation of Microquantities of Cesium by Clay Minerals: Effect of Saturating Cations (2)

The sorption and fixation of microquantities of Cs by minerals under different cationic environments are discussed. Previous work has indicated that Cs is sorbed preferentially and held more tightly by some clay types, but little is known of the mechanisms that cause the phenomenon. Experiments were run on calcium and potassium saturated illite, kaolinite, montmorillonite, vermiculite, muscovite, and biotite. In general, nonexpanding layer silicates, biotite, illite, and muscovite sorbed larger amounts of Cs than the expanding layer silicates, montmorillonite and vermiculite, and the 2:1 layer silicate kaolinite. The nonexpanding mica and vermiculite sorbed more Cs when Cs saturated than when K saturated. However, the reverse was true for kaolinite and montmorillonite. By increasing the concentration of K tenfold (0.01 to 0.1 M KCl), the sorption of Cs was drastically reduced, 85 to 31 mg/g of Cs, respectively. A similar increase in the Cs concentration does not have the same effect, 120 and 116 mg/g, respectively. A number of generalizations may be made from these experiments: 1) when saturated with similar cations, 1) given mineral sorbed similar amounts of Cs; 2) when saturated with Na, Cs, or Sr, the non-expanding layer silicates and vermiculite sorbed larger amounts of Cs than when saturated with K or NH₄; 3) when expanding layer silicates and 2:1 kaolinite are used, the reverse of 2 is true; 4) when illite and muscovite are K or NH₄ saturated, they sorb about the same amount of Cs as they do with bivalent ions; and 5) under similar conditions to 4, biotite, montmorillonite, and vermiculite sorb less. Ion-exchange adsorption process cannot explain the effect of the presence of other ions on the sorption of Cs by mica and vermiculite. However, it has been observed that cations of similar ionic radii to Cs are most effective in competing with Cs for the exchange sites. Hence, sorption of microquantities by mica and vermiculite, similarity of size, charge, and hydration of the competing cation determine its effectiveness. Calcium saturated biotite, illite, muscovite, and vermiculite sorbed and fixed large amounts of Cs. For leaching K was far more effective than was Cs. Hence the ionic environment has a marked effect on the fixation of Cs by clay mineral. The precise mechanism by which Cs is fixed in mica is still not clear. (SDV)

<68>

E.L. de Pont de Venours and Company, Aiken, SC

Prout, W. 1958, July. Soil Science, 66(1), 13-17.

Absorption of Radioactive Wastes by Savannah River Plant Soil (2)

The results of a series of experiments to determine the distribution coefficients for strontium, cesium and plutonium in soils from the saturated zone beneath the Savannah River Plant (SRP) are presented. The absorption of radionuclides was measured as a function of the concentration of the ion in question, the order of concentration of several competing ions, oxidation states, and pH. In order to simulate actual field conditions, the experimental columns were packed with soil samples from the saturated zone. Strontium adsorption was shown to be greatly inhibited by increased hydrogen ion concentration. Maximum distribution coefficients were obtained in nearly neutral pH conditions. Sodium and aluminum ions were shown to compete

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absorption with variations for absorption sites. Various distribution coefficients for cesium were obtained in solution with a pH of approximately 8. Adsorption of plutonium in the plus three and four states were observed to be more than ninety percent effective in removal between pH 2.5 and 12. For the plus four valence state adsorption of plutonium was observed to be most effective above pH 6. Based on these results, minimal breakthrough of the radionuclides was predicted at the SFP. (P7)

Although this study was performed with an emphasis on the expected effect of adsorption of fission waste radionuclides by soils, the distribution coefficient discussion is most applicable to the shallow land burial of radioactive wastes. (P7/JS)

on: Cation Exchange Capacity; Distribution Coefficient

<69>

E.I. du Pont de Nemours and Company, Wilmington, DE

Clark, J.P., and H.A. Pohl. 1955, December. TID-7517 (Part II): Sanitary Engineering Aspects of the Atomic Energy Industry. Proceedings of a seminar held in Cincinnati, Ohio, December 6-9, 1955. (pp. 162-169), 609 pp. (TID-7517, Part II).

Earth Disposal of Radioactive Wastes at Savannah River Plant (II)

A comparison of climate and geohydrology of Hanford and Savannah River Plant is made. As compared to Hanford soils, SFP soils show, lower permeability (0.2 to 1 gal/sq ft/day), lower ion exchange capacity 3-5 meq/100g, and a shallower water table (10-50 ft). Hanford soils are primarily sandy gravel soils, whereas SFP soils are dry. A discussion of SFP seepage basins, including cost assessment is included as well as a graph relating holdup time required before river disposal of Sr 90, Cs 137, Ba 137, Pu 238, Pu 239, Pu 241, Cs 137, Sr 90, and Sr 89. (P70)

Depth to Water Table; Transmissivity; Cation Exchange Capacity

<70>

E.I. du Pont de Nemours and Company, Aiken, SC

Reichert, S.O. 1962, March. TID-7628: Ground Disposal of Radioactive Wastes, J.H. Morgan, Jr., et al (Eds.), Proceedings of the 2nd Conference held in Chalk River, Canada, September 26-29, 1961. (pp. 115-129), 635 pp. (TID-7628).

Disposal of Radioactive Wastes to the Ground at the Savannah River Plant (II)

Ground disposal practices in effect at the Savannah River Plant (SFP) are discussed with a special emphasis on the geology and hydrology. The plant occupies 320 sq miles along the Savannah River downstream from Augusta, Georgia. Facilities at the plant are: a fuel preparation area; five reactor areas; two radiochemical separation areas; and a heavy water plant. SFP is underlain by alluvium of fine to coarse sand, silt, and

clay. Beneath the alluvium are formations of clay, silt, gravel, and sand lying from the recent to the Late Cretaceous. Underneath the Cretaceous rocks are the basement rocks of the Precambrian and Paleozoic. The most important formations to the disposal of radioactive wastes are the Hawthorn, Barnwell, and Kewanee. These formations and the related soils, derived from weathering, erosion, and stress alleviation, are sandy with a kaolinitic clay component. Hence, the ion exchange capacity is 2.1 meq/100 g at a pH of 5 and 1.2 meq/100 g at a pH of 10. Due to the nature of the sandy soil, the 45 to 50 inches of annual rainfall percolates into the soil. This supplies perched water tables as well as an artesian aquifer in the Pecos formation, and a normal water table. Usually the groundwater level is encountered at between 30 to 60 feet. Although the use of the water downstream is limited, the hydrologic, geologic, and climatic, and geographic characteristics of the region do not encourage disposal to the environment except under the most conservative conditions. Therefore, the basic principle followed is total containment. The total radioactivity buried at the plant through 1960 is: Pu, 152 Ci; U, 3 Ci; and fission products and induced radioactivity, 573,000 Ci. Nearly 70% of the 1960 Ci discharged to reactor seepage basins resulted from a single experimental incident. Seepage basins and burial grounds are selected on their geological and hydrological characteristics. The groundwater in both is routinely monitored. No radioactivity was detected in the groundwater at the burial ground, but Sr 90 was detected in the groundwater 500 feet from the seepage basins. No radioactivity has been found in the streams. While containment at the plant has been quite good, studies are proceeding to make the containment more complete. The efforts are concentrated on better defining the general lithology and hydrology of future waste sites, improved groundwater monitoring, and determination of the specific hydrology of the area, including seasonal fluctuations. In selecting new seepage basins the following is considered: 1) consideration of lithology, hydrology, and the source of the waste; 2) definition of the detail lithology and hydrology; 3) permeability study of the site; 4) removal of any sand lenses encountered during construction; and 5) colored photographs to serve as sedimentary layer maps of the floors and walls. Investigations are being made into using the bedrock for radwaste disposal. (P70)

Stratigraphic Unit Thickness; Ion Exchange Capacity; pH; Depth to Water Table; Mean Precipitation

<71>

EG&G Idaho, Inc., Idaho Falls, ID

Carl, D.R., and D.R. Wang. 1977, May. TREC-1079; 16 pp.

Initial Drum Retrieval, Interim Report, July 1976 to September 1976 (II)

A program for retrieval of drums containing wastes contaminated with transuranic elements was instituted in 1976. The program provides for the safe removal of the 55 gallon drums from 3 waste trenches, repackaging of the drums and their removal to the Transuranic Storage Area nearby. Methods of drum retrieval and repackaging are discussed and improvements in techniques and per drum costs

<75>

described. Most physical damage to the struts and leakage of radioactive materials are attributed to deterioration of the struts resulting from water which was allowed to accumulate in the trenches during the initial burial process. The cost of overpack containers for storage of retrieved struts has been reduced from \$52 to \$24.51 per retrieved strut. (CAB)

<75>

Sanford Atomic Products Operation, Earth Sciences Unit, Biophysics Section, Richland, WA

McHenry, J.B. 1955, February 1. 88-3889; 36 pp.

Absorption and Retention of Strontium by Soils of the Sanford Project (1)

The results of a study of the adsorption and retention of strontium by Sanford reservation soils are presented. The adsorption of strontium from solution by the soil was found dependent on strontium ion concentration, pH, equilibration time, nature and concentration of various competing ions as well as ionic strength. The quantitative results are presented graphically and indicate the magnitude of the influencing factors. Strontium adsorption is greatly reduced by the presence of high concentrations of sodium nitrate, certain cations and anions. Low pH conditions greatly reduce the degree of adsorption. Strontium was shown to be less strongly adsorbed than cesium except in the presence of phosphate and oxalate ions. The factors controlling desorption were shown to be essentially the same as those observed influencing adsorption. The removal of strontium from soil was shown to be more highly susceptible to certain factors than cesium. (18th) (JC)

The report provides good quantitative information on the adsorptive properties of the Sanford area soils where shallow land burial is carried out. (18th) (JC)

Distribution Coefficient

<75>

Sanford Atomic Products Operation, Richland, WA

Brown, S.E., and J.E. Raymond. 1962, March. 719-7628; Ground Disposal of Radioactive Wastes, J.N. Morgan, Jr., et al (Eds.), Proceedings of the 2nd Conference held in Chalk River, Canada, September 24-29, 1961, (pp. 77-98), 675 pp., (719-7628).

The Measurement of Sanford Geohydrologic Features Affecting Waste Disposal (1)

Five important concepts peculiar to waste disposal are discussed. They include 1) the vertical component of groundwater movement, 2) quantitative dispersion of groundwater contaminants, 3) the effect of aquifer anisotropy, 4) the range of groundwater flow rates within the average rate usually calculated, and 5) the hydrologic continuity between well and aquifer. Each concept is discussed briefly, and attempts to measure the hydrologic parameters at Sanford are described. Differences in potential were

measured in wells in various areas. Also was found to be present in some wells and increased in others. Dispersion of contaminants in groundwater was treated with fluorescent tracers and found to illustrate the tracer test in areas of 1) leakage in wells 11, 13, and 15, 2) flow from the injection well. Anisotropy was studied by running percolation tests and comparing the variations in vertical permeability. Test of groundwater flow rates yielded rates of movement ranging from 4 to 643 feet/day. (CAB)

Generally site-specific discussion of attempts to define hydrologic conditions at Sanford. Some very widely applicable information presented. (18th) (JC)

Hydraulic Velocity; Thickness of Upper Aquifers; Percolation Water Dispersion Coefficient; Longitudinal

<75>

Sanford Atomic Products Operation, Richland, WA

Nelson, R.W., and A.E. Reizenbaue. 1962, March. 719-7629; Ground Disposal of Radioactive Wastes, J.N. Morgan, Jr., et al (Eds.), Proceedings of the 2nd Conference held in Chalk River, Canada, September 24-29, 1961, (pp. 130-144), 675 pp., (719-7629).

General Electric Company, Sanford Studies on Flow in Porous Media (1)

A coverage of formulation and solution methods for saturated and unsaturated flow systems is presented, as well as flow of fluids with different densities. Basic equations and components are listed. Models formulated allow for heterogeneous soils (up to 15 soils can be included in any one flow pattern). The computer program can handle 1, 2, and 3 dimensional and axis-symmetrical problems with up to 4,096 grid points. Graphs showing flow pattern and moisture distribution are included. Also included is a schematic diagram illustrating the electrical analogy of ground water. (PT)

Water Content

<75>

Sanford Atomic Products Operation, Richland, WA

Phelan, J.B. 1957. Soil Science Society of America, Proceedings, 21, 147-152.

The Effect of pH on the Uptake of Radioactive Isotopes from Solution by a Soil (1)

Experiments to define the effect of pH on the uptake of several important radionuclides by soils were performed and the results reported. Calcareous subsoils found at the Sanford reservation were reacted with solutions containing less than 1 x 10⁻⁹ moles per liter of selected radionuclides. Particle size distribution reported as percent by weight was as follows: 66 greater than 2 mm diameter 474 2-0.2 mm, 104 0.20-0.02 mm, 61 0.02-0.002, and 26 less than 0.002 mm. The effect of high concentrations of competing ions was also investigated. Distribution coefficients for Ca, Sr, Ba, Pb, V, Zr, Nb, and Co are reported over the entire pH range. The optimal pH for strontium uptake was

(75) CONT.

observed to be approximately 1% and a rapid drop in distribution coefficient was noted as the pH was lowered. The polyvalent cations, Fe , Co , Zn , Mn , Cu , and Pb , were observed to have similar distribution coefficients in the 1 to 2 pH range. Above pH 2, distribution coefficients were observed to be reduced. The addition of relatively large concentrations of competing ions such as sodium was seen to greatly inhibit the soil uptake of both strontium and cesium. In the case of strontium, nitrate ion was seen to reduce the interference of sodium with strontium. (NETH) (C)

Very good information on distribution coefficient data for perfect desorption soils including values as a function of pH is presented. (DN/TC)

pH: Distribution Coefficient; Cation Exchange Capacity; Grain Size Distribution

(76)

Hanford Atomic Products Operation, Richland, WA

Schultz, W.W., and T.R. DeHessle. 1955, December. TID-7517 (Part 1): Sanitary Engineering Aspects of the Atomic Energy Industry. Proceedings of a Seminar held in Cincinnati, Ohio, December 6-9, 1955, (pp. 290-302), 689 pp. (TID-7517, Part 1).

The Removal of Cesium and Strontium from Radioactive Waste Solutions (2)

Removal of radionuclides from waste water solutions is complicated by the high salt content of the waste. Investigations of agents which will effectively remove Sr and Cs at high pH are examined. Procedures for removing cesium from alkaline solutions are discussed, as well as procedures for cesium removal from acidic solutions. Perfluorinated are effective precipitants in alkaline solutions up to a pH of about 10. Unlike cesium, strontium lends itself more readily to various scavenging techniques. By increasing iron levels, strontium levels were reduced, but sludge volume was increased. (PTO)

(77)

Hanford Atomic Products Operation, Richland, WA

Tranquist, D.P., and R.E. Toolinsson. 1956, October. TID-7517 (Part 10): Sanitary Engineering Aspects of the Atomic Energy Industry. Proceedings of a Seminar held in Cincinnati, Ohio, December 6-9, 1955, (pp. 499-505), 689 pp. (TID-7517, Part 10).

Estimated Magnitude of Waste Disposal Problems (1)

Disposal of fuel cycle radwastes are discussed. Also considered is magnitude of the problem and some criteria for problem evaluation. It is assumed that economics will require the irradiated fuel element be reprocessed for the recovery of fissile materials. For purposes of this discussion, a unit block of power of 100 million kilowatts of heat energy, representing perhaps 10 to 20 million kilowatts of electrical energy is considered. Fission releases about 200 million electron volts of energy per atom fissioned. More than 99% of this energy is

available as heat from the reactor on a continuous basis, while the rest is the decay energy as beta and gamma emissions. Assuming a constant rate of heat production at 100 million kilowatts and a fuel irradiation equivalent to 1 to 2 megawatts/kilogram of U^{235} for 250 days, then this fission product decay would release heat at a rate of about 50 to 100 million Btu/yr. This heat will be dissipated from an aqueous solution in a tank, cast in concrete at the bottom of the ocean or cast into a giant in the middle of a desert. Assuming 100 million kilowatts of heat energy was produced by the irradiation of natural or slightly enriched uranium to about 2500 megawatt-days, 25,000 gallons of highly radioactive liquid waste would be produced per day. These wastes might be self-concentrated by a factor of three on a continuous operating basis. Self-concentration would occur when the solution evaporated by the heat evolved from the fission product decay. The self-concentrated wastes would accumulate at about 2 million gallons/year and would be expected to boil for about 50 years. Storage of non-boiling wastes is in 400,000 to 1 million gallon tanks at about 20 to 25¢/gallon. Storage of boiling wastes costs about 80 to 50¢/gallon. The estimated costs of storing wastes from the reprocessing of fuel elements are 0.01 to 3.0¢ kilowatt-hr of electrical power produced. This cost amounts to less than 1% of the total cost of producing atomic power. At present, semi-permanent storage in tanks is economically viable. An alternative method would be to extract Cs 137 and Sr 90 and store the rest of the wastes in a soil with sufficient ion exchange capacity to retain them. Other methods under consideration are: calcination to a salt or oxide, preparation of a concrete or a glass and disposal in tanks or caverns, or burial in a desert or at sea. These all have drawbacks. The ideal solution would be to develop a market for these wastes. (VTR)

Waste Volume

(78)

Hanford Atomic Products Operation, Richland, WA

Brook, R.E. 1960. Disposal of Radioactive Wastes, Proceedings of a Conference held in Toronto, November 16-21, 1959, (pp. 499-516).

Desirable New Geologic Research in Support of Radioactive Waste Disposal as Indicated by Hanford Experience (2)

The need for detailed geologic and hydrologic data is illustrated by the efforts made at the Hanford project. Hanford is underlain by the Columbia River basalt series which extends to more than 2,300 ft below sea level. These flows are typified by massive, dense, fine-grained hard basalts and andesites about 100 ft thick. Above the basalts is a series of lacustrine, fluvial, and aeolian deposits. The lacustrine Ringold formation, which lies just above the basalts is noted for its low permeability. Aeolian deposits rest on the Ringold and are composed of silt, fine sand and clay. Glaciofluvial and fluvial gravels, sands, and silts lie above the aeolian formation. These deposits are composed of highly permeable, highly heterogeneous, cross-bedded, cut-and-fill bedded, deltaic-bedded sandy gravels. The structure in the region is a series of east-west trending anticlinal and synclinal folds. Regional geologic, geophysical

(75) CONT.

seismic, and in-situ well tests are some of the methods used to describe the area. By late 1964, 447 wells had been drilled which averaged to being about 1 well/1.45 sq. ft. However, there are not enough wells for an adequate description of the groundwater system. Variation in grain size and composition was found in the sediments and it was generally found that the cation exchange capacity increases as the nonvolcanic content decreases. An empirical equation was derived from the experimental values for cation exchange. By using the cation exchange capacities and grain size distribution reported, low-permeability, high-exchange-capacity beds of the lower Pingold were identified. Other preferable disposal areas were identified by using cation exchange capacity and depth to water. By combining geology, hydrology, soil chemistry, and radiochemistry it was found that the Pingold beds control the orientation of a groundwater mound that is to the west of a high exchange capacity area and was leaking detectable amounts of radioactive contaminants. From hydrological data it was found that the fluvial sediments have permeabilities ranging from 0.05 to 2.0 cm/sec/cm and the Pingold sediments have permeabilities ranging from 0.001 to 0.01 cm/sec/cm. Using long and short-term well hydrographs, it was possible to note the spring rise of the Columbia River up to 6 ft from the river. Also, the technique used in finding oil tower channels and the effect of impermeable Pingold sediments between the channels. Wells have been used to monitor the growth and subsidence of ground water mounds created by disposal of volumes of cooling waters. The distribution of natural salts was used to determine regional ground water sources and flow patterns, as well as different geologic formations. Problems remaining to be addressed are: quantitative assessments of geologic features; vertical movement of ground water; and gravity settling of wastes. (JUN)

Stratigraphic Unit Thickness; Grain Size Distribution; Cation Exchange Capacity; Depth to Water Table; Permeability Coefficients; River Flow

(76)

Hanford Atomic Products Operation, Richland, WA

Knoll, E.C., and J.L. Nelson. 1962, January. HW-7557; 11 pp.

Radioisotope and Moisture Distribution beneath a Metal Crib (B)

A field experiment was conducted to test the validity of using laboratory soil columns to predict the life of a waste disposal crib and to compare the spread of moisture beneath cribs of different sizes. Two metal cribs, one six inches square and the other twenty-four inches square, were used. Depth to ground water was approximately 10 feet. The influent solution to the crib was tracer with nitrate ion and Sr 90 at a specific activity of 1.1×10^{-6} gci/ml. Results indicate that laboratory columns can be used to estimate the capacity of the field crib for disposing of radioactive wastes when comparison is made in terms of effective column volume rather than standard column volume. Experimental results indicate a decrease in infiltration rates from 10 gci/sq

ft/hr to 1 gci/sq ft/hr in seven days. Flow rates decreased from 19.4 gci/sq ft/hr to 2.5 gci/sq ft/hr in five months. In addition the data showed that the amount of lateral spread is independent of the crib size. (JUN) (JUN)

The experimental techniques and data are applicable for the estimation crib life of radioactive wastes. (JUN) (JUN)

Infiltration Rate; Horizontal Flow Rate; Permeability Coefficients; Effective Porosity

(77)

Hanford Atomic Products Operation, Richland, WA

Stewart, W.H. 1959, June 9. HW-53649; 7 pp.

Aquifer Characteristics and Ground Water Movement at Hanford (B)

The hydraulic characteristics of Hanford aquifers have been measured and estimated by a variety of established field methods. These include the nonequilibrium pump-and-treat solution, the modified nonequilibrium and steady recovery formula, calculations from specific capacity and cyclic fluctuation data, and the results of tracer tests. Generally consistent results show that the permeability of the glaciofluvial sediments ranges from about 10,000 gpd/sq ft to more than 60,000 gpd/sq ft, and the permeability of the Pingold deposits ranges from about 100 to 600 gpd/sq ft. Based on these permeability data, calculations of the average rate of ground water flow indicate a range from a few inches per day to as much as 160 ft/day. The hydraulic studies show that wastes which reach the water table beneath disposal sites will essentially move in a general southwesterly and eastward direction some 20 miles to the Columbia River. Average rates of ground water flow indicate that travel along this estimated main lateral path of ground water contamination could conceivably be completed in an average time in the order of 100 years. Such factors as heterogeneity, and anisotropy of the aquifers, and dispersal of wastes in the groundwater, however, assume great importance in determining the path and ultimately the concentration of radioactive wastes in the water. Consequently, such additional information is needed to determine the quantitative effect of these factors in the field. (JUN) (JUN)

Hydraulic characteristics of aquifers as they pertain to low-level radioactive waste disposal. (JUN) (JUN)

Thickness of Upper Aquifer; Permeability Coefficients; Specific Yield

(78)

Hanford Atomic Products Operation, Richland, WA

Brown, D.J. 1959, October 1. HW-61760; 21 pp.

Subsurface Geology of the Hanford Separation Area (B)

Five geologic units have been identified beneath the processing plant area. These units are the Columbia River Basalts, the interbeds of gravel, sand, and clay of the Ellensburg Formation, the Pingold Formation,

Peering analysis is on the cooling characteristics of the region in which the transfer chemical processing plant would be located. (b)(7)(D)

Scientific Film Pictures

1072

Referred Atomic Projects Operation, Arlington, VA
 of Research, R.E., and R.W. McGowan. 1957, Vol.
 4. HW-5177: 21 pp.

Climate is the Stanford Water Table, 1900-1957 (1)

A summary of the fluctuation in the water table elevation beneath the Hanford liquid waste disposal facility during the period January 1964 through June 1975. During this time period, more than 27 billion gallons of waste, including more than 2 billion gallons of low-level radioactive wastes, were disposed of into the ground. The zone of saturation was measured between 300-400 feet beneath the highest terrace in the north-central part of the area south of Table Mountain. Review of ground water monitoring elevation records indicates that recharge operations resulted in the formation of two separate and distinct groundwater zones. The effects of these events has been to increase the hydraulic gradient and in some cases reversing the local natural hydraulic gradients. The alteration of the ground water contours is attributed to the recharge by liquid wastes, localized differences in the thickness and permeability of the aquifer, and by river-level fluctuations. (U)

Concerned primarily with the effect of liquid waste discharge on the water table beneath the forest. (12/2/57)

Depth to Water Table; Hydraulic Gradient;
Sedimentary Unit Thickness

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Impact of the Project on the Environment - Richmond, VA

Polvenbach, E.E. 1958. WASH-275; Sanitary Engineering, Proceedings of a Conference held in Baltimore, Maryland, April 14-16, 1956, (pp. 149-151) (WASH-275).

**Radioactive Waste Disposal and Control Program
at Sanford Atomic Products Operation (2)**

Disposal and control programs of radioactive Hanford Atomic Products Operation are presented. A review of the use of the Columbia River shows that the River below the Hanford operation is used for many water needs, irrigation, navigation, hydroelectric power, fish and wildlife, and recreation. Hence, the water problem of the waste disposal

process is to insure that radioactive effluents do not create a health hazard. The major activity concerns water cooling waters of the nuclear reactors; water from the reactors and chemical processing areas; liquids from chemical processing areas; and solid materials from all operations. The philosophy followed at the operations is to concentrate and retain certain wastes under controlled conditions and to dilute and disperse other wastes under specific conditions. Most of the radioactivity in the coolant waters has a rapid decay rate and is produced from the original dissolved solids in the water and/or corrosion products from the metals contacted by the water. The water is held in retention basins for an hour or longer then released to the river for dilution. Since the sediment tends to concentrate the radioisotopes from the water, attention will be given to the radioactivity of the suds settling in the area. Gaseous wastes resulting from extraction of plutonium and the recovery of unused uranium by chemical processes and from reactor ventilation are subjected to chemical treatment, scrubbing, or filtration before discharge to the atmosphere. Liquid wastes from the chemical processing plants are separated into two groups: high-level of activity and long-life and low-level liquid wastes. The high level are evaporated and stored in underground tanks. The low-level wastes are discharged to the ground under strict control. Contaminated solids are buried. An extensive monitoring system includes: water samples from the river and reactor cooling waters; soil samples from the river; effects on the aquatic life; effects on the terrestrial life; and wildlife. The alpha and beta particle counters in the Columbia River below Portland, Washington are well below one-tenth of the maximum permissible concentrations. Research and monitoring are continuing at the Hanford operations. (SOF)

412

Harford Arctic Projects Operations, Richland, WA

Selison, W.G., and W.A. Ramey. 1963. Retention and Migration of Radioactive Ions in Soils. Proceedings of an International Colloquium held in Saclay, France, October 16-18, 1962, (pp. 131-133).

Analogy Simulation of Hanford Ground Water Flow

The first phases of development of an electric analog for ground water flow at the Hanford Reservation are presented. Ultimately this analog will be used to answer questions about how and where radionuclides migrate in the soil. The analog method allows for solution of the flow problem using irregular boundaries and varying permeabilities. Partial differential equations are used to solve the flow equations and to find the equivalent electrical network equation coefficients. One of the problems in using this method is accurate knowledge of the permeability in the area of study. To that end measurements are being developed and tested. Problems still exist but are being resolved. (WDS)

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Hanford Atomic Products Corporation, Highland, PA

(24) CONT.

Fein, E.L., and E.J. Stebbell. 1957. Abstracts in Nuclear Engineering, Vol. 9, Part 1, J.E. Dunning and E.S. Prentice (Eds.), Proceedings of the 1st Nuclear Engineering and Science Conference held in Philadelphia, Pennsylvania, 1957, (pp. 122-128).

Concepts of Waste Disposal at Hanford (19)

Large quantities of radioactive wastes are produced at Hanford and to deal with these wastes several processes are employed. Very low-level wastes are discharged to open areas and allowed to seep into the ground. Some intermediate-level wastes are disposed of through "cribs", while acidic intermediate-level wastes are made alkaline and passed through a "cascade" of settling tanks prior to discharge to cribs. High-level wastes and some intermediate-level wastes are stored in large underground tanks. Several procedures for reduction of volume have been employed and they are: evaporation of intermediate and high-level wastes; re-use of slightly radioactive chemicals; use of heat generated by radioactive constituents present to evaporate stored wastes; and carrier precipitation techniques which permit discharge of supernatant liquids to ground. Depending on the waste, up to 70% by volume is removed on the first pass and 80% by volume of the supernatant liquid on the second pass. To re-use of chemicals, the back-cycling of aqueous raffinate from later cycles for use as saline agents in earlier cycles has reduced wastes by a factor of 2. Volume reduction by carrier precipitation is considered as an important new process in eliminating Cs 137 and Sr 90 from moderately high-level radioactive solutions. This process meets several criteria: one of the most important is reduction of Cs and Sr by as much as 1000 times. It was found that nickel ferrocyanide could remove Cs from a supernatant liquid containing 20 to 100 $\mu\text{Ci/l}$, thus leaving 0.033 $\mu\text{Ci/l}$ at a pH 7. To remove Sr, nickel nitrate is used. After precipitation the supernatant liquid is passed into cribs. This process is successful at Hanford because the alluvial sand (which is about 200 ft thick) has a high ion exchange and the travel time to the Columbia River through the ground surface ranges from 50 to 1500 years. Otherwise, Cs and Sr would be released to the environment in excess of their various permissible concentrations (APRIS), i.e. 1.5×10^{-5} and 1×10^{-5} , respectively. The process has saved \$400,000 to date. (20)

(25)

Hanford Atomic Products Operation, Richland, 21

Volcan, J.L., V.L. Parry, E.C. Froil, and D.W. Jensen. 1962. Retention and Migration of radioactive ions in soils, Proceedings of an International Colloquium held in Paris, France, October 16-18, 1962, (pp. 197-199).

Laboratory, Pilot and Field Scale Studies of Fission Product Migration Rates in Soils (2)

Results of laboratory, pilot and field scale studies of fission product migration rates are presented. In the laboratory, a 1000 ppm Na_2CO_3 and 0.1 ppm Sr^{90} solution was run through a column 1.9 cm in diameter and 80 cm long. Temperature, major ion species and concentration, trace ion concentration, pH, column diameter, column length, and flow rate were the variables considered during this

phase. The distribution coefficient K_d is associated with the position of the breakthrough curve and the value for species and concentration, trace ion concentration, and pH are studied in this method. Because there is good correlation between the equilibrium and column results, the K_d concentration is considered to have no effect on the kinetics of the reaction. Temperature affected both the kinetics and the position of the breakthrough curve, but more so for the former. Column diameter had no effect on either, while column length and flow rate affected the slope of the breakthrough curve. The breakthrough curves derived in this phase are then used directly for the longer field column between the crib base and ground water with no consideration for porewater. In pilot test a well showed an increase over a two month period to 1.5×10^{-5} $\mu\text{Ci/l}$ and then dropped off rapidly to below 5×10^{-5} $\mu\text{Ci/l}$. This indicated that Cs 137 was removed by the soil. The laboratory prediction and the field data closely agree with each other. Since Cs was not detected in any samples, it is assumed that it is held by the soil beneath the crib. Strontium 90 was generally contained in the upper soil layers. It is felt that more accurate predictions of waste disposal facility capacity could be obtained if the unsaturated, steady-state flow patterns through heterogeneous soils could be predicted. This information would then be combined with laboratory data on the slope and position of radioactive breakthrough curves. (20)

pH: Distribution Coefficient; Depth to Water Table; Hydraulic Velocity

(26)

Hanford Atomic Products Operation, Richland, 21

Brown, L.J., P.E. Brown, and W.L. Finney. 1962. Abstract 21. Retention and Migration of radioactive ions in soils, Proceedings of an International Colloquium held in Paris, France, October 16-18, 1962, (pp. 197-199); 21-22/77; 17 pp.

Appraisal of Hanford's Waste Disposal by Integration of Field Techniques (2)

Different techniques are used to integrate the movement of ground water and the contaminants in it at Hanford. The first step is the identification of waste movement through tracing fission product tracers and measuring thermal gradients. About 400 water well samples were taken and the highest concentrations were observed at the water table. The concentrations were plotted on a contour map of the water table. From the site disposal area, the tritium followed old Columbia River channels and into the eroded upper surface of the low-permeability Ringold Formation. These channels are filled with glacial outwash gravels which have about 100 times the permeability of the surrounding Ringold Formation. The waste even followed an old diversion filled with more permeable diatomaceous sediments. In the other disposal area the tritium probably travelled north and south because it was diverted by low-permeability clays. Temperature data and bore-hole measurements agreed with the tritium data. Movement of ground water and waste liquids in the vertical direction was determined by temperature logs. The geology of the Hanford area indicated that high salt wastes could easily move down dip particularly under gravity. The temperature profiles

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showed warmer water opposite the more permeable aquifers. Also, the temperatures exceeded those that would be expected from the regional geothermal gradient. Finally, movement of reactor effluent through ground to the Columbia River was traced. The effluent enters the ground primarily as retention basin leakage and is thermally warm with short-lived activation products. From this, the extent to which hot water has spread beneath the reactor area, the direction of ground water movement, and the rate and volume of thermally warm ground water moving into the Columbia River was determined. It was calculated that about 1.5 million cubic feet/day of reactor coolant effluent enters the Columbia River from sources within the area. (DDV)

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Hanford Atomic Products Operation, Richland, WA

Becker, D.B., C.E. Linderoth, J.L. Nelson, and L.L. Jones, Jr. 1960. Disposal of Radioactive Wastes, Proceedings of a Conference held in Mexico, November 16-21, 1959, (pp. 365-369).

A Review of Radioactive Waste Disposal to the Ground at Hanford (1)

The disposal of radioactive wastes to the ground from the Hanford separations plants is summarized; volumes of wastes and contained curies discharged to dumps, trenches, and cribs are presented. By June 1959, a total of 179 billion liters containing 2,500 Ci from the process cooling-water had been discharged. Significant literature on ion-exchange studies using Hanford soils is reviewed. The breakthrough of Sr 90 at varying concentrations and pH was discussed extensively. A field experiment with a model crib is described; preliminary findings indicate that spreading a waste solution below a disposal facility may be of greater benefit in disposal operations than previously assumed. Further studies with the calcite-phosphate reaction are reported; significant variables which affect Sr-90 removal are calcite surface area, pH of the influent, flow rate, temperature and phosphate ion concentration. Bone-seeking radioisotopes are also removed from P-solutions when contact is made with calcite. The zeolite clinoptilolite shows high selectivity for Cs-137 in the presence of increased Na-22 concentration. The effect of the large-scale ground disposal operation at Hanford is described by means of a map and geological cross-sections showing areas and volumes of ground and ground water contamination. Furthermore, a major ground water contaminant, uranyl, was found to be spread more widely than any other isotope. (Rich) (DDV)

Grain Size Distribution; pH; Waste Volume; Effective Porosity; Distribution Coefficient

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Hanford Engineering Development Laboratory, Richland, WA

Lorch, P.E. 1977, April. NEOL-THE-77-80; 126 pp.

Division of Waste Management, Production, and Reprocessing Programs Report for January-December

1976 (2)

The Hanford Engineering Development Laboratory (HEDL) has developed four waste management programs. The Commercial Alpha Waste (CAW) program provides comprehensive and coordinated development of treatment and disposal methods for radioactive non-high-level wastes generated in all aspects of the commercial nuclear fuel cycle (fabrication, reprocessing, and power production). To demonstrate the applicability of acid digestion for treating waste materials the Chemical Processing of Combustible Solid Wastes was established. Newly started programs include the Intermediate Level Liquid Waste Solidification and Application of Acid Digestion to Commercial Wastes. The ILW Solidification was designed to supersede the Commercial Alpha Waste Program. It is to develop and demonstrate treatment and immobilization technologies for intermediate-level liquid and dispersible solid wastes generated by the nuclear fuel cycle. The program on Application of Acid Digestion to Commercial Wastes is intended to supplement the program on Chemical Processing of Combustible Solid Wastes. It is to support development of acid digestion technology to meet requirements for processing commercial nuclear fuel cycle combustible wastes. Records for the CAW show for the first half of 1976, 16.1 cu m of combustible waste and 7.8 cu m of noncombustible wastes were shipped. The estimated plutonium content was 373 and less than 0.2 grams, respectively. Comparing with the first half of 1975 the shipments were 66.7 cu m and 1368 grams of plutonium. This was a reduction of 42% and 72%, respectively. Tests were also run on solidified products for selection of criteria for immobilization of non-high-level wastes. Initially cement immobilization was considered. Evaluation was made of waste/cement formulations which yield the least dispersible product. Salt residues included in the study were calcium sulfate, ferric sulfate, sodium sulfate, sodium nitrate, calcium chloride, and sodium chloride. The ILW Solidification was designed to identify the sources, to develop the appropriate processes of treatment, to develop acceptable test procedures verification as having 200 acres/hr at the surface and 10 acres/hr at three high-level wastes. The sources of wastes are from the reactor, spent fuel storage basins, fuel reprocessing, and HX fuel fabrication with these wastes having a total volume of 1.1 cu m/HR. The Chemical Processing of Combustible Solid Wastes is to test treating transuranic-contaminated combustible wastes by acid treatment. The process is to oxidize materials in concentrated acids. The last program was initially interested in recycling the acid in the acid digestion and to study the safety to meet licenseability requirements. The project was started in late 1976. A discussion of the recycling is also included. (DDV)

<90>

Hanford Engineering Development Laboratory, Richland, WA

Cosley, C.R., and P.E. Lorch. 1976, May. NEOL-THE-76-22; 70 pp.

Nuclear Fuel Cycle and Production Programs Progress Report for July-December, 1975 (3)

A summary of the Nuclear Fuel Cycle and Production programs being conducted at Hanford

SC755875

(90) (37)

Engineering Development Laboratory. These programs include a commercial sludge waste program and a chemical processing of combustible solid wastes program. Data on commercial burial of radioactive wastes, operational data on the Acid Digestion Test Unit and the basis for an acid digestion unit for treating radioactive wastes are also discussed. (auth) (J7)

A general overview of activities at Hanford Engineering Development Laboratory. (DB/J7)

(91)

Hanford Engineering Development Laboratory, Richland, WA

Richardson, G.L., and D.E. Clark. 1976, Rev. HEDL-72-76-22: Nuclear Fuel Cycle and Production Programs Progress Report for July-December, 1975. G.E. Cooley and D.E. Letch (Comp.). pp. 2-37. 79 pp. (HEDL-72-76-22)

Wastes From Fuel Fabrication, Fuel Reprocessing, and Reactors (2)

Waste generation data are presented for three reactor cases, a fuel reprocessing (to plutonium nitrate product) case, a plutonium oxide preparation case, and a mixed oxide fuel fabrication case. The reactor cases include both Power and Deep Bed treatment systems for UOX, and PWR's. Division between low-level wastes and intermediate-level wastes was arbitrarily set at 200 mCi/kg (surface). Wastes from an operating commercial PWR were obtained and analyzed for alpha and beta-gamma activities. These wastes include: (a) evaporator bottoms, (b) ion exchange resins (deep bed demineralizer), and (c) filter cartridges from the spent fuel pool, reactor cooling system and waste holding tank. Principle gamma emitters were found to include activation and fission products such as Cesium 137, Cobalt 60, Cobalt 58, and Rhenium 186. (auth) (J7)

A summary of the wastes generated from the nuclear fuel cycle. Uses a computer code, designated ALPO, to project amount of alpha wastes generated in commercial facilities. Also provides radiometric data on non-transuranic reactor wastes. Therefore is applicable to shallow land burial as a means of estimating source term. (DB/J7)

(92)

Hanford Engineering Development Laboratory, Richland, WA

Greenhalgh, W.O. 1976, May. HEDL-76-76-22; 79 pp.

Product Storage and Disposal Evaluation (1)

Liquid fixation tests were performed on three readily available sorbent materials-i.e., vermiculite, Torb-all, and Ion-4-cel. A 3:1 volume ratio of sorbent to liquid resulted in a 100 percent sorption of the test liquid. Reduction of this ratio to 2:1 left 5 to 20 percent of the liquid unadsorbed. The fixation ability of Portland cement was also investigated. Mixtures with contents of less than 26 percent by weight were difficult to

fix, while those with a water content of greater than 30 percent by weight resulted in the formation of free water when allowed to set in a closed system. The effects of organic liquids on the fixation ability of Portland cement and sorbent materials were also investigated. In addition to the sorption studies, data are presented on the actual amount of radioactive waste disposal of at the six commercial burial grounds, including the four WEC sites, the WES site and the Chem-Nuclear site. In these compilations, wastes are segregated as by-product materials, special nuclear materials, and source materials. (auth) (J7)

Applicable to shallow land burial in that it addresses certain fixation properties of sorbent material. Data presented does not address leach rates or leachate characteristics. (DB/J7)

(93)

Hanford Engineering Development Laboratory, Richland, WA

Richardson, G.L. 1976, June. HEDL-SA-056; COSF-760701: Management of Wastes from the 1st Fuel Cycle, Proceedings of an International Symposium held in Denver, Colorado, July 11-16, 1976. (57 pp.) (HEDL-SA-056, COSF-760701)

Technologies for Recovery of Transuramics and Immobilization of Non-High-Level Wastes (3)

Recovery of transuramics and various immobilization methods of other non-high-level wastes is presented. Transuranic elements, in particular plutonium and americium, are recovered from non-high-level wastes and scrap material. For these plutonium bearing materials that are combustible, incineration is followed by leaching in a mixture of hot nitric and hydrofluoric acids. Any undissolved plutonium is recovered by fusion with a suitable salt. In addition to conventional heated acid techniques, ultrasonic energy, hot water ball milling, electropolishing, and steam and water jet sprays remove the plutonium from surface contaminated metals, glassware, plastics, and rubber gloves. Plutonium contaminated oils and solvents are treated by extracting them and then purifying by ion exchange techniques. An assay may be made of the plutonium present by radioactive decay, spontaneous fission, or induced fission. However, these methods must be used in conjunction with one another for a good analysis. Commercially available immobilization techniques are: urea-formaldehyde resins, hydraulic cement and cement plus additives, and bitumen. Two processes not used commercially, but used at Hanford, are absorbents and evaporation to a salt cake. Other technologies under development are clay fixation, glass formation, and pelletization. Absorbents are used for oils, solvents, and organic liquids that are difficult to immobilize by other means. Widely employed materials are vermiculite, diatomite, and various dehydrated clays. A salt matrix is produced by dissolving sodium containing wastes and crystallizing them by cooling. Recently wiped film evaporators have reduced the water content so upon crystallization the cake is solid. Neutral wastes are mixed with polymerized ureas in the presence of an acid catalyst to produce a gel which hardens to a free-standing solid. Hydraulic cements and portland cement are used to solidify ashes or calcines. Bituminization reduces volume 5-fold and is an effective sealant for other

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form of waste. Clay with the insoluble mineral cancrinite in the clay fixation method. clay is used for encapsulating due to its low leach rates. Little work has been done on solidification of low- and intermediate-level wastes by this method. Immobilization of radioactive salts, calcines, and slimes are accomplished by either cold pressing or vacuum hot pressing. A brief discussion of feasibility of the above methods is included. (271)

This report supplements a preceding paper by C.P. Cosley and D.L. Clark on "Treatment Technologies for Low-Level Wastes" (NSRL-54-953). (JSTC, 1977)

(94)

Sanford Laboratories Operation, Richmond, VA

Raymond, J.P., and W.J. Stierbach. 1976. October. Transactions of the American Geophysical Union, 59(12), 172-173.

Hydrologic Investigation at Sanford (18)

The effects of disposal of large volumes of water at the Sanford Plant are investigated. Recontaminated process water, such as condenser cooling water, is disposed of by introduction in the volcanic rocks of the structural and topographic basin which the Columbia River occupies. The basaltic lavas are interbedded with sedimentary rocks and these are in turn covered by a series of poorly consolidated lacustrine fluvial, and glaciofluvial sediments. These rocks are well-suited for handling large volumes of water. The region is characterized by a low rainfall and deep water table with a low gradient. From the 95 wells the ground water is found to originate in the mountainous areas of recharge to the southwest and flows generally toward the northeast to the Columbia River. From the high areas of recharge the gradient is 15 ft/mi while the natural gradient is 5 ft/mi. During the 12 years the Sanford Plant has been in operation, it has made appreciable changes in the local water table by releasing 24 billion gallons of non-radioactive cooling water. By 1951 two major ground water mounds were 55 and 15 ft higher than the regional water table. The differences in the size and shape of the two mounds are a result of the differences in geologic controls. The mounds are now 80 and 20 ft above the natural water table. These mounds locally reversed the normal hydraulic gradient (toward the Columbia River). They also affect the velocity of movement. If a pond is rising, it increases the velocities in all directions. A six-fold increase in velocity has been observed. Well hydrographs show the natural fluctuations of the water table to be: 1.) periodic rise and fall in response to river stages; 2.) diurnal changes caused by changes in atmospheric pressure; and 3.) small, significant fluctuations caused by regional and far-distant earthquakes. Immediately beneath the discharge area water levels have risen as much as 80 ft and 20 miles to the northeast the water table has risen 0.5 ft. A two-day drawdown-recovery test in the 1900 conglomerate of the Ringold formation gave a coefficient of transmissibility of 30,000 gpd/ft and a coefficient of storage of 7×10^{-5} (E-5). An eight-day test in part of the glaciofluvial sediments indicated a transmissibility coefficient of 10,000 gpd/ft and a storage

coefficient of 0.05. A four-day test in the very coarse-grained glaciofluvial sediments gave a transmissibility coefficient of 1,000,000 gpd/ft and a storage coefficient of 0.25. The portion of the Ringold formation containing the higher ground water would have a transmissibility of 25,000 gpd/ft. From the tests it was determined that there are areas of rapidly moving water north and south of Cable Mountain and southeastward of the western ground water mound. It is believed that various usage of ground water disposal with no environmental hazards will be justified through this research. (280)

Depth to Water Table: Stratigraphic Unit
Thickness: Storage Coefficient: Transmissivity

(95)

Sanford Laboratories Operation, Richmond, VA

McHenry, J.B. 1976. Soil Science Society of America, Proceedings, 22, 549-553.

Ion Exchange Properties of Strontium in a Calcareous Soil (19)

The exchange of strontium ion for calcium on the soil complex was found to be a function of the initial strontium concentration, the pH of the equilibrium system, and the nature and concentration of the complementary ions. The soils used were coarse-textured, Sierston, similar to those commonly occurring in the western United States. The ratio of the exchangeable strontium per gram of soil to that adsorbed per milliliter of solution was constant when the strontium-ion concentration was less than $10(E-5)$ M. The presence of other cations (K^+ , D^+ , Na^+ , NH_4^+ , and Li^+ in descending order) had little effect on the exchange of strontium when the initial strontium-ion concentration was less than $10(E-6)$ M. The exchange of strontium is particularly sensitive to pH--being maximum between pH 8 and 10 and decreasing rapidly as the pH is lowered below 8.0. Anions also showed little effect on the distribution coefficients. The anions considered were $(PO_4)^{3-}$, $(C_2O_4)^{2-}$, Cl^- , $(SO_4)^{2-}$, and $(NO_3)^-$. Only phosphate and oxalate caused a higher strontium uptake with higher pH. Strontium exchange on a calcareous soil may be replaced by various cations (Li^+ , Na^+ , K^+ , Mg^{2+} , Ca^{2+} , Ba^{2+} , La^{3+} in ascending order) by extensive leaching. Hydrogen ions readily replaced strontium. The effectiveness of other cations is a function of their concentration, charge, and thermodynamic activity. Large volumes of solution containing radiostrotrium are decontaminated on passing through a unit volume of the calcareous soil employed in this study. Such a soil is capable of concentrating 0.5 mc of Sr 90 per g of soil when the percolating solution contains less than $10(E-6)$ moles per liter of strontium. (auth) (297)

Cation Exchange Capacity; pH; Distribution Coefficient; Grain Size Distribution

(96)

Health and Safety Laboratory, New York, NY

Kray, P.V., E.P. Hardy, and L.E. Yoonkel. 1977, April. HSL-110; Health and Safety Laboratory Environmental Quarterly, December 1, 1976 through

Measurements of Environmental Pollu with Integrating Instruments (2)

Two instruments have been developed to monitor environmental radon concentrations. Both instruments use alpha emitting thorium/thorium-232 lithium fluoride chips for detection. The first instrument is a "time averaged two-filter radon monitor" that uses a two filter tube and a personal sampler pump. The second is a passive system which electrostatically collects Po-210 ions on an electrode and uses a HUD for detection. The lower limits of detection, for a one week period, are 0.85 pCi/l and 0.93 pCi/l. Collectively, the first system costs approximately \$800 while the second costs about \$50. DJG

A review of two instruments that can be used to monitor taken in and ground uranium mills. Although designed for mills, the instruments can be used at the tailings disposal areas to monitor taken concentrations. (S) (U)

Health and Safety Laboratory, New York, NY

Plutonium-238 in Sediment Cor. From the Round Laboratory Area (4)

Plutonium 238 in eight sediment cores from water bodies near Sand Laboratory are reported. All have been measurably contaminated as a result of a ruptured underground waste line in the laboratory. Measurements for the next part show concentrations with depth in the sediment suggesting that chemical and/or biological processes may be quite active, and that run-off from nearby contaminated soil is probably continuing. The integrated Pu 238 deposits indicate that these samples essentially represent the complete sediment column. (Auth) (U)

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Health Services Laboratory, Idaho Falls, ID

Sill, Z.W., R.D. Pophul, and P.D. Hindman. 1974, October. Analytical Chemistry, 45 (12), 1725-1737.

Simultaneous Determination of Alpha-Emitting Nucleides of Radium through Californium in Soil (8)

a procedure is described by which virtually all alpha-emitting nuclides can be determined in soil, either singly or in any combination on a single sample. The sample is decomposed completely by a combination of potassium fluoride and pyrosulfate fusions with simultaneous volatilization of hydrogen fluoride and silicon tetrachloride. The cake is dissolved in dilute hydrochloric acid and all alpha emitters are precipitated with barium sulfate. An option is provided by which

Health and Safety Laboratory, New York, NY

George, A.C., and A.J. Breslin. 1977, August. Methods for Measuring Radiation in and around Uranium Mills, Progress Report, E.D. Hayward (Ed.), Volume 1, No. 9, Proceedings of a Workshop held in Albuquerque, New Mexico, May 23-26, 1977, (pp. 105-116). 811 pp.

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uranium can be obtained in a separate fraction to eliminate mutual interference with Sp 237 . Barium sulfate is dissolved in acetic acid, and the elements from thorium through plutonium are extracted into Aliquat 336. Acid-deficient aluminum nitrate is then added to the aqueous phase to reduce the acidity, and americium, curium, and californium are extracted into fresh Aliquat 336. Thorium is removed by scrubbing the first organic extract with 10N hydrochloric acid, and protactinium, uranium, neptunium, and plutonium are stripped with a mixture of perchloric and oxalic acids. Americium, curium, and californium are stripped from the second organic extract with 8N nitric acid. Each fraction is electrodeposited and analyzed by alpha spectrometry with few interferences. Overall recovery excluding electrodeposition ranges from 98% for protactinium to 99% for plutonium (Auth)

removing 65,000 cubic meters of waste contaminated with transuranic elements from below ground burial. The facilities consist of an Outer Weather Shield, a plastic coated fabric structure supported by air pressure from the inside, and a smaller portable Operating Area Confinement Building which covers the excavation area and can be moved from place to place as the excavation progresses. Retrieval of waste started on May 4, 1976, and by the end of the transition quarter, a total of 41.8 cubic meters of waste had been retrieved. This total includes 25.18 cubic meters of uncontained loose waste and soil, and 89 drums. Virtually all of the drums were severely rusted and ten leaked liquids when removed from the pit. Four of these leaking drums contained contaminated liquids, but only one resulted in soil contamination. This contamination was totally contained within the Operations Area Confinement Building, and equipment used for personnel safety proved to be functional and adequate for contamination protection.

<100>

Idaho National Engineering Laboratory, Idaho Falls, ID

Card, D.W. 1977, February. TREE-1007; 80 pp.

Early Waste Retrieval Interim Report (1)

The Early Waste Retrieval project was initiated in FY-76 for the purpose of investigating the problems associated with removing 65,000 cubic meters (2.3 million cubic feet) of waste contaminated with transuranic elements from below ground burial. Retrieval of waste started on May 4, 1976. By the end of the transition quarter, a total of 41.8 cu m (1458 cu ft) of waste had been retrieved. This total includes 25.18 cu m (870 cu ft) of uncontained loose waste and soil, and 89 drums. Virtually all of the drums were severely rusted, and five were either damaged or were missing the cover, but contained no liquids. Ten were deteriorated and leaked liquids when removed from the pit. Four of the leaking drums contained contaminated liquids, but only one resulted in soil contamination. However, the contamination was totally contained within the Operating Area Confinement building. Maximum soil contamination levels observed during this event were of the order of $4 \times 10^4 \text{ (Bq/g)}$ $4/9/76$. The soil contamination experience resulted in the improved handling of leaking drums. (Auth) (JTS)

Documents retrieval operations of TBN waste from burial trenches. (ESIC/PTO)

<101>

Idaho National Engineering Laboratory, Idaho Falls, ID

Card, D.W. 1977, February. TREE-1061; 80 pp.

Early Waste Retrieval Interim Report (1)

This interim report details the facilities, operational activities, and related studies of the Early Waste Retrieval project at the Idaho National Engineering Laboratory. The Early Waste Retrieval project was initiated in fiscal year 1976 for the purpose of investigating the problems associated with

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Idaho National Engineering Laboratory, Idaho Falls, ID

Harness, J.L., and J.D. McKinney. 1977, January. TREE-1061; 29 pp.

Containment of Transuranic Contamination at the Early Waste Retrieval Project (1)

The Idaho National Engineering Laboratory was first utilized as a site for radioactive waste disposal in July of 1952. In July of 1976, an Early Waste Retrieval Program was undertaken to investigate factors associated with a major effort to retrieve all of the transuranic waste buried at the Radioactive Waste Management Complex. The particular pit chosen for the retrieval project contained transuranic waste buried between October 1959 and June 1963. This pit had been flooded in 1962, and this was thought to have created the worst possible conditions for drum burial. On July 26, 1976, while retrieving buried transuranic waste under the Early Waste Retrieval Program, a corroded 55-gallon 17H drum was retrieved. When uprighted, several liters of liquid escaped from the drum. This liquid was contaminated with transuranics--principally Pu 239 , Am 241 , and some Pu 238 . As a result of the spread of this contamination in the Operating Area Confinement, six working days were required to decontaminate the area. At no time did the contamination escape the interior of the Operating Area Confinement building. No contamination to personnel resulted from this occurrence, nor was a hazard presented to the general public. The facility was designed and constructed to contain the transuranic contamination resulting from such an occurrence. Proper prior planning and personnel training prevented the contamination occurrence from becoming a major event. This report details the occurrence, the recovery, and the information obtained from this event. (Auth) (CSF)

Documents decontamination of liquid radioactive spill of about 8 to 8 liters covering 2,000 cu of soil. (ESIC/PTO)

<103>

Idaho National Engineering Laboratory, Idaho Falls, ID

Wentzer, J.C., and R.W. Snyder. 1977, September. WNEE-1072; 28 pp.

Transport, Handling, and Interim Storage of Intermediate-Level Transuranic Waste at the IREL (1)

The transport, handling and interim storage of intermediate-level transuranic (T20) waste at the Idaho National Engineering Laboratory (INEL) is discussed. Transuranic-contaminated solid waste is considered as such when the alpha-emitting radionuclides of long half-life and high specific radioactivity is greater than 10^{-6} Ci/g. Waste form criteria and packaging criteria are outlined for the Waste Isolation Pilot Plant and Radioactive Waste Treatment Complex. The current intermediate-level T20 storage facility contains 26 storage vaults. Twelve of these vaults has an inside diameter of 0.59 m and the remaining have an inside diameter of 0.19 m. The storage vaults are carbon steel pipe isolated vertically in a long, narrow bore with a crushed gravel base course and a subbase of pit run gravel. Each vault consists of a long, straight-walled lead-in section. A lid attached to the vault body seals the vault and any moisture is prevented by a bag of desiccant between the lid and the shield plug. Additional storage vaults can be accommodated at the facility. These newer vaults have been redesigned to better meet the Waste Isolation Pilot Plant criteria. Environmental monitoring is also done. The total cost of storage at the facility is \$692/Cu m or \$196/Cu ft. Waste generators as well as transportation and handling are included in the presentation. (SD9)

<104>

Idaho National Engineering Laboratory, Idaho Falls, ID

24 pp.

Waste Management at the Idaho National Engineering Laboratory (1)

Generalized review of waste management at INEL. Brief popularized discussions of the types of operations going on at the site, the type of waste burial and disposal in use, and the monitoring programs. These discussions include the disposal of low-level wastes through the use of seepage ponds and direct discharge to the Snake River Plain Aquifer, the storage of high-level wastes in liquid form and as calcined solids, and the burial of solid wastes. Brief discussion of packaging and processing wastes are also included. (CAB)

Significant data concerning shallow land burial. (DW/CAB)

<105>

Idaho National Engineering Laboratory, Idaho Falls, ID

Doleac, R.W. 1977, April. WNEE 77-2; 18 pp.

Moisture Exclusion Studies for Stored Transuranic

Waste, 1975-1976 (1)

Moisture exclusion evaluation studies were undertaken to attempt to eliminate seepage of meteoric waters into burial trenches containing transuranic wastes. Several moisture exclusion techniques were evaluated based upon predictable useful life, ease of recoverability of waste, and overall costs. The evaluations were accomplished by literature search, vendor contract, laboratory testing, and field pilot programs. Chemical sealants investigated included clay-type sealers such as bentonite, repellent surface coatings such as wax and oil, and chemical stabilizing agents such as sodium methyl silicate. These sealants were regarded as unacceptable for application at the burial grounds at INEL because of their deterioration by adverse weather conditions. Physical moisture barriers evaluated included concrete, asphalt, plastics, and soil. The physical moisture barriers given the highest ratings were thick soil cover, asphalt, and Hypalon liners. Field pilot tests currently in progress include emplacement of clayey silt overburden, polymer applications, and chemical sealants. (JC)

Evaluation is thorough but is geared toward specific INEL waste management complex needs. (SD/JC)

<106>

Idaho National Engineering Laboratory, Idaho Falls, ID

Doleac, R.W., and D.M. Janke. 1977, May. WNEE-1076; 26 pp.

Environmental Surveillance Report for the INEL Radioactive Waste Management Complex Annual Report, 1976 (1)

This report describes the environmental surveillance activities during 1976 at the two solid waste facilities of the Idaho National Engineering Laboratory. The results of environmental surveillance work conducted by the USGS and the ERDA Health Services Laboratory in the environs adjacent to the facility are also reported. Remote gamma radiation survey of the surface of the facilities was conducted and plotted on a map and identified areas whose exposure rates were greater than 1 mR/hour at 91 cm. Thermoluminescent dosimeters placed on the perimeter of the subsurface disposal area showed an exposure range of 96 to 980 mR for a six-month period. Annual soil sampling was conducted and samples were analyzed for Pu 239/240 levels at the surface and at depths of 15 cm and 10 cm. Analysis results ranged as high as 35.1 ipm/g. Maximum gross beta and gamma activity are attributed to fallout from nuclear tests conducted by the People's Republic of China. Collection and radiometric analysis of surface and subsurface was also performed. (Auth) (JT)

Data directly applicable to Shallow Land Burial. (DW/JT)

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Idaho National Engineering Laboratory, Idaho Falls, ID

ENVIRONMENTAL

Wickert, J.L., and R.W. Patterson. 1974. November. ENEC-1012; 24 pp.

Environmental Surveillance Report for the INEL Radioactive Waste Management Complex, Annual Report 1974. (1)

Continuous sampling of the environment around the Radioactive Waste Management Complex (RWMC) at INEL is conducted on, at least, an annual basis. The report summarizes this program and presents the results of the analysis of these samples collected during 1975. Gamma-survey and collection of soil samples are conducted annually. Soil samples are analyzed for plutonium isotopes and analyzed by gamma spectrometry. Air particulates, which are continuously sampled by low volume air pump, are analyzed for long-life beta-emitters and alpha. Surface and subsurface water sampling and subsurface moisture probe investigations are conducted at selective intervals. Environmental dosage is continuously measured by TLD's placed around the Complex perimeter. These TLD's are changed and read on a semi-annual basis. Gamma-surveys of the RWMC indicate general radiation levels of 0.05 μ R/hour while perimeter TLD's indicate general radiation levels of 0.40 μ R/hour (integrated exposure). Soil samples indicate various activity concentrations for plutonium 239 and 240 of 44.1 dpm/g and for cesium 137, various concentration was 1.9 dpm/g. Air sampling indicates that the predominant radionuclide was cobalt 60 with a various specific activity of 2.13 x 10(E-13) μ Ci/cc. (J7)

A summary of the environmental surveillance program at INEL's waste management facilities and the results of analysis conducted. Included are maps of the sampling locations. The data are directly applicable to shallow land burial. (J7/J7)

(100)

Idaho Operations Office, Environmental Branch, Idaho Falls, ID

Johnson, J.R., and D.L. Newcomb. 1969, April. INO-12040 (Suppl. 4); 13 pp.

Radioactive Waste Disposal Data for the National Reactor Testing Station, Idaho (2)

Radioactive wastes associated with reactor operations at the National Reactor Testing Station during 1968 are identified according to quantity, physical form, nuclide content, and installation or area originating the waste. For comparison similar data from the years 1955 through 1967 is also presented. A volume of liquid radwastes totalling 5.5 x 10(E+6) gallons and with a total activity of 2M2 Ci was discharged to the lithosphere. Alpha activity was less than 0.3 Ci. The activity of the waste came mainly from the three reactors. The effect of decay is shown when the difference between gross activity and nuclide activity is 86,108 Ci. About 250,000 gallons of high-level liquid wastes were converted to granular solids. Nonradioactive waste water with a volume of 115 million gallons was discharged in a well. The total release to the atmosphere by all NRTS sites is 18.5 x 10(E+10) cc ft containing 185,544 Ci. Almost all the atmospheric releases came from the fuel cycle facility and the transient Reactor Test Facility. The solid wastes are buried in trenches or pits in the regolith overlying the basalt. For 1968 both on and

off-site low-level solid wastes had a volume of 478,000 cc ft with an activity of about 15,200 Ci. The radioactive levels of all solid wastes were on-site buried waste, 1.9 Ci/cc ft; on-site stored waste, 1.63 Ci/cc ft; and off-site buried waste, 0.33 Ci/cc ft. The offsite wastes came from the Dow Chemical Plant, Golden, Colorado, and Aerospace Corporation, Dallas, Texas. The cost for 1968 was 13 cents/cc ft. (J99)

Several tables are given which summarize the radioactivity discharged to the environment. (E51C/E5F)

(101)

Idaho Operations Office, Health and Safety Division, Idaho Falls, ID

Schultz, B.L., and W.S. Keys. 1963. Retention and Migration of Radioactive Ions in Soils, Proceedings of an International Colloquium held in Sceaux, France, October 16-19, 1962 (pp. 243-256).

Retention and Migration of Radioactive Isotopes in the Lithosphere at the National Reactor Testing Station, Idaho (1)

The National Reactor Testing Station is located in a desert plain underlain by Tertiary and Quaternary basalt. The regolith is composed of wind and water laid sediments usually not over 20 meters deep. The climate is arid and the soils are classified with the Sierozas group. The regional water table is in aquifers in the basalt at an average of 140 meters below the land surface. Aqueous liquids containing fission and activation products in a concentration of the order of 10(E+3) μ Ci/ml, plus tritium in a concentration of 10(E+3) μ Ci/ml, are routinely discharged to ponds excavated in the alluvial regolith. Migration of radioisotopes through the regolith and basalt is delineated by samples from drill holes. The water and isotopes have been detected in the regolith at distances of 150 meters from the materials engineering testing reactor (MTR-ETR) disposal pond. The waste has been detected in perched water in the basalt at a distance up to 1.5 kilometers. The following migrating isotopes have been identified: tritium, cesium 51, cobalt 60, iodine 131, cesium 134, ruthenium 106, silver 110. Tritium, cesium 51 and cobalt 60 have been observed to be particularly migratory. The migration of cobalt 60 and cesium 137 has also been observed at other plant areas. The concentration of tritium diminishes with distance from the disposal pond. Because disposal is to the zone of aeration this cannot be explained on the basis of dilution. Ion exchange has been substantiated by laboratory studies. Columns filled with natural earth materials have shown that significant attenuation of tritium does occur despite relatively small column capacities. Migration of contaminated ground water resulting from disposal of waste at the NRTS is most extensively tapped on the basis of tritium analyses. Concentrations of 10(E+6) tritium units (T.U.) have been discovered at distances of 210 meters from a disposal well. Attenuation of the concentration to 1,200 T.U. at distances of 5 kilometers from the disposal point is observed. Attempts to trace contamination in ground water beyond 800 meters on the basis of isotopes other than tritium have been unsuccessful. Chemically contaminated wastes have also been traced to a distance of 5 kilometers. (Aeth)

<179> CONT.

Depth to Water Table; Stratigraphic Unit Thickness

<180>

Idaho Operations Office, Idaho Falls, ID

Schulz, B.L. (Comp.). 1972, October.
ID-10000; 80 pp.

Radionuclide Distribution in Soil Profile of the Lithosphere as a Consequence of Waste Disposal at the National Reactor Testing Station (N)

A study of the distribution of radionuclides in the soils and groundwater as a result of the disposal of liquid and solid radioactive wastes at the National Reactor Testing Station. The total gross activity disposed of into drainage ponds is estimated to be approximately 8.3×10^{10} Ci, at an annual rate of 2.8×10^{10} Ci per year. Distribution coefficients (Kd) for strontium 85, cesium 137, cobalt 60, and chromium 51 are presented based on ion exchange column data and theoretical calculations. Data on the distribution of cesium 137, strontium 90, cobalt 60, and cesium 137 in the soil and water adjacent to the ponds are presented. Data indicate that the sorption capacity of the alluvial deposits between pond bottoms and the basalt bedrock have been reached. Retention of cobalt 60 in soil is attributed to reactions other than ion exchange. The average specific activity of the solid waste disposed of at the burial ground is estimated at 1.15 Ci per cubic foot. Calculation of the concentration of strontium 90 and cesium 137 in soils as a function of time and depth are presented. Gross alpha, beta, and gamma activity concentration data for soil samples obtained adjacent to burial grounds are presented. Data on the concentration of uranium 235/238, uranium 239, plutonium 239 and plutonium 238/239/240 in soils beneath a pit are presented. (J7)

A root review of the distribution of radionuclides in the soils at NRTS as a result of radioactive waste disposal. (N/J7)

Distribution Coefficient; Grain Size
Distribution; Stratigraphic Unit Thickness

<181>

Illinois State Geological Survey, Urbana, IL

Hughes, G.V. 1972, April. Environmental Geology Notes No. 41; 77 pp.

Hydrogeologic Considerations in the Siting and Design of Landfills (N)

A general description of the hydrogeologic factors that are of concern in the consideration of a potential landfill site. These hydrogeologic factors include (a) the position of the landfill within the ground-water flow system; (b) the position of the water table with respect to the refuse; and (c) texture and composition of the surrounding earth materials and their ability to transport and attenuate dissolved solute. Engineering considerations addressed include liners to reduce infiltration of groundwater or refuse movement of the leachate out of the landfill, covers to reduce infiltration of

precipitation and drainage and collection systems. (N/J7)

Although specifically written as a potential guide for the consideration of potential landfill areas, the areas of concern identified are applicable to potential radioactive waste burial sites as well. (N/J7)

<182>

Kentucky Department for Natural Resources, Bureau for Health Sciences, Office of Consumer Health Protection, Frankfort, KY

1976, December. Kentucky Department for Natural Resources Project Report; 21 pp.

Six Month Study of Radiation Concentrations and Transport Mechanisms at the Nixey Flats Area of Fleming County, Kentucky (N)

The results of an intensive 6-month monitoring of radioactive concentrations in the environs of Nixey Flats Disposal Site are reported. Included in the study are subsurface water from E-Series wells, restricted area surface water, unrestricted area water, and soils. All samples were analyzed for tritium, gross alpha, gross beta, and gross gamma activity. Other specific radionuclides. (N/J7)

Useful raw data on radioactive concentrations in the Nixey Flats disposal site vicinity with somewhat controversial interpretation. (N/J7)

<183>

Kentucky State Department of Health, Radiological Health Program, Frankfort, KY

Clark, D.T. 1973, October. Radiation Data and Reports, 10(10), 573-585.

A History and Preliminary Inventory Report on the Kentucky Radioactive Waste Disposal Site (N)

The Kentucky radioactive waste disposal site (Nixey Flats Disposal Site) has been in operation since March 1961. As of January 1, 1972, approximately 0.71 cubic kilometers of waste, containing 1.15 megacuries of by product material, 200 kilograms of special nuclear material, and 39,000 kilograms of source material, has been disposed of at this facility. Most of the solid wastes are buried in rectangular trenches approximately 110 ft long, 21 ft wide, and 4 ft deep. The floor of the trench is to have a slope of approximately 1 degree to a pump and stand pipe positioned at the lowest level. Each completed trench is required to be backfilled with a minimum of 1 ft of earth materials mounded and compacted to form and maintain an "umbrella" to seal out ground water to the greatest extent possible and to divert rain water away from the trench. A shallow graded crop is then planted to prevent erosion. Small volumes of high specific gamma activity sources are deposited in special hot wells constructed about 0.6 m deep with pipes of coated steel, concrete, or tile placed vertically in the ground and closed at the lower end and capped at the upper end. Other high intensity sources of larger volumes are placed in individual pits approximately 4 m long by 1 m wide by 1 m deep. This report contains a brief history of the facility and a summary of the inventory results. (N/J7)

<117> CONT.

Useful as an introduction to the waste contained in the Energy Plant Disposal Site. (25/100)

<118>

Lawrence Livermore Laboratory, Livermore, CA

Borg, I.V., E. Stone, E.B. Levy, and L.D. Passport. 1976, May. UCRL-52078; 216 pp.

Information Pertinent to the Migration of Radionuclides in Ground Water at the Nevada Test Site. Part 1: Review and Analysis of Existing Information (2)

The Nevada Test Site (NTS), with an annual rainfall of 22-28 inches, lies in a mountainous desert region of southern Nevada. The NTS contains ash-flow tuffs, earlier sedimentary deposits as well as alluvial and lacustrine deposits. The purpose of this report was to review what is known of radionuclide migration in ground water at NTS. A relatively complete chart of stratigraphic and hydrologic units is in the document, including name, system, series, and lithology. Mean total porosity of the lower carbonate aquifer at NTS is 5.0% while the mean effective porosity is 2.3%. The hydraulic conductivities average 8×10^{-5} m/day. The transmissivity varied with depth in each hole, ranging from 16-885 square meters/day. It is believed that water movement is through interconnected fractures. Based on hydraulic conductivities of 2×10^{-5} to 2×10^{-4} m/day, effective porosities of 10-30% (estimated quite high), and vertical hydraulic gradients of .02 to .2 u/mile the ground water is estimated to move downward at a rate of 1.5×10^{-5} to 6×10^{-5} m/year downward in the tuff aquifer. The rate of lateral movement has been estimated from 1.8 to 190 m/yr, based on effective porosity between 0.01 to 1%, which is believed to be more nearly the case. The appearance of radionuclides from NTS into public wells is deemed very unlikely. The most likely source of tritium, if it appears offsite, is Pahute Mesa. The prediction of migration both within and without NTS are hampered by a lack of fundamental values used in transport calculations. A need is seen for a continued monitoring program especially of 93 as inventory of nuclides deposited beneath Pahute Mesa, and a determination of the radionuclides deposited in the Lower Carbonate Aquifer. (270)

Mean Precipitation; Total Porosity; Effective Porosity; Hydraulic Conductivity; Hydraulic Gradient; Dispersion Coefficient; Transverse Dispersion Coefficient; Longitudinal; Thickness of Upper Aquifer; Stratigraphic Unit Thickness; Depth to Water Table

<119>

Lawrence Livermore Laboratory, Livermore, CA

Borg, I.V., E. Stone, E.B. Levy, and L.D. Passport. 1976, August. UCRL-52078; 112 pp.

Information Pertinent to the Migration of Radionuclides in Ground Water at the Nevada Test Site. Part 2: Annotated Bibliography (1)

Abstracts and references for 261 documents are

included in this report. Relevance numbers 1, 2, or 3 are assigned to each reference on the basis of pertinence to radionuclide migration at the Nevada Test Site (NTS). Part 1 contains 54 references pertaining to general hydrology and hydrogeology of NTS and other U.S. sites. Part 2 contains 199 entries concerning distribution and transport of radioactivity at NTS, other U.S. sites, and foreign sites where radioactivity has been deposited. Part 3 contains 95 references pertaining to sorption and leaching studies. (270)

Relevance numbers assigned on basis of pertinence of document to radionuclide migration at NTS. Two-hundred and sixty-one references with abstracts are given. (2510/273)

<120>

Lawrence Livermore Laboratory, Livermore, CA

Borg, I.V., E. Stone, E.B. Levy, and L.D. Passport. 1976, May. UCRL-52078 (Part 1); Information Pertinent to the Migration of Radionuclides in Ground Water at the Nevada Test Site, Review and Analysis of Existing Information, Chapter 5, pp. 127-166; 216 pp. (UCRL-52078, Part 1.)

Transport of Radioactivity in Ground Water (2)

Movement of radioactivity in the ground water is dependent on the interaction of the radionuclides with the host medium. Sorption and desorption are functions of the chemical and physical characteristics of both the solid and liquid phases. Molecular diffusion has little effect on flow rates would be negligible. In a uniaxial section the average flow speed of water through the section is obtained by dividing the magnitude of the specific discharge by the effective porosity of the host medium. Sorption has been used to describe the reaction by which a species is removed from a liquid by a solid. The term "ionexchange" is used to designate a reversible sorption reaction in which an ion in the liquid phase is exchanged for an ion in the solid phase. The "distribution coefficient" is a unit of relative concentration of an ion between the solid and liquid phases, when exchange occurs under equilibrium or near equilibrium conditions. Clays and zeolites are the primary naturally occurring minerals that exhibit high ion-exchange capabilities. Cation-exchange capacities for clays range from 0.62 meq/g to 1.5 meq/g for kaolinite and montmorillonite respectively. Sorptive capacity of the host medium varies inversely with particle size. Generally a decrease in particle size will be reflected by an increase in sorptive capacity. This relationship is attributed to the increase in total surface area available as particle size decreases. For essentially impermeable host rock, the sorptive capacity is referred to as the surface distribution coefficient and reflects the surface area of the solid phase more than the mass. Additional parameters which affect the sorptive reaction between liquid and solid phases include pH, degree of complexation, concentration, ionic size, degree of hydration and hydrolyzation and oxidation state. Hydrodynamic dispersion, one and two dimensional transport models and the requirements for prediction of radionuclide migration in ground water are described. (27)

A review of the various parameters which influence the rate and extent of radionuclide

(118) (119)

visitation in the ground water. Although no specific data is presented, the discussion is directly applicable to shallow land burial. (118/119)

(119)

Lawrence Livermore Laboratory, Livermore, CA

Cohen, J.J., L.L. Schwartz, and E.A. Yeates.
1976. Transactions of the American Nuclear Society, 10, 190-195.

Economic and Environmental Evaluation of Nuclear Waste Disposal by Underground In-Situ Melting (119)

Basic premises of deep underground encapsulation in a rock matrix (DOERNIT) are presented. Originally, DOERNIT involved the direct disposal of liquid radioactive waste into nuclear chimneys formed by underground nuclear explosions. The waste would eventually evaporate to dryness from the heat produced by radioactive decay, melt the surrounding rock, dissolve in the molten rock, and ultimately resolidify and be incorporated in a solid rock matrix. Concept modifications are: use of underground cavities formed by conventional excavation methods; pre-solidification of waste and its addition in solid form; and self burial of wastes by rock-melting capsules. Potential environmental advantages of DOERNIT are: elimination or reduction of many processing operations and their attendant risks; potential for safe disposal of all levels of liquid waste; elimination of radioactive waste transportation and attendant risks; permanent binding of the radionuclide in a rock matrix deep underground; and provision of a secure disposal method assuring permanent safety from effects of disasters such as floods, sabotage, or warfare. However, there are potential problem areas in using this method. They are: irretrievability of waste; increased number of disposal sites; ground water contamination; consequences of seismic activity; and ecological alteration due to change of state of large volumes of rock. Considering all factors the advantages of the method outweigh the disadvantages. Cost comparison studies indicate DOERNIT would be the most economic method of waste disposal both in absolute terms and in cost effectiveness. Future research includes laboratory investigations on heat transfer and phase-change phenomenology, chemical studies on the properties of the resolidified waste-rock material, and engineering studies. (119)

(119)

Lawrence Radiation Laboratory, Livermore, CA

Evans, B.J. 1966. CONF-651202; IAE SR-71/81; Practices in the Treatment of Low- and Intermediate-Level Radioactive Wastes, Proceedings of a Symposium held in Vienna, Austria, December 6-10, 1965, (pp. 3-16) (CONF-651202, IAEA-SR-71/81).

Waste Management Practices at Lawrence Radiation Laboratory, Livermore (119)

This paper describes the facilities and practices currently involved in medium- and low-level radioactive waste management at the

University of California, Lawrence Radiation Laboratory, Livermore. The research programs of the Lawrence Radiation Laboratory are such that waste disposal includes a complete variety of problems ranging from mixed fission products to transuranic elements. At a cost of 6-10 \$/gal, up to 200,000 gal of liquid waste ranging from 10 (ppm) to 10 (ppm) dpm/l (5x10 (ppm) to 5x10 (ppm) uCi/ml) are decontaminated annually in the 250,000 gallon facility. After breaking emulsions and centrifuging the waste when necessary, the pH is adjusted to 3.5 and an oxidizing environment is provided. Addition of ferric and oxidation of the pH to 9.0 results in a floc capable of removing or combining with contaminants. Decantation factors of 10,000 are obtained routinely in batch sizes ranging from 500-10,000 gal. Although most polyvalent cations respond favorably to co-precipitation, the presence of alkali metals, alkaline earths, and the complex, multivalence states of ruthenium in the waste require further ion-exchange polishing. After precipitation, the hydroxide floc is partially de-watered with the aid of a rotary-drum filter, giving an over-all volume reduction greater than 99.5%. Other liquid disposal techniques in use at LRL, Livermore Laboratory, include phosphate and sulphide flocs, solidification, and solar evaporation. Over 25,000 cu ft of packaged dry waste are shipped to off-site land burial annually. Packages range from 55-gal drums to waste encapsulated in 20-t concrete casks. A variety of special Livermore containers, utilizing wood, lead, steel, polyethylene and concrete, are described together with techniques for their use. A detailed account is offered of the design and operation of a 5-t hydraulic ram for compressing drummed dry waste. Costing only \$1500, the press achieves a four-to-one volume reduction and offers significant savings. (119)

Relevant to shallow land burial only in terms of describing final packaging of waste to be shipped to land burial sites from Lawrence Livermore Laboratory. (119/119)

119

(119)

Los Alamos Scientific Laboratory, Environmental Studies Group, Los Alamos, NM

Rogers, R.A., L.E. Trocki, and C.J. Wohlgemuth. 1977, June. LA-6056-P2; Development Activities on Shallow Land Disposal of Solid Radioactive Waste, Summary Progress Report, January-December, 1976, (pp. 4-7), 8 pp. (LA-6056-P2).

Los Alamos Scientific Laboratory Radioactive Waste Disposal Site Studies (119)

As a result of the United States Geological Survey/Los Alamos Scientific Laboratory evaluation, which started in 1971, two monitoring programs have recently been initiated at the Los Alamos Scientific Laboratory, radioactive solid waste disposal site at Area G, TA-50. A soil moisture monitoring program is obtaining data describing the changes in water content (with depth and time) in fill material overlying buried waste and in the tuff surrounding waste disposal shafts to a radius of 6m. The major variations in water content for 1976 for one hole occur within a meter of the surface, presumably due to spring snowmelt and summer storms. No significant changes are seen below 1m. The downward decrease in water content

<119> CON.

we indicate a small downward moisture flux; work is in progress to resolve this question. Collection of meteorological data constitutes the second program, which is still in the constructing phase. A 60-ft. steel tower and an adjoining instrument shelter are currently being erected at Area G. The enclosed instruments will measure and record wind speed, air temperature, humidity, precipitation, surface temperature, and heat transfer in the soil. In line with the development of a monitoring program for Los Alamos solid radioactive waste disposal sites, methods and instrumentation are being developed for the detection and measurement of the radionuclides of interest at the waste disposal site in situ (on the surface and in augered holes), or *in vitro* in the form of picocuries per gram range. The elements/radionuclides of particular interest in the field at the Los Alamos waste disposal sites are principally plutonium, uranium, tritium, and strontium. Various geologic investigations have been undertaken including a horizontal core-drilling program at Area G. Geologic mapping of new waste burial pits is routinely conducted to collect structural, geology data on the area and to make sure that there are no large unbroken fractures in the walls of open fractures could provide potential migration paths. (Auth) (ST)

Monitoring programs at the Los Alamos Laboratory shallow land burial sites are discussed. (Auth) (ST)

<120>

Los Alamos Scientific Laboratory, Environmental Studies Group, Los Alamos, NM

Smith, V.J., R.L. Wheeler, and L.J. Johnson. 1977, June. LA-6856-PP; Development Activities on Shallow Land Disposal of Solid Radioactive Waste, Summary Progress Report, January-December, 1976, (pp. 3-4), 8 pp. (LA-6856-PP).

Evaluation of Transuranic-Contaminated Waste Burial Sites (3)

A program was initiated to develop a technique for evaluating the long-term adequacy of existing burial grounds containing transuranic (TRU) contaminated waste. The first task in evaluating the potential impact of buried wastes is to identify the mechanisms specific to a given burial site that would result in radionuclide releases to the environment. Second, the rates or frequency of these processes must be determined. Finally, the movement of the released radionuclides through the biosphere must be described in order to arrive at some estimate of the resultant consequences of the release. The radionuclide release and transport mechanisms specific to the Los Alamos Scientific Laboratory (LASL) waste burial facility at Area G, TA-56, were identified and a preliminary evaluation was performed during 1976. The low occurrence frequencies of potential natural release processes (such as earthquake, meteorite, impact, and tornado), combined with the small effects these mechanisms exert on burial wastes, indicate that they can be discounted as significant for radionuclide release from LASL burial sites. The soil types and climate conditions at Area G are such that movement of radionuclides into the environs by soil moisture involves transport times greatly in excess of the half-life of even Pu 239. Chronic release, resulting from soil erosion to the depth of the buried wastes, could be

expected to occur on a time scale of 50,000-150,000 years. The most evident chronic release mechanism appears to be plutonium uptake by deep plant roots, with subsequent dispersal to the above-ground environs. An analysis was made of a plant uptake release scenario. It appears that plant uptake from LASL burial grounds could, over a period of about 500 yr, increase plutonium concentrations in the soil directly over the waste emplacement by levels that are about the same as those presently observed as a result of worldwide fallout plutonium. (Auth) (ST)

A preliminary evaluation of the Los Alamos Laboratory burial site for long-term burial is made. (Auth) (ST)

<121>

Los Alamos Scientific Laboratory, Environmental Studies Group, Los Alamos, NM

1977, June. LA-6856-PP: 8 pp.

Development Activities on Shallow Land Disposal of Solid Radioactive Waste, Summary Progress Report, January-December, 1976, (pp. 3-4), 8 pp. (LA-6856-PP).

This report summarizes progress on projects focused on problems of shallow land burial of radioactively contaminated solid waste. Developments on a system to evaluate the containment adequacy of existing burial sites are described. Efforts to describe the environmental factors in monitoring the LASL disposal sites are discussed. The aims of a new program on radioactive waste burial technology is outlined. (Auth)

Progress on containment, description of environmental characteristics, and monitoring of shallow land burial sites are discussed. (Auth) (ST)

<122>

Los Alamos Scientific Laboratory, Health Division, Los Alamos, NM

Christenson, C.V., E.B. Fowler, G.L. Johnson, E.H. Fox, and V.A. Virgil. 1958, December. Sewage and Industrial Wastes, 30(12), 1979-1989.

Soil Adsorption of Radioactive Wastes at Los Alamos (1)

Los Alamos Scientific Laboratory is located on the Pajarito Plateau which is underlain by a series of tuff flows. Prior to 1951 disposal of liquid radioactive waste into seepage pits onsite was routinely practiced. As a result of the use of these practices, a study was conducted to determine the relative ability of the volcanic tuff to adsorb certain radionuclides. The permeability of the Tshirege member tuff varied from 1 to 5 gpd/sq ft under one foot head. Ion exchange capacity for the tuff ranged from 0.5 to 3.0 meq/100 g. Strontium 90 was not retained by the tuff as well as cesium and plutonium. (ST) (CSF)

A review of the ability of local tuff to adsorb radioactive waste. Directly applicable to the potential for radionuclide migration. (Auth) (ST)

Distribution Coefficient; Intrinsic Permeability; Ion Exchange Capacity

C127

Los Alamos Scientific Laboratory, Health Division, Health Physics Group, Los Alamos, NM

Tabers, J.W. 1967. COSY-570512, SLL/PWD/156: Disposal of Radioactive Wastes into the Ground. Proceedings of a Joint INER/INER Symposium held in Vienna, Austria, May 27-June 2, 1967, pp. 17-30, 666 pp. COSY-570512, SLL/PWD/156.

Solid Radioactive Waste Disposal at the Los Alamos Scientific Laboratory (19)

Shallow land burial of radioactive wastes was routinely conducted at LASL during the 10-year period reviewed. The major portion of the waste is generated from the laboratories where radioactive materials are handled. Plutonium 239 is the primary contaminant. High-level wastes, defined as those contaminated solids which leave a surface gamma exposure rate of greater than 5 r/hr, are buried in shafts. These shafts are either 0.6 meters or 0.9 meters in diameter and 5 meters deep. The shafts are backfilled till the exposure rate is less than 10 mR/hr. Low-level solid wastes, contained in plastic lined metal trash cans or plastic lined cardboard boxes, are placed in disposal trenches. These trenches average 9 meters in depth, 30 meters in width and 152 meters in length. After waste has accumulated to one meter in depth, a 45 centimeter layer of earth is placed over it. The areas selected for excavation for these disposal pits are materials by volcanic ash flows and tuffs which consist of friable to solid rhyolitic tuff. (19)

A general review of radioactive waste disposal at LASL for a ten year period. No significant numerical data on the activity of the waste are present. (19/27)

C128

Los Alamos Scientific Laboratory, Los Alamos, NM

Christenson, C.W., and R.G. Thomas. 1962, March. TID-7629: Ground Disposal of Radioactive Wastes. J. S. Rogers, Jr., et al (Eds.), Proceedings of the 2nd Conference held in Chalk River, Canada, September 26-29, 1961, (pp. 200-201), 635 pp.

Movement of Plutonium Through Los Alamos Tuff (19)

Ammonium citrate and other plutonium bearing waste solutions were disposed of in seepage pits at Los Alamos Scientific Laboratory beginning during the work on the Manhattan Project. This practice was carried on into four pits regularly up until 1952. The results of a detailed coring, liquid sampling, and volumetric moisture content study are presented in this report. The Los Alamos tuff permeability varied from 1 to 5 $\mu\text{m}^2/\text{sq cm}$ under one foot head. The ion exchange capacity for the Tuffrose member of the Bandelier tuff ranged from 0.5 to 1 meq/100 g. A thirty-foot deep investigation pit was constructed nearby the former pits and horizontal three inch holes were drilled from the pit to locations coinciding with the center of a former seepage pit. Core samples taken from these holes were analyzed for gross alpha activity. The holes were cased with 2 1/8 inch plastic pipe and ground tuff was backfilled into the annular space by air injection and the holes were sealed at the ends along the outside of the casing. At each selected depth a pair of holes were drilled, one for installation of a moisture probe the other for the installation of a vacuum cup

sampling device designed to evaluate moisture from the region surrounding the holes. The results of the alpha activity investigation revealed that the alpha activity in general decreased with increasing length of 20 feet largely through fractures in the tuff. Localized alpha activity anomalies were found to be associated with crevices in the tuff. Essentially all of the Pu in the wastes applied to selected tuff cores was retained in the top 1/8 inch of the core and the soil Pu resisted leaching by ordinary means. There was an indication that such chemicals as vermic, high molarity acids and solutions of potassium salts might move Pu species through the tuff. The results of the moisture study presented in tabular form substantiated the observation that flow of waste solutions at depth occur chiefly along fractures and crevices in the tuff. Two water and waste solutions were added to 12 pits for experimentation purposes during the study. (19) (15/7)

The report presents detailed volumetric moisture data in the vicinity of the Los Alamos Scientific Laboratory waste burial site and provides insight as to the nature of subsurface plutonium migration. (19/27)

Hydraulic Conductivity, Unsaturation, Cation Exchange Capacity, Volumetric Water Content, Stratigraphic Unit Thickness

C129

Los Alamos Scientific Laboratory, Los Alamos, NM

Barney, J.E. (Comp.). 1971, March. LA-5100; 56 pp.

Environmental Monitoring in the Vicinity of the Los Alamos Scientific Laboratory, Calendar Year 1972 (1)

The results of the routine monitoring of levels of radioactive and nonradioactive contaminants in the environs at and around the laboratory are presented. Analyses were conducted on atmospheric, water supply, surface and ground water, sewage treatment plant effluent water, soil, and sediment samples. Radiochemical analyses for gross alpha, beta, gamma, plutonium 238, 239, cesium 137, and tritium were conducted on all samples. Summary reviews of the honeybee as an indicator of environmental radioactive contamination; the LASL field pulse height analyzer; and neutron activation analysis of Pu in pine trees are presented. Solid wastes, consisting mostly of contaminant sludges from the industrial liquid waste treatment plants and potentially contaminated refuse from routine Laboratory operations, are buried in pits at TA-50 on the Mesita del Sur and in shafts at TA-29. Large pits are nominally 30 m wide by 140 m long by 9 m deep, and smaller ones are 1, by 93 by 9 m. The shafts at TA-29 are nominally 2.5 m in diameter and 5 to 20 m deep. They are asphalt-lined and do not penetrate to the water table, which is over 140 m below the surface at TA-29. The quantities of materials placed in storage during 1972 are presented tabularly. The deep ground water body is recharged from precipitation on the high mountains to the west, with the water in the aquifer moving eastward toward the Rio Grande. The top of the deep aquifer lies 800 m below the surface of the mesa at the site of a proposed Pu processing plant. Movement of water in the aquifer is estimated at 22 m/yr. (10th) (15/7)

<125> C397.

A summary of the environmental radioactivity around the Los Alamos Scientific Laboratory. The majority of the data is not directly applicable to shallow land burial of radioactive waste. (DS/JT)

Depth to Water Table; Transmissivity

<126>

Los Alamos Scientific Laboratory, Los Alamos, NM

Herczeg, J.E. (Comp.). 1972, July. LA-5970: 46 pp.

Environment-1 Monitoring in the Vicinity of the Los Alamos Scientific Laboratory, July through December 1971 (13)

The results of the environmental monitoring program at the Los Alamos Scientific Laboratory are presented. The program monitors radiation levels in the atmosphere, local surface and groundwater, sediments, soils, and external radiation levels. Airborne radioactivity was monitored on a daily and weekly basis. Samples were analyzed for gross alpha and beta, tritium, plutonium 238, 239, and uranium. Water samples were analyzed radiochemically for gross alpha, beta, gamma, tritium, plutonium 238, 239, and cesium 137. Fluorometric analyses were done for uranium sediments and soil samples were analyzed for gross alpha and beta, plutonium 238, 239, cesium 137, total uranium and other possible tritium. Thermoluminescent dosimetry indicates an average daily dose rate of 0.39 mR for offsite stations and a daily dose rate of 0.02 mR for onsite stations. Included in these reports are selected meteorological data, air sampling system comparison tests and tornado strike frequencies. The primary sources of potentially contaminated liquids effluent from LANSI operations are from the industrial liquid waste treatment plant at T-21 and from the central industrial liquid waste treatment plant at T-50. Effluents from the T-21 plant are released into DP Canyon, a tributary to Los Alamos Canyon, and the effluents from T-50 are released into Effluent Canyon, a tributary to Fortified Canyon. Solid wastes, consisting mostly of contaminated sludges from the industrial waste treatment plants and potentially contaminated ash from routine laboratory operations, are placed in pits at T-50 on the Mesita del Rey. It is lined shafts at T-21. The T-50 area was chosen in cooperation with the United States Geological Survey to assure precise localization of radioactivity. Pits are 100 ft wide by 600 ft long by 40 ft deep, and smaller ones are 50 by 100 by 40 ft. The shafts at T-21 are nominally 6 ft in diameter and 15 to 60 ft deep. They are asphalt lined and do not penetrate to the depth of the water table. A summary of the materials placed in storage during July-December 1971 is presented tabularly. (both) (JT) (JTE)

Review of radioactivity in the environs at the LANSI site. Data specific to burial ground is not presented. (DS/JT)

<127>

Los Alamos Scientific Laboratory, Los Alamos, NM

Keller, E.D. (Comp.). 1965, December 14. LA-1720: 17.

Geologic Studies and Material Properties Investigation of Mesita de Los Alamos (2)

Investigations were conducted to establish the geotechnical properties of the substrate underlying the Mesita de Los Alamos to provide data for the architect-engineers designing the Los Alamos Neutron Physics Facility. The primary structure of this facility is the half-mile long 300-MeV linear proton accelerator. The geologic history including stratigraphy and lithology is presented in the text. The probability of seismic events which could affect the facility are discussed. Two horizontal and one vertical seismometer stations were occupied for a period of nine days to monitor seismic activity in the range. This short record did not reveal any significant activity. Stress denudation rates of 5×10^{-2} feet per year were calculated utilizing the known age of the Bandelier Formation and topographic data from geologic mapping. The results of twenty-five exploratory test borings in the vicinity of the proposed facility are presented. The test holes were grouted and caliper logged. A gamma density probe and neutron scattering moisture probe were used to determine density and moisture of the substrate materials respectively. The bulk density of the rock consists of quartz and feldspar crystals and fragments in a matrix of light pink fine-grained ash ranged from 900 to 120 lb/cu ft. The bulk density for the sandstone tuff ranged from 80 to 110 lb/cu ft. Moisture content of the tuff beneath the soil cover was below 5% by volume. Detailed soil temperature logs are presented in tabular form. (JC) (JST)

Waste disposal activities are not mentioned but useful geologic information on the vicinity of the LANSI disposal site is presented. (DS/JT)

Density; Volumetric Water Content

<128>

Los Alamos Scientific Laboratory, Los Alamos, NM

Portyrum, D.D. 1973, May. LA-5286-N5: 7 pp.

Underground Movement of Tritium from Solid-Waste Storage Shafts (9)

The results of a study to determine the extent of tritium transport away from several solid waste storage shafts are presented. Movement of tritium was observed to be taking place from thirteen unlined storage shafts when additional storage shafts were assigned less than twenty feet east of the original shafts. Moisture samples distilled from tuff, surface soil, and miscellaneous sugar flight cuttings were analyzed for tritium. In one of the new storage shafts tritium activity as high as 1100 pCi/l was observed. Fourteen additional test upper holes were drilled to obtain further information about the transport of tritium. From the fourteen new test holes moisture distillate was analyzed for tritium. Flowview and vertical cross section isotritium contour diagrams were prepared. The evaluation of these plots revealed that the major tritium movement occurred along the contact between the two uppermost ashflows. Additional movement has been observed through open joints and the tuff matrix. A tritium front whose outer edge is defined by the 0.1 pCi/l contour line has been observed to move

<12> COST.

19% feet over a four year period. The release of tritium through evaporation from the soil and transpiration from local vegetation has also been documented by air probe tests in the shafts followed by moisture collection and the gathering of vegetation samples whose moisture was distilled and analyzed for tritium. It has been determined that porosity of the tuff ranges from 16-47% by volume. Precipitation has infiltrated the tuff to depths of over 100 ft with moisture content ranging from 6% at the surface to 30% at the 10 ft interval, and decreasing below that level. Movement of the tritium is by exchange with natural airborne moisture in the tuff (tritium concentration) increased to a maximum between depths of 10 to 30 ft, and then decreased with depth. About a year after wastes were stored in shafts 12 and 13, a 150 pCi/l contour has moved about 195 ft west of the shafts along the contact between two ashfalls. An extrapolated 100 pCi/l contour beneath the shafts is at a depth of about 97 ft below the surface of the waste. There is not enough precipitation infiltrating to leach the tritium through the 200 ft of tuff and 600 ft of volcanic rock and sediments, to the main aquifer at a depth of 450 ft. (JC) (PTO)

This report presents a most relevant discussion of vapor phase movement of tritium in the unsaturated zone. (PT/JC)

Horizontal Flow Rate; Infiltration Rate; Total Porosity; Volumetric Water Content; Depth to Water Table; Migration Rate

<13>

Los Alamos Scientific Laboratory, Los Alamos, NM
Perryman, W.D., and W.B. Kennedy. 1971, May. LA-5660: 12 pp.

Geology and Hydrology of Mesita del Buey (1)

Mesita del Buey is used for the disposal of wastes contaminated by radionuclides, of toxic or explosive chemicals, and of classified materials. These are buried in pits or shafts dug into the mesa surface. The mesa, covered by a clay-like soil, is underlain by a series of ashfalls of rhyolite tuffs from 200 to 500 ft thick. The tuffs are above the main aquifer of the Los Alamos area which lies at a depth of about 1,050 ft along the western margin of Mesita del Buey and at 950 ft at the eastern margin. Total porosity of the tuffs range from 15-60% in volume. Stream flow in adjacent canyons is intermittent. Water in the alluvium of the stream-connected aquifer in the canyon south of the mesa is recharged by stream runoff. The hydrologic characteristics and conditions of the soil, tuff, and waste material used to cover the wastes indicate no recharge to the stream-connected aquifer or main aquifer through the soil, buried wastes, or tuff at Mesita del Buey. Where the soil cover has been disturbed, the moisture content (volumetric water content) of the tuff indicates that precipitation may have infiltrated to a depth of 90 ft. The moisture ranges from 2.0 to 8.0% by weight, decreasing with depth. Below 10 ft, the moisture content ranges from 0.5 to 2.0% by weight. Vertical and horizontal erosion rates of the tuff surrounding the waste in pits or shafts indicate that under present climatic conditions the estimated life of the pits will

be about 27,000 years. The erosion rate for the past 1.1 million years is about 7.7 x 10⁻⁵ ft/yr. Posttime maintenance to control erosion of the seal material will extend this life. (Jeth) (JM) (CSP)

The data and discussions presented in this report are relevant to the geology and hydrology of Mesita del Buey, the topographic feature utilized for the disposal of radioactive wastes. (PST/JM)

Depth to Water Table; Volumetric Water Content; Erosion Rate; Total Porosity; Thickness of Upper Aquifer

<14>

Los Alamos Scientific Laboratory, Los Alamos, NM
Perryman, W.D., C.L. Wiente, and D.B. Jreessen. 1977, June. LA-5639-55: 36 pp.

Geology and Hydrology in the Vicinity of the Inactive Uranium Mill Tailings Pile, Ambrosia Lake, New Mexico (2)

A study was made of the geology and hydrology of the Ambrosia Lake uranium mill tailings area in New Mexico. The tailings pile is roughly a square about 620 m on a side. The thickness of the pile varies from 1-12 meters. There is an estimated 2.3 x 10¹⁰ kg of tailings in the pile. The bulk density of the tailings has been estimated at 1.6 g/cc. It has been estimated that the tailings should include 667 pCi of Ra 226/g of tailings which should give a radon flux of about 168 fCi/24-cu/sec. The major transport mechanisms of the tailings and contaminants are: wind, erosion, surface water runoff, subsurface water movement, and gaseous diffusion. The area is underlain by sedimentary rocks to depths greater than 1,000 m. The aquifers are sandstones comprising about 75% of the sediments, and the rest are impermeable shales or combinations of sediment. The Westwater Canyon member of the Morrison is the principle aquifer. Test wells here indicated a transmissivity of 120 sq-m/day and a storage coefficient of 0.007. Ra 226 concentration from the Westwater ranged from 1.1-82 pCi/l. The pH range is 7.3 to 8.3. Hardness as calcium carbonate in the Westwater ranges from 16-332 mg/l. Total dissolved solids in the sandstones range from 500-2,000 mg/l. (PT)

Transmissivity; pH; Storage Coefficient

<15>

Los Alamos Scientific Laboratory, Los Alamos, NM
Smith, B.J., R.L. Wheeler, L.J. Johnson, L.R. Procki, R.A. Rogers, and C.J. Teuberger. 1977, June. LA-5656-PP: 8 pp.

Development Activities on Shallow Land Disposal of Solid Radioactive Wastes, January-December 1976 (1)

This progress report summarizes LRL projects focused on problem of shallow land burial of radioactive waste. The importance of shallow land burial is shown by an EPA estimate that in the future 40% of the solid waste by volume will be low-level radioactive waste requiring shallow land burial. Investigations are underway to determine release mechanisms in low soil moisture areas. A program to

(111) CONT.

evaluate the efficacy of burial sites containing transuranic waste has been in progress since FY 77. Technical accomplishments during FY 76 included the completion of a procedure for evaluating biological uptake and transport of radionuclides from buried waste. (FPO)

To date, General Summary of Activities of shallow land burial projects. (ESEC/P-70)

(112)

Los Alamos Scientific Laboratory, Los Alamos, NM

Feistly, L.A., and C.V. Christenson. 1966. LADC-7711; COSP-660621; Health Physics Society 11th Annual Meeting held in Houston, Texas, June 27-30, 1966, (26 pp.) (LADC-7711, COSP-660621).

Progress and Procedures for Control of Radioactive Wastes at Los Alamos (2)

Methods for handling radioactive wastes at the Los Alamos Laboratory are reviewed. All levels of radioactive waste are dealt with in varying quantities. The largest volume of material is the liquid low-level wastes. Also, relatively large amounts of intermediate-level wastes and occasionally high-level wastes are handled. The waste management policy at Los Alamos is "concentrate and contain". The low-level wastes are collected by separate sewer systems and brought to a central point. If the liquid is acidic, it is neutralized. This system exists at both the Area 50 processing plant and at the Area 21 plant. The highly acidic americium and plutonium intermediate-level wastes are transferred in 270 gallon stainless steel tank trailers for delivery from Area 21. The high-level wastes are put in two liter plastic bottles and then placed in identified Dumpster Dumpster. The processing plants concentrate alpha activity by using a ferric hydroxide floc at a high pH. The floc is collected in sedimentation tanks, removed to separate storage for decantation of excess liquid, then further concentrated by vacuum filtration. Intermediate-level wastes are incorporated in a cement-vermiculite mortar. The wastes are neutralized with a 50% sodium hydroxide solution, cooled and then added to the mortar. The solid wastes are packaged and buried in pits within the tuff rock strata of the Los Alamos area. Area 50 has a decontamination factor of 100 and Area 21 has a factor of 2000. The volume is reduced by 370 at Area 21 and 800 at Area 50. The average cost for processing the various wastes at the facilities is about \$23. (SDV)

(113)

Los Alamos Scientific Laboratory, Los Alamos, NM

Schizger, K.J. (Comp.), and K.V. (Comp.) Apr. 1976, May. LA-5586; 57 pp.

Environmental Surveillance at Los Alamos During 1977 (3)

The environmental monitoring program at Los Alamos Scientific Laboratory is described. Data are presented for concentrations of radioactivity and radionuclides in air, ground and surface waters, liquid effluents, sediments and soils. Levels of external

penetrating radiation measured in LASL environs. The average dose rate at offsite locations was calculated to be 0.45 millirad per day; at perimeter station the average dose rate was 0.86 millirad per day; and at onsite stations the average daily dose rate was 0.48 millirad. The average whole body radiation dose to residents of Los Alamos County resulting from LASL operations was calculated. The average offsite dose to the whole body, attributable to tritium (oxide) was 0.12 millirad per year. Chemical and biological qualities of liquid effluents and surface waters around the site are presented and compared with applicable standards. Ecological investigations include (a) an environmental inventory of the site and surrounding environs, (b) the honeybee as potential tritium indicator organism, (c) radionuclides in the canyon system and (d) physical and chemical characteristics of the Los Alamos area soils. Microecological studies data and data on flood frequencies and maximum discharge are presented. (Auth) (JC)

An in-depth review of the environmental impact of operations at Los Alamos Scientific Laboratory. Data are not specific to the burial area. (DA/JC)

(114)

Los Alamos Scientific Laboratory, Los Alamos, NM

Rakowski, T.L., J.W. Syhan, and W.D. Perryman. 1976. COSP-751105; STI/PDS/810; IAEA-SR-199; Transuranium Nucleides in the Environment. Proceedings of an International Symposium held in San Francisco, California, November 17-21, 1975, (pp. 174-189) (COSP-751105, STI/PDS/810, IAEA-SR-199).

Accumulation and Transport of Soil Plutonium in Liquid Waste Discharge Areas at Los Alamos (2)

A radionuclide mass balance inventory for Pu 238 and Pu 239 for the liquid waste outfall located in the Mortandad Canyon at Los Alamos was performed to determine the accumulation zones and transport vectors for these isotopes. The inventory was based on the content of radionuclides in cores drilled in the canyon alluvium to a depth of 12.5 cm. Eleven sampling areas were selected downstream of the outfall with two control stations established upstream of the outfall influence. Numerous stations were designated within the first kilometer while farfield stations were located as far as 10 kilometers downstream. Triplicate core samples were analyzed from two sampling periods which were seven months apart. The results of this program revealed that 2 mCi of Pu 238 and 0.8 mCi of Pu 239 and Pu 240 were added to the canyon sediment regime during which time 5.5 and 0.8 mCi of Pu 238, Pu 239, and Pu 240 were discharged from the outfall. The discrepancy between the emission and the calculated accumulation was attributed to both the large sampling variability as well as loss beyond the region investigated. Presumably some of the plutonium could have been transported to depths below 12.5 cm and beyond the 10.2 kilometer stream length studied. A significant positive correlation between suspended sediment concentration and total sample radioactivity was found. Although the transport occurs principally on sediment grains the storm water runoff provides the necessary transport vector for the radionuclides. (JC)

Although the paper deals with liquid waste disposal the field observations on the behavior

<136> CONT.

of plutonium in surface waters and sediments is relevant to the release of plutonium-bearing fluids from burial trenches. (OR/K)

<137>

Los Alamos Scientific Laboratory, Los Alamos, NM
Pettus, E.L. 1976, July. LA-6252; 70 pp.

Incineration Facilities for Treatment of Radioactive Wastes: A Review (3)

Descriptions are given of the incinerator installations in the U.S., United Kingdom, France, Belgium, Portugal, Republic of Germany, India, Japan and Canada. Included in the text are descriptions of inactive incinerators, currently active incinerators and incineration facilities under construction. Special features of each installation and operational problems and techniques such as waste pretreatment, loading requirements, off-gas cleanings, ash removal and liquid waste handling, are discussed. Problems encountered with respect to the incineration of radioactive waste are discussed in relation to the composition of the waste and the amount and type of radioactive contaminant. (OR/K)(7)

A general review of operational problems and techniques associated with the incineration of combustible radioactive waste, minimal data are presented. Details on volume reduction and costs have been for the most part excluded. (OR/K)(7)

<138>

Los Alamos Scientific Laboratory, Los Alamos, NM

Theiler, E.L. 1976, August. ACS Symposium Series No. 15; Activities in the Environment, E.H. Frieman (ed.), Proceedings of a Symposium held in New York, New York, April 9, 1976, (pp. A-14), 107 pp.

Moisture and Solute Transport in Porous Media (3)

The interactions of porous geologic media with water and solutes which affect the rate and direction of transport are discussed. Natural earth materials, whether consolidated or not, contain varying amounts of space unoccupied by mineral matter due to the presence of individual pores or structured features (such as joints and bedding planes). Water placed in contact with granular material will tend to displace air or any other gases present in the pores. It is exceedingly difficult to accomplish true saturation for any granular material, in part due to the presence of pores that are not interconnected. Two forces tend to hold water in contact with granular material: (1) adhesion between the water and the solid surface, and (2) cohesion between the water molecules. Work must be performed to remove water from any saturated or partially saturated material. The "total soil moisture potential" can be briefly defined as the work required to move a unit volume, mass or weight of water in the soil at a defined elevation, temperature, and pressure to a container of pure water, at standard elevation, temperature, and pressure. In both saturated and unsaturated geologic systems, the rate at which water moves is dependent on the moisture

potential gradients as well as the hydraulic conductivity of the media. Chemical species dissolved or suspended in soil water move in response to two principal mechanisms (1) convection with moving water and (2) diffusion within the flow field. Diffusion velocities are generally small compared with convective velocities, but may be very important in computing the spatial distribution of a contaminant introduced into a flow field. (OR/K)(7)

The principles governing migration of water and solutes in the ground are discussed and have application towards possible water transport of radionuclides from burial sites. (OR/K)(7)

<139>

Los Alamos Scientific Laboratory, Los Alamos, NM

Reyer, R.D. 1955, December. TID-7517 (part II): Sanitary Engineering Aspects of the Atomic Energy Industry. Proceedings of a Seminar held in Cincinnati, Ohio, December 5-9, 1955. (pp. 212-222), 699 pp. TID-7517, Part II.

Demolition of an Alpha-Contaminated Building (3)

The successful demolition of a building, containing plutonium dust, at the Los Alamos Scientific Laboratory is discussed. Building B was the building dismantled and it had 44,300 sq feet. The structure housed the purification and fabrication facilities of plutonium for weapons. To keep the dust down the walls were wallboarded and the floors were painted a number of times during life of the building. One time, while work was being done on the building a worker stepped through the ceiling and the dust contaminated the lab below to levels of 400 f/sq ft. Anyone working in the building had to wear respirators and protective clothing because of the contaminated dust. In addition, the air outside was monitored to protect the surrounding laboratories and adjacent housing project. Demolition began on March 29, 1954 and ended on June 23, 1954. Bural was chosen for disposal due to the large quantity of noncombustible material. It was calculated that the dismantled building and contents could occupy a net volume of 3,000 cu yds. Work proceeded from the low-contamination area to the high-contamination area. Sections, 8 by 10 feet, were cut, lifted by crane and sprayed with paint along the edges. The material was contained by covering with cheese-cloth and sprayed with paint once it was on the tracks. As a final precaution the load was covered with a canvas. Once the track was unloaded it was washed at the burial site. A thousand traps were laid during the demolition. Before the saving began the room was rinsed with water from a fire hose and the liquid effluent was collected and sent to the waste disposal plant. Monitoring showed the effluent to be at least 100 times the normal activity. The building was successfully dismantled without having the workers accumulate a body burden or creating an airborne hazard to the people in the surrounding community. Such a process takes careful planning and close supervision. During the demolition the average airborne alpha activity was: in B building, 10; outside building, 1; 100 to 500 feet away, 1; community area (100 to 7500 ft), 1; and truck and/or vehicle, 1 f/sq ft. (OR/K)

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Round Facility, Nissisburg, OH

Luthy, D.F., and D.R. Bond. 1970, February 6. NLR-2040; 9 pp.

Volume Reduction System for Solid and Liquid TNU Waste from the Nuclear Fuel Cycle: July-September 1977 (3)

The problem of identifying and removing radioactive gases and particles from incinerator offgases for beta and gamma contaminated wastes is being approached by a literature search and experimental incinerator to develop new technology. The incinerator is a scaled down version of the Round Cyclone Incinerator modified to burn low-level materials. For the literature search the field of air pollution control and incinerators efficient in removing radioactive gases were consulted. In other experiments a chlorine mass balance was determined and it was found that about 70% of the chloride in the feed material (PVC) was in the scrubber solution, 5% in the flue gas, and the remaining chloride was in the ash and retained in the system. A glove box for decontaminating and immobilization was designed and built. Concrete and pressed pellets for immobilization were then compared as to crush strength, loading rate, mechanical strength, leach rates, and water content. The concrete pellets had a higher water content (0.55 vs 0.10), were not significantly different in crush strength (about 3600 psi), had a smaller loading rate (0.01 vs 0.62 g/cs cm) had lesser mechanical strength and about the same leach rate as the pressed pellets. Work on immobilizing bone char and sludge is continuing and a pilot plant for the pelletization of incinerator ash/cement mixtures is being constructed. (P89)

of Military Application (MFA), to treat Round Laboratory's low-level waste streams with bone char were outlined in the report. The project's purpose was to accomplish the following: (1) acquire engineering data such as flow rates, adsorption capacity, and optimum particle size for designing a tertiary treatment system, and (2) optimize the primary waste treatment process using coagulants and flocculants. Bone char is a natural product from granulated animal bone. Chemically, it is a form of calcium hydroxyapatite, $\text{Ca}_{10}(\text{PO}_4)_6(\text{OH})_2$, and it contains a small amount of carbon. It is characterized by a high porosity and good resistance to abrasion and crushing. Because plutonium and other actinides can be precipitated as phosphates from weakly acidic, neutral, or alkaline solutions, it appeared possible to use an insoluble phosphate adsorbent such as bone char to remove these from waste streams. The final pilot studies using bone char were conducted on the filtrate or effluent from a sandfilter in the waste treatment facility. The sandfilter effluent was pumped through a 15 micron filter which was followed by a column of bone char. The average particle size of the bone char was about 4.5 mm. At a flow of 5.5 gal/min, over 22,000 gal. of sandfilter effluent were pumped through a 20 in. high by 15 in. diameter column containing 150 lbs. of bone char. The average decontamination factor was 7.0. At a flow rate of 5 gal./min., over 100,000 gal. of sandfilter effluent were pumped through 60 lbs. of bone char, with the decontamination factors averaging between 3 and 5. From this data, the total capacity of the bone char was calculated to be 5.1×10^{12} micro-curies/g. (J87)

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Round Facility, Nissisburg, OH

Luthy, D.F., T.C. Elsvick, and J.W. Doty. 1976, January 25. NLR-2042; 37 pp.

TNU Waste Cyclone Drum Incinerator and Treatment System: April-June 1977 (3)

Activities conducted during the past quarter, in support of Cyclone Incinerator development include the completion of an extended series of incinerator runs of radioactively contaminated wastes and the analysis of data on rates of combustion, scrubber solution generation, and feed material make-up. Sections of the exhaust line and various test samples located in the system are being metallographically examined. A system for continuous feeding of the cyclone incinerator was designed. (R8b)

<141>

Round Laboratory, Nissisburg, OH

Hedding, W.D., Jr., D.E. Vallee, and J.V. Griffin. 1972, April 20. NLR-1916; 45 pp.

Documentation of DOT-59-5915 for 55/30 and 81/55 Drum Combination Packaging (2)

The test data on two combination drum transportation and disposal packaging for radioactive waste are presented. Application for a permit for this new packaging design was made by Round Laboratory so that greater than 20 curies per drum quantities of plutonium 238 could be shipped to and buried at low-level waste disposal sites. The testing was designed also to include data for liquid and semiliquid radioactive sludges. The packaging design included a 30 gallon drum within a 55 gallon drum and a 55 gallon drum within an 81 gallon drum. For both tested designs the annular space between drums was filled with moistened vermiculite. The four principal physical tests performed were the free drop, puncture, thermal, and water immersion tests. A nuclear criticality safety analysis was performed and recommendations of various mass packaged per container are presented. The various packaging tests included drums of varying DOT specifications, four different waste cans, two plastic bag types, three different gasket types, and six insulation materials. (JC)

<140>

Round Laboratory, Nissisburg, OH

Blane, D.E., and E.L. Murphy. 1976, September. NLR-2271; 10 pp.

Round Laboratory Activities on the Removal of Plutonium and Uranium from Wastewater Using Bone Char (3)

Pilot plant studies, sponsored by the Division

Report offers detailed information on corrosion, thermal damage and physical strength of waste containing drums often accepted at low-level waste burial facilities. (P8/JC)

(182)

Massachusetts Department of Health, Division of Laboratories and Research, Hempstead, NY; Massachusetts Department of Public Works, Division of Sanitation and Water Supply, Boston, MA

Lieber, H., and W.F. Velsch. 1954, June. Journal of the American Waterworks Association, 46(1954), 541-545.

Contamination of Ground Water by Cadmium (19)

Cadmium used in the aircraft production plants has been introduced into the groundwater of Nassau County, Long Island. Long Island is underlain by bedrock consisting of schists and gneisses with a gradient of 50 ft/mile in the southeasterly direction. Between the bedrock and the surface are successive layers of sand and gravel aquifers with clay lenses. Tests showed 0.2 ppm of cadmium in a recharge basin at an aircraft company. Wells near the company showed 0.1 and 0.3 ppm cadmium present. Test wells were drilled in lines perpendicular to the direction of ground water flow south of the recharge basins in question. An attempt was made to determine the depth of the recharged water table, the depth at which the cadmium was located, and the horizontal distance along which this contaminant was being carried by the natural ground water flow. The tests showed a recharge basin to the north of the source and the cadmium was travelling south. About 3000 ft from the suspected source there was no cadmium found in the ground water. The depth of contamination basin at about 85 ft and ended at sea level. Injection of cadmium has similar physiological effects to arsenic and mercury. Whether or not it is a cumulative poison like lead and mercury is not yet known. However, it does not appear that water should be considered potable if it contains cadmium. (199)

(183)

National Reactor Testing Station, Engineering and Construction Division, Idaho Falls, ID; U.S. Geological Survey

1956, October. TID-7517 (Part 1A): Sanitary Engineering Aspects of the Atomic Energy Industry. Proceedings of a Seminar held in Cincinnati, Ohio, December 6-9, 1955, (pp. 250-263), 609 pp. (TID-7517, Part 1A).

Solid Radioactive Waste Disposal at the National Reactor Testing Station (2)

A number of factors are considered when providing facilities for solid radioactive waste disposal at the National Reactor Testing Station. In selecting a site the following are considered: 1) area not less than 10 acres; 2) accessibility; 3) not less than 15 and preferably 20 feet of unconsolidated sedimentary overburden on the bedrock; 4) appreciable amounts of clay in the burial sediment; 5) overburden sufficient to withstand vertical cuts; and 6) not directly up the ground water stream from existing or potential plant sites, or nearby populated areas. On July 6, 1952, a site meeting these criteria was located, posted and trenched. The soil is a sand gravel deposit overlying 12 feet over a lava roof formation with the water table at a depth in excess of 300 feet in a lava-cinder formation. Silt burial trenches were dug and are about 1000 feet long, 11 feet deep, and about 5 feet wide. The bulk of the solid waste is low level, but some does have 2 to 150 R/hr at container surface. Bastes with

less than 2 R/hr are put in cardboard boxes, polyethylene bags, or larger items into a dump truck. For those materials exceeding 2 R/hr the light materials (200 to 300 lbs) are put into a burial cart or; the larger, heavier are transported by means of charging coffins. Estimated unit cost of disposal is \$9.11/cu yd. (190)

Stratigraphic Unit Thickness: Depth to Water Table

(184)

National Reactor Testing Station, Idaho Falls, ID

Cline, J.E. 1972, February. NRCR-1055; 31 pp.

A Relatively Simple and Accurate Technique for the Study of Plutonium Waste (2)

A technique is described for use in the study of plutonium waste. The method is that of passive Ge(Li) gamma-ray spectroscopy using a technique of differential absorption of the plutonium gamma rays themselves to determine the absorption correction. The analytic technique is simple and relatively quick requiring a simple measurement of about 20 minutes to obtain total plutonium content and relative isotopic abundances. Described in the document is the analytic technique, the instrumentation required, the experimental technique and analysis, and a typical analysis. Attempts are made to describe the limitations and uncertainties in the measurement technique. (184)

(185)

National Reactor Testing Station, Idaho Falls, ID

Morris, D.A. 1967. CORP-651100; Geophysical Monograph Series No. 11; Isotope Techniques, J.E. Stout (Ed.), (pp. 130-162) (CORP-651100).

Use of Chemical and Radioactive Tracers at the National Reactor Testing Station, Idaho (1)

The results of several years of tracer tests employing salts, fluorescein dye, and tritium at the National Reactor Testing Station (now called INEL) are presented. The saline content of groundwater in the vicinity of the Idaho Chemical Processing Plant (ICPP) where waste was disposed of from a disposal well was monitored and flow rates ranging from 15 to 50 feet per day in the regional groundwater reservoir were observed. The sodium fluorescein dye experiment indicated an average flow rate of about 21 feet per day. The tritium monitoring revealed average rates of flow of about 50 feet per day based on initial arrival of the tritium front and a rate of 10 to 11 feet per day based on the arrival of the center of mass of the tritium concentration. Similar investigations on perched water in the alluvium and basalt underlying the Test Reactor Area indicated rates of flow ranging from 2 to 10 feet per day. Tritium studies in the saturated zone in the Central Facilities Area over an extended study period have indicated flow rates of 6 to 8 feet per day under the observed 5 feet per mile hydraulic gradient over distances of 0 to 5 miles from the points of injection. (185)(JC)

This report provides site specific hydraulic velocity and conductivity observations provided

<185> CONT.

by tracer tests. (DS/JC)

Hydraulic Velocity; Hydraulic Conductivity

<186>

New York State Department of Environmental Conservation, Bureau of Radiological Pollution Control, Albany, NY

Velleher, W.J., and E.J. Michael. 1973, June 20. New York State Department of Environmental Conservation Report: 21 pp.

Low-Level Radioactive Waste Burial Site Inventory for the West Valley Site, Cattaraugus County, New York (2)

A review of the radioactive materials buried at the disposal site at the West Valley facility. Burial operations were initiated in October 1963 and were continuing at the time of this inventory. Between October 1963 and December 1972, more than 1,700,000 cubic feet of commercial radioactive waste was buried on site. In addition more than 87,000 cubic feet of radioactive waste from the E.P.S. fuel reprocessing facility were disposed of on site between 1966 and 1972. Review of inventory records indicates that nuclear power generating stations produced less than 10% of the waste buried on site. Burial of radioactive wastes was in trenches that were approximately 35 ft wide, 20 ft deep and 700 ft in length. Trenches were filled to grade level and then covered with a minimum of 8" of backfill. Inventory records indicate that over 105,000 Ci of ^{137}Cs , 16,000 Ci of ^{60}Co , 38,000 Ci of ^{225}Pu and 85,000 Ci of mixed fission products were buried on site. Included in an appendix are diagrams of the burial area and trenches, and radiometric analyses of trench water from trenches 1,3,4,5, 8,9,10, 11 and 12. (J7)

Directly applicable to shallow land burial. Data presented is specific to the nature and activity of waste buried at the NYS West Valley site. (DS/JT)

<187>

Oak Ridge National Laboratory, Chemical Technology Division, Oak Ridge, TN

Yee, C.W., A.G. Croff, and J.O. Blomke. 1976, December. ORNL/TN-5427; 131 pp.

Updated Projections of Radioactive Wastes to be Generated by the U.S. Nuclear Power Industry (3)

Eleven types of radioactive wastes to be generated within the fuel cycle operations of the U.S. nuclear power industry are defined, and projections are presented of their annual generation rates, shipping requirements, and accumulated characteristics over the remainder of this century. The power reactor complex is assumed to consist of uranium- and plutonium-fueled LWRs, HTGRs, and LWGRs, and the installed nuclear electric capacity of the U.S. is taken as 68,1, 252, and 510 GW at the ends of 1980, 1990, and 2000, respectively. (Nth)

Gives predictions of volume, activity, physical and chemical forms, weights, thermal power and

hazards of fuel cycle wastes on a yearly and accumulated basis so that shallow land burial site requirements can be determined. (DS/GM)

<188>

Oak Ridge National Laboratory, Chemical Technology Division, Oak Ridge, TN

Holcomb, R.R. 1968, August 15. ORNL-2399; 15 pp.

Maritime Reactor Waste Disposal Studies: Solidification of Ion-Exchange Resin with Portland Cement for Radioactive Waste Disposal (2)

Fixation in concrete of radioactive contaminated ion-exchange resins from the operation of nuclear aircraft ships of the U.S. Savannah class was investigated. The resins would be used to desalinize the primary loop coolant water, primary coolant blow-down water, laboratory waste, and shield water. Radioactive off-gases would be adsorbed on charcoal allowed to decay, and then discharged to the atmosphere. Aboard ship the ion resin would be a mixture of hydrogen-form strong-acid cation-exchange resin and hydroxyl-form strong-base anion-exchange resin in a 1 to 1 mixture. The simplest method of disposal, dumping the resin into the ocean, would quickly contaminate the ocean creating a hazard. The best mixture of cement and resin found in 2 volumes of Portland cement with 1 volume of resin in enough water to make a workable mud. After hardening, the density was 1.6 g/cc and the block was extremely hard and resistant to mechanical shock. The resin beads were homogeneously dispersed, with the blocks showing no tendency to fissure or crack after months of soaking in simulated seawater. Leaching tests with blocks contain 10 mCi and 20 mCi of fission products retained more than 99.5% of their activity in 25, and 1000 hr leaching tests, respectively. The method to be used on board ship would involve slushing the resins from the desalinizers into a drum, adjusting the volume of water, adding the appropriate amount of cement, mixing, sealing the drum and dumping into the ocean. The rolling motion of the drum while settling will probably provide sufficient mixing and the ocean would provide the cooling. Several problems in this type of disposal need further study: 1) the engineering problems in operating such a system aboard ship; 2) effect of pressure in the depths of ocean on the concrete; 3) the feasibility of concentrating the activity in liquid waste on ion-exchange resins. (PDW)

Tables 2 and 3 give data for leaching by simulated seawater of gross gamma and Cs 137 activity from ion-exchange resin embedded in concrete. (ESIC/CSP)

<189>

Oak Ridge National Laboratory, Chemical Technology Division, Oak Ridge, TN

Goode, J.N., and J.R. Flinary. 1968, January. ORNL-4059; 28 pp.

Fixation of Intermediate-Level Radioactive Waste Concentrates in Asphalt: Hot Cell Evaluation (2)

An asphalt incorporation process designed and

<149> COST.

developed at ORNL for the solidification of both slurries and liquid wastes which is chemically and mechanically simpler than the asphalt fixation procedures in use in Europe is examined in this report. Hot cell tests of HV-asphalt products with fission product concentrations up to 25 times greater than the normal maximum concentration (2 curies per gallon) have illustrated that three widely varying types of waste (evaporator bottoms, alkaline cladding solutions, and neutralized second-plutonium cycle concentrate from SVP and first cycle fission product waste from Hanford) can be satisfactorily incorporated into asphalt to yield a 60 wt solids product. The condensates obtained during asphalt fixation were found to be decontaminated from beta and gamma emitters by factors of $6.0 \times 10^{(2-3)}$ to $2.0 \times 10^{(2-5)}$. Entrapment was believed to be the main cause of the radioactivity in the condensate. Neither swelling nor gas evolution was observed in these experimental products. Leaching rates of the major insoluble fission products (Sr 90, Ba 106 and the rare earths) from the product was shown to range from less than $10^{(2-5)}$ to $10^{(2-7)}$ g per square centimeter per day. The leaching rates of cesium and sodium were shown to be about $10^{(2-4)}$ g per square centimeter per day. These rates appear to be sufficiently low to provide safe long term storage in drums. (Auth) (C)

Data in this report are part of the very small amount of information on the leachability of asphalt solidified radioactive waste as utilized in the United States. Commercial usage of this type of fixation is currently not widespread. (DS/JC)

<150>

Oak Ridge National Laboratory, Computer Sciences Division, Oak Ridge, TN; Oak Ridge National Laboratory, Environmental Sciences Division, Oak Ridge, TN

Peaves, R., and J.O. Duquid. 1975, March. ORNL-8927; 235 pp.

Water Movement through Saturated-Unsaturated Porous Media: A Finite-Element Galerkin Model (1)

A two dimensional transient model for flow through saturated-unsaturated porous media is presented. Model was quadrilateral finite elements for the geometrical assembly, bilinear Galerkin interpolation for the spatial integration, and Gaussian elimination for the solution of the resulting matrix equations. Several types of boundary condition options are available including constant flux, constant head, and pressure dependent boundary conditions. Hydrogeologic properties of each element may vary spatially. Report includes listing of the code, sample input and output, and comparison of results with experimental data. (MO)

Best available numerical model that can be adopted for specific sites with relatively little difficulty due to the complexity of the methodology. Detailed and thorough description with listing, input, output, for the code provided. (DS/MO)

<151>

Oak Ridge National Laboratory, Environmental Sciences Division, Oak Ridge, TN

Duquid, J.O. 1975, July. ORNL-5917; Environmental Sciences Division Publication No. 658; 63 pp.

Status Report on Radioactivity Movement from Burial Grounds in Helton and Bethel Valleys (1)

The offsite radioactivity releases in the Clinch River are less than 1% of the amount allowable for unrestricted use of the water by a population. However, in keeping with EMDA's objective to maintain releases to "as low as practicable," studies directed toward locating sources of radioactivity release and toward seeking methods for reducing or eliminating them have been continued. This particular study, initiated in April 1973, is concerned primarily with determining the radioactivity contributions to the Clinch River from the buried waste at ORNL and with implementing corrective measures. Studies of the groundwater transport of radionuclides from buried waste at Oak Ridge National Laboratory show that burial ground 5 is the major contributor of Sr 90 to the groundwater. The concentration of Sr 90 in the groundwater below burial ground 5 increases the amount of Sr 90 in White Oak Creek, which drains the area and flows into the Clinch River. The burial ground area was used for the disposal of unencapsulated fuel after burial was completed in 1954. The fill increased the surface elevation and also increased the infiltration rate, thus raising the groundwater table to be less than 9 ft below the original land surface because of the change in topography and permeability. The resulting saturated conditions increased the transport of Sr 90 from the buried waste. Estimates of Sr 90 discharge from the burial ground made from hydrologic data and groundwater monitoring show that 1 to 2 Ci of Sr 90 are transported from the burial ground annually. Total discharges from burial ground 5 for calendar years 1971, 1972, and 1973 were 1.19, 1.47, and 2.19 Ci of Sr 90 for stream monitoring, and the calculated estimates were 1.00, 1.10, and 1.78 Ci of Sr 90 based on the average discharge and hydrologic data. During the water years, 1963-1973, Sr 90 discharge from the burial ground decreased from 87.1 mCi/in. to 22.2 mCi/in. due to leaching and radioactive decay. Suggestions of engineering methods designed to decrease the Sr 90 discharge are made. However, more field studies and experimental field tests are required before suggestions are made in the form of proposed solutions to the problem. Reconnaissance data collected in Helton and Bethel Valleys show that burial ground 1 and 3 and the west side of burial ground 5 do not contribute significant quantities of Sr 90 to White Oak Creek above the confluence with Helton Branch. Burial ground 5 contributes a significant amount of Sr 90 to Helton Branch (an average of about 0.6 Ci/yr). As an experiment, one waste trench in burial ground 5 will be sealed in order to reduce the discharge of Sr 90 from the area and to determine the applicability of this type of seal for larger areas. The seepage pits and trenches located in Helton Valley contribute little or no Sr 90 to the White Oak drainage. Mathematical simulation models are currently being applied to predict the future behavior of seepage. Once future problems can be predicted, preventive measures can be applied before the problem develops. (Auth) (CSF)

Depth to Water Table; Leaking Rate

<152>

Oak Ridge National Laboratory, Environmental Sciences Division, Oak Ridge, TN

Slavovick, J.C. 1978, June. Journal of the Water Pollution Control Federation, 50(6), 16 pp.

Radioactive Waste (2)

Management of high-level and low-level wastes in the environment are reviewed. High-level wastes fall into two categories: fission products of intermediate atomic weights (Pu 137 or Sr 90) with half-lives of about 30 yrs and actinides (Pu 239) with long half-lives of around 24,000 yr. To isolate this waste and to render it harmless to man, 500,000 to 1 million yrs are required. If the actinides are extracted and recycled in reactors at reduced efficiencies storage time would be cut to 700 to 1000 yr. Geologic disposal seems to be best for these wastes, but it is the consensus of several investigators that international cooperation is vital for such a waste management system. The project at Lyons, Kansas was mentioned as well as the full-scale hunt for six waste-terminal storage repositories. Ice sheet disposal of high-level radioactive wastes has been considered. The hot canisters would be allowed to melt their way to ice-rock interface 1000 to 10000 m below the surface. Cables could be used to tether the canister for eventual recovery. Problems exist with understanding ice sheet flow and political problems exist because an international agreement forbids radioactive waste disposal in Antarctica. Ocean disposal is complicated by the need for agreement on the international political and legal problems as well as the scientific. A number of studies on circulation models and dose rate models are briefly discussed. Marine pathways are evaluated for intermittent releases of low-level wastes. The radionuclides of interest are Zr 65, Cs 137, Co 60, Mn 54. It is their concentration in edible marine organisms that are of concern. Also the concentrations of the above radionuclides are discussed with respect to bottom sediments. Various methods of treating wastes with strontium, plutonium, and ruthenium are briefly considered. Also, leach rates were compared by three methods of mathematical analysis. The present and past land burial and storage techniques have to this point in time been adequate, however such practices may not be sufficient in the future. Computer analysis of a one-dimensional transient response of a soil column to infiltrating water is mentioned. Assessments of power plant impacts are now including one- and two-dimensional mathematical models for the transport of dissolved radionuclides. Effects of sediment-radionuclide interaction, routine and accidental discharges, and aquatic and atmospheric dispersion, deposition, and resuspension are included. The aquatic and terrestrial food chain transport and the calculation of doses resulting from internal and external modes of exposure are considered as well. When comparing the behavior of plutonium and americium in marine and freshwater environments, there is no preference of uptake between the two transuranics. The major reservoirs of plutonium and americium are the sediments in both environments. Several studies were briefly included on the uptake by organisms of transuranics. (PDR)

<153>

Oak Ridge National Laboratory, Environmental Sciences Division, Oak Ridge, TN

Tomara, T. 1976. CONF-751105: IAEA-SR-199/52; STI/PUB/810: Transuranium Declides in the Environment, Proceedings of a Symposium held in San Francisco, California, November 17-21, 1975, (pp. 213-229), 720 pp. (CONF-751105, IAEA-SR-199/52, STI/PUB/810).

Physical and Chemical Characteristics of Plutonium in Existing Contaminated Soils and Sediments (3)

Density gradient zonal centrifugation was employed to determine the particle size association of plutonium in contaminated soils from the Nevada Test Site (NTS), Oak Ridge National Laboratory (ORNL) and Sandia Laboratories (SL). In soils from NTS, plutonium was observed to be pre dominantly associated (50-75%) with the coarse silt (20-53 micron) fraction with a density greater than 2.9 g/cc suggesting an oxide form. The plutonium found in a sandy silt at NTS beneath desert shrubs was found to have a density of 2.5 to 2.7 g/cc suggesting an association with the feldspars. At ORNL and SL, the plutonium in contaminated soils was found to be predominantly associated with the clay (less than 2 micron). The density of the plutonium contaminated material from SL was observed to be 2.3 to 2.6 g/cc for over seventy percent of the Pu and less than 1.0 g/cc for organic fraction for about 6 percent of the Pu. Citrate extractions and x-ray crystallography were also performed on some of these samples. The citrate solubility test appears to be a useful tool in predicting the amount of plutonium available for plant uptake. At a pH of 2.0 and a citrate concentration of 0.1 M, extraction of Pu ranged from 42 to 59 percent for SL soils, 23 to 46 percent for ORNL soils, and less than two percent for NTS soils. (JC)

A very thorough investigation into the physical and chemical characteristics of environmental plutonium. Particle size data most useful in light of the particle problem associated with Pu soil analysis. (PDR/JC)

Grain Size Distribution

<154>

Oak Ridge National Laboratory, Health Physics Division, Oak Ridge, TN

Lewenick, T.P., and K.E. Cowser. 1961, December 29. ORNL-3162; 36 pp.

Status Report on Evaluation of Solid Waste Disposal at ORNL: 2. (1)

An assessment of the final status of Burial Ground No. 9 at Oak Ridge National Laboratory following closure is presented. A description of the site geology and hydrology is also included. Water level measurements from sixteen of the burial ground observation wells have indicated that the water table fluctuates between 2 and 3 feet below ground surface in the topographically low portions of the site to 10 to 15 feet below ground surface in the topographically high portions. These observations reveal that much of the buried waste at the burial ground comes in contact with the ground water and that in some sections of the site the waste is continuously submerged below the water table. Measurements

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of radioactivity in these wells has revealed activity above background in eight of the sixteen wells. Attempts to correlate level of activity with rainfall and water table fluctuations are presented in graphic form. Several wells were shown to have increased observed activity concomitant with water level rises perhaps suggesting increased leaching of the buried waste. In other wells, the activity was observed to drop following water table rise perhaps suggesting dilution of contaminated fluids. Chemical analysis of the water from seepage wells, seeps, and streams are compared to the analysis of uncontaminated well samples taken at Burial Ground No. 6. The high concentrations of ions found in the contaminated water samples show that chemical ions are also being leached from the burial material. The results from the other wells were too ambiguous to draw conclusions. Monitoring of the streams and seeps around the site was also performed and results are presented. The seeps were attributed to overflow of trench fluids. The analysis of creek water samples, collected between February 16, 1960 and May 25, 1960 showed that Burial Ground No. 6 contributed activity to White Oak Creek in quantities so small as to be undetectable. It was concluded that no significant radioactivity was entering White Oak Creek from the burial ground. (100/UC)

One of the finer comprehensive post operations site evaluations. The discussion on the water table and the observed subsurface contamination is relatively extensive. (100/UC)

Total Cation Concentration; Stratigraphic Unit Thickness; Depth to Water Table; Hydraulic Velocity; Migration Rate

<155>

Oak Ridge National Laboratory, Health Physics Division, Oak Ridge, TN

Losenick, T.V., B.G. Jacobs, and E.C. Strunness. 1967. Health Physics, 13, 897-905.

The Behavior of Strontium 90 and Cesium 137 in Seepage Pits at ORNL (1)

Two former seepage pits at the Oak Ridge National Laboratory were cored and the samples were analyzed for radionuclides and leachability. The seepage pits were utilized for disposal of intermediate level waste consisting predominantly of strontium 90, cesium 137, and ruthenium 106. A majority of the radionuclides and radiostrontium was found to be associated with sludges and precipitates near the base of the former pit excavation and also within the first several inches of the weathered shale which comprise the bottom and side walls of the pit. A significant portion of the strontium 90 was observed to exist as a coprecipitate of calcium carbonate in the sludge. The sludge was generated at the low level radioactive waste water treatment plant on site. The equilibrium pH of the sludge ranged from < 0.1 to 12.2 and from < 0.1 to 12.8 for the weathered shale. A majority of the radionuclides was observed to occupy selective exchange sites on the illitic clay minerals. Tracer tests using tritium were performed in the field to determine hydraulic velocities and dispersion coefficients. Distribution coefficients were developed from cation distribution equations using available exchange capacity and cation concentration data. Radionuclides were discharged in a

highly basic solution of sodium nitrate during operation of the seepage pits. Strontium 90 was primarily removed from the solution by CaCO_3 precipitation. Thus, the total divalent cation concentration of pit water was $0.3 \times 10^{-5} \text{ M}$, and the total monovalent cation concentration was $2.5 \times 10^{-5} \text{ M}$. The actual rate of ground water movement in the water-pit area is considered to be about 0.5 ft/day with a dispersion coefficient of about $6 \times 10^{-5} \text{ cm}^2/\text{sec}$. The water table at the pit site is a subdued replica of the land surface, rising slightly under the low hills, where it normally lies at a depth of about 20-30 ft. The distribution coefficients developed from the observed data were shown to agree well with the earlier experimental data. Release rate calculations were performed utilizing theoretical chromatographic plate models and ion exchange capacity data. The results of these calculations agree favorably with observed releases and reinforces estimates that significant off-site release of radionuclides to surface streams should not occur. The leachability of radionuclides from the sludges and the shales is also briefly discussed. In the inconceivable event of preferential dissolution of all the Sr 90 in a single year, the maximum predicted releases of Sr 90 would be 1.6 Ci/yr after 160 yr for a theoretical plate height of 15 ft or 2.8 Ci/yr after 250 yr for a theoretical plate of 8 ft. (back) (100/UC)

This is a very comprehensive evaluation of radionuclide behavior in a specific subsurface environment. (100/UC)

Stratigraphic Unit Thickness; pH; Total Cation Concentration; Hydraulic Velocity; Dispersion Coefficient; Longitudinal; Dispersion Coefficient; Transverse; Depth to Water Table

<156>

Oak Ridge National Laboratory, Health Physics Division, Oak Ridge, TN

Losenick, T.V., and B.J. Wyrick. 1965, December. ORNL-TN-1327; 17 pp.

Geohydrological Evaluation of Solid Waste Storage Area 6 (2)

The geologic and hydrologic characteristics of a proposed burial ground are presented in this report. General guidelines are discussed which seek to minimize the leaching of radioactive waste in burial trenches. A very essential requirement noted was that all trenches be constructed so that the waste is suspended above the water table during all seasons. A brief discussion of observations made at the three western semi-arid burial grounds and at the two eastern humid sites operated by the USARL (now ERDA) is presented. A description of the subsurface geology at the proposed Burial Ground No. 6 (SWSA 06) is presented. The proposed seventy-acre site was investigated by the drilling of numerous auger holes to delineate lithology, stratigraphy and also serve as water table observation wells. The depth to ground water at the proposed site was observed to range from less than six feet to 38 feet below ground surface. Optimal burial site locations were proposed in the southwestern section. Depth to water table maps also indicate other attractive regions for shallow land burial at this site, however, approximately twenty-five percent of the acreage appears unsuitable because of the shallowness of the water table. It is additionally recommended that where burial

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trenches are located on slopes that the trench length be restricted to 100 feet or less. The "bathtub" effect or the overflowing of accumulated trench water is given as the reason for restricted trench length. Ten known seeps at the older Burial Ground No. 8 are reported with cesium-137 and strontium-90 activities ranging up to 5.9×10^{10} pCi/l and 1.1×10^{10} pCi/l, respectively. (JC)

This report offers philosophical and logistical discussions for shallow land burial site selection. (JW/JC)

Depth to Water Table

<157>

Oak Ridge National Laboratory, Health Physics Division, Oak Ridge, TN

Authors: E. F. Brinkley, D. Catron, O. E. Sealard, D. W. Jacobs, S. Amaratunga, A. L. Hobbs, and J. Harlock. 1969. ORNL-3189; Health Physics Division Annual Progress Report for Period Ending July 31, 1969, (pp. 27-32) (ORNL-3189).

Fundamental Studies of Sorption by Minerals (1)

In order to obtain the effectiveness of expanded biotite and vermiculite to sorb Cs from simulated waste solutions, these minerals in their expanded and unexpanded (treated) forms were tested in 0.1M NaCl solutions soaked with Cs-137. The expanded lattice minerals respectively showed a larger amount of Cs-137 sorption. Desorption data from a number of leaching solutions on layer-lattice clay minerals showed the mechanism of exchange reactions to be influential in determining the effectiveness of various cations for replacement of sorbed Cs. Sorption of Cs in these materials was affected by 3 ion exchange mechanisms: (1) reversible ion exchange at freely accessible charged surfaces, (2) sorption at sterically favorable exchange sites at the edges of collapsed lattices (edge fixation), and (3) interlayer entrapment caused by collapsing of the layer lattice during the exchange process (interlayer fixation). All leaching solutions employed were effective in removing easily exchangeable Cs-137 from illite though 3-1.5 % of the cesium was not removed after leaching with 500 mg. of leaching solution. Cesium sorbed at edge fixation sites of illite were most effectively desorbed by cations having steric favorableness for the fixation sites. The leaching ability of the cations having steric favorability for edge fixation sites (Ca, Pb, and K) in vermiculite were offset, especially after the initial leach, by the ability of these same ions to cause collapse of the vermiculite lattice with the resultant entrapment of the remaining Cs by interlayer fixation. Cesium held at interlayer fixation sites in vermiculite were much less subject to leaching than cesium held at other exchange positions. In characterizing the reactions of Sr with sorbent materials, four possible mechanisms were suggested: (1) ion exchange as an absorption process the clay minerals; (2) ion exchange as an absorption process exemplified by the resins, clinoptilolite, and the reaction of aluminum; (3) metasomatic replacement as characterized by the CaCO₃-phosphate reactions; and (4) precipitation as evidenced by natural vermiculites and clinoptilolite in contact with phosphated waste. Bithionite (Na₂S₂O₆) was used to reduce to 10% for subsequent sorption on

vermiculite and metal powders. High Pu removals were also obtained by successive Na₂S₂O₆ precipitation processes and by sorption on chalcocite. Slurry and column techniques were used in the sorption of radionuclides (Pu-106, Cs-137, Sr-90, Co-60) from aqueous solutions by bituminous coal, anthracite coal, peat, and lignite. The best slurry removals were obtained with peat and lignite whereas the most effective column removals were obtained with those packed with lignite-vermiculite. Short-term uptake of Cs-137 by oaks grown in mixtures of sand and Cs-137-treated vermiculite were also studied. Very little Cs was generally removed by the plants. (Ruth) (JW)

Important data relevant to sorption of radionuclides from shallow waste burial sites' leakages are presented. (JW/JW)

Cation Exchange Capacity: pH

<158>

Oak Ridge National Laboratory, Health Physics Division, Oak Ridge, TN

Strassner, L. G., R. E. Cowser, N. De Laguna, D. E. Jacobs, R. J. Sooton, and T. Tanura. 1969. Disposal of Radioactive Wastes, Proceedings of a Conference held in Reno, November 16-21, 1959, (pp. 881-899).

Waste Disposal Research and Development in the United States of America (2)

Treatment and disposal of low- and high-level liquid wastes are reviewed. At Oak Ridge low-level wastes are run through a plant which is specifically designed to reduce the concentration of radionuclides to acceptable standards for disposal in the Clinch River. The water goes to a flash mixer to be mixed with lime-soda and clay dosages. After mixing, the wastes are put into a coagulation basin, and finally a settling basin. The plant is capable of handling 350 gal/min with a detention time of over 2 hr. The sludge that is formed is then trucked to a disposal pit in the Combsburg formation. Efficiency of the process when Granulite (illite) is used is 86% and the cost per 1,000 gal is 14 cents. More studies on improving the efficiency are underway. It was suggested that disposal pits would provide better decontamination if buried soil columns or lined pits were used. The layers would consist of vermiculite, rock phosphate, and graded gravel. This would permit a high exchange capacity for strontium and cesium and mechanical stability (sufficient flow rate with plugging). At Oak Ridge the soil column design would perhaps replace the pit system, now in use, for disposal of intermediate-level wastes. The cost is anticipated to be low. Geochemical studies are on going with respect to behavior of radionuclides in soil columns above the water table and in contact with the water table. Thermodynamics of ion sorption and sorption mechanisms are also briefly discussed. At present the best method for disposal of high-level wastes is to convert them to solids and then to store them in a salt mine. A number of methods exist for conversion to solid waste. At the Idaho Chemical Processing Plant aluminum nitrate waste is converted to solid oxide in a fluidized-bed calciner. Brookhaven National Laboratory fixes the waste on clay by heating in a kiln to 1700 degrees F. Another process, now under study, is the evaporation of waste to a pumpable sludge to be sent into a pit

(159) CONT.

calciner. Sanford Atomic Products Operations is evaluating the calcination of both Porex low-acid and neutralized Porex wastes. The Argonne National Laboratory is also conducting feasibility studies on the fluidized-bed calcination of Porex low-acid wastes. The ultimate disposal of high-level wastes in rock salt, mines in massive unfractured horizontal limestone beds, mines in granite or shale, deep well disposal, and disposal by fracturing the formation are discussed. (SDW)

(159)

Oak Ridge National Laboratory, Health Physics Division, Oak Ridge, TN

Samra, T. 1963. Retention and Migration of Radioactive Ions in Soils. Proceedings of an International Colloquium held in Seclay, France, October 16-18, 1962, (pp. 95-109).

Selective Ion Exchange Reactions for Cesium and Strontium by Soil Minerals (1)

Dioctate and illite were shown to be effective in removing Cs 137 from solution. Also, vermiculite was effective when the concentration was sufficient to collapse the lattice. Montmorillonite when heated will collapse the c-axis to the 10 Angstrom spacing required. Whether sorption is solely controlled by structure has not yet been determined. However, strontium sorption is controlled by the exchange capacity of the minerals. Sorption for strontium is also pH sensitive. Montmorillonite and illite in a desalinized water system have exchange capacities and distribution coefficients of 90 meq/100g, 1700 ml/g and 20 meq/100 g, 49,000 ml/g, respectively. Lowering the pH, lowers the ability to sorb strontium. Also the surface area of the hydrous iron and aluminum oxides is a controlling property in their sorption of strontium. (SDW)

Ion Exchange Capacity; Distribution Coefficient; pH

(160)

Oak Ridge National Laboratory, Health Physics Division, Oak Ridge, TN

Jacobs, D.G. 1963. Retention and Migration of Radioactive Ions in Soils. Proceedings of an International Colloquium held in Seclay, France, October 16-18, 1962, (pp. 87-98).

Ion Exchange in the Deep-Well Disposal of Radioactive Wastes (1)

For safe use of deep wells as disposal sites, the movement of radionuclides must be predicted. The most important factor contributing to the slow migration of the nuclides is the ion exchange of clays in the injected formations. The three nuclides of interest are Sr 90, Cs 137, and Pu 106. Strontium 90 was run through the Richfield Sand with an average capacity of 2.96 meq/100 g. Also it was found that strontium is preferred over alkaline earth cations with increasing size of the hydrated ion. The pH when lowered reduces the uptake of strontium. Cesium was found to enter the clays through the basal hexagonal layer with an apparent

diffusion coefficient of 1×10^{-11} sq cm/sec. This taking more time to migrate than Sr 90. It is mathematically impossible to describe the flow of radionuclides when injected in to a formation due to turbulence created by injection and the possible peptization of clays due to improper electrolyte differential. However, extension of Gluckauf's simplified equation provided an approximation. Using this equation breakthrough curves for strontium and cesium were derived. It was found that velocities of fission-products will be less than water due to the clay minerals. Precipitation and filtration reactions will also aid in slowing down the radionuclide migration. (SDW)

Table contains an extensive list of sandstones and clays with strontium-calcium exchange data. (ESIC/SDW)

Ion Exchange Capacity; Distribution Coefficient; Dispersion Coefficient; pH

(161)

Oak Ridge National Laboratory, Health Physics Division, Oak Ridge, TN

Lacy, W.J. 1957, November 1. OBNL-2015; 21 pp.

Radioactive Waste Disposal Report on Seepage Pit Liquid Waste--Shale Column Experiment (1)

While the Conasauga shale appears to have the capacity to absorb liquid radioactive wastes of interest still remains: 1) Is there any way of telling when breakthrough of large quantities of radionuclides will occur; 2) what will be the breakthrough sequence for the radionuclides present in the waste; and 3) when the pits are abandoned, will the leaching action of rain and groundwater remove dangerous quantities of activity from the saturated shale? Using an ion exchange technique about 10% of Pu 106 in a carbonate solution with a pH of 12, was removed on a cationic resin, 50% on an anionic resin and 80% was not exchanged. The shale has a ion exchange capacity of 27.8 meq/100 g. Hence, about 1 million gallons of waste can be decontaminated adequately with 10 cu yd of shale and the shale will remove 85% of the total activity. Of the remaining 15%, most will be Pu 106. The 1 million gallons is not the total capacity of the shale but the breakthrough capacity. Ruthenium is the first radionuclide to breakthrough, followed by trivalent rare earths, then strontium and cesium. Capacity of the shale for cesium is 1.7×10^{-11} dpm/g. Upon leaching only 1% of the total activity in the column was found in the effluent. A material balance is also included. More work needs to be done on the breakthrough sequence, identification of the other radionuclides which are present in the waste solution, investigation of the change in concentration of cesium before breakthrough, and a more quantitative study on the effects of leaching a saturated column with tap water and with weak acid, salt solutions. (SDW)

pH; Ion Exchange Capacity

(162)

Oak Ridge National Laboratory, Health Physics Division, Oak Ridge, TN

<162> CONT.

Tsura, T., and E.C. Struness. 1963. Health Physics, 9, 697-708.

Reactions Affecting Strontium Removal from Radioactive Wastes (1)

The purpose of this study was to describe the sorption reactions with several sorbent materials that appear promising for waste treatment applications and to characterize the sorption mechanisms that may be operative in the removal of strontium from radioactive waste solutions. Alumina powder with an exchange capacity of about 3 meq/100g removed as much strontium as a montmorillonite sample with 91 meq/100g capacity when tested in a basic pH. Additions of orthophosphate to the simulated waste solution resulted in improved strontium removal by CaCO_3 powder. With 5000 ppm of orthophosphate, 0.5 g of CaCO_3 removed over 99 percent of the strontium from 50 cc of simulated waste adjusted to pH 9. Under the same test conditions, natural vermiculite showed improvement, but sodium-saturated vermiculite showed a reduction in strontium removal. By pretreating vermiculite with solutions of NaCl and NaCl-PHOS, this mineral's affinity for strontium was improved, and an increase from 35 to 85 percent removal was obtained using a 0.5 g sorbent/50 ml solution ratio. From these slurry tests four possible mechanisms for removing strontium from radioactive wastes are suggested. These are (1) ion exchange as an adsorption process exemplified by vermiculite, clinoptilolite, and the clay minerals; (2) ion exchange as an adsorption process characterized by alumina and possibly variscite; (3) cationic replacement as characterized by the CaCO_3 phosphate waste reaction; and (4) precipitation reactions as evidenced by natural vermiculite in contact with phosphated waste. (Auth)

Important data relevant to pre-burial liquid waste treatment and sorption of Sr 90 from shallow waste burial site leakages are presented. (OR/W)

<163>

Oak Ridge National Laboratory, Health Physics Division, Radioactive Liquid Waste Research and Development Sections, Oak Ridge, TN

Horton, R.J. 1950. WASH-275; Sanitary Engineering, Proceedings of a Conference held in Baltimore, Maryland, April 15-16, 1950, (pp. 120-129). (WASH-275).

Waste Disposal Problems (1)

The nuclear energy industry is in a stage of expansion and technological development for peacetime uses. From the viewpoint of radioactive wastes this expansion and the accompanying developments may be expected to present new and perplexing problems of control and disposal; and potential hazards of such greater magnitude than have been considered in the past. This period of expansion presents the opportunity and the challenge for sanitary engineers to adapt their special knowledge and experience and to achieve leadership in developing the criteria and the methods that are essential for satisfactory radioactive waste disposal. (Auth)

<164>

Oak Ridge National Laboratory, Health Physics Division, Oak Ridge, TN

De Laguna, R. 1963. Retention and Migration of Radioactive Ions in Soils, Proceedings of an International Colloquium held in Saclay, France, October 16-18, 1962, (p. 1).

Radioactive Waste Disposal by Hydraulic Fracturing (1)

The possibility of disposing of radioactive waste by mixing it with Portland cement and pumping it down a deep specially constructed well was tested. The mixture would be under sufficient pressure to force the waste out in a thin sheet between the layers of rock at the bottom, where it will harden. Required is a site that is underlain at depth by well-bedded sedimentary rocks of very low permeability in which horizontal fractures can be made by the injections. Field tests have been done at Oak Ridge in a local shale formation. A preliminary test included injecting 27,000 gallons at a depth of 230 feet. In another well 1050 feet deep, 92,000 gallons of waste were injected at a depth of 930 feet at an initial injection pressure of 7,300 psi. In the same well a week later, 137,000 gallons were injected at a depth of 690 feet. By using gamma-ray logging, the fractures were found to be parallel to the bedding and about one-tenth to four-tenths inch thick. The fractures extended out from the wells for distances of up to 500 feet. Further tests will be done in formations at 1600 and 2000 feet with actual middle-level waste-cement mixtures. The ultimate capacity under favorable conditions is about 200,000 gallons per inch of waste containing up to 10 to 20 curies/gallon of long-lived fission products. Each disposal well should be capable of accepting a total of 10 to 20 million gallons or more as separate sheets vertically spaced a few feet apart. The waste would appear to represent no possible future hazard. (OR/W)

Initial Injection Pressure

<165>

Oak Ridge National Laboratory, Health Physics Division, Oak Ridge, TN

Cover, L.E. 1963. Retention and Migration of Radioactive Ions in Soils, Proceedings of an International Colloquium held in Saclay, France, October 16-18, 1962, (p. 229-230).

Movement of Rethonium in the ORNL Waste-Pit System (1)

The amount and concentration of fission products released to the ORNL waste-pit system increased in 1959. Of particular interest was the radionuclide Ru 106 which was found in concentrations of 90 cc/ml. An estimate was made of the concentration and quantity of Ru 106 that could be released to the pits without creating undue hazards in the Clinch River. By calculation 20,000 curies of rhenium per year, along with the annual release of the remaining radionuclides, would be 100% of the calculated maximum permissible concentration (MPC). A dilution factor of 3.7×10^{10} was used to determine the probable average concentration of the radionuclides released to the river in 1959. No fission products have been detected in observation wells beyond the streams bordering the waste-pit system and

(1955) CRST.

This is corroborated by lack of nitrates, which were introduced into the pits, on the other side of the stream. By comparing average concentrations, the calculated reduction in Pu 106 due to dilution, decay, and sorption was 90% in 1955. It was also found that concentration increases when quantity of wastes increase and as the concentration of Pu 106 increases in the pit. When a pit is empty it was found that the Pu 106 concentration dropped off in accordance with an exponential function. It took an average of 67 days for the concentration to drop from 10,000 cc/ml to 5,000 cc/ml. Since it is assumed that Pu 106 can be released in quantities of 20,000 curies or a total of 5 million gallons of sewage per year, also it is expected that 75% reduction in concentration will occur due to dilution, decay, and sorption. A final assumption is that the effluent will remain in the dispersed liquid phase and not be re-concentrated by the silt in the river water. From calculations not more than 750,000 curies in 1.7 million gallons of sewage should be released to the pit system. (1955)

(1955)

Oak Ridge National Laboratory, Health Physics Division, Oak Ridge, TN

Linnick, T.P. 1955. Retention and Migration of Radioactive Ions in Soils. Proceedings of an International Colloquium held in Sicily, France, October 16-18, 1952, pp. 275-279.

Movement of Radioactive Ions in the Soil of White Oak Lake (19)

Liquid intermediate-level wastes disposed of in sewage pits in Helton Valley leaked wastes into the groundwater and the wastes were carried over part of the bed of the former White Oak Lake. The isotopes of interest is Pu 106 and approximately 2000 curies were detected at White Oak Lake during 1959 and 1960. The bed of the former lake is underlain by a 2 foot layer of recent lacustrine sediment, 6 to 12 feet of alluvium and finally the Coconino shale formation. Physical analysis shows the sediment to be composed of 54 sand, 60% silt, and 75% clay. The average porosity of all the sediments is 20%. It also shows upward and toward the shores of the lake. The alluvial material consists of a complex mixture of sand, silt, clay, and gravel. In the deepest part of the lake is material that is a remnant of an ancient flood plain of the Clinch River. The water table was found to vary from less than 1 to 1.5 feet in depth in the winter to 3 to 5 feet in the summer. Water table contour maps show ground water movement towards White Oak Creek in the lower portion in the lake bed and a complex motion in the upper part of the area due to the two streams flanking the area. The hydraulic conductivity was measured to 19 feet/day in the upper 2 feet of soil and 1 foot/day in the material between 2 and 5 feet. Hydraulic gradients beneath the old lake bed vary from 0.05 to 0.01. Ground water velocity in the upper 2 feet averages 1 to 5 feet/day, whereas the velocity in the material 2 to 5 feet deep varies from 0.05 to 0.25 feet/day. Ground water in the upper material moves 20 times faster than in the lower portion. Through soil samples taken in the lake bed, the vertical and horizontal distribution of Pu 106 was determined. It was found that approximately 70% of the Pu 106 in the lake

bed is associated with the uppermost 2 feet of soil. By varying the pH beyond the limits of petroleating ground water or surface water (6.5 to 8.5) only Pu 106 was leached and the supposed mechanism for holding Pu 106 in the soil is by the hydroxide form. Therefore, Pu 106 is expected to move at such a slow rate that radioactive decay (1/2-life years) would reduce Pu 106 before any leaching water reached the creek to an insignificant level. (1955)

Grain Size Distribution; Hydraulic Conductivity; Hydraulic Gradient; Effective Porosity; Hydraulic Velocity; Depth to Water Table

(1957)

Oak Ridge National Laboratory, Health Physics Division, Oak Ridge, TN

Conner, R.L., T.P. Linnick, and V.B. Schuster. 1957. February 6. 1955-1957; 20 pp.

Status Report on Evaluation of Solid Waste Disposal at W-16. 1. (19)

Solid waste is disposed of by burial at Oak Ridge National Laboratory (ORNL). New burial sites must meet the requirement of being stable for 10 to 15 years as well as meeting the geologic and hydrologic criteria. A field survey was done in Helton Valley to determine which of four sites was the best suited. Area 1 was the selected area and it is 25 to 35 acres in extent to moderately sloping land within the White Oak Lake drainage basin. The rock types at the site are shale, siltstone, and limestone. The limestone becomes somewhat spotty and friable when the calcium carbonate is leached from the rock. Siltstone layers have well developed joints that usually open near the surface. Ground water circulation in the well-jointed layers is probably greater than in the layers which do not have the joints. These rocks are part of the Coconino shale which is a structurally incompetent unit between two competent units. The important zone of flow is the weathered zone. Water fluctuation ranges from 1.5 to 10 feet. The water table generally follows the surface topography. Ground water flows along the strike of the formation. Chemical analysis of the water shows a high calcium content. By analyzing solid waste burial records (beginning in 1957) the volumes of waste were estimated. For alpha contaminated waste the volume will be 1.1×10^{10} cu ft. and the beta-gamma waste, 9×10^{10} cu ft. Using 15 ft as the maximum depth of trenches 11×10^{10} cu ft are available. An area providing 1.4×10^{10} cu ft will be ample for the alpha waste burial through 1960. In the same area 2.2×10^{10} cu ft is available for beta-gamma waste. High-level wastes will be placed in another site of 1.1 acres. A new trench design is recommended. The bottom should be covered with 6 in. of gravel, and sloped to an asphalt-lined ramp. The ramp meets a 6 in. perforated casing. Any liquid entering the trench would drain through the gravel and into the ramp where samples could be analyzed. Once the trench is filled it will be backfilled with shale and capped with asphalt. The total cost for such a trench is \$1,000. The trench was about 75 ft long, 10 ft wide, and 12 ft deep containing a volume of 0,700 cu ft. The cost was increased only by \$0.02/cu ft for the ramp wall, gravel underdrain, and asphalt cover. Cost of individual drum placement in the trench was \$0.07/cu ft. A larger trench would afford cheaper monitoring costs. Additional studies on the vegetation

<167> COSY.

prior to waste burial are planned for the year. (SDW)

Depth to Water Table; Thickness of Upper Aquifer; Stratigraphic Unit Thickness; Waste Volume

<169>

Oak Ridge National Laboratory, Health Physics Division, Oak Ridge, TN

Jacobs, D.C. 1956. Health Physics, p. 157-163.

Absorption of Cesium by Conasauga Shale (1)

Results on the sorption of cesium 137 by the Conasauga shale are presented. Intermediate wastes (1.9 x 10⁶ Ci/m³) are disposed of in 1 one million gallon pits at Oak Ridge National Laboratory (ORNL). The pits are constructed in the illitic portion of the Conasauga shale. Cation exchange capacity is 16.5 meq/100 g for this portion of the formation. Experimental results show that in more concentrated solutions of Cs 137, sorption of cesium is decreased with increasing valence of the competing cation. In dilute solutions, however, the complementary cation was found to have little influence on the sorption of cesium. Also, as the cesium concentration is decreased a greater proportion of Cs ions sorbed by the shale are held at "fixation sites". The activity for Cs 137 increases in this situation. When cesium is at 1.0 meq level, the selectivity coefficient in a 0.1 molar NaCl solution is 10. When the cesium content is 0.001 meq, the selectivity coefficient is 723. Hence, the solution pH is of importance only when the hydrogen ion concentration is high enough to change the ionic activity of the solution. The anion in the solution is of secondary importance. The important parameter in cesium retention is the sorption mechanism. Of the 16.5 meq/100 g, 8.0 meq/100 g or 20% of the exchange sites are found within the interlayer spacing of the nonexpanding clay minerals. Desorption studies show that 1.33 meq/100 g of cesium are "fixed". Since the partial cesium capacity of the shale for cesium is low (0.0056 meq/100 g), all cesium sorbed would be expected to occupy "fixation sites". No danger of cesium transport due to leaching processes are foreseen. (SDW)

Cation Exchange Capacity; Selectivity Coefficient; pH

<169>

Oak Ridge National Laboratory, Isotopes Division, Oak Ridge, TN

Pinshaw, S.J., and D.C. Binkley. 1960, April. ORNL-CP-60-8-17; 82 pp.

Removal of Cesium 137, Strontium 90, and Ruthenium 106 from ORNL Plant Wastes by Sorption on Various Minerals (1)

A series of minerals (120) were tested as to their efficiency in removing cesium, strontium and ruthenium from dilute alkaline wastes prior to ground disposal. Strontium 90 exchanges rapidly with calcium in Florida pebble phosphate with a distribution coefficient ranging from 55 to 1500 depending

on contact time. The best results were obtained with Tennessee phosphate heated to 600 degree C for one hour, but part of the increase in sorption of strontium is due to ion exchange. Heating Tennessee phosphate resulted in a material with excellent hydraulic properties that sorbs Cs 137 and Sr 90 from dilute alkaline solutions. Other calcium minerals such as calcite or dolomite can be activated to absorb Sr 90 by heating or by treating with caustic or phosphate solutions. Cesium 137 in dilute alkaline solutions exchanges preferentially with the potassium present in a number of mica schists and mica minerals that possess a layer lattice type of structure. A distribution coefficient of 1106 for mica augite peridotite (mica schist) was measured. The high selectivity for cesium of Tennessee phosphate heated to 600 degree C for one hour is ascribed to the presence of bentonitic impurities present in this material. The kinetics and adsorption of Sr 90 are known to be complex and slow due to the large number of chemical forms and complexes of ruthenium that can exist under varying conditions. Copper in conglomerate, various sulfide minerals containing copper, cuprite (copper oxide) and chalcocite (basic zinc lead vanadate) remove 90% of the ruthenium under reducing conditions at a pH of 7 when heated at 60 degree C for 16 hours. For the copper in conglomerate the distribution coefficient was measured as 92.7. At lower temperatures (25 degree C) the removal of ruthenium from acid solutions takes days or even weeks. (SDW)

Distribution coefficients for all 120 minerals are listed in the appendices. (SDW/SDW)

Distribution Coefficient; pH

<170>

Oak Ridge National Laboratory, Oak Ridge, TN

Abee, R.W. 1956. TID-7517 (Part 10); Sanitary Engineering Aspects of the Atomic Energy Industry, Proceedings of a Seminar held in Cincinnati, Ohio, December 6-9, 1955, (pp. 223-229) (TID-7517, Part 1A).

Problems in the Burial of Solid Wastes at Oak Ridge National Laboratory (1)

In this report the general problems associated with shallow land burial of radioactive waste are discussed. The discussion includes information on personnel exposure to radiation and the contamination potential associated with the collection, handling, transportation, and burial of the waste. Waste material is currently buried in a Conasauga shale formation approximately 1530 ft thick. This shale exhibits ion exchange capacities of from 5 to 25 meq/100 g of soil. Descriptions of solid waste receptacles, personnel protective apparel, health physics considerations, transport vehicle requirements, and decontamination procedures are provided. Typical burial operations, costs, land utilization rates, and records are briefly discussed. (JC) (SDW)

This report is a dated discussion on safety, economy, and convenience of shallow land burial of radioactive waste. (SDW/JC)

Cation Exchange Capacity

<171>

Oak Ridge National Laboratory, Oak Ridge, TN

Cowser, R.E., and P.L. Parker. 1958. Health Physics, 1, 152-163; Health Physics Society. Proceedings of an Annual Conference held in Pittsburgh, Pennsylvania, June 17-19, 1957, (17 pp.).

Soil Distribution of Radioactive Wastes at ORNL: Criteria and Techniques of Site Selection and Monitoring (1)

A discussion of the significant findings in the study of intermediate level liquid disposal into seepage pits at ORNL is presented. The program included the use of three one million gallon capacity seepage pits to dispose of sodium nitrate wastes containing cesium 137, ruthenium 106, strontium 90, cobalt 60, antimony 125, and several radioactive isotopes of the rare earths. Surface pits were constructed in the Chattanooga shale for the disposal of intermediate level fission product wastes. The pits are located in the White Oak Lake drainage basin in which surface runoff and basal flow are collected and monitored before the liquid leaves the controlled area. Between 1952 and 1956, approximately 5.6 million gallons of this waste containing 54,000 curies of cesium 137, 15,000 curies of ruthenium 106, and lesser amounts of the other radionuclides was disposed of at these pits. The geology and the hydrology of the pit area is discussed in qualitative terms. Proposed and ongoing water balance studies are discussed. The migration of radionuclides from the pits has been studied by the installation of observation wells both cased and uncased. Sampling and radiology of these wells provided information necessary for conclusions as to routes and rates of movement. The estimated rate of seepage from pits No. 2 and No. 3 are given in tabular form. The rate of underground waste movement from pit No. 2 is from 10 to 30 ft/day; and from pits No. 2 and No. 3 about 1/5 as great. The movement of nitrate was observed and a nitrate concentration contour diagram was constructed to delineate waste solution dispersion. The radiation levels observed in the pit vicinity are presented in map form and their significance with respect to allowable work time around the pits was discussed. (JC) (CSF)

The sequel of this report contains considerably more hard data (see De Laguna, Cowser, and Parker, 1958, reprint from the Second UN Geneva Conference, London, England, Pergamon Press). (OR/JC)

Cation Exchange Capacity; Leaking Rate; Migration Rate

<172>

Oak Ridge National Laboratory, Oak Ridge, TN

De Laguna, V. 1956. TID-7517 (Part 1); Sanitary Engineering Aspects of the Atomic Energy Industry, Proceedings of a Seminar held in Cincinnati, Ohio, December 6-9, 1955, (pp. 226-256) (TID-7517, Part 1).

Some Geologic Factors that Influence Disposal of Radioactive Wastes into Pits (2)

A generalized conceptual discussion of the nature of ground water flow and how it relates to the proper selection of sites for

radioactive waste disposal is presented. In addition, brief descriptions of the hydrogeology of the Brookhaven and Oak Ridge National Laboratories is presented. Brookhaven National Laboratory is composed of unconsolidated clay and clayey sand. Bottom sediment beds have a base-exchange capacity of about 18 meq/100 g, as compared to 0.8 to 0.6 meq/100 g for the overlying, cleaner material. Initial considerations with respect to site selection include the cost consideration. Cost considerations must include both the disposal as well as the required monitoring costs since the half-lives for many of the important waste radionuclides are long enough to require relative containment for centuries. The least expensive site is thus one that is cheapest and easiest to monitor. Advantageous hydrogeologic parameters for liquid waste disposal include large porosity, relatively large aquifer thickness, and large distance from hydrologic boundaries such as streams. Barriers to fluid movement such as faults or igneous intrusions are not necessarily as deleterious as linear features with high permeability such as gravel lenses, solution cavities, or joints. Homogeneity and high cation exchange capacity in the substrate are also favorable. (JC) (CSF)

A generalized conceptual and philosophic discussion on waste disposal is presented. Site specific data of ORNL and Brookhaven National Laboratory are also presented. (OR/JC)

Cation Exchange Capacity

<173>

Oak Ridge National Laboratory, Oak Ridge, TN

De Laguna, V., R.E. Cowser, and P.L. Parker. 1958. A/COW-15-P/2351; Peaceful Uses of Atomic Energy, Proceedings of the 2nd United Nations International Conference held in Geneva, Switzerland, September 1-17, 1958, (pp. 131-145) (A/COW-15-P/2351).

Disposal of High-Level Radioactive Liquid Wastes in Terrestrial Pits: A Sequel (1)

The suitability of seepage pits for storage and treatment of high level wastes (intermediate level by present definition) is discussed. Three seep pits at Oak Ridge were studied to help evaluate the long term risks and environmental hazards related to the operation of such seep pits. When seepage pits were first conceived they were expected to act as storage basins as well as natural ion exchange columns. The concept of complete containment was later discarded but the seep pits did offer some distinct advantages over conventional tank containment. Although ruptures which often occur in conventional tank containment are not expected in seep pits dug in low permeability argillaceous materials, the slow release of radionuclides to unrestricted areas reserved in the vicinity of these pits was considered to pose a potential unacceptable long term risk. The operating procedures at these seepage pits are discussed and a water budget was derived which considered liquid gains from waste influent and precipitation as well as liquid losses from seepage, liquid pit to pit transfer, evaporation and seepage. The report also includes a generalized description of the local geology along with relatively detailed notes on the structural geology and weathering characteristics in the immediate vicinity of the pits. The clay content of the pit area was 85 to 95 % for illite; 0 to 82 % for

<173> COST.

kaolinite, and 5 to 25 % for quartz. The hydrologic characteristics of the seepage pit area was investigated by use of pressure tests, pump tests, and tracer analyses. In general the radioactive waste was observed to be leaving the seepage pits through the weathered shale in a direction parallel to the bedding. Ion exchange capacity of the weathered shale ranges from about 6 to 12 meq/100 g; a value of 20.6 meq/100 g has been reported for one sample. A discussion of the liquid waste composition and the monitoring program employed is also included. Laboratory ion exchange column experiments were performed to establish the decontamination factors afforded by these "natural" exchange columns (the seep pits). It was noted that the column tests were done on crushed shale samples and that actual retardation of radionuclides by adsorption could be significantly different in the fractured substrate encountered. Additionally, it was observed that for ruthenium the actual retentive capability of the local shales was better than that observed experimentally. (JC) (257)

This report is a very comprehensive treatment of the parameters, especially water budgets, which are critical to the assessment of subsurface radionuclide migration. (DM/JC)

Hydraulic Conductivity, Saturated; Total Cation Concentration; Grain Size Distribution; Cation Exchange Capacity; Clay Content; Stratigraphic Unit Thickness

<174>

Oak Ridge National Laboratory, Oak Ridge, TN

Jacobs, D.C., and T. Tansu. 1960, March. Nuclear Safety, 1(3), 65-69.

Retention and Movement of Radioisotopes in Soils (1)

Investigators found that Pu is strongly sorbed by soils, particularly in the pH range of 2.2-8.0. Pu exists as a polymer in this pH range, and the sorption is nearly irreversible. Cs 137 sorption is related to the structure of silas found in the soil. Oxylate and phosphate ions were shown to have increased Sr sorption in a 0.1 M NaCl solution, while nitrate, chloride and sulfate decreased Sr sorption. From a study on grain size distribution, total exchange capacity, pH, and distribution coefficients of soils, there appears to be an inverse relation of pH and distribution coefficient. With increasing pH there is competitive influence of calcium from the hydrolysis of limestone. Removal of Na 106 was greatest with a pH of 5 (97-98%) and decreased with a change in pH. Vanadium-Niobium sorption is nearly complete in the pH range of 6.0-7.7 and at pH 12.2 sorption is at a minimum at pH 9. Mechanical analysis was done on the five soil samples for sand, silt, and clay content. The clay content ranged from 3.0% to 82.0%. Total exchange capacity was from 5.8 to 60.0 meq/100 g and pH varied from 4.5 to 8.3. The distribution coefficient for the samples ranged from 70 to 600 ml/g. Grain size distributions for sand, silt, and clay are given.

Distribution Coefficient; pH; Cation Exchange Capacity; Grain Size Distribution

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Oak Ridge National Laboratory, Oak Ridge, TN

Tansu, T. 1966. CONF-660401: Clay Conference, Proceedings of an International Conference held in Jerusalem, Israel, June 20-24, 1966, Volume 1, (pp. 425-439) (CONF-660401).

Development and Applications of Minerals in Radioactive Waste Disposal (1)

As sorbents selective for Cs 137 and Sr 90, clays have been used in decontaminating waste solutions. Illite and mica have been used due to their high affinity for Cs. Increased concentrations of Cs collapse the silicate layers and form more favorable sites for Cs. When montmorillonite was heated to 600 and 700 degrees C, improved sorption of Cs was observed, due to a collapse of the expanded 001 layers. Ion exchange capacity of Na-montmorillonite is 76 meq/100 g, as compared to 31 meq/100 g for Ca-hydrobiotite. The ED ranged from 4000 and 1000 at the 100(2-3) m level to 60 and 3 at the 70(2-3) m level for the 600 and 700 C samples respectively. Removal of Sr and Tl have averaged 80% and 90% respectively using lime and soda ash. Addition of 200 mg/l of Gravelite (Illite) resulted in increasing Sr removal from 20% to 80%. The clay found was also instrumental in increasing the removal of Sr 106 to 76%, Co 60 to 70% and gross beta activity to 80%. Results show by heating aluminum hydroxide to 350 degrees C, removal of Sr was increased from 3.0% to 99.9%. By heating bentonite to the same temperature, an increase from 65% to 99% was noted. At pH 10 and 10 (2-5) Sr(103) 2 concentration, F-23 grade alumina has a Kd of about 6000. The ion exchange capacity of F-23 was about 10 meq/100 g; the Bowen 50 was 500 meq/100 g; and clinoptilolite was 80 meq/100 g. The addition of iron oxide to the surface of acid-washed sand resulted in an increase in Sr sorption from 26% to 60%. (The sand contained .25% Fe2O3). (PTO)

Distribution Coefficient

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Oak Ridge National Laboratory, Oak Ridge, TN

Tansu, T., and D.C. Jacobs. 1960, May. Health Physics, 5, 109-150.

Improving Cesium Selectivity of Bentonites by Heat Treatment (1)

Sorption of cesium from a 0.1 M NaNO3 solution by Ca-, Na-, and K-exchanging bentonites was measured after heating the clays over a range of 100 to 600 degrees C and allowing solution contact time of 1 to 696 hours. Maximum sorption occurred after the samples were heated from 600 to 700 degrees C. For Na- and K-montmorillonite maximum sorption was achieved at the 696 hour contact time and 700 degrees C level. Sorption values for heating at 700 degrees C for three hours and 696 hours of solution contact time were: K-82.6% (0.013 mg Cs/g clay); Na-63.5% or 0.212 mg Cs/g clay; and Ca- 87.3% or 23.7 mg Cs/g clay. The ion exchange capacity for all bentonites dropped from a range of 79.7 to 96.2 meq/100 g at 100 degrees C to 15.6 to 26.1 at 700 degrees C. This drop was associated with a high cesium affinity. Increased cesium sorption appears

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to be a result of lattice collapse particularly when it is noted the curve for Ca-montmorillonite treated at 600 degree C resembles that of illite (30 Angstrom mineral). The c-axis distance influences clay solution contact time which is important to exchange capacity. However, lattice collapse may not be the only mechanism for increased cesium sorption. If cesium selectivity increase is a function of c-axis collapse to 10 Angstrom then this technique might be diagnostic for differentiating bentonites. The data does support higher specificity for cesium due to collapsed structure due to heat treatment. The material settles fast and is easy to wet which means it could be used in a liquid system with out clumping. Bentonites could be used in regions without illite. (SDW)

This paper reports the sorption of cesium by montmorillonites which had been heated, measurements of the c-axis spacing, ion exchange capacity, and weight loss of the clays. (ESTC/SDW)

Ion Exchange Capacity

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Oak Ridge National Laboratory, Oak Ridge, TN

Parker, F.L. 1960. Nuclear Safety, 1, 73-75.

Problems of Waste Disposal into Freshwater Systems (4)

Radioactive wastes disposed of in fresh-water systems pose problems. However, such method of disposal is common in the United States, Britain, France, and Canada. In the early days discharges were regulated by the ICRP and PCRP and maximum permissible concentrations were used. It was soon realized that the nuclides could be re-concentrated in the fresh water environment. Calculations on the percentage of lifetime dose that should be allowed were found to be complicated because of dilution, diffusion, and radioactive decay. Also, some isotopes are selectively concentrated in the sediments or biota. When studying a site, the probable sources of wastes to streams, chemical and physical properties of the wastes, limnological factors, and biota need to be delineated. With the accumulation of data mathematical models were used to describe the movement of isotopes in river systems. The models were simplified because it was difficult to model decay, dilution, diffusion, and selective uptake by sediments and biota. Other modeling attempts included using the point of injection and analytically solving the diffusion equation for simple geometry and velocity transport. Selective removal of isotopes is considered to be extremely important and equally as hard to predict. (SDW)

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Oak Ridge National Laboratory, Oak Ridge, TN

Tanaka, T., and D.G. Jacobs. 1960. Health Physics, 2, 397-399.

Structural Implications in Cesium Sorption (1)

Intermediate-level wastes at the Oak Ridge National Laboratory are pumped into pits excavated in the local Cosasaga shale formation. About 75% of the activity in the supernate is due to radiocesium. Seepage of the solution through the shale formation results in a high degree of removal of this element from the waste. This paper reports the results of tests made with several clay minerals, including the local Cosasaga shale, and discusses sorption of cesium by considering the effect of the c-axis dimensions of the clay minerals. The samples investigated were an illite (Pithian, IL), a montmorillonite (Clay Spur, UT), a kaolinite (Macon, GA), a vermiculite (Travelers Rest, SC), and the hydrous mica and kaolinite that are the principal clay minerals of the Cosasaga shale. For the studies conducted in this series of experiments, the Al³⁺ concentration was 1.67 N, and the Na⁺ concentration was 6.0 N. The cesium concentration was limited to the range of 0.2-0.8 x 10⁻⁶ moles/l; this level of cesium concentration would be found in high-level wastes. For analytical purposes Cs 137 was added and cesium sorption was then measured by counting the waste solution before and after being in contact with the clay mineral. Solution-clay mineral contact time was limited to 16 hours. The interesting feature of the Cosasaga shale is the strong preference which it exhibits for the shale for cesium. The sorption of cesium from 1.67 N Al(NO₃)₃ solution showed that of the materials tested, under these conditions shale has the highest affinity for cesium. In the lower cesium concentration range (high Al/Na ratio), illite shale sorbed the highest amount of cesium, with vermiculite also being effective. With increasing cesium concentration, montmorillonite surpasses vermiculite for sorbing cesium, but the surprising feature is the high specificity exhibited by illite, a mineral with only a moderate ion exchange capacity (0.15) when compared with montmorillonite (1.00) and vermiculite (0.57). Changing the system to a 6.0 N NaNO₃ waste type did not affect the sorption of cesium to any great degree and once again, illite was more effective than montmorillonite on a weight basis. These results showed that illite is an outstanding clay for sorbing cesium from both aluminum nitrate and sodium nitrate waste solutions. If ion exchange capacity cannot explain the differences in the clays' ability to sorb cesium, then one must look to other distinguishing features. There are two immediately apparent features by which illite differs from montmorillonite and vermiculite. Illite has a c-axis spacing of 10 angstroms, whereas montmorillonite and vermiculite have spacing greater than 10 angstroms which depend on the degree of hydration. Illite also contains a high amount of potassium in its chemical make-up, and these potassium ions are intercalated between the aluminosilicate sheets. It was found that when methods used to induce collapse in the structures of montmorillonite and vermiculite were used, converting the higher spacing to 10 angstroms, both minerals obtained an increased ability to sorb cesium. It was also shown that when these samples were not potassium-saturated, that the reduction of c-axis spacing did not show an increase in sorption of cesium. (JNT)

Cation Exchange Capacity

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Oak Ridge National Laboratory, Oak Ridge, TN

<178> COT.

Jacobs, D.G. 1966-1967. Nuclear Safety, 8(2), 175-178.

Behavior of Radioactive Gases Discharged into the Ground: (2)

The feasibility of discharging radioactive gases and aerosols from a reactor containment vessel into the ground following a fuel-melt-down incident has been discussed by an AEC working group. This review incorporates much of the information discussed. Fission-product iodine is considered to be the principal hazard in nuclear accidents, and as such, its behavior in the ground is considered in more detail than that of other nuclides. When elemental iodine vapor is passed through sandstone, it is quickly absorbed onto the mineral surfaces and its motion is stopped. If suitable formations are available at a reactor site, the behavior of radioactive gases injected into the ground is such that the hazards to populations in surrounding areas due to the consequences of the postulated MCA would be greatly reduced compared with the case of direct release to the atmosphere. A few months delay time seems quite feasible, and sorption of the elemental I 129, together with decay of I 131, would be sufficient for removal of almost all iodine. It is presented as a longer term contamination problem of much lower intensity, but the slow rate of effusion from the ground would tend to eliminate this exposure problem. The important question at the moment is whether there is a great enough advantage of ground injection of radioactive gases over surface cleanup systems to warrant the development costs. (JBT)

<180>

Oak Ridge National Laboratory, Oak Ridge, TN

Vorton, F.J. 1960. Nuclear Safety, 1, 68-73.

Management and Disposal of Radioactive Wastes (2)

Low-, intermediate-, and high-level wastes are discussed with respect to storage, treatment, and monitoring procedures at various sites. High-level wastes generally exist as liquids that must be contained in tanks and encased in heavy concrete before burial in temporary underground storage. The tanks, although economical, will not last more than a fraction of the hazard-life of the fission products. Therefore, several methods for ultimate disposal are under development. Possible methods for permanent disposal of high-level wastes are: storage in cavities in natural salt formations; injection through specially constructed wells into deep permeable formations in which natural conditions would provide storage space and prevent migration of the wastes; deep-well injection into impermeable formations after they have been fractured by hydrostatic pressure to form storage spaces for a slurry containing the waste liquids; concentration and fixation of waste constituents in a stable, solid matrix; and calcination with appropriate burial. Disposal of high-level wastes in the ocean are under research and a great deal of oceanographic information is required for the determination. Salvage and utilization of valuable waste byproducts is a possible solution. However, the extraction must be very efficient; decontamination factors of 10(4) to 10(6) to be feasible. Low-level wastes have been dispersed to the environment

with treatment if necessary. But, as the nuclear power industry increases in size this may become a problem. Low-level releases are the principal sources of environmental contamination in the nuclear industry. The acceptability and assurance of long-term safety of low and intermediate-level radwastes are dependent on the accurate knowledge of the environmental factors and their effect conditions at the specific site. Monitoring is necessary for the safety of the workers at the site and for the environs great distances from the site. Several sampling programs are discussed at a various sites. (UDW)

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Oak Ridge National Laboratory, Oak Ridge, TN

Albrecht, W.L. 1960. Nuclear Safety, 1, 75-77.

Handling of Liquid Wastes at U.S. Reactor Installations (3)

As a general philosophy, high-level wastes are stored and low-level wastes are treated and reused whenever possible. Low-level wastes are discharged to the environment when cooled reactors is the primary coolant. The coolant becomes contaminated with activated corrosion products and fission products from ruptured fuel cells. However, the coolant is continuously purified by ion exchange and therefore is not an actual waste. Other sources of liquid waste come from spent-fuel handling, storage basins, ion exchange resin regeneration, and heavy water. Yankee and Indian Point reactors use ion exchange to treat compatible wastes as well as primary coolant. Saxton and Elk River shutdowns and use ion exchange but leave the boron in the water. Vallecitos uses ion exchange to make the wastes suitable for discharge into the environment at no greater than background levels. At seven of the listed reactors there are concentration facilities for high level wastes. At Yankee and Shippingport the concentrated liquid is mixed with cement in drums. At BOWEN, the high-level waste liquid will be evaporated to a slurry and solidified. Few of the stations have facilities for long-term storage of high-level liquids at the site. Yankee and Dresden discharge low-level wastes into impounded streams. Three others of the reactors discharge wastes into unlined earth pits. Other reactors use ponds for their low-level radwastes. For the Dresden reactor a release of about 10 curies/year and for Yankee 0.001 curies/year have been measured. (UDW)

An extensive summary table of liquid waste handling practices is presented. (ESIC/UDW)

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Oak Ridge National Laboratory, Oak Ridge, TN

Burnett, F.J. 1960. Nuclear Safety, 1, 77-82.

Fission-Product Release Tests (3)

Field release tests were done to evaluate the hazards of fractional release of fission products from melted fuel elements and the meteorological factors. Particular attention was paid to the fractions of the various isotopes released under given conditions, the physical form of the various activities, and

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the dispersion of this activity by the atmosphere. Three independent estimates of the fraction of I 131 released during Operation Boot were: Residue analysis, 0.25; Effluent sample analysis, 0.026; and Source strength to give measured isopleth concentrations, 0.025. During this test some Sr 91 was observed in the effluent samples but there was no confirmation. The particle sizes were either large or very small with the in between sizes missing. The field measurements indicated that the shape of the isopleth pattern may be described by Sutton's diffusion theory. Subsequent tests were run to determine release percentages, particle size and size distribution and atmospheric diffusion and deposition. Analyses of the samples showed that iodine was released in the first 7 to 10 minutes, followed by cesium, strontium, ruthenium, zirconium-niobium, and cerium. The values observed were: iodine, 0.50; cesium, 0.10; strontium, 0.01; ruthenium, 0.008; cerium and zirconium-niobium, small. Cesium and strontium appeared as aerosols while the others appeared as gross particles. The observed centerline air concentrations during lapse conditions were greater by an order of magnitude over inversion conditions. This was attributed to the vertical diffusion coefficient being a similar order of magnitude greater. Further study is needed to be able to determine deposition velocity. (100)

Dispersion Coefficient

<103>

Oak Ridge National Laboratory, Oak Ridge, TN

Cowser, R.E., R.J. Norton, and E.J. Witkovski. 1958. ACONF-75/P-235a; Peaceful Uses of Atomic Energy, Proceedings of the 2nd United Nations International Conference held in Geneva, Switzerland, September 1-13, 1958, Vol. 10, (pp. 161-173) (A/CONF.75/P-235a).

The Treatment of Large-Volume Low-Level Waste by the Lime-Soda Softening Process (3)

Since 1943, the waste systems at the Oak Ridge National Laboratory have been operated with the aim of directing all major discharges of radioactivity to the underground tank system and keeping the level of contamination in the process wastes low enough to permit disposal by dilution in the White Oak Creek and then to the Clinch River. These methods, however, were only partially effective and as operations expanded, the normal discharges of radioactivity in the process wastes caused the average downstream levels to approach and during some periods to exceed, the maximum permissible concentrations in the receiving water. The total volume of flow of the process waste during the years 1950 to 1957 ranged from 165 to 298 million gallons per year or an average 0.85 to 0.91 million gallons per day. The waste discharged from the collection system is normally clear, but it varies widely in acidity or alkalinity, with pH ranging from about 2.0 to 11.5. The wastes discharged to White Oak Creek are diluted and flow approximately three miles through the creek channel, the basin of White Oak Lake, White Oak Bay, and the embayment above the south of the creek. The creek discharges into the Clinch River at Clinch River Mile 21.8. The estimated minimum time of flow from the south of White Oak Creek to Chattanooga is 20 days. A number of water-treatment processes were investigated in

the laboratory to determine their efficiencies in the removal from tap water of the major contributors to radioactivity in the Clinch River; namely Sr 90, Cs 137, and the rare earths. A primary consideration in the evaluation of each process was its ability to remove 90% or more of the radioactivity. Sand filtration and chemical coagulation with aluminum and iron salts were unsatisfactory for the removal of Sr and Cs. Lime-soda softening, phosphate coagulation, and ion exchange were all found to remove more than 90% of the Sr and the total rare earths. The process-waste treatment plant demonstrated that the lime-soda softening process was the most effective and economical method for the removal of Sr and the total rare earths from large volumes of low-level waste. Cesium can be removed from these wastes by the addition of clay in this process. The experience in operation to date indicates that this facility will fulfill the primary purpose of increasing the factor of safety in the control of radioactive wastes released to the Clinch River. Designed especially for the removal of Sr, the plant has shown reductions of 80 to 90% of the radioactivity due to strontium in the wastes that have been treated. The treatment system has provided means for detection and control of accidental or emergency releases which might exceed the capacity of the river for safe disposal. (JRT)

PR

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Oak Ridge National Laboratory, Oak Ridge, TN

Tamura, T. 1972. Resoir 10; Underground Waste Management and Environmental Implications, T.O. Cook (Ed.), Proceedings of a Symposium held in Houston, Texas, December 6-9, 1971, (pp. 318-323).

Sorption Phenomena Significant in Radioactive-Waste Disposal (1)

At the Oak Ridge National Laboratory (ORNL) low-level wastes are treated with lime-soda ash to remove strontium and cesium at 80 and 96% levels, respectively. With an increase in the lime-ash addition, of the 96% strontium will be removed. Medium-level waste is placed into a bedded shale formation by the hydraulic-fracturing technique. Many ion adsorption equations have been derived for the adsorption by minerals. One of the common features is that the concentration of the radionuclide and its stable counterpart is usually very low compared to the concentration of dissolved ions. For example, in low-level liquid waste strontium is 1/2500 of the molar sum of the cations. Soils, as well as the different chemical quality of the waste solutions effect ion adsorption. Montmorillonite has a capacity of 100 meq/100 g. This capacity is a result of exchange properties associated with the octahedral layers and isomorphic substitution. Vermiculite has a similar capacity to that of montmorillonite but its isomorphic substitution is related to the tetrahedral layers. Another type of substitution is due to the ionizable ion, hydrogen, present at the edges of the clay mineral edges. While in montmorillonite and vermiculite this kind of exchange accounts for only 5% of the total capacity, in kaolinite it makes up to 50% of the total and 100% of the total in sesquioxides. Ionization substitution is pH dependent, where above 7 there are substantial increases in capacity. The

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Distribution coefficient of vermiculite and talcinite show decreased sorption when a NaCl solution is used (52,000 vs 2,700 and 2,500 vs 94, respectively). Such a decrease is explained by sodium ions competing for exchange sites. This decrease is not evidenced by illite due to crystal structure. Edge-lattice fixation was suggested as a suitable mechanism for illitic minerals. Strontium adsorption in natural systems is much lower than cesium due to the competition of calcium of exchange sites. However, heated alumina and limonite exhibit high distribution coefficients. Also by increasing the pH of the natural water to 10, adsorption is increased. It has been suggested that the Gouy-Chapman electric double-layer theory adequately explains the exchange capacity of the activated alumina. The theory was also used to conclude that strontium adsorption by vermiculite at pH 10 is due to the existence of hydroxyl species. Plutonium in soils has been studied very little and work is now proceeding on adsorbing plutonium from water systems. Rock-fluid or sediment-fluid interaction is discussed for low-level waste disposal in permeable formations and medium-level waste disposal by hydraulic fracturing. Some leaching data are also included. (DPW)

Ion Exchange Capacity; pH; Distribution Coefficient; Effective Porosity; Density

<175>

Oak Ridge National Laboratory, Oak Ridge, TN

Jacobs, D.G., and O.R. Sealand. 1962, November 12. ORNL-3347: Health Physics Division Annual Progress Report for Period Ending July 31, 1962, (pp. 1-5), 180 pp. (ORNL-3347).

Radioactive Waste Disposal, Liquid Injection into Deep Permeable Formations (2)

The potential application of liquid injection into deep permeable formations is discussed in this report. At the time of this report, large volumes of low-level wastes from ORNL were being injected into permeable formations beneath the site. It is suggested that this method of disposal could also be applied to disposal of intermediate-level wastes requiring segregation from the environment for up to 500 years. Because of the extreme handling hazard and the potential for breakthrough of some radionuclides, the use of this technique for high-level waste is discounted. The retentive properties of the Richland oil sand, some standard reference clays, and the Conasauga shale were studied and the results presented. Multicomponent exchange systems were investigated to establish the effects of ionic competition for exchange sites on these materials. The multicomponent systems analyzed were calcium nitrate, sodium nitrate, calcium chloride, sodium chloride, and strontium chloride. The strontium chloride was spiked with strontium 90 for analytical purposes. The results revealed that the selectivity coefficient for sorption of calcium compared with sodium is 25 grams per milliliter. The selectivity for strontium over calcium was shown to increase with decreased calcium occupation of exchange sites. At pH=7, the Richland sand was shown to strongly favor strontium over sodium. Similar results were obtained on reference clay and Conasauga shale samples in competition with other alkaline earth

elements, strontium selectivity decreased with decreasing size of the hydrated ion. The sorption of cesium on clay minerals is also briefly discussed. The behavior of ruthenium in subsurface formations is discussed as it relates to precipitation, filtration, and complexing with nitrate and nitrate (nitrosyl) ligands. It was concluded that as a worst case ruthenium 106 in low-level waste should not pose any problem since in this waste, however, twelve years of retention by soils is required to reach HVC. Mathematical expressions for the velocity of metal ions in contact with layered silicates is discussed and the Glueckauf theoretical plate model is presented for description of radionuclide breakthrough. (JC)

Although the discussion in this report is intended for decision making for the disposal of low- and intermediate-level wastes the information on ionic selectivity is very germane to the burial of low-level solid waste. (DR/JC)

Cation Exchange Capacity; Total Cation Concentration; pH

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Oak Ridge National Laboratory, Oak Ridge, TN

Jacobs, D.G., O.R. Sealand, and R.W. Shaith. 1964. ORNL-3697: Health Physics Division Annual Progress Report for Period Ending July 31, 1964, (pp. 3-6) (ORNL-3697).

Movement of Radionuclides through Natural Porous Media (3)

The extent and rate of movement of radionuclides through a porous media while in solution, may be affected by the ion exchange properties of the host media. The delay factor of a specific radionuclide is given as the sum of one plus the distribution factors $K_{sub d}$ for that radionuclide times the bulk density of the sorbent divided by the porosity. Solution dispersion studies conducted in sandstone indicate breakthrough (50% C/C₀) for strontium at flow rates of 7.2×10 (E-3) cm/sec and 41.9×10 (E-3) cm/sec. (Auth) (JT)

Although concerned with the behavior of radionuclides in deep permeable formations, the data obtained in the study are applicable to shallow land burial. (DR/JT)

Ion Exchange Capacity; Dispersion Coefficient

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Oak Ridge National Laboratory, Oak Ridge, TN

McMaster, W.N., and W.D. Waller. 1965, May. ORNL-TN-1108; 35 pp.

Geology and Soils of White Oak Creek Basin, Tennessee (1)

Related soil and geologic factors affecting movement of water containing chemical and radioactive wastes. Surface runoff and infiltration are controlled by topography and soil permeability. Vertical movement of water is largely controlled by porosity and clay content of the soils. Physical characteristics of the underlying geologic formation and how it weathers will ultimately

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exert the strongest control on movement of groundwater in the saturated and unsaturated zones. At ORNL the Knox dolomite and Chickasaw limestone are the principal water-bearing formations. The soils on the Knox dolomite exhibit high infiltration capacities. Movement of water in the rock is mainly through solution openings. In contrast, clayey soils characteristically overlie the Chickasaw limestone, limiting infiltration. Storage in bedrock is in small openings of unspecified origin. Soils of the basin are red-yellow podzolic, reddish-brown laterite and lithomels. Text is rather brief. Tables give some detailed geologic and soils descriptions. (CAB)

Discusses geologic setting, soil characteristics and hydrologic characteristics as they relate to ground water movement and migration of radionuclides from shallow land burial sites. Detailed description of soil and rock useful for this region only. (DR/CAB)

Cation Exchange Capacity; 48

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Oak Ridge National Laboratory, Oak Ridge, TN

Browder, F.W. (Ed.). 1959, April 16. ORNL-2601; 57 pp.

Radioactive Waste Management at Oak Ridge National Laboratory (2)

The collection, treatment, disposal, and monitoring of radioactive wastes (solid, liquid, and gaseous) at Oak Ridge National Laboratory are described in detail. Illustrations of facilities, maps, and tables of data on waste volumes and radionuclides discharged to the environment are included. The philosophy and history of waste management are discussed. The report constitutes an evaluation of waste management at ORNL, concluding that the low degree of radioactive contamination of the air and water by ORNL does not represent a hazard to the local environment or population. At present a 7000-gallon/day liquid waste stream containing between 0.001 and 0.02 Ci/gal is produced. This waste is put through a series of tanks and finally stored in concrete storage tanks. Liquid uranium is produced at a rate of 100 gal/hr and is stored underground until there is a sufficient quantity to run the uranium recovery facility. Process waste water, produced at a rate of 700,000 gal/day is sampled and ultimately discharged to the creek, with 172 to 250 Ci/yr of gross beta activity. Process water is treated as necessary. Low activity waste from the Low Intensity Test Reactor, Oak Ridge Research Reactor, Homogeneous Reactor Test, Aircraft Reactor Test, Tower Shield Facility, ORNL Laundry, CBRL Rolling Mill, and ORNL Gas Disposal Stock Pile are held in retention ponds and finally released to nearby creeks. Gaseous wastes are filtered. Solid wastes from ORNL and other institutions such as Argonne National Laboratory, Knolls Atomic Power Laboratory, Naval Laboratories, Battelle Memorial Institute and General Electric Company are buried in pits and trenches in the Chattanooga Shale formation. Also included are surveys on the effectiveness of methods used. (Meth) (DDV)

This report was previously issued as ORNL-2601-1-97. (ESIC/CSF)

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Oak Ridge National Laboratory, Oak Ridge, TN

Johnson, J.L., S.B. Felthousen, L.W. McVay, and J.W. Harbo. 1956, October. TID-7517 (Part 19): Sanitary Engineering Aspects of the Atomic Energy Industry. Proceedings of a Seminar held in Cincinnati, Ohio, December 5-9, 1955, (pp. 339-351), 609 pp. (TID-7517, Part 19).

Heat Experiments for Self Fixation of Radioactive Wastes in Clay-Flux Mixtures (1)

A proposed method of disposal of high-level wastes would allow the heat of radioactive decay to fix a clay-flux-waste mixture. This requires wastes containing an energy generation of at least several watts/gallon and is predicted on the development of portable clay-flux-mixtures which will adequately "fix" the wastes. The pits to be used would be at least 20 ft in diameter and 20 ft deep, lined with concrete and insulated with granular vermiculite. Several heat experiments were devised to determine the temperatures which well insulated dry clay wastes would reach as a function of their surface to volume ratios for various specific energies. The area/volume ratios of 4:1 were used. It was found that a 20 foot diameter pit with a dry clay mass about 6 ft deep generating 0.005 watts/cc (1 Ci/cc) would reach 900 degrees C. A second set of heat experiments were done to observe the frothing, boiling, fuming, drying, and sintering of the clay mixtures. The first run produced a final cake which was not stable to attack by water. In the second experiment the mixture became a frothy gel and filled the container. Heat was then introduced at a power level of 20 watts and the gel became a liquid and the level dropped gradually until after 50 hours when it was half the volume. The experiment was ultimately run at full power, 200 watts. The maximum equilibrium temperature was 850 degrees C while the maximum average temperature was 780 degrees C with a specific energy of 0.22 watts/cc. The final cake was found to be solid, free of cracks and well sintered. A pilot pit experiment is planned. While this method seems to be a good possibility, many problems remain, including evaluating the degree of volatility of fission products at high temperatures, the handling of wastes from their source to the pits, and the operation of large numbers of such disposal pits. (DDV)

<192>

Oak Ridge National Laboratory, Oak Ridge, TN

McVay, T.W., E.L. Hanner, and H.P. Raydon. 1956, October. TID-7517 (Part 18): Sanitary Engineering Aspects of the Atomic Energy Industry. Proceedings of a Seminar held in Cincinnati, Ohio, December 5-9, 1955, (pp. 335-338), 609 pp. (TID-7517, Part 18).

Fixation of Radioactive Wastes in Clay-Flux Mixes (3)

Results are presented on the use of fired ceramic mixes to fix radwaste. The objectives of primary importance in this program are: radioactive wastes are to be treated as received from the fuel reprocessing plant and if the activity is present they will

<199> COST.

be allowed to be self-sintered; materials added to the process solutions are to be cheap (clays, shale, silica, limestone, dolomite, fly ash, phosphate tailings and soda ash); temperature of firing should be low; the amount of clay or other diluents should be kept as low as possible to minimize the weight and volume of the final atomic garbage; and materials added should be capable of forming a slurry to minimize some settling of the additives. The "Hope solution", 1.6 moles of aluminum nitrate and 0.2 mole of nitric acid, was used with different process solutions. The Hope solution was tagged with Sr-90, Ce 144, Pr 144, Cs 137, Ba 137, Ba 106, and mixed fission products. After such testing the two best solutions were limestone-sodium carbonate and shale. Leaching experiments were then conducted on these two. It was found that satisfactory firing occurred at 1050 degree F. These tests indicate there is a good possibility of firing radioisotopes from waste solution in a ceramic body so the leaching effects will be minimal. (199)

<191>

Oak Ridge National Laboratory, Oak Ridge, TN

Witkowski, E.J. 1956, October. TID-7517 (Part 14): Sanitary Engineering Aspects of the Atomic Energy Industry, Proceedings of a Seminar held in Cincinnati, Ohio, December 6-9, 1955, (pp. 105-115), 509 pp. (TID-7517, Part 14).

Operating Experience in the Disposal of Radioactive Wastes in Open Pits (1)

The evolution of the open pits and their use is presented. Originally waste disposal consisted of putting the liquid wastes in eight underground concrete storage tanks with a total capacity of 1.1 billion gallons. Even using precipitation when the tanks could not handle the incoming effluents proved to be inadequate. The tanks were filling faster than could be emptied and the radwaste going into White Oak Lake could not be kept below the maximum permissible concentration (MPC) level. In 1949 the storage tank precipitation procedure and discharge was discontinued and a steam evaporator was built. However, by 1951 this system became inadequate and economics forced the Laboratory to investigate using pits for the disposal of wastes. The first pit was in the Conasauga shale and was 100 ft long, 20 ft wide and 15 ft deep with vertical walls. The capacity was 100,000 gallons. A total of 385 curies in 29,000 gallons of concentrated evaporator wastes and 98,000 gallons of waste containing high concentrations of salts were pumped into the pit. The soil around the pit allowed a breakthrough in 2.5 months about 150 ft down the hill. No actual hazard developed because the activity leaking out was from Ba 106 which has a high MPC. With the success of the first pit, a million gallon pit, 15 ft deep and 270 ft by 100 ft was dug. Instead of trucking in the liquid wastes they were now pumped in through a pipeline. More pits have also been added since the second one was excavated. To date, more than 2.7 billion gallons containing 35,000 curies have been transferred to the waste pits. The disposal pits are considered satisfactory by the operating personnel because of the limited exposure to radiation. Radiation has been measured at 250 mR/hr at the edge of the pit and 1200 mR/hr in the center of the pit. Leakage of Ba 106 is less than 1/1000 MPC. It costs \$70,000 to build

the million gallon pit and pipeline, while it saves \$275,000 for the evaporator project. (191)

Waste Volume

<192>

Oak Ridge National Laboratory, Oak Ridge, TN; Battelle-Pacific Northwest Laboratories, Richland, WA

Blanco, R.L., J.W. Davis, E.W. Cobben, L.J. King, J.Y. Roberts, W.C. Lee, S.J. Alkire, R.M. Irick, and R.W. Harker. 1966. COST-659202; IAEA-SR-71/26; Practices in the Treatment of Low- and Intermediate-Level Radioactive Wastes, Proceedings of a Symposium held in Vienna, Austria, December 6-10, 1965, (pp. 793-839), 990 pp. (COST-659202, IAEA-SR-71/26).

Recent Developments in Treating Low- and Intermediate-Level Radioactive Wastes in the United States of America (1)

Recent research and development work in the treatment of low- and intermediate-level radioactive wastes is surveyed and brief economic evaluations of new treatment methods are included. A scavenging-precipitation ion-exchange process was developed for treating low-level waste which provides decontamination factors of greater than 10 (2-3) for strontium and cesium (for 2000 resin column volumes) and satisfactory decontamination of other activities. The decontamination factor for ruthenium was 10 at 300 column volumes. Pilot-plant tests showed this process could be used at many installations to decontaminate wastes adequately. Laboratory studies with a similar process, designed to treat water before its recycle and reuse, which included the use of activated carbon, showed 10 to 100 times higher decontamination for ruthenium and cobalt and equally good results for other activities. A scavenging-precipitation foam-separation process was developed and tested on a laboratory and pilot-plant scale as an alternative treatment method. Representative decontamination factors are: Sr, greater than 1000; Cs, 10; Ba, 5; and Ce, greater than 20. Cesium removal was achieved by sorption on Grandite clay. A process was developed and tested on a small engineering scale for treating process condensate wastes containing sodium and organic materials. Over 97% of these impurities are removed in a steam-stripping column. The process steps are steam stripping, filtration, and sorption in sequence on anion and cation exchange resins. Decontamination factors of up to 5300 are obtained with the exception of ruthenium. About 90% of the ruthenium was removed. Electro-deionization and electrodialysis were also tested for removing ruthenium from intermediate-level wastes. A process for incorporating intermediate-level wastes in asphalt was developed in the laboratory, and design of a pilot plant is in progress. The process is designed to handle a variety of wastes such as solids from the low-level waste-treatment process and miscellaneous evaporator concentrates. A free-flowing emulsified asphalt containing about 20% water is used; thus, mixing with liquid wastes or solids is easily accomplished at room temperature. Mixing is achieved either in batches or continuously in a wiped film evaporator. After the water is volatilized, the temperature is raised to about 130 degrees C. At this temperature the product flows from the evaporator into the final disposal container. Products containing up to 60%

C192) CONT.

solids showed suitable radiation resistance at 10(R-8) rad. The leach rates of contained solids were not affected by this dose level. (Auth)

Distribution Coefficient: pH

C193)

Oak Ridge National Laboratory, Oak Ridge, TN;
Brookhaven National Laboratory, Upton, Long
Island NY

Cowart, L.E., L.C. Lasher, L. Gennel, and S.C. Pearson. 1965. CONF-651202; IAEA-50-71; Practices in the Treatment of Low- and Intermediate-Level Radioactive Wastes. Proceedings of a Symposium held in Vienna, Austria, December 6-10, 1965, (pp. 301-303), 908 pp. (CONF-651202, IAEA-50-71).

Operational Experience in the Treatment of Radioactive Waste at Oak Ridge National Laboratory and Brookhaven National Laboratory (N)

Operating experience with the 1330-litres/min process waste-treatment plant at ORNL has demonstrated that plant efficiency exceeds the design specifications of 50% removal of gross radionuclides. The treatment process used by the horizontal flow plant includes a CaCO₃ precipitation using lime and soda ash for removing Sr 90 and the rare earths and the addition of illitic clay for removing Cs 137. Under normal operating conditions, an average of 80% to 90% of these important radionuclides are removed at a cost of about 70, 1/10000 litres. By optimizing the combination of lime, soda ash and clay, it has been demonstrated that the removal of strontium and cesium can be increased to 90% and 92%, respectively. Excess rates of flow through the plant and the occurrence of detergents and complexing agents in the waste increased the suspended solids in the plant effluent and reduced efficiency. To counter decreased efficiencies, 25% of the plant effluent is recycled for additional treatment, a polyelectrolyte was added to improve coagulation, and the treatment plant effluent was routed through a 5.7-million-litre settling basin. Efficient monitoring of the process waste system has resulted in reduced volumes of waste that require treatment (750 litres/min) and reduced amounts of Sr 90, Cs 137, and rare earths in the waste (less than 3 x 10(R-5) uCi/ml). Intermediate-level liquid waste (1.5 x 10(R-7) litres/yr, containing 0.26 to 2600 uCi/ml) will be treated by means of a 2300-litres/h evaporator, which was scheduled for operation in 1965. At ORNL, low-level liquid wastes and sanitary wastes are combined to receive biological treatment by an Isohoff tank and sand filter. As a result of diligent waste management, the quantity of gross activity in these wastes (average flow of 2200 litres/min has been reduced to 1 x 10(R-7) uCi/ml. The filter beds are now removing 20% of the radionuclides. An evaporator is used to process intermediate-level wastes that average 1 x 10(R-6) litres/yr and contain 0.005 to 0.2 uCi/ml. A decontamination factor of 10(R-4) to 10(R-6) and volume reduction of 85 to 100 are now achieved. Previously, 200-litre drums were used to package contaminated solid waste and evaporator concentrate sludged with cement for off-site shipment. As a result of increased volumes of solid waste and excessive external radiation levels, reinforced concrete vaults are now used with walls 15 cm to 23 cm

thick for gamma shielding. Waste slurry from the evaporator is now solidified in the vaults with cement and vermiculite to reduce handling and shipping costs and to preserve the integrity of the container. Additional reduction in cost and in exposure to personnel during solid-waste processing is realized by balling contaminated filters, by decontaminating metal objects with shot-blasting, and by dismantling large, grossly contaminated items with shaped charges of high explosives. (Auth)

pH

C194)

Oak Ridge National Laboratory, Operations Division, Oak Ridge, TN

Withowski, E.J. 1956, April 10.
ORNL-CT-57-12-193; 31 pp.

Radioactive Waste Disposal and Decontamination. Annual Report for 1957 (N)

The main waste disposal facilities at Oak Ridge National Laboratory which are under the jurisdiction of the Operations Division, serve the laboratories and operating buildings located in the Bethel Valley area. This report covers the operation of these facilities in 1957, which include the hot-chemical and the metal waste systems, the process waste system (frequently called the "sewage waste system") and the radioactive gas disposal system, which utilizes the 250 ft. stack located in the Radioisotope Area. The total 1957 operating cost, charged to research programs through monthly cost allocations, was \$177,600 with \$116,620, or 66%, representing basic costs (labor and material). A total of 189 curies of activity was discharged into White Oak Creek in 1957, representing the lowest discharge since 1951 and a decrease of 31% under that of the previous year. The volume of waste was increased from 260,710,000 gal. in 1956 to 272,910,000 gal. in 1957 and was due entirely to an increase in large scale chemical processing. Construction of the Process Waste Treatment Plant, begun in August 1956, was completed and operation was started on August 8, 1957. The installation of automatic diversion equipment and the treatment of process wastes with materials other than lime and soda is expected to increase the efficiency of the plant and to further reduce the amount of activity released to the Creek. The disposal of all hot wastes to waste pits 2, 3, and 4 continued throughout 1957. There was no indication of a significant loss of pit seepage capacity or breakthrough of activity into White Oak Creek. The neutralization of acid wastes (as they are collected in the stainless steel monitoring tanks) and the continuous agitation of wastes in S-5 were begun in January, 1957. The expansion of the coil ventilation and off-gas facilities at the 3039 Stack Area is nearly complete. Preliminary engineering design is in progress for increasing the present off-gas capacity by 8000 cfs to meet an anticipated increase in demand as a result of expanding Laboratory programs. (Auth) (N)

Material possibly pertinent to preburial waste processing are presented. Size diagrams of the waste treatment systems at Oak Ridge are included. (DN/NT)

<1975>

Oak Ridge Y-12 Plant, Radiation Safety
Department, Oak Ridge, TN

Sanborn, S. 1977, October. Y/80-230 (Rev. 1): 27
pp.

Assessment of Solid Low-Level Radioactive Waste
Management (7)

The low-level radioactive burial areas for the Y-12 plant are assessed as to their effect on the environment. The burial areas are located in highly deformed, metamorphosed limestones, dolomites, and calcareous shales. Also there are arenaceous and argillaceous shales and sands. Bear Creek and the East Fork of Poplar Creek drain the Y-12 plant area and ultimately flow into the Tennessee-Ohio-Mississippi water system. Average annual precipitation is between 50 and 60 inches. The soils in the burial area are of the ultisol group which includes red and yellow podzolic soils. The low-level waste burial sites are in Bear Creek Valley 1.5 miles to the west of the main plant. Burial Ground 1-A contains low-level solid waste such as wood and paper which is generated at 1000 tons per year and the area will be sufficient for the next 60 years. The burial ground steps 1 to 30 feet above the water table depending on the weather conditions. Burial Ground 2-B contains power, depleted uranium which is accountable and recoverable. This material is generated at the rate of 800 tons per year and the site will be sufficient for the next 30 years of continuous operation. Burial Ground 2-C is used to dispose of materials contaminated with enriched uranium and natural thorium. The wastes are of the solid type disposed of in 1-A. With 500 tons of waste generated annually, the site will be sufficient for the next 50 years. Burial Ground 2-B and 2-C are 80 to 100 and 2 to 6 feet, respectively above the water table at various times of the year. Monitoring these areas showed the uranium in the drinking water to be less than 2×10^{-7} (E-7) cf/cu cm which is well below the Radiation Protection Guide (RPG). No deleterious effects are revealed. (1977)

<196>

Sandia Laboratories, Albuquerque, NM

Houzon, L.L., and J.V. Ott. 1976. CONF-760813; IAEA-SR-10/19; Design, Construction and Testing of Packaging for the Safe Transport of Radioactive Materials, Proceedings of a Symposium held in Vienna, Austria, August 23-27, 1976 (pp. 195-200) (CONF-760813, IAEA-SR-10/19).

Special Closure for Steel Drum Shipping
Containers (3)

The closures on the steel drum shipping containers were found to be inadequate so TDA requested new closures be developed. The lids were redesigned with the following criteria: as strong and resistant to a drop as the bottom of the container; have minimal economic impact on the overall container cost; minimize the use of existing container designs; consider crush load; and result in less dependence on personnel and loading procedures. From the tests on various closure techniques (lid extension, inner lid, C-clamp, and clips) the following conclusions: Critical container weight of a standard 77C closure is 270 kg, without the closure the critical weight is a minimum of 850 kg;

"152-mm lid extension" technique strengthens the closure to a critical container weight of 600 kg minimum; "152-mm internal lid" technique strengthens the closure to a critical weight of 850 kg minimum; "C-clamp" strengthens the closure to 850 kg minimum with 6 C-clamps; "clip" technique using eight clips strengthens the closure to 300 kg minimum; a 890-kN static load causes the 77C lid closure to fail; both the "152-mm lid extension" and "152-mm internal lid" techniques extend the crush load capability beyond the container bottom capability of 535-kN static load; and using 6 C-clamps and lock ring, the "C-clamp" technique fails to improve the closure crush limit beyond the standard closure capability of 890-kN static load. While all four techniques were proven to be more than adequate in meeting the specified criteria of structural integrity, economics, and minimum impact on existing container designs, the "152-mm lid extension" offers more advantages than the other methods and is recommended. (1977)

<1977>

Sandia Laboratories, Albuquerque, NM

Lynch, R.W. 1977, August. Nuclear Technology, 30(7), 963.

A Short-Duration Leach Test for Radioactive Waste
Forms (3)

A short-duration leach test was developed at Sandia Laboratories for quick evaluation of solidification and immobilization of liquid radioactive waste by ion exchange with a hydrated titanate complex. Instead of requiring 20 hours the new test required only 4 hours. The instantaneous leach test is reproducible and the results are within acceptable error margins. For this test a total mass balance was not attempted due to the limited number of elements of interest. The test is also useful for evaluating the effects of composition on the leaching behavior. However, this test does not reveal anything of the low temperature or high-temperature behavior of a sample, which can be varied and complex. Since the test is reliable, it provides a quick screening method for those materials that should be subjected to more exhaustive leaching tests. (1977)

<1980>

Sandia Laboratories, Albuquerque, NM

Smith, D., E. Lenn, J. Taylor, and A. Decharme. 1976. CONF-760813; SAND-76-5373; IAEA-SR-10/20; Design, Construction and Testing of Packaging for the Safe Transport of Radioactive Materials, Proceedings of a Symposium held in Vienna, Austria, August 23-27, 1976, (pp. 19-27) (CONF-760813, SAND-76-5373, IAEA-SR-10/20).

A Risk Assessment for the Transportation of
Radioactive Materials in the USA (4)

The radiological risk of transporting radioactive materials in the United States has been evaluated in terms of expected additional latent cancer fatalities (LCF). Two risks were estimated: that resulting from normal (accident-free) transport and that resulting from transportation accidents involving radioactive shipments. A standard shipment

<199> COST.

model was devised to represent the radioactive material shipping industry. The calculation of the normal transport risk included estimates of exposures to aircraft passengers and crew, truck drivers, cargo handlers, and population along the transport link. The accident risk calculation incorporated accident probabilities and package release fraction estimates. Dispersible materials were assumed to be aerosolized in severe accidents and the aerosol cloud transported downwind according to a Gaussian diffusion model. An annual normal transport risk of 9500 person-rem, or 1.2 LCF, resulted primarily from radiopharmaceutical shipments. The annual risk due to accidents was 5.6 x 10¹² LCF, resulting almost entirely from PuO₂ shipments. (Both)

Relevance to shallow land burial. (DS/CS)

<199>

Savannah River Laboratory, Aiken, SC

1975, June. DPST-75-125-2: Savannah River Laboratory Quarterly Report, April-June, 1975, (pp. 53-56), 56 pp. (DPST-75-125-2).

Migration of Organic Complexed Plutonium through Soil (1)

Postulated leaks from the storage tanks were simulated in laboratory tests, to determine the mechanism of migration of the solvent-complexed plutonium. In the first set of tests, a small amount of stored plant solvent was first sorbed by dry soil, and this dry soil was placed at the top of each of two columns of water-saturated soil. It was then washed with soil water from the burial ground. Analysis of segments of the columns showed little movement of Pu, and approximately 95% of it was retained in the top half-inch. The distribution coefficient was estimated to be 6000 for the short column and 3000 for the long column. The second simulation of postulated leakage used relatively large amounts of solvent and columns of water-saturated soil. Effluent analysis show that the solvent-complexed plutonium moves rapidly through the moist soil. After only one column volume (25 ml), plutonium in the column was at 75% of the feed concentration, where the bulk density was 1.5 g/cc and the effective porosity was 0.6. Collectively, the tests show that small volumes of solvent-complexed plutonium will not migrate significantly through dry surface soil, but large volumes in moist subsurface soil would be more mobile.

Distribution Coefficient; Density; Effective Porosity

<200>

Savannah River Laboratory, Aiken, SC

Penixmore, J.W. 1968, March. DP-MS-68-21; CONF-680309; Hydrology in Water Resources Management, Proceedings of a Conference held in Clemson, South Carolina, March 28-29, 1968, (28 pp.) (DP-MS-68-21, CONF-680309).

Tracing Soil Moisture and Groundwater Flow at the Savannah River Plant (1)

Groundwater movement studies were conducted at the F and H areas and the burial ground at SRR, using tritium tracing methods. The tests used were (1) injection-detection, results analyzed according to the capillary flow model, and (2) point-dilution. Comparison of the results of the two tests indicates that the point-dilution test is applicable to low-velocity flow situations but tends to underestimate high velocity flow by as much as fifty percent. Injection-detection tests conducted down gradient from the F-area storage tanks indicate a flow range of 0.8 to 0.5 feet per day. Near the tanks, both tests give identical flow ranges, 0.01 to 0.02 feet per day. Point-dilution tests conducted in the vicinity of the burial ground indicate a groundwater velocity of 0.08 to 0.07 feet per day while injection-detection tests indicate a groundwater flow range of 0.08 feet per day to 0.13 feet per day. Depth to the burial-ground water table is 40 ft. A downward movement of 0.95 in. per in. of rainfall in the Coliad sandy loam typical of the burial area was found. In a study of the ability of bentonite clay to prevent infiltration of rainwater, a downward movement of 0.6 in., during a year in which 48 in. of rain fell, was also found. (J7) (CS)

The report provides a general summary of the groundwater flow rates and flow duration at the Savannah River Plant. The amount of data presented is minimal. Data on the groundwater velocity near the burial ground is a summary of velocity ranges measured by different tests. (DS/J7)

Depth to Water Table; Hydraulic Velocity; Moisture Potential; Moisture Content

<201>

Savannah River Laboratory, Aiken, SC

Horton, J.H. 1977, March. DP-1056; 11 pp.

Excavation of Radioactive Solid Wastes Buried for Fourteen Years (1)

Observations during the excavation of low-level waste buried 14 years in the humid environment of the Savannah River Plant are presented in this report. The site for burial of solid radioactive waste is located in an area of unconsolidated sands, clayey sands, sandy clays, and clays, which extend to a depth of nearly 1000 feet. The rainfall averages 47 inches per year; but because of surface runoff and evaporation, only about 15 inches per year flows through the soil to the water table. The average depth to the water table is 45 feet, and in the unsaturated zone above the water table the vertical percolation rate of the water is about 1 foot per year. Because water permeability is higher in backfilled than in undisturbed soil, the bottom of some trenches can contain perched water. However, the duration and/or extent of the perched water is limited so that most waste is not subjected to water saturated soil. Burials are made in trenches that are approximately 20 feet deep and 20 feet wide. The waste is segregated into transuranic alpha, low-level, and high-level waste categories. The waste includes wood, steel, plastics, cotton cloth, rubber, and paper. Cardboard boxes not enclosed in plastic were the only materials to deteriorate visibly. Apparently, decades would be required for all cellulosic materials to decompose, and plastics and metals would survive indefinitely. (JNY)

<291> COS*.

Depth to Water Table; Infiltration Rate

<297>

Savannah River Laboratory, Aiken, SC

Borton, J. B., and J. C. Carey. 1976, June. DP-1356; 22 pp.

Storing Solid Radioactive Wastes at the Savannah River Plant (14)

The facilities and the operation of solid radioactive waste storage at the Savannah River Plant (SRP) are discussed and the monitoring results obtained from studies of the movement of radionuclides from buried waste at SRP are summarized. The solid radioactive waste storage site is divided into sections for burying waste materials of specified types and radioactivity levels, such as transuranium (TRU) alpha waste, low-level waste (primarily beta-gamma), and high-level waste (primarily beta-gamma). Detailed records are kept of the burial location of each shipment of waste. With the attention currently given to monitoring and controlling migration, the solid wastes can remain safely in their present location for as long as is necessary for a national policy to be established for their eventual disposal. At the solid waste storage site, the stratigraphic section consists of nearly a thousand feet of unconsolidated sands, clayey sands, sandy clays, and clays. Downward flow of groundwater is prevented by hydrostatic head reversal. Migration of nuclides is confined to the direction of surface stresses. Average depth to the water table at the solid waste storage area is about 85 ft. Water flows at a rate of about 7 ft/yr in the water saturated zone. Migration of transuranium, activation product, and fission product nuclides from the buried wastes has been negligible. However, monitoring data indicate that tritium is migrating from the solid waste emplacements. Because of the low movement rate of ground water, the dose-to-man projection is less than 0.02 mrem for the inventory of tritium in the burial trenches. Limits are placed on the amounts of beta-gamma waste that can be stored so that the site will require minimum surveillance and control. The major portion (approximately 90 percent) of the transuranium alpha radioactivity in the waste is stored in durable containers, which are amenable to recovery for processing and restorage should national policy so dictate. SRP experience has shown that vegetation can absorb significant amounts of radionuclides from buried radioactive waste. Continuing studies are evaluating shallow-rooted grasses and nonvegetative soil covers. Other alternatives include chemical and mechanical means of control. (JTB) (K37)

Depth to Water Table; Horizontal Flow Rate, Unsaturated; Horizontal Flow Rate, Saturated

<203>

Savannah River Laboratory, Aiken, SC

Andrejain, R. S. 1976, October. DP-1427; 17 pp.

Composition and Corrosiveness of Low-Activity Waste Supernates Stored at the Savannah River

Plant (12)

Compositions of low activity radioactive waste (LAW) supernates stored at the Savannah River Plant were determined in conjunction with a study of the possibility of stress corrosion of storage tanks by the supernates. Stress corrosion appears unlikely on the basis of (1) a statistical correlation between acid steel elongation and supernate composition and (2) measured polarization of steel in actual LAW. According to the statistical correlation, the tanks should not crack. Furthermore, the polarization data shows the steel acts as an active-passive metal, and the open-circuit potentials are outside the range of those reported for pure sodium nitrate. The LAW supernates were analyzed in October 1975 from four F-area tanks and three H-area tanks. Concentrations of major constituents (Na, Mg, KCl, NO₂, and H₂SO₄) are each higher in F-area supernates because F-area LAW appears to be in equilibrium with salt in the tanks. Minimum concentrations of major constituents in H-area LAW are low because one tank (H-30) contains water from a fuel storage basin and wastes from evaporating low exchange resin. Other nonradioactive constituents that were determined include SO₄, CO₃, PO₄, Cl⁻, Fe, V, U, Pu, K, and Ca. Radionuclides determined include Cs 137, Sr 90, and Pu 238-239. Cesium 137 was the major gamma emitter; its activity was as high as 1000 Ci/m³ (1000 Ci/m³). Activities of Sr 90 (beta) and Pu 238-239 (alpha) were all very low (100 Ci/m³ - 1000 Ci/m³ (alpha)). (Auth)

<200>

Savannah River Laboratory, Aiken, SC

Wiley, J. B. 1976, June. DP-1400; 10 pp.

A Study of Methods for Removing Strontium, Plutonium, and Ruthenium from Savannah River Plant Waste Supernate (4)

As a part of long-term waste management studies at the Savannah River Laboratory, tests were made to study removal of strontium, plutonium, and ruthenium from simulated and actual waste supernates. Plutonium was washed by Doolite AHC-357 ion exchange resin (H₂-200), the same resin that is used to remove cesium from waste supernate. Strontium was removed from supernate by sorption on a chelating resin Chelon 100 (H₂-215), or by precipitation as Sr₃(PO₄)₂. Activities of Cs 137, Sr 90, and Pu 238-239 remaining in processed waste supernate should be 1-10 nanocuries of each element per gram of salt. Of the methods that were tested, none was adequate for plant-scale removal of ruthenium. (Auth)

Distribution Coefficient; Cation Exchange Capacity

<205>

Savannah River Laboratory, Aiken, SC

Welch, R. P. 1976, November. DP-1406; 27 pp.

Radionuclide Content of an Etched Canyon Vessel and Neighboring Soil (2)

This paper summarizes a study designed to assess the long-term hazard potential associated with the burial of retired, highly

2205 CONT.

contaminated process equipment. A Porox feed adjustment tank from the hot creep of an SFR operations plant was enhanced and studied. This piece of equipment was retired from service and tested in 1978. This report describes soil sampling, emanation techniques, assay results and conclusions. Radiocesium migration through the soil surrounding the tank was limited. After 120 days of leaching tests, it was that 0.01 uCi/ml or less of Pu 239 leached in water. The maximum total quantity leached was 20 pCi or about 1% of the Pu 239 initial surface activity. Analysis indicated that more than 50% of the original plutonium and cesium radioactivity remained within the three-inch layer of soil contiguous to the vessel. Strontium migration exceeded 12 inches. The results of the study suggest that burial of highly radioactive equipment may not have a significant effect upon the environment or the dose-to-man. (S214) (S27)

The study was designed to answer the long-term burial potential associated with the disposal of highly contaminated equipment. The data are applicable to shallow land burial especially with respect to radiocesium migration. (S214) (S27)

Leaching Tests

2206

Savannah River Laboratory, Aiken, SC

Hartman, R.H., and J.R. Norton. 1967. Health Physics, 11, 287-292.

Bentonite as a Protective Cover for Buried Radioactive Waste (19)

Wetting bentonite clay prevented infiltration of rainwater into radioactive waste burial above the water table in a humid region. A lysimeter study showed that a 1-in.-thick bentonite layer was adequate and that drying and cracking of the bentonite during prolonged drought could be prevented with 2 ft of soil cover. A large subsurface bentonite structure built in the field demonstrated the feasibility of applying a continuous bentonite layer over extensive vertical and horizontal areas. The test was evaluated by 130 tracing of soil moisture both outside and under the bentonite structure. Structures must be maintained free of all plant growth because bentonite is easily penetrated by roots. (S214)

Directly applicable to shallow land burial in that it considers means of limiting infiltration into trenches excavated for the disposal of radioactive waste. (S214) (S27)

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Savannah River Laboratory, Aiken, SC

Norton, J.R. 1976. PP-MS-75-110; Actinide-Soil Interactions in Waste Management at the Savannah River Plant, N.P. Holcomb, et al, 52 pp. (PP-MS-75-110); CONF-760210; Actinide-Soil Interactions, Proceedings of a Conference held in Richland, Washington, February 10-11, 1976, 52 pp. (CONF-760210).

Volume Reduction of Plutonium-Contaminated Soil

2208

A laboratory study was conducted to determine if plutonium in soil at the Savannah River Plant burial ground is primarily associated with the sand, silt, or clay fractions. A series of simple laboratory experiments involving water scrubbing and washing showed that the clay-silt soil fraction, which comprised only one-third of the soil, contained about 75% of the plutonium. The volume of plutonium-contaminated soil could thus be reduced to one-third by scrubbing and separating the clay-silt fraction. Only the plutonium-rich fraction would then require storage in durable containers; the remaining two thirds of the soil could be returned to the burial trenches. (S214) (S27)

The results of this study are applicable to preburial processing of plutonium bearing waste. (S214) (S27)

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Savannah River Laboratory, Aiken, SC

Wright, E.L. 1976. PP-MS-75-110; Actinide-Soil Interactions in Waste Management at the Savannah River Plant, N.P. Holcomb, et al, 52 pp. (PP-MS-75-110); CONF-760210; Actinide-Soil Interactions, Proceedings of a Conference held in Richland, Washington, February 10-11, 1976, 52 pp. (CONF-760210).

Recovery of Organically Bound Plutonium in Soil (19)

A safety evaluation of underground storage of spent Porox solvent (tri-n-butyl phosphate (TNBP) in hydrocarbon (HLC)) was made. Porox solvent is used in chemical reprocessing of irradiated fuel elements. The present 150,000 gallons of spent solvent at the SFR contains 0.6 curies of transuranium nuclides and about 86.2 curies of fission products. Plutonium-239 is the predominant transuranium nuclide in the solvent, and primary fission product is ruthenium-106. The characteristics of plutonium transfer from the spent solvent were investigated in a series of laboratory column tests in which distribution coefficients were determined. Small volumes of organically complexed plutonium were found to be effectively sorbed and immobilized in dry (ground surface) soil. Moist subsurface soil was found, however, to permit extensive migration of postulated large volumes of solvent-complexed plutonium until the plutonium transfers to the water phase with subsequent adsorption on the soil. It was concluded that a massive leak of solvent would result in soil and groundwater plutonium contamination via most of the plutonium decaying within the Savannah River Plant boundaries. Any transport of plutonium to local streams would result in releases below the present operating guides for normal installation operation. Some steps have recently been taken to minimize the probability of large releases of waste solvent to the subsurface environment. (S214)

Information relevant to the routes and means of transport of plutonium leaching from plutonium-bearing liquid, burial vaults are presented. (S214) (S27)

Distribution Coefficient

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Savannah River Laboratory, Aiken, SC

Polcomb, W.P., J.R. Horton, and E.L. Wilhite. 1976. PP-75-75-110: Actinide-Soil Interactions in Waste Management at the Savannah River Plant, E.P. Polcomb, et al. 52 pp. (OSST-75-75-110); OSST-760210: Actinide-Sediment Interactions, Proceedings of a Conference held in Richmond, Washington, February 10-11, 1976, 52 pp. (OSST-760210).

Actinide-Soil Interactions in Waste Management of the Savannah River Plant (3)

Three aspects of the transuranium actinide-soil interaction were studied in connection with Savannah River Plant burial ground operations. Results of the studies are reported separately in the three sections: Actinide-soil interactions in waste management at the Savannah River Plant, Radionuclide Content of an Unburied Canyon Vessel, and Movement of Organically Bound plutonium in Soil. (3T)

Information relevant to pre-burial waste processing, behavior of burial leach, and long term hazard potential associated with certain buried radiochemical separation process equipment are presented. (3H/3T)

Distribution Coefficient

<210>

Savannah River Laboratory, Aiken, SC

Horton, J.R. 1975, January. DPST-75-210; 10 pp.

Soil Moisture Flow as Related to the Burial of Solid Radioactive Waste (2)

Solid radioactive waste, at SDP, is routinely buried in water-saturated soil above the water table. Although buried, radionuclides are leached from the waste by rain water moving from the ground surface to the water table. The forces and mechanisms controlling water movement in a static equilibrium soil are (1) capillary potential and (2) gravitational potential. The relative significance of each is determined by soil particle and pore size. Studies of the movement of water through a soil column consisting of three vertical sections of different size soil particles are downward and horizontal. The vertical movement is attributed to the greater gravitational potential of the larger size pore spaces and the horizontal is attributed to the greater capillary potential of the smaller pore spaces. The occurrence of patchy groundwater is attributed directly to the difference in permeability of soil strata. Identification of these controlling factors implies a means of reducing leaching of radionuclides from buried solid wastes. (3T)

Identifies the forces and mechanisms involved in the movement of water through the unsaturated backfill soil. Suggests a potential means of utilizing these forces to minimize infiltration into trenches and reducing radionuclide leaching. (3H/3T)

Volometric Water Content

<211>

Savannah River Laboratory, Aiken, SC

Wallace, V.R., W.R. Hale, R.P. Bradley, W.L. Hall, J.A. Kelley, J.D. Stone, and G.M. Thompson. 1976. OSST-760306: High-Level Radioactive Waste Management, W.R. Campbell (Ed.), Proceedings of a Symposium held in Los Angeles, California, April 1-2, 1976, (pp. 9-30), 166 pp. (OSST-760306).

Solid Forms of Savannah River Plant Radioactive Wastes (3)

The Savannah River Plant, operated by the DuPont Co. for the Energy Research and Development Administration, includes a nuclear reactor fuel fabrication plant, three operational reactors, two fuel reprocessing plants, and a facility for heavy water production. The radioactive wastes from plant operations are stored as liquids or slurries in double-walled carbon steel tanks. Methods are being developed to immobilize Savannah River Plant wastes in solid forms such as cement, asphalt, or glass. Cerium 137 and Strontium 90 are the major biological hazards and heat producers in the alkaline wastes produced at SDP. In the conceptual process being studied, Cs 137 removed from alkaline supernatant, together with insoluble sludges that contain Sr 90, will be incorporated into solid forms of high integrity and low volume suitable for storage in a retrievable surface storage facility for about 100 years, and for eventual shipment to an offsite repository. Immobilization of Cs 137, or its fixation in zeolite prior to incorporation into solid form, is also being studied. Economic analyses to reduce costs and fault-tree analyses to minimize risks are being conducted. Methods are being studied for removal of sludge from tank final decontamination of waste tanks. (3H/3T)

Information on possible methods of waste processing prior to shallow land burial is presented. (3H/3T)

<212>

Savannah River Laboratory, Aiken, SC

Kelley, J.A., and V.R. Wallace. 1976, July. Nuclear Technology, 30, 67-71.

Procedures for Determining Leachabilities of Radioactive Waste Forms (2)

Sound-Robin leach testing of USG glass 710 by numerous laboratories sponsored by the Leach Rate Subcommittee of the Waste Solidification Development Working Group of USERDA produced test results varying by as much as a factor of ten. The leachant pH in these tests was observed to exceed a value of 9. A new procedure was developed in this study to improve on the Nespe method used in the former study. The improved procedure emphasized the need for effective removal of leached ions and the maintenance of pH below a value of nine. Two different types of system were developed both utilizing cation and anion exchange resin columns to continuously purify the leachant. Ineffective removal of the leached ions was shown to result in localized high pH and a marked rise in leachability in later portions of the test. The unexpected rise in leachability was postulated to be a result of the loss of a protective amorphous silica coating around the tested portion. A continuous flow through system was shown to produce the most rapidly stabilized leach

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results and also the lowest leaching rates.
(JC)

Report offers comparative data on different leach testing systems. (DR/JC)

<213>

Savannah River Laboratory, Aiken, SC

Christl, R.J., and F.R. (DR.) Springer. 1968.
March. DP-588; 106 pp.

Storage of Radioactive Wastes in Basement Rock
Beneath the Savannah River Plant (N)

The geology, geophysics, and hydrology were studied in detail for a storage facility of radwastes in the basement rock beneath the Savannah River Plant. Also included was the conceptual design of the storage facility. The geologic formations are tabulated with their age, exposure, description, water content, and thickness. A hornblende gneiss, chlorite-hornblende schist with quartzite and saponite characterize the basement rock series. The foliation and schistosity are parallel and dip at 55 degrees. The average compressive strength ranges from 9,000 to 16,000 psi and the modulus of elasticity ranges from 7.0×10^{10} to 12×10^{10} on the average. The coefficient of thermal expansion, specific heat, thermal diffusivity, and thermal conductivity were also determined for the engineering design. Using both acidic and alkaline solutions it was found that only a few inches of rock would dissolve from the chamber walls. Extensive piezometer surveys were done to determine the water flow and water characteristics. Water from the basement rock was found to have a 6% helium content and it was calculated that 500,000 to 900,000 yrs were required for the helium to form. Hence, the water naturally present in the rock has different chemical properties which readily distinguishes it from water in overlying aquifers and indicates the rock water is not directly connected with the water above. Essentially there are two hydrologic systems shallow and deep, and the two have minimal if any contact. The permeability in the sound rock is 0.002 gpd/sq ft and the porosity is 0.01%. A saponite clay layer separates the two hydrologic systems and allows the head in the rock to be independent of that of the sediments above. Migration of liquid radwastes through the rock with no consideration of sorption would take 30,000 years to a point beneath the Savannah River. In the fractured rock migration would take 600 years to move 1,000 to 2,000 ft without sorption. The design of the facility is 20 million gal at 1300 to 1700 feet and the cost would be \$0.625 per gallon of stored wastes. (MNV)

Appendices contain the detailed data. Thorough coverage of the subject is given. (EJC/MDN)

Stratigraphic Unit Thickness; Hydraulic Gradient; Effective Porosity; pH; Ion Exchange Capacity; Permeability Coefficient; Distribution Coefficient; Grain Size Distribution; Transmissivity; Storage Coefficient; Depth to Water Table; Thickness of Upper Aquifer

<214>

Savannah River Laboratory, Aiken, SC

Drebaugh, E.J., and W.R. Hale, Jr. 1976, July.
DP-1001; 26 pp.

Dispersion Study of Buried Elemental Mercury (3)

A study on the movement of mercury through the soil is presented. There are two modes by which mercury can migrate: 1) evaporative diffusion of vapor to the atmosphere through the soil overburden; and 2) dissolution-percolation of elemental mercury to the water table via a vertical soil-water flux. An estimated 20,000 pounds of mercury is 200 to 300 five-gallon steel cans are in trenches 20 ft. deep at the Savannah River Plant. The undisturbed soil around the trenches has a stable moisture content of 20 to 22% volume, with a water table at 30 ft. The soil-water flux for these soils is on the order of 10 to 15 in/yr, while the trench soil-water flux is 8 ft/yr. Or, the mean hourly flux is 0.027 cm/hr which is 10 times greater than that of normal soils. The effect on mercury transport from the trench is to increase it. From measurements, the coefficient of diffusion in a capillary-saturated, packed, moist soil is 21 sq cm/hr and a dry soil has a coefficient 5 times greater. Also the flux to the water table was calculated to be 13 mg/hr. Hence, it is concluded that water passing through the burial ground to Four Mile Creek could transport mercury at a rate of about 275 mg/hr and therefore contributing 0.2 ppb mercury to the water. The average natural value is 3.03 ppb and the drinking water limit is 5 ppb. Hence there is apparently no significant environmental impact on surface water in the area of burial ground. (MNV)

Detailed mathematical derivations and calculations are included in two appendices.
(EJC/MDN)

Dispersion Coefficient; Effective Porosity; Density; Moisture Content; Depth to Water Table; pH

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Savannah River Laboratory, Aiken, SC

Hawkins, R.W. 1975, September. DP-75-75-25;
CONF-750967; Environmental Protection,
Proceedings of the 1st EPA Conference held in
Chicago, Illinois, September 23-26, 1975, (1)
pp-1 (DP-75-72-25, CONF-750967).

Migration of Tritium from a Nuclear Waste Burial
Site (3)

At Savannah River Plant a major source of tritium is the buried, passive, Li-Al residues (melts) from the thermal extraction step in the SRR tritium production process. A melt with its extraction crucible and lid were immersed in water to measure the amounts of tritium released as HT and HT₂ to the water and to air. In another experiment, three crucibles and lids were buried in a soil-filled, open top lysimeter, and the percolating water, and gaseous release (HT) were measured. Some dose calculations to man are also presented. (OO)

Some lysimeter tests and some actual tests on the tritium leaching from Li-Al melts are described.
(DR/MDN)

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Savannah River Plant, Aiken, SC

Penimore, J.W. 1963, May: 1966. DPSPW-63-30-2: 15 pp.; Health Physics, 10, 224-236.

Last Burial of Solid Radioactive Waste During a Ten-Year Period (7)

A general summary of the radiological impact of last burial of solid radioactive wastes. These wastes were segregated into low-level waste (less than 100 millirad per hour at three inches) and high-level wastes (greater than 100 millirad per hour at three inches). Radioanalysis of core samples collected indicated the presence of cobalt 60, cesium 137, strontium 89, strontium 90, cerium 141, cerium 144, ruthenium 103, and ruthenium 106. The maximum distance that radionuclides migrated in the downward direction was 6.9 feet. At this location, 9 ft of soil remains between the radionuclides and the water table. Average depth of the water table in the burial area is 40 ft. Should radionuclides enter the water table, they must traverse a flow path over 1 mile long before outcropping at the surface on the floodplain of a Savannah River tributary. Ground water velocity was measured using tritium as the tracer to be greater than 0.00 ft/day and less than 0.11 ft/day. (JT) (CSF)

A general review of the impacts of ten-years of radioactive waste burial. No significant data on geohydrologic parameters. No data on radionuclides measured in core sample. (DR/JT)

Depth to Water Table; Hydraulic Velocity

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Savannah River Plant, Aiken, SC

Tarter, V.L. 1967. CONF-670512; Disposal of Radioactive Wastes into the Ground, Proceedings of a Joint IAEA/EDPA Symposium held in Vienna, Austria, May 29-June 2, 1967, (pp. 95-106) (CONF-670512).

Ground Waste Disposal Practices at the Savannah River Plant (2)

A description of the general ground waste disposal practices at SRP are detailed in this report. The discussion is based on experience in solid waste land burial since 1953. The contaminated waste buried at the time of this report contained approximately 1.5 million curies of activation and fission product radionuclides along with 9000 curies of transuranic elements. Low level wastes which do not include transuranic activity exceeding 100 millicuries per waste container is buried in 6 meter deep trenches located 8 to 12 meters above the water table. The normal water table is found at depths ranging from 12 to 18 meters in the areas currently being used for ground waste disposal. Transuranic wastes are placed in concrete containers and then buried. Alpha waste is segregated from beta and gamma waste and the beta and gamma waste is further segregated into high and low level categories. The average cost for land burial was estimated to be 35 dollars per cubic meter. At the time this report was written, significant levels of activity resulting from migration had not been observed along the flood plains of the adjacent tributaries. The report also contains a discussion of the success of the seepage pit program at SRP including cost estimates, the observance of tritium

breakthrough at the pits closest to the tributary, and the operational procedures adopted. A total of 1500 Ci of fission products (exclusive of tritium) and 13 Ci of transuranic elements have been committed to seepage basins. Only tritium oxide has been detected in a surface stream. The soil surrounding the basins has an ion exchange capacity that delays the movement of radioactive materials other than tritium oxide. (Muth) (JC) (CSF)

This report is chiefly a general summary without a great amount of hard data. (DR/JC)

Cation Exchange Capacity; Depth to Water Table

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Savannah River Plant, Aiken, SC

Peichert, S.O., and J.W. Penimore. 1962, October. DPSPW 62-30-218; Geological Society of America Annual Meeting held in Houston, Texas, November 14, 1962, (36 pp.) (DPSPW 62-30-218).

Lithology and Hydrology of Radioactive Waste Disposal Sites at the Savannah River Plant (1)

Groundwater beneath the SRP site occurs under the following conditions: (1) as perched water tables, (2) normal water tables and (3) as artesian aquifers. The depth to water beneath the area around the chemical separation areas, V and W, ranges from 20 to 65 feet. The depth to the water table between the two areas varies as a function of rainfall and exhibits a lag time of approximately two months. Disposal at SRP was limited to solid radioactive waste and very low-level liquids. Migration of radionuclides through the subsurface strata is chiefly in water passing through sandy strata or sand-filled elastic joints. Strontium 90 is poorly absorbed and has been detected as far as 500 feet from the seepage area. Soils at the site are kaolinic and have ion exchange capacities that range from 0.1 milliequivalents per 100 grams at pH 5 to 1.2 milliequivalents per 100 grams at pH 10. (JT)

A general summary of the geology and hydrology of the sub-surface strata beneath the chemical separation areas, Areas V and W. Data on the geohydrologic conditions beneath the burial ground were not presented. (DR/JT)

Thickness of Upper Aquifer; Depth to Water Table; Stratigraphic Unit Thickness

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Savannah River Plant, Aiken, SC

Clark, J.B. 1954. WASH-275; Sanitary Engineering, Proceedings of a Conference held in Baltimore, Maryland, April 15-16, 1954, (pp. 192-195) (WASH-275).

Disposal of Aqueous Radioactive Wastes at the Savannah River Plant (2)

In disposing of liquid radioactive wastes particular attention was paid to the location of the plant with respect to offsite population centers, river characteristics, geology of the site, and other matters. The policy followed at the Savannah River Plant is to contain the radwastes within the plant as

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long as possible and to hold the release of activity to a minimum. There are two classes of low-level wastes: those less than 10(B-10) Ci/ml which are disposed of onsite and those which are discharged to the creeks and hence to the Savannah River. Low-level wastes are first run into unlined settling basins for several days of detention time and then into seepage basins. The locations for the seepage basins were selected with regard to location of drinking water wells, soil conditions, and water table level and slope. All basins are enclosed by earthen dikes. From studies done at the plant it was found that clays are good absorbers of radwastes with low salt concentrations. When the salt content is equal to or greater than 30%, cesium and strontium are not absorbed. While cation exchange appears to be most important in fixation in clays, other mechanisms are involved. Some of these are: immobilization of the entire solution in the fine capillaries and the water of hydration. The most toxic anionic form of radwaste, I^{131} , has a short half-life, 8 days, and is allowed to decay in the lined basins before being discharged into a seepage basin. Most of the anions have maximum permissible concentration (MPC) values for drinking water of 10(B-3) to 10(B-6) times that of Ra 226. Discharge of radwastes into the creek consists chiefly of surface runoff carrying particulates from stack fallout, and possible overflow from low-level waste seepage basins. The thrust of the Savannah River program are to minimize the discharge of activity to the river and to prevent the buildup of activity in the river biota, or in silt deposits. In addition to the above program regular samples of creek and river water, bottom mud, fish, and bank vegetation are taken as part of a regular site survey program. (SDP)

<220>

Savannah River Plant, Health Physics Department, Aiken, SC

Teigler, C.C. 1975, December. DPSPN 75-30-11; COM-760202; Operational Health Physics, Proceedings of the 9th Topical Symposium held in Denver, Colorado, February 9-12, 1976, (11 pp.) (DPSPN 75-30-11, COM-760202).

Computer Handling of Savannah River Environmental Monitoring Data (3)

Computer programs used to calculate, store, and retrieve radioactive and non-radioactive environmental monitoring data at the Savannah River Plant are discussed. Daily, monthly, and annual summaries of data, tabulation of releases by radionuclide or non-radioactive pollutant, and mode of entry to the environment (atmosphere, stream, etc.) are included. (OO)

Details the computer programs utilized and the environmental data at SRP that is processed. Methodology is adaptable. Informative on the available data. (DH/OO)

<221>

Savannah River Plant, Separations Technology Section, Aiken, SC

Girdler, P.V. 1966. COM-651202; IAEA-SR-71/80; Practices in the Treatment of Low- and Intermediate-Level Radioactive Wastes. Proceedings of a Symposium held in Vienna, Austria, December 6-10, 1965, (pp. 477-496) (COM-651202, IAEA-SR-71/80).

Handling of Low- and Medium-Level Liquid Waste at Its Savannah River Plant (4)

Technical standards for the discharge of waste from the SRP are established in accordance with AEC policy and Federal Radiation Council's guidance to prevent human uptake of radioisotopes above the permissible levels for off-site population. Liquid wastes originating in the reactor and separations areas which contain low levels of radioactivity are discarded to streams or seepage basins. In most cases these wastes are first decontaminated as much as is practicable by methods such as evaporation, ion-exchange, or absorption. Plant policy (and AEC policy) is to minimize the discharge of radioactivity to the environment, rather than to release all that is permitted by technical standards. Fresh radioactive wastes from the processing of irradiated material and enriched uranium fuel elements are made alkaline and stored in large underground steel tanks which have cooling coils to prevent the boiling of the liquid-waste contents. Sludges, formed as the alkaline waste is continuously cooled, settle in the tanks. These sludges contain much of the radioisotopes of the original waste. The aged supernatant liquor, an intermediate-level waste (less than 10(B-6) uCi/ml) by the criteria of this symposium, is transferred to lower-cost, uncooled, steel-lined concrete tanks. An evaporator adjacent to these uncooled tanks is used to reduce the volume of the stored supernates. The hot concentrate is returned to the uncooled tanks where salts crystallize as the liquor cools. Repeated evaporation and cooling the stored intermediate-level supernates will be done until all these liquors are in fact reduced to solids. Activity in the evaporator condensate, low-level and principally cesium 137, is removed by absorption on zeolite before the condensate is discarded to a seepage basin. (4uth)

Not directly relevant to shallow land burial. (DH/SDP)

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U.S. Army Corps of Engineers, Ohio River Division Laboratory, Cincinnati, OH

Carlton, P.V. 1957. Advances in Nuclear Engineering, Vol. 1, Part 1, J.R. Dunning and D.R. Prentice (Eds.), Proceedings of the 2nd Nuclear Engineering and Science Conference held in Philadelphia, Pennsylvania, 1957 (pp. 403-411).

The Application of Radioisotopes to the Measurement of Soil Moisture Content and Density (4)

Using the principles of neutron and gamma-ray scattering moisture content and density can be measured in-situ with a minimum of disturbance to the soil. This method allows data to be taken on cohesionless soils, frozen soils, and soils in which the sugar hole intercepts saturated pervious strata. Also, any depth of soil may be sampled just by setting the approximate geometry of the sensors. Moisture content is determined by the attenuation of neutrons in the soil. The more water (hydrogen) present in the soil the slower the

<222> CONF.

neutrons will travel and hence the number of the slower neutrons will increase. Gamma rays are used to determine the density of the soil. By using the probabilities of scattering and absorption of gamma rays electron density and ultimately the density of soil can be found. Essentially a correlation of the relative number of gamma rays at the detector with the soil density is possible. Design and operation of the meters are included in the discussion as is the laboratory calibration. Field tests were conducted on airfield pavement subgrades and foundations. The tests show the moisture contents can be determined with an average accuracy of $\pm$ or $-$ 1 lb of water per cu ft of soil. The density measurements have an average accuracy of $\pm$ or $-$ 3 lb per cu ft. Further development on the techniques is being made to streamline the instrumentation. (DDV)

Moisture Content; Density

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U.S. Atomic Energy Commission

Daly, G.H., and A.P. Kink. 1976, October. Transactions of the American Nuclear Society, 19, 76-75. CONF-761017; CONF-761036; American Nuclear Society Winter Meeting Proceedings of a Conference held in Washington, D.C., October 27-November 1, 1976, (pp. 76-75) (CONF-761017, CONF-761066).

Transuranium Nuclides in the Environment from Management of Solid Radioactive Waste (2)

In the past the Atomic Energy Commission (AEC) has permitted burial of solid wastes contaminated with transuranium nuclides in geologically and hydrologically remote environments. Due to the inability of predicting migration over geologically long periods of time a policy of retrievable storage has been instituted. The period of this storage is set at 20 years. At present over 1 million cu m of radwaste has been buried containing 884 kg of TNU nuclides, however, only 30,000 cu m (119.3 kg) are stored retrievably at AEC sites. The current annual generation rates for all sites are about 6570 cu m and are expected to remain the same or decline. Most of the AEC's TNU waste is generated at Rocky Flats and is shipped for storage to the National Reactor Testing Station. The waste is stacked on an asphalt pad and covered with plastic, plywood and a layer of dirt. Waste reduction techniques are emphasized with compaction being the most widely used. Incineration is used but is more complex. In commercial burial grounds about 40 kg TNU are released. The volume of commercial TNU waste is expected to increase in the future due to the projected expansion of the nuclear power industry, the recycle of plutonium and the development of the breeder reactor. At present all data indicate that TNU nuclides have not migrated significantly from their burial locations. (DDV)

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U.S. Atomic Energy Commission

Pittman, F.K. 1976, October. CONF-761017; CONF-761066; American Nuclear Society Winter

Meeting, Proceedings of a Conference held in Washington, D.C., October 27-November 1, 1976, (pp. 211-212) (CONF-761017, CONF-761066); Transactions of the American Nuclear Society, 19, 211-212.

Management of Commercial Radioactive Waste (2)

According to Atomic Energy Commission (AEC) policy spent-fuel processing operations will convert acidic waste solution to a stable solid no more than 5 years after generation. The solid will be sealed in high-integrity canisters in accordance with AEC and Department of Transportation regulation no later than 10 years after generation of the radwaste. Surface and near surface storage facilities will be constructed for retrievable storage. The design and operation of these facilities is to assure protection of the environment and the health and safety of the operators and the public. Three storage approaches are possible: a) storage of waste canisters in shielded steel-lined basins with circulated-water coolant; b) storage of waste canisters in shielded steel-lined vaults with convective-air coolant; and c) storage in individually shielded, sealed steel casks cooled by ambient air. The site will be selected by 1976 and operational by 1981. Since surface storage requires surveillance and maintenance, burial of the waste in deep-seated bedded salt formations which offers the most protection as the aboveground storage without the monitoring and maintenance problems is attractive. Work is underway to determine if geologic storage is preferable to surface storage. Other long-range techniques, such as extraterrestrial disposal and transmutation are under consideration. (DDV)

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U.S. Atomic Energy Commission

Beiter, W.G. 1963. Retention and Migration of Radioactive Ions in Soils, Proceedings of an International Colloquium held in Saclay, France, October 16-18, 1962, (pp. 3-10).

Ground Disposal. Its Role in the U.S. Radioactive Waste Management Operations (1)

Ground disposal experience and practice in the United States are presented. Ground burial is used for only low and intermediate activity, solid and liquid effluents. For this discussion the waste disposal concept of delay and decay is most important. Safe disposal criteria of the low and intermediate activity liquid wastes at the major USNRC installations are: chemical and radiochemical characteristics of the waste; retention of the radioactivity either by adsorption or ion exchange in the soil formation above the water table; degree of permanence of this retention; and rate and direction of ground water flow. The Hanford installation is used as an example of ground disposal operations. The plant needs a minimum of 15 to 21 billion liters of water/year. Factors favorable to ground disposal of this quantity of water are: distance, 10 miles from the Columbia River; all ground water under AEC controlled land seeps toward the Columbia River; favorable soil ion exchange; and large dilution potential in the Columbia River. Process cooling water containing less than 10 (E-5) ac/ml is the largest volume of waste with 173 billion liters (1961). Steam and process condensate containing 10 (E-1) to 10 (E-3) ac/ml is the next largest volume with 16.2 billion liters (1961). These wastes are discharged

<225> C-37.

into "swamps" and "cribs", respectively. The other type of disposal facility is a trench, and as of 1961, 106 million liters containing 667,000 curies has been disposed. Included in the discussion is research and development on disposal in salt domes and beds, basement rock studies, impermeable shale by hydrofracturing, and geochemical and geophysical studies. Also solid waste burial operations are discussed. (SBR)

A table containing the diversity of hydrological conditions at present waste-producing sites is presented. (EHC/SBR)

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U.S. Atomic Energy Commission, Division of Reactor Development and Technology, Environmental and Sanitary Engineering Branch, Washington, DC

Norton, R.J. 1966. WASH-1183; 133 pp.

Land Burial of Solid Radioactive Wastes: Study of Commercial Operations and Facilities (I)

The report includes a review of commercial waste burial operations, descriptions of health and safety considerations, and data pertaining to waste volumes and activity buried. Two appendices describing the geology and hydrology of the Sheffield and Beatty commercial sites are included. (JC)

The title text and each appendix has been abstracted separately. (BR/JC)

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U.S. Atomic Energy Commission, Division of Reactor Development and Technology, Environmental and Sanitary Engineering Branch, Washington, DC

Norton, R.J. 1968. WASH-1183; Land Burial of Solid Radioactive Wastes: Study of Commercial Operations and Facilities, R.J. Norton, (pp. 1-60), 133 pp. (WASH-1183).

Land Burial of Solid Radioactive Wastes: Study of Commercial Operations and Facilities (I)

The history of low-level radioactive waste disposal is briefly discussed and the advent of federal and commercial shallow land burial sites described. The background, environmental characteristics, operating equipment and methods, and health and safety progress for the five operating commercial sites are tabulated. Each of these categories is then considered in the light of necessary prerequisites for site selection or suitability. Composed of general discussions of requirements technical aspects left for the appendices. (See separate abstracts). (CAB)

A broad brush approach to safety, burial practices and environmental requirements for shallow land burial sites. (BR/CAB)

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U.S. Atomic Energy Commission, Division of Reactor Development and Technology, Washington, DC

Belter, S.G. 1970. COSF-700905; IAEA-SR-137/61; STI/PNS/264; Management of Low- and Intermediate-Level Radioactive Wastes, Proceedings of a Symposium held in Aix-en-Provence, France, September 7-11, 1970. (pp. 155-169) (COSF-700905, IAEA-SR-137/61, STI/PNS/264).

Recent Developments in the United States Low-Level Radioactive Waste-Management Program--A Preview for the 1970's (2)

Environmental problems are being considered as the challenge of the 1970's. Recent United States developments in power reactor waste management, land burial, sea disposal, and deep well injection, are summarized, principally as they relate to the establishment and modification of existing or new waste-management policies and procedures. Many public criticisms have been directed at the efficient control operations of the expanding United States nuclear power industry such as the discharge of heated effluents and their potential effect or impact on our environment. Much controversy has also centered on the discharge of very low quantities of radioactivity from the normal operation of United States nuclear power plants, which has been generally at levels of less than a few per cent of internationally accepted radiation protection standards. Power-reactor waste-management experience is described, including the significance of tritium and noble gas releases in these operations. While the release of heat from nuclear power plants is not unique, nevertheless, because of a lower thermal efficiency, light-water nuclear plants of current design discharge more waste heat to the environment than a conventionally fired plant of the same size. The radiological effects of low-level releases and the problem of heated effluents from nuclear power plants are interrelated factors when one considers the potential total impact of these operations on the environment. An expanded thermal effects research and development program is being developed by the United States Atomic Energy Commission in concert with other Federal and State government agencies and the utility industry to provide the technical basis for the safe development and public acceptance of nuclear energy. The scope of this emerging program is described. Because of the rapid growth of nuclear power and increasing uses of radioactive materials and other sources of radiation, the AEC has proposed amendments to its regulations on radioactive effluents from light-water-cooled nuclear power reactors, to help ensure that total radiation exposures to the public from licensed atomic energy activities remain low. Bases for the amendments to the AEC regulations are discussed with their possible significance indicated. With the growth of the United States nuclear energy industry, disposal of solid radioactive waste materials by conventional land burial has also continued to increase. The magnitude of radioactive waste land burial, including the AEC and industrial operations, is summarized. In this connection, during the past several years the volumes of waste materials contaminated with transuranic nuclides have also shown a marked increase. Technical studies on the segregation and retrievability of these solid wastes from other waste materials in AEC operations are discussed. The disposal of solid waste materials by sea burial, has essentially ceased, primarily because of the availability of commercial land burial services. Development in this area since the 1965 IAEA conference are summarized. Deep-well injection has become increasingly popular for the disposal of all types of industrial

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wastes, principally from the chemical, petrochemical and steel industries. However, the technique has essentially not been used for the disposal of radioactive waste materials. The limitation of this waste disposal method and recent actions which have been initiated by the U.S. Department of the Interior to regulate and control these underground disposal operations are described. During the 1960's an extensive research, development, and demonstration program was carried out on the treatment and disposal of all types of gaseous, liquid and solid waste effluents. Waste-management technology is now available for the removal of radioactivity down to small fractions of authorized radiation protection guides. During the 1970's, major emphasis in the radioactive waste-management program will be placed on industrial application and the obtaining of public acceptance of this control technology. (Auth) (CAB)

Good summary, but outdated. (RM/CAB)

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U.S. Atomic Energy Commission, Division of Waste Management and Technology, Transportation Branch, Washington, DC

1976, August. WASH-1339; 11 pp.

Shipments of Nuclear Fuel and Waste - Are They Really Safe? (R)

Types of nuclear materials, their packaging and modes of transport are discussed with a view toward examining the risks associated with the movement of such materials. Numbers of such shipments are projected into the future on the basis of exposure and accidents are discussed. Frequency and severity of accidents, likelihood of package damage or failure in accidents and consequences of package failure are analyzed. It is concluded that the probability of death, injury, or massive property loss due to transport of radioactive materials is determinable, not zero, and very small. (CAB)

Simplified discussion of risks associated with transport of nuclear materials. (RM/CAB)

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U.S. Atomic Energy Commission, Health and Safety Division, Idaho Falls, ID

Gilmond, J.W., and B.L. Schmalz. 1966, August. IDO 12080 (Supplement No. 1); 11 pp.

Radioactive Waste Disposal Data for the National Reactor Testing Station (2)

During 1965 $2.57 \times 10^{(20)}$ liters of radioactive liquids, containing 2,095 Ci of activity were discharged. This was approximately 50% of the 1966 release. The major source of this volume was the YCPF ($1.57 \times 10^{(20)}$). Detailed monthly data on the volume discharged to the makeup ponds and to the lithosphere are presented. A total of $12.06 \times 10^{(10)}$ cu ft of gaseous radioactive wastes, containing 528,621 Ci, were discharged to the atmosphere. The major sources of this waste, with respect to activity, were the HTS

and PCP (451) facilities. Data on the monthly releases to the atmosphere on a per facility basis are presented. Radioactive solid wastes buried at HTS during 1965 totaled 7,529 cu ft with an activity of $1.06 \times 10^{(20)}$ Ci. Of the volume disposed of the largest volume was 167,478 cu ft of low-level waste generated on site. Detailed semi-annual, solid waste disposal inventories for each facility are presented. (RM)

A summary of the quantities, types and activities of radioactive wastes disposed of at HTS. (RM/ST)

Waste Volume

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U.S. Atomic Energy Commission, Industrial Hygiene Branch, New York, NY

Harris, W.D., and E.J. Weinstein. 1956, October. TID-7517 (Part 1A): Sanitary Engineering Aspects of the Atomic Energy Industry. Proceedings of a Seminar held in Cincinnati, Ohio, December 6-9, 1955. (pp. 229-235). 509 pp. (TID-7517, Part 1A). American Industrial Hygiene Association Journal, 17, 388-398.

Open Field Burning of Low-Level Radioactive Contaminated Combustible Wastes (2)

Combustible materials have been burned in large very costly incinerators, but with the expanding scope of the Atomic Energy Program this method is not the best. Upon examination of the nature of the waste materials some of the precautions seem to be unnecessary. It was decided to burn the low-level contaminated paper as if it were non-contaminated. Three tests were set up. In the first, 500 lbs were burned, in the second 4000 lbs, and in the third, 13,500 lbs. For all cases a superficial examination of the meteorology was made and the height of the smoke plume was estimated. The weight was reduced by 66, 93, and 90% for cases 1, 2, and 3 respectively. The volume was reduced by 90% for both cases 2 and 3. Case 1 had an estimated recovered fallout of 0.26 uc. For case 2 it was 20 uc and case 3, 100 uc. Maximum fallout for all cases was 10,000 d/s/sq ft (case 3) and the minimum was negligible (case 1). Air contamination by gamma particles range from 1.4 to 3.7 uc/al $\times 10^{(12)}$. The beta particle ranged from 1.4 to 4.6 uc/al $\times 10^{(12)}$. The results of the three experiments indicated no biologically significant contamination either of the soil or of the air during incineration. If incineration of the type considered is carried out, then the volume and weight of materials to be disposed of will be significantly reduced. (RMV)

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U.S. Atomic Energy Commission, Washington, DC

Belter, W.G. 1962, March. TID-7628; Ground Disposal of Radioactive Wastes, J.H. Morgan, Jr., et al (Eds.), Proceedings of the 2nd Conference held in Clark River, Canada, September 26-29, 1961. (pp. 12-16), 635 pp. (TID-7628).

New Developments in the U.S. Atomic Energy Commission Ground Disposal Program 1959-1961 (R)

The report mentions briefly that studies on ion exchange and sorption have been done at

<222> COS?

Oak Ridge National Laboratory. Evidence cited that vermiculite can remove strontium under selected conditions of pH and phosphate additions. Cesium removal was also found to be enhanced by high pH in the presence of vermiculite. (CAB)

Brief mention of cesium and strontium sorption by soils. (DA/CAB)

<223>

U.S. Atomic Energy Commission, Washington, DC

Daly, C.E., and D.F. Gornley. 1976. AICHE Symposium Series No. 158(72): Radioactive Wastes from Nuclear Fuel Cycle, (pp. 10-16), 178 pp.

Handling, Storage, and Disposition of Solid Low-level Waste (1)

Current methods of handling, storage, and disposition of solid low level wastes from both Energy Research and Development Administration and licensee installations are surveyed, including fission product and transuranic-contaminated solids. A forecast of generation rates of these wastes is presented. Potential changes in regulations and handling methods are discussed, including plans for developing an acceptable method for ultimate disposition of transuranic wastes. (Auth)

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U.S. Bureau of Mines, Salt Lake City Metallurgy Research Center, Salt Lake City, UT

Dean, K.C., and V. Ravens. 1971, April. E/WJ; 7 pp.

Stabilizing Mineral Wastes (4)

Physical, chemical, vegetative and combined methods of stabilizing mineral (mine, mill, and smelter) wastes are discussed. Other than water for sprinkling, the materials most used in physical stabilization are rock and soil obtained from areas adjacent to the wastes to be covered. Crushed or granulated smelter slag, the use of bark covering, the harrowing of straw into the top few inches of tailings, and the placement of windbreaks can also be used for physical stabilization. Chemical stabilization involves reacting chemicals with the waste to form an air- and water-resistant crust or layer. Of the 64 chemicals tested by the U.S. Bureau of Mines on laboratory samples of copper, lead-zinc, clay, uranium, and vanadium process plant wastes; the resinous, elastomeric polymer, lignosulfonate, bituminous base, wax, tar and pitch products proved to be effective stabilizers (on the basis of coherency) for one or more types of fine-grained mineral wastes. In these experiments the chemicals were first applied to the samples and the samples then subjected to alternating wetting-and-drying and freezing-and-thawing cycles to determine the resistance to these disruptive forces. Several of the more promising chemicals have been evaluated by field tests on tailings from different mineral processing plants such as the uranium tailing pile at Yuma City, Arizona. The successful initiation and perpetuation of vegetation on fine wastes

depends upon improving a number of adverse factors such as (1) deficiency in plant nutrients, (2) excessive silt and heavy metal concentrations, (3) unconsolidated sands, (4) lack of normal microbial populations, and (5) problems involving the variance of the amount of solar radiation with the various sloping sides of piles. The U.S. Bureau of Mines has also conducted studies on combined chemical-vegetative stabilization. (Auth) (EJ)

This paper is relevant to the stabilization of shallow land burial of uranium mill tailings. (DA/EJ)

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U.S. Department of Agriculture, Agricultural Research Service, South Burlington, VT

Benett, C.W., and J. Bornstein. 1972. Soil Science Society of America, Proceedings, 36, 819-820.

Considerations for Effective Sloping Land Drainage Systems (4)

A comparison is made between the theoretically expected results and actual field results for a Cabot silt loam (a poorly drained glacial till (traprock soil). Use of only interceptor drains at seepage points was found to eliminate only part of the seepage problem. Subsurface flow was found to be a significant consideration in management of the problem. The requirements for an effective drainage system for wet sloping soil are (1) inclusion of surface drains to handle runoff and saltwater, subsurface drains located where the bedrock is closest to the soil surface, and (2) drains (subsurface) located between the drains in (2) to intercept bypass flow. (Auth) (JF)

Applicable to shallow land burial in that it provides data which may be used to eliminate infiltration into burial trenches. (DA/JF)

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U.S. Department of Agriculture, Agricultural Research Service, Soil and Water Conservation Research Division, Beltsville, MD

Miller, J.P., and R.P. Bittman. 1963. Soil Science Society of America, Proceedings, 27, 101-106.

The Leaching of Radiostrontium and Radiocesium through Soils (2)

Strontium 90 and Cesium 137 are hazardous, long-lived, nuclear fission products. Experiments were conducted in the greenhouse to determine their downward movement in soils under intensive leaching. The five soils (Norfolk, Hagerstown, Miami, Fort Collins, and Huntley maries) selected for the investigation represented a wide range of soil properties, and the leaching treatments consisted of 30 inches and 300 inches of deionized water, 1.00% NaCl, and 0.00% CaCl₂. Cation exchange capacity, pH, calcium carbonate equivalent and organic matter were parameters of interest for each soil. There was little downward movement of Cs 137 when the soils received the applications of deionized water, NaCl or CaCl₂. Radioactive assays of the soil columns showed that 96.4 to 100% of the Cs 137 was in the surface two layers of the soil

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columns (average depth 1.4 inches) after 300 inches of leaching. The slight movement of cesium in the test soils is due to the low exchange ability of adsorbed Cs and fixation in a nonexchangeable form. In the leaching experiment with Sr, the CaCl₂ produced the greatest movement of Sr 99 and deionized water the least. The maximum distance Sr 99 penetrated into the soils when leached with 30 inches of water was 1.3 inches, and with 300 inches of water the distance was 5.3 inches. In general, there was more movement of Sr 99 in the Norfolk soil and least in the Bentley, with the other soils being intermediate. The difference in movement between the two soils is the large difference in the exchange capacity. Other factors important in the movement of Sr are: pH, organic matter content, composition of the exchangeable cations, and predominate type of clay mineral. Possible factors affecting migration of Sr and Cs are: freezing and thawing, presence of macroscopic cracks, wetting and drying cycles, and the burrowing of earthworms and other small animals. (Auth) (DDP)

PR: Cation Exchange Capacity

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U.S. Department of the Interior, Petroleum Research Center, Bureau of Mines, Bartlesville, OK
Watkins, J.W., F.L. Armstrong, and P.J. Reesstra.
1966. Nuclear Science and Engineering, 7, 133-143.

Feasibility of Radioactive Waste Disposal in Shallow Sedimentary Formations (1)

The feasibility of using shallow sedimentary formations is examined, as a working model for liquid radioactive disposal oil-field brines disposal is discussed. Brines have been disposed of by injecting them into subsurface formations. Some wells have been known to take 12,000 to 18,000 barrels daily at well-head pressures up to 700 psig. Brines, like radwastes, are toxic substances and the problems of injectivity, potential plugging, corrosion, and inter-formation communication are the same. Brine disposal costs between 0.210 to 0.033 cents/gallon of brine while radwaste disposal costs 0.20 to 0.20 cents/gallon of waste. So the cost is less and would probably be less with any special precautions. Shallow formations appear to be most suitable because the cost is \$1.00 to \$2.25/ft whereas in deep formations it is about \$5/ft. The best shallow formations would be lenticular sandstones in the oilcontinent oil-producing areas. In order to use these sandstones research must be done on ion-exchange, adsorption, chemical and physical reactions, corrosivity, injectivity, determination of potential heat gradients generated, and instruments and techniques adaptable to monitoring disposal sites. A pilot plant study is also outlined. Transportation of the radwastes is another important consideration. Disposal of radwastes in shallow formations appears to be promising. (DDP)

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U.S. Department of the Navy, Nuclear Power

Directorate, Naval Ship Systems Command

Hiles, H.E., C.L. Sjoblom, and S.D. Burke. 1972. September. Radiation Data and Reports, 13(9), 467-470.

Environmental Monitoring and Disposal of Radioactive Wastes from U.S. Naval Nuclear-Powered Ships and their Support Facilities, 1971 (4)

This report assesses the effect on the environment of disposal of radioactive wastes originating from U.S. Naval nuclear propulsion plants and their support facilities. The total radioactivity discharged into 11 ports and harbors from the core than 100 reactor plants and supporting tenders, bases, and shipyards was less than 0.002 curie in 1971. This small amount of radioactivity has had no significant or discernible effect on the quality of the human environment. Results of environmental surveys of harbor water and bottom sediment for gross radioactivity and for cobalt 60 show that (1) no increase in radioactivity has been detected in harbor water, (2) discharge of liquid wastes from U.S. Naval nuclear-powered ships have not caused a measurable increase in the general background radioactivity of the environment, and (3) low-level cobalt 60 radioactivity is still detectable in localized areas of harbor bottom sediment around a few piers at operating bases and shipyards where maintenance and overhaul of Navy nuclear-powered ships have been conducted over a period of several years; these levels have decreased in recent years. During maintenance and overhaul operations, solid low-level radioactive wastes consisting of contaminated rags, plastic bags, paper, filters, ion exchange resin and scrap materials. These wastes are packaged and shielded as necessary and shipped to burial sites. (Auth) (JTE)

Solid wastes produced by U.S. nuclear powered ships and their support facilities during 1967-1971 are shown in Table 3. (JTE/PTO)

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U.S. Department of Transportation, Materials Transportation Bureau

Grillo, A.W. 1977. April. NEU(PDA)77-0021; Radiation Control Radiation Benefits and Risks; Facts, Issues, and Options, Proceedings of the 9th Annual National Conference, May 2-7, 1976, (pp. 349-387) (NEU(PDA)77-0021).

State of Current and Proposed Regulations and Legislation for Transport of Radioactive Materials (2)

An update of the regulatory and legislative situation with respect to the safe transportation of radioactive materials is presented. Included in the various regulatory amendments, proposals, or legislation are: 1) miscellaneous changes relating to radioactive materials; 2) radiation and regulation; 3) transport of radioactive materials; 4) larger carrying aircraft; 5) consolidation of the regulations; 6) transportation regulations; 7) transport of plutonium by air; 8) monitoring of radioactive packages by air carriers; 9) other miscellaneous matters relating to air transportation; 10) interagency responsibility-radiological incident emergency response planning; and 11) amendments to be

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proposed based on international changes. One of the elements that has been proposed is the establishment of a low-level solid radioactive material category. The parameters for qualification of a material as "LLS" are as follows: activity under normal transport conditions is and remains distributed through the solid or binding agent and does not exceed on the average 2×10^4 (Bq/g) Bq/g and even with the loss of the outer package the activity loss per package per week resulting in total immersion in water does not exceed 0.1 Bq/g; and the concentration of nonradioactive material is in a nonreadily dispersible form and the contamination level averaged over 1 sq m is not greater than 2 uCi/sq cm for high toxicity alpha emitters and 20 uCi/sq cm for all other radionuclides. (BDD)

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U.S. Energy Research and Development Administration, Grand Junction Office, Grand Junction, CO

McGinley, P.E., and W.E. Haldane. 1977, August. Methods for Measuring Radiation in and Around Uranium Mills. Program Report, E.E. Harvard. (E.E.). Volume 3, No. 9, Proceedings of a Workshop held in Albuquerque, New Mexico, May 22-26, 1977, (pp. 15-34), 811 pp.

Inactive Uranium Mill Sites and Tailings Piles Program (3)

A summary of the joint program being conducted by EPDA, EPA, eight western states and the Navajo Nation on the remedial actions required at 22 inactive mine-mill-tailings sites. The Phase I portion of the program determined site conditions, corrective actions required, location to populated areas and environmental problems. Phase II is designed to assess the engineering aspects of remedial actions. The phase II report includes a review of plant operation, current condition of the mill site and tailings and discusses local geology, hydrology and meteorology. Of the site problems addressed, inhalation of radon daughters was considered the most significant pathway, and presented the greatest potential for health effects. General cost estimates are provided for the remedial actions. (J7)

A general summary of the survey program conducted, jointly by the AEC, EPA, the State and the Navajo Nation in discussing remedial actions needed to be taken at inactive mines and mill sites. (BDD/J7)

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U.S. Energy Research and Development Administration, Division of Waste Management and Transportation, Washington, DC

Samoy, P. 1975. 15 pp.

What Shall We do With the Waste? (3)

A theoretical discussion of radioactive waste disposal is presented and an attempt is made to define three component systems that are available to define the waste management system, provide a clear statement of criteria for management and disposal of wastes and provide a methodology for evaluating the

design of candidate systems. (CAB)

A philosophical discussion of waste disposal alternatives. Little of specific interest regarding shallow land burial. (BDD/CAB)

(26)

U.S. Energy Research and Development Administration, Division of Waste Management, Production and Processing, Washington, DC

Dieckhoner, J.E. 1977, May. COMF-770512; Management of Low-Level Radioactive Wastes, Proceedings of a Symposium held in Atlanta, Georgia, May 23-27, 1977, (17 pp.) (COMF-770512)

Sources, Production Rates and Characteristics of EPDA Low-Level Wastes (1)

A system called SORIS, developed for EPDA at INEL to store and retrieve information on solid nonhigh-level radioactive waste characteristics encompassing all EPDA owned burial sites and waste generators, is described. It includes all categories under the solid, nonhigh-level radioactive waste classification, e.g., TRU, fission products, beta-gamma TRU, etc. and all modes of disposal, e.g., retrievable storage, burial, etc. It is undergoing trial in 1977, and is expected to be operational in 1978. (COP)

The system will not be available until 1978. (BDD/COP)

(27)

U.S. Energy Research and Development Administration, Division of Waste Management and Transportation, Washington, DC

Daly, G.W., and A.P. Kisk. 1975, April 1. HASL-291; Health and Safety Laboratory Environmental Quarterly, December 1, 1976 through March 1, 1977, E.P. Hardy, Jr., (pp. 1-110 - 1-126), 227 pp. (HASL-291); COMF-761017; COMF-771006; American Nuclear Society Winter Meeting, Proceedings of a Conference held in Washington, D.C., October 27-November 1, 1976, (17 pp.) (COMF-761017, COMF-761006)

Transuranic Nuclides in the Environment from Management of Solid Radioactive Waste (3)

Up to 20 percent of solid radioactive wastes which have been generated at EPDA sites may be contaminated with TRU nuclides. Prior to the requirement for 20-year retrievable storage in March 1978, solid waste contaminated with TRU nuclides was buried with other radioactive waste at carefully selected locations. A total of about 900 kg of TRU nuclides are contained in just over 1 million cubic meters of radioactive waste at these locations. Approximately 760 kg of TRU nuclides are contained in the buried waste, while the remainder is contained in the stored waste. Another 80 kg of TRU nuclides are contained at the five (5) commercial burial sites. All evidence to date indicates that TRU nuclides have not migrated significantly from their burial location. (BDD)

The volumes of transuranic waste produced and modes of disposal (including shallow land burial) as of 1976 are discussed. (BDD/B7)

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U.S. Energy Research and Development Administration, Washington, DC

1977, September. EMDA-1536; Final Environmental Impact Statement, Waste Management Operations, Idaho National Engineering Laboratory, Idaho (pp. 11-24 - 11-25) 709 pp. (EMDA-1536).

Characterization of the INEL Environment, Environmental Monitoring Program (1)

Routine monitoring of the environs at and adjacent to the INEL site was initiated in the early 1950's to characterize the routine atmospheric and accidental releases from the various facilities. Groundwater samples are collected bi-weekly from 22 onsite production wells and semi-annually from 12 offsite wells. Continuous air sampling is run at nine onsite stations and ten offsite stations. Collection of soil samples from four offsite and nine boundary stations was begun in 1971 and resumed in 1973 and 1976. Biological sampling is conducted on an intermittent schedule. Food stuffs produced from areas onsite and adjacent to the INEL facility are sampled on a routine basis. Grade A and Grade B silt samples are collected weekly and monthly, respectively. The samples are analyzed for iodine 131, strontium 90, and tritium. Wheat samples are sampled yearly and are analyzed for strontium 90 and cesium 137. (J7)

A descriptive summary of the routine environmental monitoring program conducted by INEL. This program assesses the impact of burial of radioactive waste in addition to the other potential sources. (08/J7)

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U.S. Energy Research and Development Administration, Washington, DC

1977, September. EMDA-1536; Final Environmental Impact Statement, Waste Management Operations, Idaho National Engineering Laboratory, Idaho, (pp. 11-163 - 11-179), 707 pp. (EMDA-1536).

INEL Solid Radioactive Waste Management Area (2)

Several areas within the INEL boundaries are or have been used for the storage and/or disposal, by burial, of radioactive wastes. One of these areas is the Radioactive Waste Management Complex (RWMC) which was initially established to handle the radioactive wastes generated by the laboratory. The RWMC is subdivided into the Subsurface Disposal Area, the Transuranic Disposal Area and the Transuranic Storage Area. The Subsurface Disposal Area (SDA) is an 88 acre section used for the burial of nontransuranic radioactive wastes. These wastes are disposed of in trenches or pits. The trenches average about 400 ft in length, 6 ft in width and 12 ft deep. Prior to 1970, most of the onsite solid low-level radioactive wastes were packaged in 12 cu ft cardboard boxes prior to burial. The wastes were compressed while in the trench. Since 1970 the waste is packaged in fiberboard boxes. Pits are on the average, 12 ft deep, 100 ft wide and of various lengths. These pits handle bulky irregular sized wastes. During 1970, over 10,000 curies of activity were disposed of at the SDA. Of this activity approximately 17.0% was identified as mixed fission products, 62.6% was attributed to Co 60, 8.0% was Sr 90, and 7.4% was Cs 137. The total activity of waste disposed of at the

RWMC during the period 1952 to 1970 is 5,978 ± 19 (2%) curies with a volume of 4.99 x 10⁶ (2%) cubic feet. Additional descriptions and data on the SL-1 Burial Ground, the ICPP Calcined Fuel Storage Facilities and the INEL Radioactive Scrap Waste Facility are provided. (J7)

A good general description of the radioactive waste management facilities at INEL including the shallow land burial facility. Some data on waste characteristics are provided. (08/J7)

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U.S. Energy Research and Development Administration, Washington, DC

1977, September. EMDA-1536; Final Environmental Impact Statement, Waste Management Operations, Idaho National Engineering Laboratory, Idaho, (pp. III-95 - III-98) 709 pp. (EMDA-1536).

Environmental Impact of Routine Operations, Radioactive Solid Waste Disposal and Storage (3)

During the period 1952-1970 more than 60 million curies of solid radioactive wastes were stored and/or disposed of by the waste management facilities at INEL. The total land committed for these wastes is 150 acres, about 0.03% of the total INEL area. Routine environmental surveillance of the environs around the RWMC and the SL-1 burial grounds indicates no significant contamination of the regional aquifer (depth 300'). Measurement of air samples showed no excessive airborne contaminant levels; gross alpha activities were less than 1 x 10⁻¹³ cpi/cc. Surface water samples from rainfall or snow meltwater were analyzed and only two were found to have elevated Cs 137 activity levels (<1.0 C 10⁻⁶ cpi/ml). Radiological impact on biota and man have been found to be negligible. (J7)

A descriptive review of the environmental impact of radioactive waste storage and disposal operations. No significant data points are presented. (08/J7)

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U.S. Energy Research and Development Administration, Washington, DC

1976. EMDA-76-162; 16 pp.

The Management and Storage of Commercial Power Reactor Wastes (2)

The processing of spent fuel elements generates four types of radioactive waste. Liquid high-level waste is first to be produced in the solvent extraction cycle. Fission products and small amounts of uranium and transuranic elements comprise this waste. During fuel-element processing solid and liquid non-high-level wastes are generated. One of the major constituents is the protective cladding hulls. The liquids vary widely in chemical and radioactive content. Volatile radioisotopes are evolved during the acid dissolving step and are treated to remove radioactive I 129 before being discharged from the processing facility. Non-high-level wastes are separated into radioactive and nonradioactive components. Evaporation is then used as an initial volume-reduction step. Other processes which may be used are:

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adsorption, flocculation, precipitation, filtration, and ion exchange. Absorbents are used to immobilize the liquids for transportation and disposal. Vermiculite, silica gels, plaster of paris, and various clays are some of the absorbent materials used. Ventralized evaporator concentrates, sludges, ion-exchange media and incinerator ashes have been immobilized in asphalt or bitumen. For solidified low-high-level wastes the final disposal is burial. Solids, soil, rags, and gloves are some of the solid wastes and these can be easily compacted. Those wastes which can be incinerated are and the exit gases are filtered to remove harmful levels of radioactivity. Some soluble solid wastes are treated chemically to remove surface contamination. Radioactive disassembly is another way in which the bulk of radioactive materials can be reduced. Included in the report is a brief introduction to the nuclear fission and the fuel cycle. The report also covered fuel cycle options, spent fuel, interim storage, gaseous wastes, storage, transportation, and nuclear waste quantities. The storage section is comprised of a discussion of geologic isolation, the barrier concept, and potential storage sites. (SDV)

(208)

U.S. Environmental Protection Agency, Washington, DC

Keyer, G.L., and R. O'Connell. 1973, March. COF-730919: Underground Waste Management and Artificial Recharge, J. Braunstein (Ed.), Proceedings of the 2nd International Symposium held in New Orleans, Louisiana, September 26-30, 1973 (pp. 795), 931 pp. (COF-730919)

Potential Impact of Commercial Low-Level Radioactive Waste Disposal Practices on Hydrogeological Environment (1)

The present practices, trends, and conditions in the shallow land burial of "low-level" radioactive wastes have a potential impact on the hydrogeologic environment and on environmental safety. New data are available from recently conducted inventories and surveys of operating conditions at the six commercial radioactive waste-burial facilities in the United States. "Low-level" radioactive wastes (as defined by the AEC) are being buried under widely differing conditions caused by local variations in geology, hydrology, weather, and operating procedures. The wastes themselves vary greatly in character from relatively harmless (due to decay or dilute concentrations) to extremely hazardous (due to chemical or radioactive toxicity). Other new data include: (1) the potential environmental impact which present trends in "low-level" waste character and quantities pose to the hydrogeologic environment and environmental safety; (2) specific areas where better knowledge of waste-hydrogeologic interrelations may be needed; and (3) recommendations concerning present practices or for acquiring the information required to evaluate present practices. (Complete Text)

(209)

U.S. Environmental Protection Agency, Office of Radiation Programs, Las Vegas, NV; U.S. Environmental Protection Agency, Office of Radiation Programs, Washington, DC

Hann, B.J., S.R. Goldberg, and W.D. Hendricks. 1975, November. Transactions of the American Nuclear Society, 22, 307; COF-751101: Joint Meeting of the American Nuclear Society and the Atomic Industrial Forum held in San Francisco, California, November 16-21, 1975, (15 pp.) (COF-751101)

Low-Level Solid Radioactive Waste in the Nuclear Fuel Cycle (1)

The nature of low-level solid wastes generated at each LWR fuel cycle facility type and the method of disposal is discussed. Those fuel cycle operations which ship wastes to commercial burial sites are identified. Estimates are made to relate annual quantities of waste shipped to facility throughput of uranium. A composite or solid fuel cycle is used to identify solid waste quantities generated in support of an annual fuel requirement for a 1000 Mw light water reactor year. The model fuel cycle and annual fuel requirement concepts, as developed and used in studies by the former Atomic Energy Commission (AEC) and by the Environmental Protection Agency (EPA), form a convenient basis for comparing environmental quantities from different fuel cycles and as a basis for projecting future quantities. This report follows the practice of using a 1000 Mw LWR operating at 80 percent load factor producing 7×10^{12} Kwhr of electricity at the bus bar. The fuel cycle throughputs in metric tons (MT) of uranium for the composite fuel cycle are scaled from the calculations of Pigford, which are based on a reactor of 32 percent thermal efficiency. (JTE)

Published in summary form only. (ESIC/JTE)

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U.S. Environmental Protection Agency, Office of Radiation Programs, Las Vegas, NV

Hann, B.J., and B.J. Nelson. 1976, June. ORP/LV-76-3; 35 pp.

Review of State Licenses for Disposal of Low-Level Radioactive Waste by Shallow Land Burial (2)

This paper reviews state licenses for burial of radioactive waste by commercial firms. The terms and conditions contained in licenses issued by the States of Illinois, Kentucky, Nevada, New York, South Carolina, and Washington are summarized. For illustration, a license developed for a proposed commercial site in the State of Oregon is included as an appendix. The procedures and mechanics of license development and administration are reviewed. This information is derived from questionnaires sent to state radiation control officials, supplemented by recent literature and personal communications with knowledgeable officials in state and Federal agencies. A review of problems encountered with the burial sites and the administration of licenses reveals a number of unresolved difficulties. Some of these concerns have been previously addressed by the Conference of Radiation Control Program Directors Task Force on Radioactive Waste Management (Cashman, 1973, 1974), and by the Federal General Accounting

<250> CONT.

Office (247, 1974). Additional problems, not covered elsewhere in the area of license enforcement, are reviewed herein. (Auth)

no data included. Covers purpose, authority, financial responsibility, form, and enforcement of licenses for shallow land burial sites. (ESEC/PTO)

<251>

U.S. Environmental Protection Agency, Office of Radiation Programs, Washington, DC

Yepet, G.L. 1976, February. EPA-529/3-75-021; 72 pp.

Preliminary Data on the Occurrence of Transuranium Radionuclides in the Environment at the Radioactive Waste Burial Site, Haney Flats, Kentucky (1)

Between 1963 and 1970, approximately 100,000 cu m of solid "low-level" radioactive waste were buried at the Haney Flats, Kentucky, site. It has been estimated that 70% of the waste, by volume consists of paper, which would yield a waste density of 12 lb cu/ft (0.16 gm/cu cm). These wastes contained approximately 20 kg of plutonium 239 and a large undetermined quantity of other plutonium isotopes. In 1972, elevated levels of radioactivity were detected in monitoring samples collected near the burial facility by the Kentucky Department for Human Resources (KDHR). Subsequently, the KDHR conducted a special radiological study of the burial site and its environs. Based on the concentration of plutonium present or the ratio of plutonium 239 to 238, 49 of 50 samples collected on or near the burial site were contaminated with plutonium from a source other than atmospheric fallout. Plutonium was detected in surface soil, in soil cores 90 cm deep, in monitoring wells, and in streams which drain the site. Annual mean precipitation for the Haney Flats region is 110 cm/yr. The burial trenches lie entirely within the Haney Member, a poorly fissile green shale, which is plastic when wet and has siltstone and sandstone interbeds. The Haney Member and underlying bed have extensive fracturing and jointing, which constitutes a potential migration of contamination from the trenches. Test wells show iron stained joints indicating groundwater passage. Results from test wells show injection rates from .0006-.015 (l/s)/s (kg f/cu cm). Water, believed to be the primary mobilizing agent for Pu, enters the ground as recharge, moves downward and laterally through the hydrogeologic system with its movement complicated by differences in permeability between strata, dip of the strata (0.7 m/km), and extensive jointing. Leachates in the trenches average 217 dpm/ml Pu 238, and 10.72 dpm/ml Pu 239. Background levels from atmospheric fallout are .02 dpm/ml for Pu 239, and have a Pu 238/239 ratio of .15 or less. Four samples from the mound trenches showed a Pu 238/239 ratio of 1.0. Pu 238/239 ratios from leachates and leachate contaminated liquids in tank storage averaged about 23.0. The hydrostatic head of 0-6 m which existed in some of the trenches could have furnished, and may still furnish considerable driving force of the leachate. Volume reduction of the leachate is achieved by settling and heating, aiding evaporation at a rate of 19 l/min. The vapor is passed through a mist eliminator and discharged to the atmosphere by 10 m stacks. (PTO)

Stratigraphic Unit Thickness: Soil: Density: Stack Height: Mean Precipitation: Evaporation Rate

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U.S. Environmental Protection Agency, Office of Radiation Programs, Washington, DC

Feldman, F.L. (Ed.). 1976, May. EPA-529/3-76-010: Radiological Quality of the Environment, Chapter 5, (pp. 05-123), 207 pp. (EPA-529/3-76-010).

Uranium Fuel Cycle (1)

High-level and low-level wastes are buried on installations run for ESHA by the operators. The six sites are at Beatty, NV; Haney Flats, NV; Sheffield, IL; Hanawell, SC; West Valley, NY; and Richland, WA. Trenches are used to bury the radwastes by stacking and covering with dirt. The trenches are eventually capped with a mound of earth to reduce infiltration from precipitation. It has been found that it is difficult to keep ground water out of the trenches. At present the only way to combat this is by pump and treat. In 1973 about 1.75 million cubic feet of waste containing 300,000 curies of by-product material, 150,000 grams of special nuclear material, and 205,000 pounds of source material was buried at the six facilities. By 2000, 60 to 100 million cubic feet of waste containing 19 million curies of by-product material, 7 million grams of special nuclear material, and 11 million pounds of source material will be buried annually. Of the six facilities contamination of the environment has occurred at Haney Flats and West Valley. Detected leachates are: H 3, H 22, H 54, H 55, C 57, H 63, H 65, Sr 90, H 106, Sb 125, I 129, I 131, H 133, Cs 137, H 226, Ac 228, Th 229, Th 232, U 234, U 235, U 236, Pu 239, Pu 240, and Pu 241. No information exists on potential losses to individual or general population from low-level waste burial practices. The sites are operated on the premise that the radwastes would not migrate for hundreds of years, but in about 10 years radioactivity has been detected offsite. However no current indication of significant contamination levels in the environment has been detected from low-level waste burial sites. Although the goal is to have land burial sites with zero release this is impossible to achieve particularly in the Eastern United States. Also included in the chapter are uranium mining and milling, fuel enrichment, fuel fabrication plants, power reactors, research reactors, transportation and reprocessing operations, and spent fuel storage aspects of the fuel cycle. The transportation of low-level waste will provide the greatest radiation dose. The annual population dose is expected to increase from 100 person-rem/yr in 1975 to 2,000 person-rem/yr in 2020. (POT)

<253>

U.S. Environmental Protection Agency, Office of Radiation Programs, Waste Environmental Standards Program, Washington, DC

1976, February. U.S. EPA Background Report; 61 pp.

Considerations of Environmental Protection Criteria for Radioactive Waste (1)

(250) CONT.

Control of radioactive materials due to the potential risk to man and the environment is important. Difficulties are encountered when trying to derive risk estimates of long-lived radionuclides such as C-14, Pu-239, and I-129 and then trying to base criteria on such calculations. Development of radioactive protection requirements involves: 1) designation of radioactive materials and their hazard potentials over time of decay; 2) use of risk estimates to determine the level of control; 3) the costs of control and the type of control that would best achieve the goal; 4) allowable levels of short- and long-term risks associated with various means of disposal; and 5) other environmental considerations such as retrievability, monitoring, and transfer of information to succeeding generations. Low-level wastes are those materials that would not present a waste hazard to normally exposed individuals. This classification may include reactor wastes and discrete medical and industrial sources. The potential hazard from low-level wastes is radionuclides leaching into the water which may ultimately be ingested by humans through the food chain. Such exposure depends upon the rate of transfer of the radionuclide through the surrounding soil and groundwater, the amount of dilution or concentration that occurs, and other factors. Also radioactive dust could pose a serious hazard if inhaled. Through 1976, the commercial sector generated 14 million cubic feet of waste packages with 1.9 million curies of low-level waste. Government sites in 1976 were estimated to contain 17 million curies in 62 million cubic feet of waste. Waste generation in the commercial sector is at 2 million cubic feet/year and increasing while wastes from government programs is projected at a stable rate of 1.1 million cubic feet/year. Other wastes considered in this report are high-level and long-lived wastes as well as fabricated aerobically radioactive and diffusive wastes of naturally-occurring radionuclides. Risk considerations for radioactive wastes, control of radioactive wastes, risk considerations and other considerations for radioactive waste are also included in the report. (250)

(250)

U.S. Environmental Protection Agency, Office of Radiation Programs, Las Vegas, NV

Kant, J.W., Jr. 1977, August. Methods for Measuring Radiation in and Around Uranium Mills. Progress Report, E.D. Harvard (Ed.), Volume 1, No. 1, Proceedings of a Workshop held in Albuquerque, New Mexico, May 23-26, 1977, (pp. 275-292), 811 pp.

Gamma Radiation Surveys Around Uranium Mill Tailings Pile (1)

In order to determine the gamma exposure rate attributable to direct shine from tailings piles, development of an indirect measurement technique able to differentiate between terrestrial and tailings radiation was developed. In order to differentiate between the tailings and terrestrial radiation, a portable demineralization rate meter was calibrated with a shield assembly. The instrument was calibrated against a sealed radium-226 source. In this technique the unshielded readings above the shielded readings were related to surface contamination. The above-ground exposure rate was then determined from the

contamination. (27)

Directly applicable to shallow land burial is that the reduction of gamma radiation from tailings to background is one of the criteria used to assess cover thickness. (27/27)

(255)

U.S. Environmental Protection Agency, Office of Radiation Programs, Las Vegas, NV

Kant, J.W., Jr. 1977, August. Methods for Measuring Radiation in and Around Uranium Mills. Progress Report, E.D. Harvard (Ed.), Volume 1, No. 1, Proceedings of a Workshop held in Albuquerque, New Mexico, May 23-26, 1977, (pp. 191-197), 811 pp.

Techniques for the Estimation of Radon-222 Source Terms for Uranium Mill Tailings Piles (4)

The techniques discussed provide a means of calculating the radon source term from active tailings, i.e., tailings covered by water. The source term is estimated by measuring effluent and downwind radon-222 concentrations in air and inserting these concentrations in a standard meteorological dispersion equation. Factors affecting radon exhalation include fluid cover, moisture content of tailings, particle size, atmospheric stability, and wind speed. (27)

Reviews the techniques for determining the radon source term from active tailings. (27/27)

(255)

U.S. Environmental Protection Agency, Office of Radiation Programs, Las Vegas, NV; U.S. Environmental Protection Agency, Office of Radiation Programs, Washington, DC

McDonnell, R.V., and W.P. Ralston. 1976, December. Radiation Data and Reports, 15(12), 75-767.

A Summary of Low-Level Radioactive Wastes Buried at Commercial Sites Between 1962-1977, with Projections to the Year 2000 (2)

A review of the six commercial shallow land burial sites is presented with tables showing types and amounts of radioactive material buried at each site since its inception. Projections of future waste production indicate that the current burial capacity of all six existing sites will be filled by 1999. (248)

Next review of commercial burial grounds. Tables with amounts and types of material buried at each site through 1977. (27/259)

(255)

U.S. Environmental Protection Agency, Office of Radiation Programs, Washington, DC

Kant, J.W., and W.B. Niskey. 1977, Radiological Health Data and Reports, 12(4), 105-112.

Radioactive Waste Discharged to the Environment

(25) CONT.

From a Nuclear Fuel Reprocessing Plant (B)

The Nuclear Fuel Services fuel reprocessing plant has been in operation since 1966 and has provided valuable experience in waste management problems related to this type of facility. The large quantities of radioactivity which must be handled at a reprocessing plant virtually precludes the dilution and discharge approach to waste management. Radionuclides such as strontium 90, ruthenium 106, cesium 137, cesium 134, cobalt 60, tritium, krypton 85 and plutonium have been found present in the environmental media at the site. The observed presence of these radionuclides in the site environment indicate that pathways to the public do exist, however, few assessments for the public in the site vicinity indicate that the doses are not significantly different than those received in other regions of New York State. The six ways in which radionuclides are potentially released to the site environment are leakage during shipment and handling, excess of contaminated personnel or material, gaseous effluent from the plant stack, low-level radioactive liquid release to the adjacent stream, leakage from high-level waste storage containment, and leakage from the low-level solid waste burial area. These releases are not considered to create a significant health hazard. (auth) (JC)

A general discussion of the potential pathways of radionuclides to the general public from the reprocessing facility, burial ground, high-level waste storage and general operational activity.

(25a)

U.S. Environmental Protection Agency, Office of Radiation Programs, Washington, DC

Russell, J.L. 1976. NE-CONF-001; CONF-760602: PB-256 717; Management of Radioactive Waste: Waste Partitioning as an Alternative, Proceedings of the Nuclear Regulatory Commission Partitioning Workshop held in Seattle, Washington, June 8-10, 1975, (pp. 81-98), 523 pp. (NE-CONF-001, CONF-760602, PB-256 717).

Potential Environmental Advantages from Partitioning of Radioactive Wastes (B)

Partitioning of radioactive transuranics from both high- and low-level wastes allows more options for environmentally safe management. Activities requiring attention to deal with the problem are: the need for environmental criteria or standards; source term data, including waste form and packaging; environmental transport information; potential dose delivered to man; the availability and suitability of disposition alternatives; possible remedial actions and their costs; perpetual care considerations; and monitoring, with action levels. Partitioning of low-level wastes is primarily a management problem. Most of the wastes that should be kept isolated will come from reprocessing and fuel recycle plants and I 129 and C 14 will come from the off-gas stream at these plants. Mixed oxide fabrication will also produce low-level waste that is transuranic contaminated. For sound management all transuranic contaminated wastes should be delivered to a federal repository instead of to a shallow land burial site. From the limited experience at West Valley, the total plutonium present in the light-water reactor

recycle may be greater than that in high-level waste. Hence, a greater effort is justified for partitioning low-level waste than for high-level wastes. Partitioning and the costs should be investigated with respect to the radon produced by uranium mill tailings. With partitioning, waste classes and disposition alternative can be paired. The expected sources of wastes are: high-level, low-level, and transuranic-contaminated low-level from the nuclear power industry; decommissioning waste; and a variety of wastes used in medicine, research, and industry. Disposal alternatives include: shallow land burial, emplacement-in-subsurface, geological disposal, extraterrestrial and ice cap disposal. Classification of radwastes should emphasize half-life as well as waste source and toxicity. (BWT)

(25b)

U.S. Geological Survey

La Sala, A.V., Jr., and C.C. Doty. 1975. Open File Report 75-625; 73 pp.

Geology and Hydrology of Radioactive Solid-Waste Burial Grounds at the Hanford Reservation, Washington (B)

Annual precipitation in the Hanford Reservation area is 6.4 inches, with 50% falling from November to February. The burial grounds on the high terrace in the 200 areas are underlain by materials of low permeability. In this area the depth to water table is 230 feet or more. Low terrace areas have a higher ground water recharge rate than the high terrace areas, due to a shallower water table depth and the presence of glaciofluvial deposits. The hydraulic conductivity ranges from 1 ft/day for fine-grained deposits, to 80 ft/day in coarse-grained deposits. The slope of the water table is 5 ft/mile toward the Columbia River. The water table has been modified by considerable discharge from 200 East area and from the 200 West area. In these areas the water table has risen 30 and 60 ft, respectively. The movement of wastes through the ground water system reflects the directions of ground water flow. Tritium concentration in the river is 2 pCi/l whereas monitoring wells around the disposal area show a tritium concentration in the range of 20-30 pCi/l. Burial grounds on low river terraces could be flooded during high river stage or eroded away if a dam rupture occurred. Contents and conditions of each of the disposal areas are discussed separately along with recommendations for their continued operation. The low terrace sites were deemed unsuitable for long-term disposal as a result of (1) conceivable radionuclide leaching by percolating soil water and rapid transport to the Columbia River, (2) possible inundation of the burial sites by catastrophic floods, (3) depressions and swirls at some of the sites that might enhance water infiltration through the waste, and (4) possible rise of the water table into certain burial grounds during a high stage of the Columbia River. (PTO) (CR)

Mean Precipitation; Stratigraphic Unit Thickness; Depth to Water Table; Hydraulic Conductivity

<250>

U.S. Geological Survey

Robertson, J.P., and J.T. Harralough. 1973. COSY-730919 (Vols. 1-2): Underground Waste Management and Artificial Recharge, J. Braunstein (Ed.), Proceedings of the 2nd International Symposium held in New Orleans, Louisiana, September 26-30, 1973, (pp. 251-322), 931 pp. (COSY-730919).

Radioactive and Chemical Waste Transport in Groundwater at National Reactor Testing Station, Idaho: 20-Year Case History and Digital Model (1)

Industrial and low-level radioactive liquid wastes at the National Reactor Testing Station (NRTS) in Idaho, have been discharged to the Snake River Plain aquifer since 1952. The movement and distribution of these wastes has been monitored and data is presented. The aquifer is probably more than 1000 feet thick, but a thickness of 250 feet was used in this study, on the basis of apparent layering effects in the aquifer. The upper layer appears to be somewhat separated from, and more permeable than, the lower layer. The model assumes that flow in the aquifer obeys Darcy's Law, which, for this aquifer, may or may not be completely valid. The total waste discharge to the aquifer at NRTS has averaged about 1×10^{10} gallons per year, and contained small quantities of tritium, Sr 90, Cs 137, Co 60, chloride, hexavalent chromium, various acids and bases, and heat. Tritium and chloride have dispersed over a 15-square mile area of the aquifer in low but detectable concentrations, and have migrated as much as 5 miles down gradient from discharge points. The movements of the cationic waste solutes, particularly Sr 90 and Cs 137, have been significantly retarded owing to sorption phenomena, principally ion exchange. Cs 137 has shown detectable migration in the aquifer and the Sr 90 has migrated only about 1.5 miles from a discharge well. Digital modeling techniques have been applied successfully to the analysis of this complex waste-transport system by numerical solution of the complete equations of groundwater motion and mass transport. Transmissivities for the aquifer were obtained by flow-net and pumping station analysis. Porosity of the aquifer in the waste-transport model was assumed to be 10%, based on the best available evidence. The most speculative inputs are the dispersivities and distribution coefficients. An effective way of measuring these coefficients in the field is presently practical because of large scale aquifer inhomogeneities. It is therefore invalid to extend ordinary laboratory measurements to field conditions. These parameters must be estimated. (JNT)

Distribution Coefficient; Effective Porosity; Dispersion Coefficient; Longitudinal; Dispersion Coefficient, Transverse; Hydraulic Velocity; Storage Coefficient; Head; Thickness of Upper aquifer

<261>

U.S. Geological Survey

Thies, C.V. 1955, December. TID-7517 (Part 1); Sanitary Engineering Aspects of the Atomic Energy Industry, Proceedings of a Seminar held in Cincinnati, Ohio, December 6-9, 1955, (pp. 116-131), 609 pp. (TID-7517, Part 1).

A Review of the Ground-Water Geology of the Major

Waste-Producing Sites (1)

The report is a comparative analysis of the major waste producing sites in the U.S. Sites are compared on the basis of climatic, geologic, and hydrologic factors. The sites included in the report are Hanford, Idaho Falls, Oak Ridge, and Savannah River. Comparisons are made of precipitation, geography, depth to water table, transmissibility flow rates and stratigraphic units. The Pingold formation on the Hanford site shows a transmissibility ranging from about 10,000 to 50,000 gal/day. The average rate of movement of water through the formation appears to be from 1/2 to 1 ft/day. The water table lies within the Pingold formation which makes it the most important formation in the area of the waste-processing plants. Average permeability coefficients of approximately 10,000 gal/day/sq ft are evident in the glaciofluvial deposits. The average ground water velocity is 20 ft/day. Depth to the water table at the Idaho Falls area varies from about 200 ft in the northern part to over 500 ft in the southern parts and slopes at a rate of 5-10 ft/mi. The transmissibility of around 1,000,000 gal/day/ft. Assuming a porosity of 15 and an average thickness of the aquifer of 800 ft, the average rate of movement of water through this basalt would be about 30 ft/day. Samples of the Big Lost River have yielded ion exchange capacities ranging from about 1 1/2 to 7 meq/100 g. The Oak Ridge and Savannah River area show a low permeability than the other areas. The Tuscaloosa area of the Savannah River site has a transmissibility of about 230,000 gal/day/ft. The overall average velocity of ground water in the Tuscaloosa under natural gradients seems to be about 1 ft/day. (CSF)

Transmissivity; Depth to Water Table; Mean Precipitation; Hydraulic Velocity; Permeability Coefficient; Cation Exchange Capacity

<262>

U.S. Geological Survey

Webster, D.A. 1976. U.S. Geological Survey Open-File Report 76-727; 81 pp.

A Review of Hydrologic and Geologic Conditions Related to the Radioactive Solid Waste Burial Grounds at Oak Ridge National Laboratory, Tennessee (1)

The exact boundaries of the early burial sites developed at ORNL during the 1960's are not known due to poor record keeping and a fire in 1961, which destroyed some of the records. Relatively little is also known of the waste character (identity, quantity, concentration, etc.) although it is generally referred to as low-level solid waste. The report includes a detailed geographical and topographical and hydrological description of the burial sites. The annual precipitation at ORNL averages 58 inches/year. This precipitation exceeds average evaporation rate of 42 inches/year, resulting in little accumulation of salts in the soil, which might interfere with ion exchange capacity of the soil. The soil component which overlies the Conasauga shale is thin in low lying areas, and thicker on the ridges (ranges from 4-60 feet). The Conasauga shale, which underlies the largest burial grounds has weathered to form illite and vermiculite, and the Chickamauga Limestone, which underlies other burial grounds, has weathered to form a kaolinite and illite mixture and occasionally some contourillite.

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The mobilization of constituents is due to conditions prevailing at ONSI disposal sites such as: high rainfall, shallow water table, low soil permeability, diversion of runoff into the trenches, and excavation of the trenches below the water table. The principle vehicle for radionuclide migration is ground water. Actual migration of nuclides is retarded by absorption, adsorption, and ion exchange. The composition of the Clinch River sediment is 60% illite, 15% kaolinite, 10-15% vermiculite, and 10-15% quartz. The average distribution coefficients of Clinch River sediments in distilled water are as follows: Cs 88,000; Co 72,000; Sr 85 1,800; Zr-W 95 12,900. The Clinch River sediments show the following percent activity sorption in distilled water: Cs 97.6%, Co 97.3%, Sr 85 81.8%, and Zr-W 95 86.6%. There is a need for continued hydrogeological studies of the area as well as a complete ground water-surface water monitoring program. These studies may in turn result in a model for prediction of radionuclide migration under present and future conditions. (PTO)

This report documents the topography, geology, and hydrology around the Oak Ridge burial grounds. (ESIC/PTO)

Mean Precipitation; Distribution Coefficient; Stratigraphic Unit thickness; Depth to Water Table

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U.S. Geological Survey

Grown, P.R., and R.S. Pei. 1976. Geological Survey Professional Paper No. 881; 87 pp.

Geologic Evaluation of Waste-Storage Potential in Selected Segments of the Mesozoic Aquifer System Below the Zone of Fresh Water, Atlantic Coastal Plain, North Carolina through New Jersey (2)

Presented are the data from a reconnaissance survey conducted on the Atlantic Coastal Plain from North Carolina to New Jersey. The survey is a geologic evaluation of waste storage potential in portions of the Mesozoic aquifer system in the area. General geologic information required is: understanding of the geometry of the sediment mass; the conditions existing during its deposition; and how it was affected and modified by tectonic and structural events during and after its deposition. The specific geologic information needed to delineate high porosity and permeability rocks from low permeability rocks is of their external and internal geometry and their relative spatial distribution within the sediment mass. Also the formation needs to be isolated hydrologically as well as having a favorable ion exchange with the intended radwaste. In selecting the reservoir environment, the potential reservoir rock should be underlain and overlain by seal rocks. The seal rocks must be characterized by relatively low permeability, an absence of fractures, and sufficient thickness and lateral extent to qualify. Ideally, the reservoir rock should be connected laterally with rock having the capacity to accept the native fluid that moves out of reservoir storage in response to injection pressure. This will reduce the danger of fracturing and breaching of the reservoir seals. A preliminary definition of the required environment is a sand or sandstone layer 20 ft or more in thickness that is directly underlain and overlain by a shale or clay

layer 20 ft or more in thickness. Units of interest in the study area are of Late Jurassic to Early Cretaceous in age. Since the fresh water environment must be protected, the fresh-saline water boundary zones within these three units was delineated. From control wells the following data were determined by geological and geophysical methods: unit thickness and sand thickness; average depth to the top of the unit's potential waste-reservoir sand; thickness of potential waste-reservoir sand; thickness of overlying shale per foot of potential waste-reservoir sand; thickness of underlying shale per foot of potential waste-reservoir sand; overburden thickness per foot of potential waste-reservoir sand. This data is intended to aid management in deciding the favorable storage areas. This decision will be made within a cost-risk benefit framework for detailed drilling of those areas most favorable. (SW)

Maps are included in back pocket of report. (ESIC/SOW)

Effective Porosity; Stratigraphic Unit Thickness; Total Porosity; Hydraulic Conductivity; Intrinsic Permeability; Depth to Water Table

<264>

U.S. Geological Survey

Johnson, A.L. 1963. U.S. Geological Survey Water-Supply Paper No. 1546-P; 27 pp.

A Field Method for Measurement of Infiltration (3)

The determination of infiltration-the downward entry of water into a soil-is receiving increasing attention in hydrologic studies because of a need for more quantitative data. The rate of infiltration is usually determined in the field by flooding basins or furrows, sprinkling, or measuring water entry from cylinders (infiltrometer rings). Rates determined by ponding in large areas are considered most reliable, but the high cost usually requires that infiltrometer rings, preferably 2 feet in diameter or longer, be used. The hydrology of subsurface materials is critical in the study of infiltration. The zone controlling the rate of infiltration is usually the least permeable zone. Other factors affect infiltration rate. These include the soil structure, the condition of the sediment surface, the distribution of soil moisture, the physical and chemical nature of the sediment, the head of the applied water, the temperature of the water and the sediments, the percentage of trapped air in the sediments, the atmospheric pressure, the length of time of application of water, the biological activity in the sediments and the type of equipment or method used. It is concluded that specific values of the infiltration rate for a particular type of sediment are probably non-existent and that measured rates are primarily for comparative use. A standard field test method for determining infiltration rates by means of single-or double-ring infiltrometers is described and the construction, installation, and operation of the infiltrometers are discussed in detail. (Auth) (CAS)

Basic guide for making field measurements of infiltration rates. (DH/CAM)

Infiltration Rate

(264)

U.S. Geological Survey

Valer, F.P. 1958. WASH-1143; Land burial of Solid Radioactive Wastes: Study of Commercial Operations and Facilities. P.J. Norton, (pp. 103-123). 133 pp. (WASH-1143).

Review of Geologic and Hydrologic Conditions at a Proposed Site for Burial of Solid Radioactive Waste, Southwest of Sheffield, Bureau County, Illinois (1)

The geologic and hydrologic conditions at the proposed commercial low-level burial site at Sheffield, Illinois are described in this report. The presentation includes the surface topographic, drainage and the rainfall data for the site. A description of the site subsurface geology is also presented based on test borings conducted by the original site operator, California Nuclear. Discussions of permeability, hydraulic velocity, and porosity are presented based on data from pump tests performed in the site vicinity. The conclusions of the report state that the site seems suitable for shallow land burial of low-level solid radioactive waste if certain precautions are taken in construction, filling, drainage design, and compaction of the trenches. (JC)

Report includes the data from the preliminary reconnaissance and investigative studies. (07/JC)

Cation Exchange Capacity; Depth to Water Table; Hydraulic Velocity; Stratigraphic Unit Thickness

(266)

U.S. Geological Survey

Clebeck, R. 1968. WASH-1143; Land Burial of Solid Radioactive Wastes: Study of Commercial Operations and Facilities. P.J. Norton, 133 pp. (WASH-1143).

Geology and Hydrology of a Proposed Site for Burial of Solid Radioactive Waste Southwest of Beatty, Nye County, Nevada (1)

The geologic and hydrologic conditions of the then proposed commercial low-level burial site at Beatty, Nevada are presented. The presentation includes a description of the site location, surface drainage, climate, rainfall, and evapotranspiration. The subsurface geology of the site is described based on both previous investigations made at the Nevada Test site and by other investigators as well as from test borings drilled at the proposed site. Ion exchange capacity data from some of the subsurface materials are presented. Hydrologic data for the site are derived from two bailers and one injection test. Discussions of permeability and groundwater velocity are also presented. Petrochemical background data from one test well are presented in tabular form. The effects of potential erosion and earthquake damage to the site are briefly discussed. The overall conclusions of the study indicate that the Beatty site is quite favorable for shallow land burial of low-level radioactive wastes. (JC)

Report includes the data from preliminary reconnaissance and investigative studies. (08/JC)

Depth to Water Table; Cation Exchange Capacity; Hydraulic Conductivity; Hydraulic Velocity; Total Cation Concentration

(267)

U.S. Geological Survey

Theis, C.V. 1956. WASH-275; Sanitary Engineering. Proceedings of a Conference held in Baltimore, Maryland, April 15-16, 1956. (pp. 261-283) (WASH-275).

Geologic and Hydrologic Factors in Ground Disposal of Waste (2)

The factors controlling ground water movement and the factors peculiar to liquid radwaste are discussed with emphasis on their interaction in the resulting movement of wastes underground. Ground water moves through an aquifer in accordance with Darcy's Law, which states that the rate of flow is proportional to the difference in head between any two points (hydraulic gradient). Other parameters defined are the coefficient of permeability, and coefficient of transmissibility. These coefficients help describe the velocity of the water in an aquifer. The average speed of water in a good producing formation (20% porosity) is on the order of 2/3 foot/day. Such velocities are of interest in surface disposal where waste might enter the near-surface. However, in deep-seated producers, such as an oil formation, the velocity is on the order of 1 foot/year. Also considered is the effect of diffusion of the solute which is expressed as the coefficient of diffusion. From the discussion it is concluded that the waste would move rather slowly in a formation. The concept of cone of depression (or build-up) is presented along with the formula to determine the shape of that cone. The path of a contaminant from the injection well is generally represented by use of flow and potential lines that are generated when the waste is injected. The effects of density differences of the liquids and ion-exchange are discussed. The most favorable features determined from the brief dissertation is that the aquifer should have a low velocity of ground water and some ion-exchanging capacity. However, before discharging wastes to the ground the precise geology and hydrology must be known. (007)

(269)

U.S. Geological Survey; New York State Science Service, Albany, NY; New York State Department of Health

Davis, J.F., R.H. Fahnestock, J.W. Pford, R.J. Dingman, R.H. Ronzheimer, and J.M. Satuszek, Jr. 1976. CONF-761104; Geoscience Information Society and the Geological Society of America, Proceedings of a Symposium held in Denver, Colorado, November 8-11, 1976. (15 pp.) (CONF-761104).

Evaluation of Radionuclide Pathways at a Shallow, Low-Level Radioactive Waste Burial Site in Western New York (2)

A discussion of the preliminary results of and descriptions of continuing studies being conducted at the West Valley facility in order to determine the containment capabilities of shallow radioactive waste burial site soils and to identify and evaluate the potential pathways of nuclide migration. The major

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<268> CONF.

emphasis of the studies being conducted is the development of an empirically derived computer model which simulates radionuclide migration from the trenches. The site, located 30 miles north of Buffalo, was in operation from late 1962 to Spring 1975. The disposal trenches, 25 ft deep, 15 ft wide and 600 ft to 700 ft long were excavated in glacial till 120 ft thick. Preliminary trench water monitoring indicates a slow downward movement of trench groundwater from the trenches. The rate of water accumulation is determined by precipitation infiltration through the trench cover. Collection and analysis of gas samples from void spaces above the trench water contained large amounts of carbon dioxide and methane both of which had high C 13 isotopic values. (Ruth) (J7).

A review of studies being conducted and that will be continued. No significant data presented. (J7) (J)

<269>

U.S. Geological Survey, Albuquerque, NM

Kelly, T.E. 1975, August. Open File Report 75-404; 82 pp.

Evaluation of Monitoring of Radioactive Solid-Waste Burial Sites at Los Alamos, New Mexico (J)

This report includes studies of 8 disposal sites at LASL, 4 of which contain solid waste. Detailed descriptions of known radionuclides buried, monitoring activities, and geological and topographical characteristics are included for each area. The average annual rainfall is 17 inches per year. The average depth to the potentiometric surface at LASL is 1,000 ft and the regional slope of the potentiometric surface is 70 ft/mile from west to east. All of the solid waste pits lie in the Tshirege Member of the Bandelier Tuff. Radionuclide retention by the tuff was measured for Cs 137, Pu 239, and Sr 90. The lowest retention of Cs 137 by the tuff was 99.6%. Plutonium 239 was tightly bound by the tuff but organic complexes released the Pu. Strontium 90 wasn't retained very well by the tuff, and was easily released. The tuff formation is highly jointed. It has been shown that water which has passed through the soil profile will move in the vapor phase along the horizontal bedding planes in the tuff and secondarily through open joints and through the tuff matrix. Due to the fact that little information is available on exact quantity or composition of waste buried in many locations, a post-burial monitoring operation is necessary to detect radionuclide migration to the biosphere. At LASL geologic or hydrologic parameters have not been adequately defined. Special emphasis could be placed on the Pajarito fault zone and its possible areas of recharge. Due to extreme variations in the Bandelier Tuff, geologic maps of each disposal site would be helpful to determine infiltration and runoff patterns. (PTO)

Stratigraphic Unit Thickness; Depth to Water Table; Mean Precipitation; Hydraulic Gradient

<270>

U.S. Geological Survey, Albuquerque, NM

Thies, C.V. 1962, March. 719-7628; Ground Disposal of Radioactive Wastes, J. N. Horyan, Jr., et al (Eds.), Proceedings of the 2nd Conference held in Chalk River, Canada, September 1-29, 1961, (pp. 166-170), 635 pp. (719-7628).

Notes on Dispersion in Fluid Flow by Geologic Features (J)

Attempts to explain the difference between dispersion as measured in the laboratory and in the field. Greater dispersion in the field is attributed to sedimentary structures and other geologic inhomogeneities. These inhomogeneities enhance dispersion by causing water to move at different velocities at different points within a bed. Lateral dispersion will result from lenticularity in sedimentary deposits. Vertical dispersion tends to be inhibited by bedding in such deposits. Field tests of dispersion in glacio-fluvial deposits at Hanford, Washington are cited. (CAB)

Just skins the surface. (DM/CAB)

<271>

U.S. Geological Survey, Denver, CO

Key, W.S., and T.H. Taylor. 1976, February 27. Technical Memorandum No. 37; 10 pp.

Preliminary Interpretation of Geophysical Logs made at Oak Ridge National Laboratory, February 16-21, 1976 (J)

Summaries of USGS logs and gamma spectra data at ORNL on burial grounds 1, 5, and 6, and intermediate-level waste pits are given. Areas where further analysis are required are identified, and some preliminary results of logs are discussed. (OO)

Excellent field data on ORNL burial grounds. However must be used in conjunction with other field data. (DM/OO)

Stratigraphic Unit Thickness

<272>

U.S. Geological Survey, Denver, CO; U.S. Geological Survey, Menlo Park, CA

Grove, D.B., and J. Rubin. 1977. CONF-760966; Disposal of Residues on Land, Proceedings of a National Conference held in St. Louis, Missouri, September 11-15, 1976, (pp. 176-178), 216 pp. (CONF-760966).

Transport and Reaction of Contaminants in Ground Water Systems (J)

Assessment of the environmental impact of disposal of waste in the subsurface environment requires that the reactions between the two be determined. This is most frequently determined by use of mathematical models such as the solute transport model (STN). The STN usually consists of two submodels. The first submodel, the waterflow submodel, computes water seepage velocities. The second part, the solute-transport model, uses the velocities to determine

<272> (cont.)

concentration. The solute transport model requires data on convection; hydrodynamic dispersion; ion-exchange reaction rates; rate-controlled chemical reactions and radioactive decay (where applicable). These equations are most frequently solved by numerical techniques. Models are currently available for assessment of one or two dimensional transport equations. Techniques currently used are either finite differences or finite element methods. (JT)

A review of the "State-of-the-Art" for predicting the reaction between contaminants and the subsurface environment. Can be applied to shallow-land burial. (DM/JT)

<273>

U.S. Geological Survey, Department of the Interior, Washington, DC

Abraham, J.R., Jr., L.E. Veir, and W.D. Hartmann. 1961. Professional Paper No. 518-P: Short Papers in the Geologic and Hydrologic Science, Articles 293-415, (pp. 316 - D-145).

Distribution of Moisture in Soil and Near Surface Tuff in the Pajarito Plateau, Los Alamos, New Mexico. (J)

The Pajarito Plateau is underlain by pumice deposits, ash falls and ash flows of welded rhyolite tuff. Three soil zones are identified: an A zone from which most of the clay has been leached, a B zone containing montmorillonite, and a C zone with a high clay content. Measurements of the moisture content of soil was made under natural and controlled conditions. Moisture measurements under natural conditions, indicate that the moisture content was found to increase from surface to a depth of about 1 foot then decrease to a depth of 6 to 12 feet below which the moisture content remained relatively constant. Moisture content in soil ranged from 10% to 50% as a function of depth and time. The tuff's moisture content ranged from 8% to 12% as a function of depth and time. Under controlled conditions, the moisture content of the tuff, below 6 feet, never exceeded 15%. (JT)

Studies were not conducted at the site of the primary burial ground, Mesita del Bury. However, since the Mesita is part of the Plateau and underlain by a similar general lithology, extrapolation of the data is justifiable. (DM/JT)

Voluetric Water Content; Depth to Water Table

<274>

U.S. Geological Survey, Idaho Falls, ID

Jones, P.H., and R.L. Schmalz. 1962, April.

Distribution of Radionuclides in Ground Water at the National Reactor Testing Station with Particular Reference to Tritium. (J)

The National Reactor Testing Station, located in southeastern Idaho, has an annual precipitation of 7.5 inches. The regional water table lies at a depth of 200 ft in the northern part of NRTS, and at 400 ft in the southern part. The average flow of ground

water is 100 ft/day. The movement of tritium in the ground water aquifer beneath the National Reactor Testing Station in southeastern Idaho is discussed. Tritium was introduced to the Snake River Plain aquifer from injection wells, seepage pits and seepage ponds from 1956 to 1961. The movement of the tritium was determined from the spread of contaminated water to monitoring wells. The evidence indicates that there has been a high degree of mixing; a rather uniform degree of dilution of waste water over a distance of several miles from point of injection. Downer distribution of tritiated waters showed anisotropies of the aquifer and that water flowed in sheets or tabular zones within rather restricted depth ranges for several miles. Use of the tritium as a tracer yields accurate measurements of rates of flow of water in the aquifer. (CS)(PT)

Gives an insight into the movement of tritium wastes in ground water aquifer and their usefulness as a tracer. Some of the findings could be applied to shallow land burial although the sources discussed are injection wells and seepage ponds. (DM/CS)

Depth to Water Table; Mean Precipitation; Hydraulic Velocity

<275>

U.S. Geological Survey, Idaho Falls, ID

Jones, P.H. 1962, March. WID-747: Ground Disposal of Radioactive Wastes, J.R. Horton, Jr., et al (Eds.), Proceedings of the 2nd Conference held in Chalk River, Canada, September 26-29, 1961, (pp. 71-116), 415 pp. (WID-747).

Geophysical Research at the National Reactor Testing Station. (J)

Six types of borehole geophysical logs were used to obtain information relevant to waste disposal hydrology at the National Reactor Testing Station (NRTS). The methods utilized were formation resistivity and spontaneous potential, gamma ray, caliper, flow meter, temperature, and water resistivity logging. Electric logging was found to be unsatisfactory because of groundwater and formation conditions, while gamma-ray logging was useful for identifying sediments interbedded with lava flows. Caliper logging was very successful for identifying the more porous aquifers, while temperature, flow meter and water resistivity logging helped to define the subsurface movement of injected aqueous wastes. Gravity and magnetic surveys were not found to be useful at NRTS. (CS)

Indirectly related to shallow land burial. Discusses methods of geologic/hydrologic parameters qualitatively. (DM/CS)

<276>

U.S. Geological Survey, Idaho Falls, ID

Robertson, J.L. 1977, January. IOW-22557; 64 pp.

Numerical Modeling of Subsurface Radioactive Solute Transport from Surface Seepage Ponds at the Idaho National Engineering Laboratory. (J)

Radioactive, chemical and military wastes have been discharged to seepage ponds in the West

<276> CONT.

Reactor Area (RPA) at INEL for a number of years. A number of perched water bodies have formed on basalt and sediment layers at various depths beneath the seepage ponds. Mapping of contaminant distribution in perched water bodies has been done. Cesium 137 and Strontium 90 were found to be strongly adsorbed by soil and rock, while Cobalt 60 is adsorbed to a lesser degree. Tritium and chloride contaminants are not removed from solution by this process. A hydraulic model was developed to simulate solute transport in the subsurface using hydraulic parameter measurements from various other studies at INEL. Modeling results indicated that the distribution of tritium is not changing with the time and that inflow into the Snake River Plain aquifer does not change significantly with time. Strontium concentrations greater than 0.001 pCi/ml would not enter the aquifer by the year 2005, the last year for which predictions were made. Further assumptions indicate that significant strontium concentrations could enter the aquifer under certain conditions. Predictions for cesium 137, cobalt 60, chromium 51, cerium 144 and nonradioactive wastes were made by qualitatively relating them to model behavior of tritium and strontium. The results indicate that only solutes with low sorbability and relatively long half-lives have reached the Snake River Plain aquifer in detectable quantities. Only tritium was found to have done so. (CAB)

Study of movement of radionuclides in solution in the subsurface is applicable to similar problems at shallow land burial sites. (DR/CAB)

Effective Porosity; Hydraulic Conductivity; Distribution Coefficient; Dispersion Coefficient

<277>

U.S. Geological Survey, Las Vegas, NV

Blankenship, R.K. 1968, July. Ground Water, 6(4), 26-31.

Geophysical Logging and Hydraulic Testing, Pahute Mesa, Nevada Test Site (3)

Extensive geophysical logging and hydraulic testing in deep exploratory holes at Pahute Mesa, Nevada Test Site are described. Discussion on the interpretation of the logs based on rock characteristics is presented. It is concluded that "some qualitative data on rock lithologies and hydraulic conditions in the borehole may be determined by electric, caliper, temperature, and fluid resistivity logs." (OO)

Useful information on methodologies and potential uses of geophysical logging. (DR/OO)

Stratigraphic Unit Thickness; Transmissivity

<278>

U.S. Geological Survey, National Reactor Testing Station, Idaho Falls, ID

Robertson, J.E. 1978. CONF-780312; INEA-54-182/50; Isotope Techniques in Groundwater Hydrology, Proceedings of a Symposium held in Vienna, Austria, March 11-15, 1978, Vol. 2, 1pp.

451-078) (CONF-780312, INEA-54-182/50).

Application of Digital Modeling to the Prediction of Radioisotope Migration in Groundwater (2)

A digital model is presented along with field verification for the prediction of radioisotope migration at the National Reactor Testing Station. The influences include space and time variations in ground-water flow, hydraulic dispersion, radioactive decay, ion exchange and other chemical reactions. These processes are included in problems of movement of radioactive wastes in ground water; design and analysis of tracer tests in ground water systems; and analysis of natural isotope distributions in ground water. The model is composed of two coupled phases--the first simulates the hydraulics and the second simulates solute transport. The hydraulic phase solves the transient, two-dimensional partial differential equation of ground water flow for a bounded, two-dimensional, one-layer aquifer, using finite difference techniques (iterative, alternating-direction implicit scheme). This method is described by Bredehoeft and Pinder. Ground water velocity vectors are computed, by this equation, for every grid point at any finite time step. The velocities are transferred to the solute transport phase of the model that solves the transient partial differential equation of transport, using the method of characteristics. This method characterizes the dissolved nuclides by characteristic imaginary particles. Considered terms in the solute transport phase are: hydraulic dispersion, convective transport, aquifer compression factors, sources and sinks, radioactive decay and seepage. Input for the model includes transmissivity, storage coefficient, boundaries, hydraulic dispersion coefficients (transverse and longitudinal), initial concentration distributions, ion exchange, distribution coefficient, radioactive decay constant, and source-sink inputs. The Station occupies 890 sq miles of semiarid land on the eastern Snake River Plain. The Plain is a basin which is filled with 5,000 feet of thin basaltic lava flows and interbedded sediments. Most of the eastern Snake Plain is underlain by a vast ground water reservoir known as the Snake River Plain aquifer. The aquifer contains more than 1 billion acre-feet of water and the velocities range from 5 to 25 feet/day. Annually 200 million gallons of water are discharged from the Station and in this water the annual average of radionuclides is 940 Ci of H 3, 8 Ci of Sr 90, and 7 Ci of Cs 137. The wastes seep into the ground through several perched water tables and finally into the upper portion of the Snake River Plain aquifer. Within the detection limits of 2 pCi/ml, the H 3 and chloride plumes cover an area of 15 sq miles. The Sr 90 plume occupies only an area of 1.5 sq miles and the detection level is 0.005 pCi/ml. The model adequately described the H 3 plume but not the chloride plumes. (NDV)

The digital model presented in this paper seems to be a potentially useful tool for radionuclide migration predictions. (ESIC/NDV)

<279>

U.S. Geological Survey, Reston, VA

Papadopoulos, S.S., and L.J. Vinograd. 1978. EPH-520/3-78-009; Open File Report 78-388; 83 pp.

<279> CIST.

Storage of Low-Level Radioactive Wastes in the Ground: Hydrogeologic and Hydrochemical Factors with an Appendix on the Haney Plats, Kentucky, Radioactive Waste Storage Site: Current Knowledge and Data Needs for a Quantitative Hydrogeologic Evaluation (3)

Hydrogeologic and hydrochemical characteristics affecting the suitability of proposed sites for low-level radioactive waste disposal are reviewed and expanded. Factors such as depth to the ground water table, thickness of soil cover, groundwater flow patterns, geosynclinal stability, groundwater residence times and rates of radionuclide migration are explained and briefly discussed. The status of prediction of groundwater flow and solute transport and the data requirements for development of such models is reviewed. The hydrogeologic conditions at the Haney Plats Radioactive Waste Storage Site are described in the light of those factors discussed in the body of the report. The low permeability of shale strata beneath the site, the high probability of groundwater flow through fractures are pointed out as factors which make it difficult to monitor and understand hydrogeologic conditions at Haney Plats. The objective of the report was to present an overview to some of the factors determining site selection, and some of the problems encountered in providing some of the necessary data. In areas where migration of radionuclides would be complicated by faults, heterogeneous media, anisotropic conditions, etc., predictive modeling is very difficult. An Appendix on the knowledge, problems, and future needs of Haney Plats hydrogeology is presented. (CAB) (CST)

Overview of siting considerations for shallow-land burial sites with emphasis on hydrogeologic and hydrochemical aspects as well as mathematical simulation of solute transport. (DNR/CAB)

<280>

U.S. Geological Survey, Reston, VA

Winograd, I. 1976, October. Transactions of the American Geophysical Union, 55(10), 888-898.

Radioactive Waste Storage in the Arid Zone (3)

The disposal of high-level radioactive wastes in thick unsaturated zones in arid environments is suggested. Some of the discussion is applicable to shallow land burial of low-level wastes in that problems of solution and transportation of radionuclides by groundwater are common to both types of waste disposal as are surface erosion problems. Hydrogeologic and logistical factors favoring the use of thick unsaturated zones as repositories include 1) the probable absence of an effective mechanism to dissolve and transport radionuclides, 2) probable protection from exhaustion by erosion, 3) availability of remote federally owned lands, and 4) ease of placement and retrieval. Some problems common to both deep burial of high-level waste and shallow burial of low-level wastes include disruption of the ground surface during burial possibly resulting in increased erosion and infiltration rates, change in climate leading to increased precipitation and degradation of storage containers with time. (CAB)

Discusses only high-level waste disposal. Some

of the discussion is relevant to shallow land burial of low-level wastes. (DNR/CAB)

<281>

U.S. Geological Survey, Reston, VA

DeDuchanasse, C.D. 1976, December. Nuclear Technology, 29, 154-161.

Geohydrologic Considerations in the Management of Radioactive Wastes (1)

Volcanic radioactive wastes occur as liquids containing high-level concentrations of radionuclides, liquids containing low concentrations of radionuclides, and solids contaminated by radioactivity. Whether released by accident or design into the earth or onto the earth's surface, water serves as the principle transport agent for movement of radionuclides away from radioactive waste disposal sites. Geohydrologic information that is required for accurate prediction of the velocity and direction of radionuclide transport includes the depth to water table, climate, detailed understanding of the subsurface geology, permeability, porosity, the sorption properties of the subsurface materials seismic potential of the site, and geologic history of the site. The application of mathematical models for the accurate prediction of radionuclide transport requires extensive knowledge of the geohydrologic parameters of the site. (A-14) (JC)

Review of the data requirements for site selection and evaluation. Includes a list of sixteen important data needs suggested by Papadopolos and Winograd. (DNR/CST)

<282>

U.S. Geological Survey, Reston, VA

Appel, C.A., and J.D. Breckhoff. 1976. U.S. Geological Survey Circular No. 717; 9 pp.

Status of Ground Water Modeling in the U.S. Geological Survey (2)

The status of modeling activity for various problems are reported as being in developmental, verification, operational, or continued improvement phase. Types of problems include analytical and numerical application to: (1) hydraulic flow in saturated and unsaturated materials, (2) flow in coupled ground water-stream systems, (3) coupling of rainfall-runoff basin models, and (4) transport of contaminants in an aquifer. (COT)

An excellent review of state of the art in hydraulic flow and mass transport. Comprehensive bibliography on all aspects of modeling. (DNR/COT)

<283>

U.S. Geological Survey, Richland, WA

LaSala, A.N., Jr., G.C. Doty, and V.J. Pharron, Jr. 1973, January. U.S. Geological Survey Open File Report No. 302; 54 pp.

<293> COST.

* Preliminary Evaluation of Regional Groundwater Flow in South-Central Washington (2)

The characteristics of regional groundwater flow were investigated (principally by well analysis) in a 4,500 square mile region of south-central Washington, centered on the U.S. Atomic Energy Commission's Hanford Reservation. The investigation is part of the Commission's feasibility study on storing high-level radioactive wastes in chambers mined in basaltic rock at a depth of about 2,000 feet or more below the surface. Groundwater flow, on a regional scale, occurs principally in the basalt and in interbedded sediments of the Columbia River Group, and is controlled by topography, the structure of the basalt, and the large streams, the Columbia, Snake, and Yakima Rivers. The groundwater beneath the main part of the Hanford Reservation south and west of the Columbia River, moves southward from recharge areas in the uplands, including Cold Creek and Dry Creek valleys, and ultimately discharges to the Columbia River south of the reservation. East and northeast of the Columbia River groundwater flows generally southward and discharges to the river. The Yakima River valley contains a distinct flow system in which movement is toward the Yakima River from the topographic divides. A large southward flowing groundwater system beneath the southern flank of the Horse Heaven Hills discharges to the Columbia River in the westward trending reach downstream from Wallula Gap. (Auth) (R)

The study provides a good regional description of the groundwater characteristics in the vicinity of the shallow waste burial sites at Hanford. (R/R/T)

* * * Precipitation; Transmissivity; Hydraulic Conductivity

<294>

U.S. Geological Survey, Washington, DC

Carroll, D. 1961, June. TET-785; 31 pp.

Soils and Rocks of the Oak Ridge Area, Tennessee (1)

This report summarized the mineralogic and chemical data obtained from the analysis of soil and rock samples collected in the area of Oak Ridge, Tennessee, and attempts to correlate the soil formation and bedrock lithology. The soils derived from limestone and the Knox Dolomite contain kaolinite as their principal clay mineral, while the soils derived from the Conasauga shale are dominated by the micaceous clay minerals such as mica, dioctahedral vermiculite, and vermiculite mica. Mineralogic and chemical data are presented in tabular or graphic form. The cation exchange capacity of the soils was shown to range from 3 to 17 meq/100 g while the cation exchange capacity of the shale samples ranged from 5.5 to 28.6 meq/100 g. The grain-size distribution of soils at or near Oak Ridge ranged from 1.1 to 59.9 percent for sand, 25.9 sand, 25.8 to 66.5 percent for silt, and 7.5 to 61.0 percent for clay. The pH of the residual soils was from 4.5 to 6.1 and are leached of exchangeable cations. (Auth) (JC) (JT) (CS)

This report, although dated, represents one of the best studies on the adsorptive capacity and

general physicochemical properties of the subsurface at a waste facility. (R/R/JC)

Cation Exchange Capacity; pH; Clay Content; Thickness of Upper Aquifer; Grain Size Distribution; Total Cation Concentration

<295>

U.S. Geological Survey, Washington, DC

Washburn, W.L., G.B. Despatch, Jr., and R.H. Stevens, Jr. 1975. U.S. Geological Survey Professional Paper No. 933-D; 35 pp.

Distribution of Radionuclides in the Columbia River Streambed, Hanford Reservation to Longview, Washington (3)

Until all the eight reactors at Hanford Reservation, cooled by once-through flow of treated Columbia River water, were shut down in 1971, their cooling-water effluent was the main source of dissolved and particulate radionuclides in the Columbia River. The distribution and quantities of radionuclides accumulated in the riverbed were investigated; reconnaissance surveys were made of radionuclide concentrations, particle size of surficial sediment, and sediment at depth; radionuclide discharges were defined at two locations; and radionuclide concentrations in surficial sediment were observed continuously at three river locations. The pattern of seasonal variation of radionuclide concentrations in surficial sediment of the Columbia River generally was attributable to seasonal changes in concentration of suspended-particulate and dissolved radionuclides at Pasco, Washington, and changes in hydrodynamic and transport characteristics of the river. Radionuclide concentrations were at a maximum during November-early January and late March-early May, and at a minimum during June-July and late January-early March. At all river locations, radionuclide concentrations in coarse surficial sediment (mostly sand with some fine gravel) of main channels were significantly lower than concentrations in fine surficial sediment (mixtures of sand, silt, and clay) of secondary channels and shallow areas. Chromium 51 and scandium 46 usually had a greater affinity for fixation to fine sediment, relative to coarse sediment, than did zinc 65 or cobalt 60. Radionuclide concentrations in both coarse sediment and fine sediment did not vary significantly (95 percent confidence level) within relatively long river reaches. However, within the reach from the reactors to Longview, Washington, radionuclide concentrations in surficial sediment did attenuate with distance downstream; respective concentrations of chromium 51, zinc 65, scandium 46, and cobalt 60 at Vancouver, Washington, Columbia River mile 106 (Rn 171), averaged 8, 2, 1, and 1 percent of levels at Pasco, Washington, Columbia River mile 130 (Rn 531). The stratigraphic distribution of radionuclides varied considerably. Differences were distinguishable between coarse sediment of main channels and fine sediment of secondary channels and shallow areas, but differences were not distinguishable within these sediment-size classes. Radionuclides tended to be distributed equally throughout relatively great depths (more than 60 in. (1.5 m) in some places) in sand beds of main channels. A predominance of chromium 51 over zinc 65 in the estuary bed and an opposite predominance in the riverbed probably indicate less seasonal variation in the distribution of

<285> CCST.

radioisotopes (especially chromium 51) in the estuary bed than in the riverbed. It also suggests that the main source of particulate radioisotopes discharged to the ocean during June was the riverbed rather than the estuary bed. (Ruth) (JTE)

<286>

U.S. Geological Survey, Washington, DC

Pinder, G.F., and R.E. Cooper, Jr. 1970. Water Resources Research, 6(3), 875-882.

A Numerical Technique for Calculating the Transient Position of the Saltwater Front (4)

The movement of the saltwater front in coastal aquifers, including the effect of dispersion, can be determined by using numerical methods. A method of characteristics is used to solve the solute transport equation, and the alternating direction iterative procedure is used to solve the groundwater flow equation for the two dimensional problem. This approach permits the treatment of transient flow in nonhomogeneous aquifers with irregular geometry. (Ruth)

One of the first papers on contaminant transport in porous media. Equations developed are still valid, but adsorption and decay are not considered. (BR/MN)

<287>

U.S. Geological Survey, Washington, DC

Stole, G.E. 1967. U.S. Geological Survey Water-Supply Paper No. 1801: 113 pp.

Geology and Ground Water of the Savannah River Plant and Vicinity, South Carolina (3)

A detailed investigation of the hydrogeologic characteristics of the area around the Savannah River Plant site is presented. This area is underlain by a series of unconsolidated and partly consolidated sediments, which were deposited unconformably on aqueous, metamorphic and sedimentary basement rocks. The unconsolidated sediments strike N 60 E and dip 6-20 feet per mile to the southeast. They form a wedge-shaped zone that increases in thickness toward the southeast. The principal aquifer in the area is composed of the beds of sediments to coarse sand and gravel contained in the Tuscaloosa and Ellenburg Formations. Grain-size distribution of some disturbed samples are also presented for these areas. The ground water in the principal aquifer occurs in water-table conditions in outcrop areas but under artesian conditions in the down-dip sections of the formations. Data indicates that recharge into the primary aquifer is mainly by leakage through overlying formations. Pumping-test data for the principal aquifer is summarized. This data shows that the coefficient of transmissibility ranged from 31,500 gpd/ft to 500,000 gpd/ft, the coefficient of storage from 0.0002 to 0.0008, and the coefficients of permeability ranged from 209 gpd/sq ft to 1,569 gpd/sq ft. Secondary aquifers include deposits of sand and limestone. Water in these aquifers occur under conditions similar to those occurring in

the principal aquifer. Water quality in the primary aquifer is very low in dissolved solids, soft, and slightly acidic. Water quality in the secondary aquifers are generally more acidic than that in the primary aquifer. Water-level fluctuations in wells are given for five formations. The 24 of most samples ranged from 6 to 7, that slightly acidic. Ion exchange capacity of surface and subsurface samples from Aiken and Barnwell Counties, S.C., ranged from 0.2 meq/100 g to 15.2 meq/100 g. Stratigraphic and age relations, lithology, and water-bearing character of the geologic formations that occur in the area are summarized. (JTE) (CST)

The report was generated to provide the USAR with knowledge of the geohydrologic conditions beneath the Savannah River Plant area. Data provided is not specific to the burial ground area but deals with the overall general geohydrologic characteristics beneath the Savannah River Plant vicinity. (JTE/JTE)

Stratigraphic Unit Thickness; Thickness of Upper Aquifer; Effective Porosity; Grain Size Distribution; Cation Exchange Capacity; Transmissivity; Hydraulic Conductivity; Unsaturated; Storage Coefficient; Depth to Water Table; Distribution Coefficient; Clay Content; pH

<289>

U.S. Geological Survey, Washington, DC

Tanner, A.B. 1968. Natural Radiation Environment, Chapter 9. University of Chicago Press, Chicago, Illinois, (pp. 167-189).

Radon Migration in the Ground: A Review (3)

A literature review on subsurface radon migration and exhalation is presented. It is concluded that any appreciable exhalations of Ra 222, Ra 220 or Ra 219 atoms come from radium isotopes distributed in secondary cracks or films or in the shallow surface layers (approximately as deep as the recoil range of intact crystals of the host minerals. Two different mechanisms of radon migration are distinguished: (1) diffusion, where there is radon isotone movement with respect to the fluid filling the pores of the medium, and (2) transport, where there is movement of the radon isotopes with the fluid through the porous medium. Either or both mechanism in the migration of radon isotopes is unsaturated, undisturbed soil and porous rocks near the earth's surface. The three most commonly observed meteorological factors that are observed to have pronounced effects on radon concentration and exhalation are rainfall, freezing, and snow cover. With heavy rainfall the soil gases near the surface tend to be displaced upward, carrying radon with them and increasing the exhalation rate temporarily thereafter, the reduced diffusion coefficient, and reduced permeability of the wet ground restrict migration by both mechanisms (thus decreasing radon exhalation and increasing the ground radon concentration). In unsaturated rocks and soil which are fractured, radon isotopes should tend to diffuse through undistributed zones into fractures and channels where transport is important. The diffusion coefficients of radon isotopes in water saturated porous media are extremely small. If radon isotopes in liquid-saturated rock or soil are to migrate distances significant in environmental radioactivity studies or in prospecting, the transport mechanism must therefore predominate. With respect to environmental

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surveys, it is pointed out that there is no necessary correlation between the gamma ray field and the amount of radon, thorium, or actinium on migrating into the atmosphere or into natural waters. Mathematical expressions describing the upward movement of Pa from a subsurface, infinite planar source in unsaturated, undisturbed porous rock and soil are also presented in this paper. (Auth)(M)

Information on subsurface radon migration, which is important to uranium mill tailing burial studies is presented. (DR/ST)

Distribution Coefficient

<299>

U.S. Geological Survey, Washington, DC

Repor, F.W. 1978. U.S. Geological Survey Report of Investigations No. 75: 32 pp.

Evaluation of Hydraulic Characteristics of a Deep Artesian Aquifer from Natural Water-Level Fluctuations, Miami, Florida (M)

Knowledge of the hydraulic characteristics of aquifer systems is fundamental to defining the vertical and horizontal controls on fluid movement, information which is needed for assessing the environmental impact of subsurface waste storage. To meet this objective, natural water-level fluctuations in the 2,987 foot deep Peninsula Utilities disposal well near Miami, Florida were analyzed to obtain estimates of the hydraulic diffusivity, hydraulic conductivity, specific storage, transmissivity, and the storage coefficient of the Boulder Zone. The fluctuations are caused chiefly by oceanic and earth tides, and by changes in atmosphere pressure. The oceanic tidal fluctuations probably result from loading due to tides in Biscayne Bay. Water from the well indicates that locally the water in the Boulder Zone is chemically equivalent to sea water and has a temperature of 16 degree C. The pressure head of the salt water in the Boulder Zone at the 2,987 foot depth probably fluctuates at or near sea level. The quality and temperature of the water, and with geologic considerations, suggest that the Boulder Zone and the Straits of Florida. The hydraulic diffusivity of the Boulder Zone is estimated to be 2.1×10^{-11} sq ft/day. The hydraulic conductivity and specific storage are estimated to be 2.1×10^{-15} ft/day and 1.0×10^{-6} , respectively, based on an assumed porosity of 50 percent and a 15 foot thickness of aquifer. The transmissivity and storage coefficient are estimated to be 3.2×10^{-6} sq ft/day and 1.5×10^{-5} , respectively. (Data)

*transmissivity; Hydraulic Diffusivity; Hydraulic Conductivity; Storage Coefficient; Stratigraphic Unit Thickness; Thickness of Upper Aquifer; Head; Depth to Water Table; Hydraulic Gradient; Effective Porosity

<290>

U.S. Geological Survey, Washington, DC

McGrand, H.P. 1962, March. TID-7624; Ground Disposal of Radioactive Wastes, J.H. Morgan, Jr.,

et al (Eds.), Proceedings of the 2nd Conference held in Chalk River, Canada, September 26-29, 1961, (pp. 67-76), 635 pp. (T-5-7624).

Graphic Evaluation of Hydrologic Factors in Management of Radioactive Wastes (2)

Discusses those geohydrologic conditions which are most favorable for disposal of radioactive liquids in pits and solid radioactive wastes in trenches. Factors discussed are depth to water table, permeability, sorptive capacity of near-surface materials, distance to streams or points of discharge of subsurface water, absence of fresh water in surface streams and in groundwater. Depth to water table is controlled by precipitation, topography and permeability. Greater depth to water table is the more favorable condition. The degree of permeability is related to the depth to the water table and distance between interstream divides especially in humid regions. Sorptive capacity is found to be inversely proportional to the depth to water table and to permeability except in special cases such as glauconite and phosphatic sands. Concludes that arid regions are generally more acceptable for waste burial, but that design and engineering may locally add safety a factor in more humid regions. (CAB)

Simplified discussion of geohydrologic conditions favorable for shallow land burial. (DR/CAB)

<291>

U.S. Geological Survey, Washington, DC

Seacomb, R.C., J.R. Strand, and F.J. Frank. 1972. U.S. Geological Survey Professional Paper No. 717: 76 pp.

Geology and Ground Water Characteristics of the Hanford Reservation of the U.S. Atomic Energy Commission, Washington (3)

Information on the geological and hydrological characteristics that control many of the operations at the Hanford Reservation are obtained by well drilling, geologic mapping, and sample analysis. The Hanford Reservation is located on broad, sandy terraces along the Columbia River in the semiarid basin of south-central Washington. Basalt of Miocene and early Pliocene age of the Columbia River Group constitute the bedrock in the region. The partially eroded Ringold Formation of middle or late Pleistocene age overlies the basalt and consists of up to 1,200 feet of bedded silts and fine sands containing some gravel and one prominent gravel train. Overlying the erosional surface are glaciofluvial and fluvial deposits which underlie the wind scarred terraces. These deposits have thicknesses of up to 200 feet and consist mostly of gravel, sand, and lenses of silt. The principal water-bearing units are the basalt, conglomerate of the Ringold Formation, and the glaciofluvial and fluvial deposits. The water table lies mainly in the Ringold Formation and only locally does the saturated zone extend into the post-Ringold deposits. High terraces are used for burial of the most highly radioactive wastes. Metallic radioactive wastes are stored in these terraces in tanks, whereas fluids are disposed to the geologic materials by means of infiltration cribs. Data on the subsurface migration of nuclides from these burial sites are included in this study and the potential hazard of disposal beneath the low terraces along the Columbia River is pointed out. (Auth)(M)

<291> CONF.

This study is a good reference for any questions on the environment of shallow waste burial at Hanford. (DB/RT)

Transmissivity; Hydraulic Velocity; Effective Porosity; Depth to Water Table; Head; Thickness of Upper Aquifer

<292>

U.S. Geological Survey, Washington, DC

Forster, E. 1957. Advances in Nuclear Engineering, Vol. 3, Part 7, J.E. Fanning and B.E. Prentice (Eds.), Proceedings of the 2nd Nuclear Engineering and Science Conference held in Philadelphia, Pennsylvania, 1957, (pp. 359-371).

Atomic Waste Disposal by Injection into Aquifers (2)

The problem of injecting acid aluminum nitrate wastes into aquifers is analyzed in this paper. To a large degree, the compatibility of waste with aquifer minerals is based on rate processes, and accordingly, a realistic approach to the problem of disposal involves the time and rate of flow. Most natural aquifers that might be considered for waste disposal sites consist almost completely of a small number of minerals. The quartz, feldspar, mica, clay, limestone, and carbonate groups of minerals usually account for at least 95% of the mass of most sedimentary aquifers. From a consideration of the mineralogical composition of natural aquifers and the chemical reactions that would take place, the injection of raw acid aluminum nitrate waste into ordinary aquifers would cause the precipitation of aluminum hydroxide gels, effectively blocking further injection. By careful exploration, testing, and selection of aquifers, it might be feasible to inject wastes through well into deep aquifers under certain conditions, but there are numerous possible and probable technical difficulties inherent to the process, as well as the problem of high costs. The most likely solution to the problem of compatibility seems to lie either in chemical processing of the waste to a form that will not readily precipitate upon injection into aquifers, or in the use of an acid pretreatment of the aquifer to improve compatibility. (JRT)

PH

<293>

U.S. Geological Survey, Water Resources Division

Jones, P.H., and N.K. Skibitzke. 1963. Retention and Migration of Radioactive Ions in Soils, Proceedings of an International Colloquium held in Saclay, France, October 16-18, 1962, (1 p.).

Film: Dispersion of Aqueous Radioactive Waste in a Heterogeneous Aquifer (1)

The path taken by 203 series of tritium through an aquifer at the Idaho National Reactor Testing Station was traced. The movement was monitored by 18 observation wells at distances of 703 to 3,502 feet from the disposal well. Accurate maps of the head

distribution in the aquifer during and following the discharge were made. Also, the thickness of the aquifer was mapped. Predictions of the paths of waste movement based on analysis of the map of aquifer thickness were well substantiated whereas, the analysis based on the piezometric maps was grossly in error. Using a series of hydraulic models, it was found that the path of flow, the dispersion fan, and the rate of attenuation of the concentration of the waste water were independent of the ratio of the rate of disposal discharge to the rate of flow of ground water in the aquifer. (DBV)

Head; Stratigraphic Unit Thickness

<294>

U.S. Geological Survey, Water Resources Division

Richardson, E.E. 1963. Retention and Migration of Radioactive Ions in Soils, Proceedings of an International Colloquium held in Saclay, France, October 16-18, 1962, (pp. 297-298).

Significance of Climate in Relation to the Disposal of Radioactive Waste at Shallow Depth Below Ground (2)

Climate is important when considering a site for the disposal of radioactive waste at shallow depths. Climate controls: depth to ground water in the upper zone of rapid water circulation; distance between drainage divides of perennial surface streams or the distance between points of recharge and discharge; physical and chemical characteristics of the soil; and abundance and types of vegetation. A line extending north and south across the United States near the 97th meridian is an area in which evaporation and transpiration rates are about equal to the average annual precipitation. East of this line is the humid portion of the United States and west of the line is the arid part. In the humid regions the density of surface stream is high and the water tables are shallow. This means the retention time of precipitation reaching the water table is short, usually tens of days. Such rapid circulation is not conducive for near surface disposal of isotopes if the philosophy is "delay and decay". Arid soils with a deep water table, carbonates, and other inorganic salts are highly conducive to the philosophy of "delay and decay". However with such a low flow of water through the arid soils, there is a very real possibility of contaminating the surface water sources. This possibility is much reduced in humid areas. The contamination of surface water sources in arid regions is also controlled by the sorptive properties of the ground and the location of the disposal facility with respect to the nearest perennial surface stream down gradient as well as depth to the water table. Hence, an accidental release of high-level liquid radwastes may not be as serious as once considered. Solid, packaged radwaste burial provides only a slight possibility of contaminating either ground or surface water, provided the site is in an area of substantial depth to the water table and is removed from areas subject to floods. It appears from this study that arid sites are preferable to those in humid regions. (DBV)

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U.S. Geological Survey, Water Resources Division, Idaho Falls, ID

Arrington, J.T., W.C. Teasdale, J.S. Robertson, and E.C. Jensen. 1967, October. IDO-DE-1; 107 p.

Hydrology of the National Reactor Testing Station Idaho, 1966 (1)

Studies by the U.S. Geological Survey to determine the hydrologic effects of disposal of radioactive waste to the ground at the National Reactor Testing Station are discussed. The project involved the collection and analyses of ground- and surface-water samples for radiometric and chemical changes. The altitude of the water table in the NRTS area ranges from 4,502 feet to 4,420 feet above sea level. The average slope of the water table is about 5 feet per mile and the depth to water within the station boundaries extends northern part of the NRTS, near the Birch Creek valley, the water table gradient is relatively flat. This flat gradient is a result of relatively greater aquifer permeability or thickness than in the Birch Creek valley. The net changes of ground-water levels ranged from a one foot decline to as much as a five foot rise. The flow of the Big Lost River is derived from precipitation on its drainage area. Above Arco, the river drains approximately 1,350 square miles of which 66 square miles are irrigated. The mountains in the drainage area consist of limestones, shales, and volcanic rocks. The average discharge of the Big Lost River below Arco is about 86,000 acre-feet per year, but total water yield of the Big Lost River basin is about 330,000 acre-feet per year. The average infiltration rate during 1965 and 1966 for the Big Lost River between the NRTS diversion and the Lincoln Boulevard Bridge was 1.5 feet per day. The average infiltration rate in Area A in the NRTS diversion was 0.7 feet per day, and this rate seems reasonable because Area A is covered with silt. In Area B, the average infiltration rate was 2.6 feet per day, nearly four times as high as the rate in Area A. The soil is similar, but several basalt pressure ridges are exposed in the floor of Area B and fractures in the basalt would increase the average infiltration rate. Several places in Area B were found where the silt floor had collapsed into permeable zones in the basalt. The holes ranged from 1 to 13 feet deep and from 2 to 6 feet in diameter. Such holes help explain the high infiltration rate. Tritium is the only waste radionuclide at NRTS that can be readily detected in ground water at significant distances from points of radioactive waste disposal. The average background level of tritium in water from the Snake River aquifer is about 0.05 to 0.1 pCi/ml, or from 10 to 30 TU (tritium units). About 130 million gallons of liquid low-level radioactive waste was discharged into the TPA ponds during 1966. About 80% of the radioactivity discharged to the TPA ponds has a half-life of a few days or less. Infiltration from the TPA waste-disposal ponds has formed a perched-water body in the basalt, covering about 125 acres. Perched water in the alluvium from the chemical waste-disposal pond apparently inhibits the southward migration of the contaminated perched water from the TPA radioactive waste ponds. If migration were not retarded, the TPA supply wells could become contaminated. The estimated quantity of tritium discharged to the TPA ponds from 1952 to 1966 was about 3,730 curies. Radioactive decay would reduce this to about 2,730 curies. Dissolved chromium has been used to trace TPA pond waste water in perched

ground water bodies and down gradient 2 1/2 miles in the Snake River aquifer. Concentrations of hexavalent chromium ranged as high as 1.7 ppm in the perched water and 0.6 ppm in the water from the Snake River aquifer. Chromium serves as a good tracer of TPA wastes because it does not occur in nearby KPP wastes, and is not usually present in natural waters, and can be determined in very low concentrations.

Depth to Water Table; Infiltration Rate; Hydraulic Gradient; Head; Storage Coefficient

<296>

U.S. Geological Survey, Water Resources Division, Idaho Falls, ID

Robertson, J.S. 1970, May. IDO-22050; U.S. Geological Survey Open-File Report; 51 pp.

Digital Modeling of Radioactive and Chemical Waste Transport in the Snake River Plain Aquifer at the National Reactor Testing Station, Idaho (1)

The NRTS, located in a deserial part of SE Idaho, overlies the Snake River aquifer which is about 1,000 ft thick. The flow of groundwater in the aquifer is to the southwest at velocities from 5-25 ft/day. Since 1952, dilute or low-level aqueous chemical and radioactive wastes have been discharged to the Snake River aquifer by means of disposal wells and seepage ponds. Since 1962, the effluent has contained an average of 460 Ci of H 3, 0 Ci of Sr 90, and 7 Ci of Cs 137. Digital (numerical) modeling is applied to the water and contaminant transport in the Snake River Plain Aquifer using finite difference methods. Simulation includes effects of convection, dispersion, adsorption, and radioactive decay. The proposed model used only the upper 250 ft of the Snake River Aquifer. Porosity was estimated to be 10%. Due to heterogeneities, the dispersivities and distribution coefficients could not be measured, and were therefore estimated. The model has been used to estimate future waste migration patterns for varied assumed hydrogeological and waste conditions up through the year 2000. The model indicates that chloride and tritium could move as much as 15 miles downgradient and Sr 90 only 2 to 3 miles. (OO) (770)

Simulation of hydraulic flow regime and radionuclide transport for the NRTS using finite difference methods. Summary of hydrogeologic parameters applicable. Comprehensive and thorough reference, currently applicable. (DR/OM)

Depth to Water Table; Transmissivity; Horizontal Flow Rate

<297>

U.S. Geological Survey, Water Resources Division, Washington, DC

Callahan, J.F. 1972, May-June. Ground Water, 10(3), 6-9; National Water Well Association, Proceedings of an Annual Meeting held in Las Vegas, Nevada, December 5-8, 1971, (8 pp.).

The Role of the U.S. Geological Survey in Waste Disposal Monitoring (1)

<297> CONT.

The disposal of all types of liquid and solid wastes threatens the health and well-being of mankind. In recent years the constraints on the disposal of industrial and municipal wastes into rivers and the seas have prompted the disposal through wells into the subsurface. Limestone terrane is particularly amenable to the acceptance of all types of wastes in the cavernous subsurface, and has resulted in widespread contamination of shallow ground-water resources. Highway salting has caused the contamination of thousands of household wells, causing large-scale replacement drilling programs in some northern States. A sanitation problem also has arisen, because liquid wastes injected into the subsurface have not been disposed of, but rather have been placed in a new environment. They may be in storage, they may be attenuating, or they may be changing character by reaction with the rock mass or formation fluids. The U.S. Geological Survey has been concerned with the study of ground-water resources for more than 60 years, and with the problems of radioactive waste contamination since World War II. A newly identified program of investigations of waste emplacement into the subsurface was begun two years ago. The purpose of the program is to develop the ability to predict the fate of any wastes deliberately or accidentally emplaced in the subsurface. The program includes research contracts and grants with universities and governmental organizations as well as in-house research. (Auth)

<299>

U.S. Geological Survey, Water Resources Division, Idaho Falls, ID

Robertson, J.B., R. Schoen, and J.F. Sarracough. 1970, February. IDO-22053; 231 pp.

The Influence of Liquid Waste Disposal on the Geochemistry of Water at the National Reactor Testing Station, Idaho: 1952-1970 (1)

Comprehensive discussions of liquid waste disposal at NRTS and the effects of such disposal on the geochemistry of groundwater are included. The geologic, hydrologic, meteorologic and geochemical conditions in the region and at the site are described to develop a sufficient background against which any changes in the environment resulting from operations at NRTS can be compared. The U.S.G.S. investigated the subsurface movement of low-level radioactive wastes and examined the geologic, hydrologic, and geochemical factors which control such movement. Geologically, the NRTS site is located in a structural basin extending northeast-southwest and filled with 5,000 feet or more of interbedded basaltic lava flows and consolidated lacustrine and fluvial silt, clay, sand, and gravel. Unconsolidated surficial deposits are lacustrine, fluvial, and eolian in origin. Geochemically, the groundwater beneath the Snake River Plain relatively is low in dissolved solids, but exhibits a composition indicative of reaction with minerals in the rocks of the surrounding mountains. No evidence of reaction with rocks of the Snake River Plain is present. Water with higher dissolved solids are introduced by recharged irrigation water which quickly loses its identity through dilution and dispersion. Radiochemical, chemical and sanitary wastes introduced from seepage ponds to perched water bodies and the regional aquifer and from deep

injection wells to the regional groundwater aquifer were traced by sampling strategically located observation wells. Some wastes were found to percolate downward first to perching beds and eventually to the regional groundwater aquifer. Movement of the groundwater within the regional aquifer was toward the south rather than directly down the hydraulic gradient which is toward the southwest. This is attributed to anisotropy and heterogeneity of the aquifer. Two radioactive isotopes, Sr 90 and H 3 were detectable over a significant area. Other isotopes were not detectable for a number of reasons including insufficient discharge concentrations, short half lives and rapid sorption reactions acting to reduce concentrations. (Auth)

Excellent discussions of geology, hydrology, and geochemistry of NRTS which are applicable to shallow land burial. (DM/CM)

Transmissivity; Hydraulic Velocity; Effective Porosity; Storage Coefficient

<299>

U.S. Naval Research Laboratory, Washington, DC

Lochhart, R., W.L. Pitterson, and A.W. Saunders. 1965, December 15. Journal of Geophysical Research, 70(24), 6033-6041.

The Size Distribution of Radioactive Atmospheric Aerosols (2)

Atmospheric air containing natural and fission product radioactivity was passed through a series of filters of decreasing pore size. The size distribution of the radioactive particles in the atmosphere was deduced from the relative amounts of radioactivity collected on the various filters and a knowledge of the retention characteristics of the filters as a function of particle size. Results of analyses conducted indicate that short lived radon daughter products are associated primarily with particles less than 0.3 μ in diameter while fission products from the stratospheric source of old nuclear bomb detonations are associated with particles ranging between 0.5 μ to 1.0 μ in diameter. The larger size of the fission product activity particles suggests that the fission particles attach themselves to airborne as they migrate towards the ground surface. It is concluded that the distribution of radioactivity with respect to particle size is governed by meteorological factors which control the generation, coagulation and deposition of aerosol particles. (Auth) (J7)

A review of sampling equipment and procedures used and results of analysis obtained in the investigation of particle size distribution. Data are present in tabular form. (DM/J7)

<300>

U.S. Nuclear Regulatory Commission, Office of Nuclear Material Safety and Safeguards; U.S. Nuclear Regulatory Commission, Office of State Programs

Cunningham, P.E., K.S. Dragonette, J.A. Cedars, P.G. Ryan, P.H. Lohaus, and J.S. Burns. 1977, March. NUREG-0217; 60 pp.

<300> CONT.

SBC Task Force Report on Review of the Federal/State Program for Regulation of Commercial Low-level Radioactive Waste Burial Grounds (1)

The issue of Federal vs. State regulation of commercial radioactive waste burial grounds is explored in the report. The need for research and development, a comprehensive set of standards and criteria, a national plan for low-level waste management, and perpetual care funding are also discussed. Five of the six commercial burial grounds are regulated by agreement states; the sixth is regulated solely by the SBC. The sites are operated commercially and the operators contribute to the perpetual care fund for the sites at varying rates. The states have commitments for the perpetual care of the decommissioned sites except for one site, located on Federally owned land. The states, through their regulatory programs have adequately protected the public health and safety. However, waste disposal in a national low-level waste disposal program. The citizens of individual states should not bear the cost of major contingency actions or inadequacies in perpetual care funding for burial sites which serve national rather than state needs. The SBC Task Force recommends that federal control over the disposal sites should be increased by requiring joint federal/state site approval, SBC licensing, federal ownership of the land, and a federally administered perpetual care program. In addition, the Task Force recommends that the SBC accelerate the development of its regulatory program for the disposal of low-level waste, to insure the avoidance of an unbridled proliferation of low-level burial sites, and to evaluate alternative disposal methods. (JN)

<302>

U.S. Nuclear Regulatory Commission, Washington, DC

Reer, G.W., W. Gamill, J. Kautner, L.G. Nelson, G.P. Yori, J.S. Wood, and P.H. Lohaus. 1975, July 7. SBC Review Group Report: 18 pp.

Report of the Nuclear Regulatory Commission Review Group Regarding Honey Flats, Kentucky Commercial Radioactive Waste Burial Ground (3)

An SBC review group was appointed consisting of staff members knowledgeable in Agreement State relationships, hydrology, and radiological assessment to conduct an assessment of the current situation at the Honey Flats Disposal Site, and to provide findings. Report conducts a radiological and hydrological assessment of the site, and provides specific and general recommendations for consideration by the state. (00)

Summary of the status of the Honey Flats Disposal site from the regulatory point of view. (DN/00)

<307>

U.S. Water Conservation Laboratory, Phoenix, AZ

Watson, R.R. 1967. Soil Science Society of America, Proceedings, 31, 716-720.

The Measurement of the Hydraulic Conductivity of

Unsaturated Porous Materials Utilizing a Zone of Entrapped Air (2)

Methodology for the determination of the relationship between hydraulic conductivity and water content in unsaturated porous materials is presented in this report. The method utilized a column filled with the compacted soil of interest with transducer-pressure transducer assemblies for pressure head readings and ceramic-tipped transducers for air pressure measurements. An initially saturated column of porous material is allowed to drain to a specified water table at its base. After an appropriate delay the column is taken by the opening of a few centimeters of water at the column head. This action initiates an increase in the pore air pressure in a zone of entrapped air which lies between the wetting and draining fronts. Physical consequences of this flow condition include the formation of a well-defined water content which is determined quantitatively by mass attenuation ratios and the rapid attainment of steady-state conditions. This effect for the determination of the hydraulic conductivity to water content relationship is termed "water content in that mode." (JN)

This article presents a relatively simple laboratory determination procedure for unsaturated zone conductivity. (DN/JN)

Volumetric Water Content, Hydraulic Conductivity, Unsaturated, Head

<303>

U.S. Weather Bureau, Oak Ridge, TN

Clifford, V. 1956, October. TID-7517 (Part 1A); Sanitary Engineering Aspects of the Atomic Energy Industry, Proceedings of a Seminar held in Cincinnati, Ohio, December 6-9, 1955, (pp. 57-59), 609 pp. (TID-7517, Part 1A).

Meteorological Parameters in Waste Disposal (3)

Meteorologists become interested in the problem of waste disposal either when the atmosphere is used as a vehicle for the transport and diffusion of waste products or when the disposal of wastes into some other media can be shown to depend on atmospheric processes. An area of concern is in connection with waste disposal in open pits, since the rate of evaporation from such pits is atmosphere-dependent. Fundamentally, the rate of any kind of material taken up by the atmosphere is controlled by the initial gradient of the property and the strength of the air turbulence. Wind variability, turbulence, is controlled largely by vertical atmospheric temperature gradients. This turbulence can be classified into four regions of mean wind speed and thermal stability and are known as the "Boussinesq turbulence types". Classical theories of conduction and aerodynamic boundary layer conclude a property is dispersed most rapidly when: turbulence intensity is greatest; degree of thermal stability is least; mean wind speed is greatest; and the gradient of the property is greatest. These theories also try to account for secondary effects such as roughness of ground surface and rate of deposition or absorption on the ground. To determine the evaporation rate, the necessary data were collected and calculations by three complementary methods were performed. The three methods are: Weather Bureau evaporation pan; U.S. Geological Survey evaporation pan; and one of one or more "mass transport" theories.

(193) CONT.

In the field study at Oak Ridge a multipronged approach was used due to small size of the pits, and the hilly nature of the surrounding terrain which may cause dispersion effects. (1909)

(194)

Union Carbide Corporation, Nuclear Division, Oak Ridge, TN

Coplin, B.V., P.J. Nye, and L. Sutland. 1976. "OSW-760901: Packaging and Transportation of Radioactive Materials, Proceedings of the 5th International Symposium held in Miami Beach, Florida, September 22-27, 1976, (pp. 504-516). 1047 pp. (OSW-760901).

A Cost-Benefit Analysis of Disposable and Reusable Radioactive Shipping Containers (9)

A cost benefit comparison was made between disposable and reusable shipping container concepts for handling radwaste from nuclear power generating plants. For this study, reinforced concrete containers were used to typify the disposable container concept, and thin shell steel containers with lead and steel auxiliary shields were used to typify the reusable container scheme. Concrete containers were found for this example to be economically competitive and could represent a significant savings in overall waste disposal costs. Other equally significant advantages which may also result from the use of disposable concrete containers include reduced shield inventories, maintenance, or rental costs for the utility; fewer shelving problems associated with availability of shielding for radwaste transportation; more convenient and safer handling at the power station and the burial site; potential longterm durability and ease of retrievability at the burial site. (Auth)

The paper evaluates the feasibility of utilizing large disposable containers for other than high-level wastes generated at nuclear power stations. (OR/ST)

(195)

Union Carbide Corporation, Office of Waste Isolation, Oak Ridge, TN

Shoup, R.L. 1977, July-August. Nuclear Safety, 18(4), 502-512.

International Waste-Management Symposium (3)

An International Symposium on the Management of Wastes from the LWR Fuel Cycle was held in Denver, Colorado, on July 11-16, 1976. The symposium covered a broad range of topics—from policy issues to technology. Presentations were made by national and international speakers involved in all aspects of waste management—government and agency officials; laboratory managers, directors, and researchers; and industrial representatives. Many speakers advocated pragmatic action on programs for the management of commercial nuclear wastes to complete the light-water reactor (LWR) fuel cycle. The industrialized nations' demand for increasing supplies of energy and their increasing dependence on nuclear energy to fulfill this demand will necessitate the development of an acceptable solution to the disposal of nuclear wastes within the next decade for some industrial nations. Waste-disposal technology should be implemented on a commercial scale, but the commercialization must be accompanied by the decision to use the technology. An important issue in the use of nuclear energy is the question of sharing the technology with the less industrialized nations and with nations that may not have suitable means to dispose of nuclear wastes. The establishment of international and multinational cooperation will be an important key in realizing this objective. Pressing issues that international organizations or task groups will have to address are ocean disposal, plutonium recycling and safeguards and disposal criteria. The importance of achieving a viable waste-management program is made evident by the increased funding and attention that the back end of the fuel cycle is now receiving. (Auth)

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Argonne National Laboratory, Chemical Engineering Division, Argonne, IL; University of Missouri at Rolla, Rolla, MO

Trevorrow, L.E., D.L. Warner, and R.J. Steindler. 1977, March. ANL-76-76; Considerations Affecting Deep-Well Disposal of Tritium-Bearing Low-Level Aqueous Waste from Nuclear Fuel Reprocessing Plants, Section 5, (pp. 4-70), 190 pp. (ANL-76-76).

Legal and Regulatory Controls (9)

The section considers the legal and regulatory requirements and implications of injection of aqueous wastes. The regulation of the actual disposal operation would be the responsibility of the selected state agency, the EPA and possibly the 190 Public Law 92-523, Safe Drinking Water Act. Licensing a low-level aqueous waste facility would require Federal as well as state permission. The applicant would be required to submit a preliminary safety analysis report as part of an application for a construction permit. This application would be subjected to a technical review by the regulatory staff and a public hearing. After final design information is developed, the applicant would be required to submit a final safety analysis report (FSAR). This FSAR would be subjected to a technical review and may or may not be subjected to a public hearing. States which have adequate regulatory programs would assume control as the primary regulatory body. The potential roles of EPA and the USIS are reviewed. (JT)

Addresses the various legal and regulatory requirements that should be considered in selecting a site. (RM/JT)

<307>

Argonne National Laboratory, Chemical Engineering Division, Argonne, IL; University of Missouri at Rolla, Rolla, MO

Trevorrow, L.E., D.L. Warner, and R.J. Steindler. 1977, March. ANL-76-76; Considerations Affecting Deep-Well Disposal of Tritium-Bearing Low-Level Aqueous Waste from Nuclear Fuel Reprocessing Plants, Section 3, (pp. 22-66), 190 pp. (ANL-76-76).

Siting of a Waste Injection Well (9)

In considering a potential site for selection as a disposal area, information on (a) the structure, lithology and stratigraphy of the host rock; (b) the chemical composition and physical characteristics of the native subsurface water; (c) hydrologic characteristics (permeability, porosity, etc.); and (d) mineral resources of the area should be obtained. Determination of the potential flow patterns and projected rates of movement is important in analysis of when waste may enter the biosphere. Average porosity of the St. Simon formation in Illinois ranges from about 24 to 16%. Average permeability values for the St. Simon formation was from more than 100 millidarcies in the north to less than 1 millidarcy in the south. The storage coefficient was estimated to be a high value of 0.8 to 0.9 (R-J) due to the thickness of the aquifer. At the location of the Empire - Nevers injection well, the hydraulic gradient is 6 ft/mile toward the northeast, the permeability was 20 millidarcies, and the porosity was 0.04. Hydraulic fracturing, inducing fractures by

injection of water under pressure may significantly alter the flow pattern of the aquifer. Well logging techniques that can be used to obtain data on the subsurface environment include spontaneous potential (determination of water resistivity), gamma-gamma (relation of bulk density to porosity and lithology), neutron gamma (porosity), and gravity meter (formation density). Injection of water under pressure may induce earthquakes or fractures as a result of the alteration of significant stress directions. The potential for production of these stresses must be addressed. (JT)

The geologic and hydrologic parameters addressed in the report are important regardless of the mode of disposal, only the relative significance will change. (RM/JT)

Hydraulic Gradient; Seepageable Unit Thickness; Retention Capacity; Permeability Coefficient; Storage Coefficient

<308>

Argonne National Laboratory, Chemical Engineering Division, Argonne, IL; University of Missouri at Rolla, Rolla, MO

Trevorrow, L.E., D.L. Warner, and R.J. Steindler. 1977, March. ANL-76-76; Considerations Affecting Deep-Well Disposal of Tritium-Bearing Low-Level Aqueous Waste from Nuclear Fuel Reprocessing Plants, Section 2, (pp. 6-22), 190 pp. (ANL-76-76).

Characteristics of the Waste Fluids to be Injected (9)

Data on the characteristics of low-level aqueous wastes resulting from the commercial reprocessing of non-military power reactors is poorly defined. The predicted characteristics summarized in this report are based, somewhat, on the flow sheets from the Allied-General Nuclear Services and Nuclear Fuel Services, Inc. plants. Heavy low-level wastes are projected as having a density of 0.998 kg/l at 0 deg C and 0.9972 kg/l at 20 deg C while waste from a process up pit would have a specific weight in the range of 1.03 to 1.06 kg/l. Viscosity of the low-level aqueous is expected to be approximately 1.0 centipoise at 20 deg C while the viscosity of untreated process waste will be 1.05 to 1.10 centipoise at 20 deg C. Chemically, the wastes will be acidic (pH of 2) and be reactive with materials in the mechanical systems, the fluid in the aquifer and the minerals composing the aquifer. From a chemical standpoint, it is estimated that the normal low-level waste will present no potential health hazard except for nitrate. The nitrate concentration is estimated to be 11.8 times greater than the P.H.S. Drinking water standards. (JT)

Provides the generic physical and chemical characteristics of low-level wastes. The extent to which this data may be utilized with respect to shallow land burial is questionable. (RM/JT)

<309>

Argonne National Laboratory, Chemical Engineering Division, Argonne, IL; University of Missouri at Rolla, Rolla, MO

Trevorrow, L.E., D.L. Warner, and R.J. Steindler.

CONFIDENTIAL READER

(307) COST.

1977, March. ARL-76-76; 190 pp.

Considerations Affecting Deep-Well Disposal of Tritium-Bearing Low-Level Aqueous Waste from Nuclear Fuel Reprocessing Plants (3)

Factors to be considered with respect to the deep well disposal of low-level aqueous wastes are discussed. Present concepts of disposal of low-level aqueous wastes (LLAW) that contain much of the fission-product tritium from light-water reactors, involve dispersal to the atmosphere or to surface streams at fuel reprocessing plants. These concepts have been challenged in recent years. Deep-well injection of low-level aqueous wastes, an alternative to biospheric dispersal, is the subject of this presentation. Many factors must be considered in assessing its feasibility, including technology, costs, environmental impact, legal and regulatory constraints, and siting. Examination of these factors indicates that the technology of deep-well injection, currently developed for other industrial wastes, would require little innovation before application to low-level aqueous wastes. Costs would be low, of the order of magnitude of 10 (\$10-20) million. The environmental impact of normal deep-well disposal would be small, compared with dispersal to the atmosphere or to surface streams; abnormal operation would not be expected to produce catastrophic results. Geologically suitable sites are abundant in the U.S., but a well would best be collocated with the fuel-reprocessing plant where the LLAW is produced. Legal and regulatory constraints now being developed will be the most important determinants of the feasibility of applying the method. Sections 2, 3, and 5 were separately entered into the data base. (Auth) (JW)

German to tritium-bearing low-level waste deposited in deep wells so it is relevant in terms of low-level waste but slightly in terms of SIB. (DH/SW)

(3107)

Nattelle-Pacific Northwest Laboratories, Richland, WA; University of Montana, Water and Land Resources Department, Missoula, MT; Washington State University, Pullman, WA

Peismann, A.E., D.B. Cawlock, C.A. Bryan, and G.S. Campbell. 1975. BNWL-1713; 32 pp.

Partially-Saturated Transient Groundwater Flow Model Theory and Numerical Implementation (3)

The mathematical development of a computer model used to test the formulation for simulating isothermal, unsaturated, liquid flow in heterogeneous is described. Such a model is needed because radwaste at Hanford are stored in the ground in unsaturated sediments lying between 45 and 60 m above the regional water table and because the vadose zone is relied upon as a safety factor to minimize radwaste access to the ground water in case of storage tank leakage. The model is designed to predict moisture movement in sediments as a function of time and space for the initial and boundary conditions specified. Some of the assumptions for the model are: 1) Darcy's law is valid for types of sediments and gradients in the vadose zone; 2) pressure head is a unique function of the volumetric moisture content; 3) hysteresis is a second order effect; 4) soil is isotropic; 5) flow is

isothermal; 6) hydraulic conductivity is a unique function of the moisture content; 7) hydraulic characteristics of the sediments are not altered by the chemical composition of the waste. A brief theoretical analysis and functional description of the model characteristics are provided. In the model, due to simplification of the descriptive equations, finite difference approximation (crank-nicolson method) and an iterative technique (Gauss-Seidel) were used to obtain the solutions. When used the model proved to be computationally slow and somewhat impractical as a management tool let alone the equation could be solved for flow entering dry soils. (DHV)

INDUSTRY

(311)

Atlantic Richfield Company, Richmond, VA; University of Michigan, Ann Arbor, MI; Computer Sciences Corporation, Richmond, VA; University of Missouri, Columbia, Mo

Isaacs, R.E., L.E. Russell, R.P. Wilson, and L.L. Roethlis. 1976. January. BNWL-169; COW-740312; INH/SA-102/6; Isotope Techniques in Groundwater Hydrology, Proceedings of a Symposium held in Vienna, Austria, March 11-15, 1976, (25 pp.) (BNWL-169, COW-740312, INH/SA-102/6).

Soil Moisture Transport in Arid Site Vadose Zones (2)

A comprehensive ongoing study of soil moisture transport in the vadose zone is being performed at the USERDA Hanford site in the state of Washington. Field investigations have included tritium profiling, temperature, pressure and humidity data collection, and the construction of a lysimeter. Tritium profiles in the unsaturated zone have indicated that percolation of meteoric waters appears to be largely restricted to the upper several meters. In situ temperatures and water potentials were measured in four wells drilled from the ground surface to the water table (about 90 meters) by the use of temperature transducers and thermocouple psychrometers to establish thermodynamic data for moisture transport studies. Two lysimeters, one open bottom and one closed bottom, were installed complete with redundant moisture measuring devices (FHR, neutron probe access tubing and a similar temperature transducers thermocouple psychrometer set up as used in the wells. Theoret. 1) mathematical models based on conservation of momentum expressions have been developed to analyze nonisothermal soil moisture transport. The field work and theoretical work will be integrated to formulate a detailed water balance which will be able to predict fluid inputs which could generate migration to the water table. (Auth) (JC)

A very thorough unsaturated zone study is presented here. However, it is unfortunate that a more detailed discussion of how the lysimeter data are evaluated is not present. See also BNWL-2983, (DH/JC, ESIC/CS)

Volumetric Water Content; Depth to Water Table; Moisture Potential

<112>

Oak Ridge National Laboratory, Oak Ridge, TN;
 Atomic Energy Establishment, Trombay, Bombay,
 India

Wohlin, A.L., E.G. Jacobs, and E.G. Straszynski.
 1962, August 11. ONSL-TN-329: 19 pp.

Ruthenium Sorption by Minerals (1)

At ONSL, investigations were made of the ruthenium sorptive properties of sulfide minerals. In view of the chemical nature of ruthenium, a two-fold approach was made in the study of ruthenium retention. First, an attempt was made to take advantage of the insolubility of laurite (PuS_2) by replacing Pu for other lattice ions at the surface of a number of sulfide minerals. Secondly, attempts were made to reduce Pu to positively charged species for subsequent sorption by natural cation exchangers. The four sulfide minerals used as sorptive media were pyrite (FeS_2), chalcocite (Cu_2S), chalcocite (Cu_2S), and stibnite (Sb_2S_3). Slurry studies of the effect of particle size of the sulfide minerals were inconclusive. With varying hydrogen ion concentration (pH 3 to 0.22 N HCl) ruthenium removal was greatest between pH 6 and pH 10. This is the range in which the maximum formation of polymeric ruthenium species would be expected. Ruthenium removal from diluted deep solution (pH 11.8) by 270 mesh chalcocite ore was maximum with 1 g of ore per 100 ml of solution. It was found that appreciable sorption can be obtained on sulfide minerals if the ruthenium is present in a suitable chemical form. Strong reducing agents in alkaline media (for example $Na_2S_2O_4$) improve sorption of ruthenium, but rather large quantities are necessary. The sulfide minerals do not do an effective job in reducing the ruthenium to an easily sorbed form. (JST)

09

<113>

U.S. Geological Survey, Washington, DC; CEN, Mol,
 Belgium

Stepson, E.S. 1962, March. YID-7629; Ground
 Disposal of Radioactive Wastes, J.N. Morgan, Jr.,
 et al (Eds.), Proceedings of a Conference held in
 Chalk River, Canada, September 26-29, 1961, (p.
 145-154), 635 pp. (YID-7628).

Investigations on the Movement of Radioactive Substances in the Ground: Part 1. Geohydrology and General Considerations (2)

Investigations were conducted at two waste
 burial sites to determine to what degree an
 environment of low containment (a site
 underlain mostly by permeable sand) may be
 used for the disposal of relatively insoluble
 waste as opposed to a site with an environment
 of high containment for the disposal of
 untreated or relatively soluble waste. A
 method was developed to study the velocities
 and patterns of groundwater at each site. The
 method utilizes a metal tube encased well into
 which a radiation detector is lowered. The
 detector measures the amount of a tracer
 isotope which has been injected into the
 groundwater and is picked up by a chemically
 reactive coating on the surface of the well
 tube. The amount of tracer picked up in a
 given time interval is related to groundwater
 velocity. Alternatively the tube could be
 coated with a radioisotope and the amount lost
 to reaction with a known dissolved solid would
 indicate groundwater velocity. (CAB)

Brief discussion of factors affecting subsurface
 migration of radiocontaminants. Proposes method
 for detecting groundwater flow velocities,
 direction, anisotropies, etc. (DA/CAB)

<314>

William R. Wickfield Hanford Company, Research and Engineering Division, Research Department, Richland, WA; Boeing Computer Services Richland, Inc., Scientific Systems Department, Richland, WA; Battelle-Pacific Northwest Laboratories, Water and Land Resources Department, Richland, WA

Arnott, R.C., R.A. Dejeu, R.W. Nelson, C.B. Cole, and R.E. Gephart. 1976, October. 228-57-103; 107 pp.

Conceptual and Mathematical Modeling of the Hanford Groundwater Flow Regime (2)

Disposal of radioactive wastes to surface disposal sites at the Hanford Atomic Reservation has resulted in some radioactive and chemical contamination of the underlying groundwater flow system. In support of the Hanford groundwater management effort a preliminary conceptual model of the groundwater system has been formulated as a first step in understanding possible contaminant movement. The mathematical modeling capabilities needed for better understanding and prediction of such contaminant movement are discussed in this paper and the state-of-the-art in groundwater modeling as related to Hanford is summarized with emphasis upon computer solution methods. A set of operational flow and transport codes which allow us to model the unconfined aquifer in two-dimensional, horizontal space. A two-dimensional parameter identification code for calculating a hydraulic conductivity distribution throughout the Hanford Reservation is also available. These models have been tested using synthetic cases and verified as far as possible using actual Hanford field data. An inventory of potentially applicable codes available both at Hanford and elsewhere is included. The areas where groundwater modeling capability is lacking are outlined and the steps needed to overcome such deficiencies discussed. (auth) (UK)

Derivation of a mathematical model is discussed. Although little specific data is presented, some general geologic and hydrologic information is given. (251C/UK)

<315>

Oak Ridge National Laboratory, Oak Ridge, TN; Plunkhote Company

Watson, C.D., A.J. Seiberg, and G.A. West. 1958, August. Industrial and Engineering Chemistry, 50(8), 878-884.

Asphalt Linings of Radiochemical Waste Storage Basins (8)

One method of storing long-lived high-level radioactive wastes is to put them in an asphalt lined storage basin. Since such asphalts have softening points, it will be necessary to first neutralize and decay the wastes so the heating temperature does not exceed 150 degree F. When the temperatures are low, the membranes remain flexible and have high durability, especially when relieving internal stresses without failure. The asphalt will require more than 25 years to acquire a dose of 10(E+9) R. It is noted that gamma irradiation of asphalts causes: evolution of hydrogen and carbon dioxide, resulting in 18 to 30% volume increase in honeycomb structure; increase in softening point, slight increase in infusibility, and decrease in penetration; decrease in flash point, but no increase in "loss on heating" or solubility in carbon tetrachloride; and increase in asphaltene and resins and decrease in oils. Cost of constructing a 1 million gallon basin would be \$0.03/gal, when a roof is required the cost would be \$0.07/gal. A 5 million gallon basin would cost \$0.02/ gal. and with a roof \$0.05/gal. In 1956 an asphalt lined basin of 300 million gallons was constructed without a roof for about 1.5 mils/gallon. It appears the use of either plant-type or membrane-type asphalt lined storage basins may be practical. (NOV)

REPORT

<116>

American Society of Mechanical Engineers, Nuclear Engineering Division

Wheeler, R.W., and J.W. Bicket. 1976. COMF-740104; American Society of Mechanical Engineers, Proceedings of the Winter Meeting held in New York, New York, November 17-21, 1976, (2 pp.) (COMF-740104).

Waste Solidification Cement or Urea Formaldehyde (2)

The advantages and disadvantages of the two major radioactive waste solidification systems are presented. The report describes the operations of these type systems and presents figures to illustrate the general procedures. Operational data on radioactive waste volumes for recent PWR's, projected design volumes for other PWR's and BWR is presented in tabular form. The physical properties of Portland cement, Portland cement with sodium silicate additives and urea formaldehyde are compared in tabular form. The comparisons include tolerance for variations in mixing proportions, the resultant amounts of residual water, shelf life, and shipping efficiency. Estimates of annual operating costs for the Portland cement, Portland cement with sodium silicate, and urea formaldehyde are presented for high and low waste volume PWR's as well as BWR's. (JC)

Good summary review of general physical properties and operational costs for cement and urea formaldehyde solidification systems. (D1/JC)

<117>

Burns and Poe, Inc.

Richardson, J.B. 1976, January. Nuclear Engineering International, 19(212), 31-37.

Radioactive Waste Quantities Produced by Light-Water Reactors (2)

Operational statistics for radioactive liquids, gases, and solids from light water reactors up to 800 MW(e) are tabulated together with projections for 1100 MWe reactors. Handling and transportation procedures for the radioactive wastes and spent fuel are described. Solidification and immobilization techniques employed at these LWR's or at commercial burial sites are also described. Waste processing, transportation and burial costs are outlined. (Both)(JC)

Excellent general discussion on radioactive waste quantities generated at LWR's as well as information on costs of processing, transportation, and burial. (DN/JC)

<118>

Caroline Power and Light Company

Webster, R.N. 1976, September. COMF-740901; Packaging and Transportation of Radioactive Materials, Proceedings of the 8th International Symposium held in Miami Beach, Florida, September 22-27, 1976, (pp. 483-489), 1067 pp. (COMF-740901).

Waste Packaging and Cost Analysis (4)

The H.B. Robinson Nuclear Plant is a pressurized-water reactor located near Hartsville, South Carolina. The wastes generated during 1973 included 526 cubic feet of spent resins, 750 liters of evaporator concentrates and 750 liters of miscellaneous solid waste. The costs of packaging and disposal were \$25.04 per cubic foot for resins, \$15.82 per cubic foot for evaporator concentrates and \$8.53 per cubic foot for miscellaneous solid wastes. (Both)(JT)

A review of volumes of wastes generated at the H.B. Robinson Nuclear Plant, South Carolina and their associated costs. Data are limited to this one plant. (DN/JT)

<119>

Danes and Moore, White Plains, NY

1976, October. Interim Status Report, First Stage; 117 pp.

Development of Methods to Eliminate the Accumulation and Overflow of Water in the Trenches at the Radioactive Waste Disposal Site at West Valley, New York (1)

In 1975 it was discovered that high water levels in radioactive waste burial trenches at West Valley, New York had resulted in formation of surface seeps. An investigation was begun by Danes and Moore to determine the extent and pattern of migration of waterborne radionuclides from trenches and to identify the geohydrologic characteristics that influence such migration. Methods for eliminating the accumulation and overflow of water in the trenches were to be evaluated in terms of technical feasibility, possible radiation doses to operating personnel and the public, cost effectiveness and compliance with applicable rules and regulations. In the course of the investigation two sources of accumulated water were identified: 1) infiltration of precipitation through the trench soil cover and 2) to a much lesser extent, ground water movement from adjacent silty till. Two general approaches to the overflow problem were suggested. The first was the limiting of infiltration of precipitation into the trenches by emplacement of a low permeability barrier over trenches. The second approach was the regular removal of accumulated water by pumping and treatment of the contaminated water. For the impermeable barrier option, 11 potential methods were considered for reducing infiltration into the trenches. It was determined that use of synthetic liners and pumping accumulated trench water were the two most viable options for reducing trench-water accumulation to the greatest extent. The use of an asphalt cap exhibits the highest ratio of trench-water reduction to annualized cost. The pumping option exhibited a low ratio of water accumulation reduction to annual costs because of high estimated operational costs. It is pointed out that the use of synthetic liners and caps should be instituted only after relative stability of the trench pond cover has been achieved and localized seeping has ceased. The need for a regular, intensive trench-water monitoring program was stressed. (CAB)

Thorough discussion of remedial action for specific trench water problems. (DN/CAB)

Infiltration Rate; Hydraulic Velocity; Permeability Coefficient

<320>

Dames and Moore, White Plains, NY

1977, March. Report to the Executive Department for Finance and Administration, Commonwealth of Kentucky; 189 pp.

Assessment of the Levels, Potential Origins and Transport Routes of Radioactivity Measured in the Vicinity of the Haney Flats Low-Level Radioactive Waste Disposal Site (1)

The purpose of this study was the development of a unified body of critical data and analyses from the numerous previous investigations at the Haney Flats commercial low-level radioactive waste disposal site, to determine what conclusions could be drawn as to the status of the site with respect to radionuclide migration, and to define and specify areas where more information is necessary for an adequate understanding of the present and future status of the site. The available literature and data about the site was collected, summarized and evaluated. The discussions include extensive information on the hydrogeologic conditions at the site, the characteristics and activity of the buried wastes, evaluation of site surface contamination, the scope of the current water management program, the impact of radionuclide emission from the evaporator stack, the nature of the trench leachate, the concentration of observed radioactivity in the environment, and evaluation of the current monitoring program, and calculations of dose commitments to the public. Two large appendices are provided which include extensive hydrogeologic and radiologic data. Trench water and spillage during waste operations were identified as the two basic origins of radioactivity which contribute to emissions. Air, surface runoff, interflow, and subsurface flow are the four potential routes of radionuclide migration. Although the nature and size of the data base precludes the drawing of specific quantitative conclusions, it is apparent that surface runoff and the evaporator stack effluent currently account for a large portion of the observed disposal of radioactivity in the environment. Recommendations on water management alternatives and extended care and maintenance were presented. Recommendations on the expansion of the current monitoring program were also made. No significant health problem to the public associated with the release of radioactive material from the site was identified. (JC)

A very thorough review and critique of the available information on Haney Flats. (DN/JC)

Depth to Water Table; Hydraulic Conductivity; Distribution Coefficient; Transmissivity

<321>

Dames and Moore, White Plains, NY

1977, August. Report to New York State Energy Research and Development Authority; 76 pp.

Second Stage Study: Low-Level Radioactive Waste Management Program at West Valley, New York (1)

This report includes the results of the second stage study performed at the low-level radioactive waste burial site located at West Valley, New York. Field data from the site investigation as well as an evaluation and recommendations for site improvement and rehabilitation. These studies were initiated

as a result of the observation of seeps from Trenches 4 and 5. The two stage program was initiated to determine the cause of, and recommend solutions, to the trench water accumulation and overflow problem. The second stage study consisted of a field soils exploration and laboratory testing program to establish the pertinent physical and engineering data necessary for trench cover rehabilitation specifications. Surface and subsurface soil conditions in the area of Trenches 1 through 5 were explored by digging 16 test pits into the trench cover, and by conducting numerous field tests. Undisturbed soils samples were obtained for detailed laboratory analysis for such parameters as permeability, dry density, and moisture content. After careful examination of the trench cover property data, a detailed rehabilitation program was recommended. Recommendations include the excavation and removal of some contaminated and poor engineering quality soil from the trench covers, the thorough reconstruction of the cover materials, the installation of a single or double barrier synthetic liner, and the construction of a trench area drainage and leak detection system. (JC)

One of the first prescriptions offered after many years of diagnostic work. (DN/JC)

Permeability Coefficient; Density; Moisture Content; pH; Temperature

<322>

Dames and Moore, White Plains, NY

1977, June. Final Report; 65 pp.

Characterization of Selected Low-Level Radioactive Waste Generated by Four Light-Water Reactors Located in New York State (1)

The results of a sampling program at the waste management facilities at two BWRs and two PWRs in New York State are reported. The primary purpose of this study was the delineation of the characteristics of the source term for low-level radioactive waste burial sites. The sampled wastes include spent ion-exchange resins, evaporator concentrates, and filter sludges. Sampling logistics and high personnel exposure risks precluded the sampling of resins at two plants and allowed for only wipe samples to be taken from filter sludges at two of the plants. In both the PWR and BWR sampled, Cs 137, Cs 138 and Co 60 comprise over ninety percent of the observed activity in spent resins. The radionuclide composition of evaporator concentrates was shown to vary considerably from plant to plant with predominance by such radionuclides as Cs 137, Cs 138, Co 60, Fe 55, Ni 63, Co 60, Mn 54, Cr 51, and Zn 65. The radionuclide composition of the filter sludges was shown to vary widely with Cs 138, Cs 137 and activation products such as Co 57, Co 60, Co 58, Fe 55, Mn 54, Ni 63, and Cr 51 being the prominent observed radionuclides. Important variables observed to influence the radionuclide composition include type of reactor, waste process system design, degree of fuel element inefficiencies, extent of corrosion, waste form, location of sampling point, and sample age. (JC)

Even though there exists some sizeable data gaps, this report represents one of the most thorough waste characterization studies to date. (DN/JC)

(323)

Dow Chemical Company, Rocky Flats Division, Golden, CO

Ryan, E.S., J.W. Vance, and R.E. Hays. 1966. CONF-651202; IAEA-SR-71/43; Practices in the Treatment of Low- and Intermediate-Level Radioactive Wastes, Proceedings of a Symposium held in Vienna, Austria, December 6-10, 1965, (pp. 517-526), 948 pp. (CONF-651202, IAEA-SR-71/43).

Aqueous Radioactive Waste Treatment Plant at Rocky Flats (3)

The operation of a two-stage aqueous radioactive waste treatment facility at the Rocky Flats Plant of the United States Atomic Energy Commission is described, including details of construction, flow charts, operating data and problems encountered. Typical alpha activity of the liquid waste treated is 1.0×10^6 dpm/gal. The first stage consists of a continuous-carrier precipitation process utilizing ferric hydroxide calcium chloride Perfluc 501. This stage has a capacity of approximately 200 gal/h. A decantation factor of 20 to 50 is obtained. The second stage is a batch-flocculation process using ferric hydroxide and calcium chloride, to effect a further decantation factor of 100. The capacity of this stage is approximately 10,000 gal/h. Over-all decantation through both stages can be accomplished at a cost of 35 cents/gal. The output averages 200,000 to 300,000 gal/month. Further plans include the installation of a 250-gal/h continuous evaporator to reduce the volume of effluent pollution containing noxious chemicals. The evaporator is designed to obtain a decantation factor of 10 (2+). (auth) (PTO)

(324)

Dow Chemical Company, Rocky Flats Division, Golden, CO

Thompson, R.A. 1975. RPP-2341; CONF-750662; IAEA-SR-198/30; Radiological Impacts of Releases from Nuclear Facilities into Aquatic Environments, Proceedings of a Symposium held in Otanien, Finland, June 30 - July 5, 1975, (pp. 213-226) (RPP-2341, CONF-750662, IAEA-SR-198/30).

Plutonium in the Aquatic Environment Around the Rocky Flats Facility (3)

The Rocky Flats Plant of the United States Atomic Energy Research and Development Administration has been fabricating and chemically recovering plutonium for over 20 years. During that time, small amounts of plutonium have been released with liquid process and sanitary waste discharges. The liquid waste flows through a series of holding ponds from which it is discharged into a creek that is part of a municipal drinking water supply. The water flows for about 1.5 km between the last holding pond and the municipal drinking water reservoir. In addition, liquid wastes containing high levels of chemical contaminants and plutonium concentrations less than allowable drinking water standards have been discharged to large evaporation ponds. The fate of the plutonium in both the surface and subsurface aquatic environment has been extensively monitored and studied. It has been found that plutonium does not move very far or very rapidly through subsurface water. The majority of the plutonium released through surface water has been contained in the

sediments of the plant holding ponds. Small amounts of plutonium have also been found in the sediments of the receiving reservoir. Higher than normal amounts of plutonium were released from the waste treatment plants during times when suspended solids were high. Various biological species have been examined and plutonium concentration factors determined. These concentration factors are defined as the plutonium concentration in the biota divided by the concentration in the water associated with the biota. They range from approximately 0.89-1.5 (bullhead sturgeon) to 10 (2+) (algae). Considerably less than 1% of the 210 act of plutonium released has been detected in biological systems including man. After more than 20 years of large scale operations, no health or environmental hazard has been identified due to the release of small amounts of plutonium. (auth) (BT)

Information on the fate of plutonium that might be leached from burial sites is presented. (RM/MT)

(325)

Dow Chemical Company, Rocky Flats Plant, Denver, CO

Ryan, E.S., and L.C. Farrell. 1955, December. TID-7517 (Part 1A); Sanitary Engineering Aspects of the Atomic Energy Industry, Proceedings of a Seminar held in Cincinnati, Ohio, December 6-9, 1955, (pp. 236-242), 669 pp. (TID-7517, Part 1A).

Costs Involved in the Offsite Disposal of Solid Wastes (3)

The costs of shipping contaminated solid wastes from the Rocky Flats installation to the AEC installation at Idaho Falls, Idaho. At first, the wastes were going to be shipped to San Francisco for sea burial but it proved to be too expensive. The wastes, paper, rags, and sludges, were placed in 55 gallon drums lined with polyethylene bags. Detailed steps are followed in record keeping and preparing the drums for shipment. From April 1950 to September 1955, 81 trailers moved 1,456,000 lbs or 81,900 cu ft of solid wastes. The total cost was \$42,730 or cost/cu ft was \$2.95. The cost/cu ft was \$1.02 and the cost/ton-mile (750 miles) was \$0.06. (RM)

Waste Volume

(326)

Florida Power and Light Company, Miami, FL; Nuclear Safety Association, Bethesda, MD

Laddicotte, G.W., G.A. Rodger, R.L. Frensdorff, and H.W. Norton. 1977. CONF-770512; Management of Low-Level Radioactive Wastes, Proceedings of a Symposium held in Atlanta, Georgia, May 23-27, 1977, (30 pp.) (CONF-770512).

Suggested Quantity and Concentration Limits to be Applied to Key Isotopes in a Low Level Burial (3)

Two scenarios were developed for shallow land burial sites, one in a humid region and the other in an arid area. Included in the scenarios are isotopic limits both in quantity and in concentrations. This was to establish protection criteria for individuals

data presented in tables form and some of the
 correct color are included. (257/207)
 then for or what to use for. (258)
 later higher than has been anticipated using
 of type of size is capable of acceptance
 significantly better than basic ones; and
 some on operation criteria; different are not
 it was concluded that not enough time has been
 prior to leaving the site. From the operation
 over control situation in the water control
 travel time from the trench to the nearest
 emergency; decay of radioactivity during
 on the soil between trench and any point of
 burial (leach hole); retention of radioactivity
 it and on water, and/or retention with the
 containment area; retention of radioactivity
 structural mechanisms that provide for
 structural elements (columns or supports).
 work); natural insulation (concrete); and
 persons (interior observation, inspection, and
 operation located (ground water and spillage).
 The area considered for the two sites; size
 closed containment control will be lifted.
 the inspector and 100 yards after the site is
 resulting in no more than a 15 centigrade rise to
 in feedwater or natural intake pathway by
 potential public use; any intrusion pathway by
 0.05 MFC in air or water at point of interest
 or degree of health protection and a limit of
 isolation. Criteria followed for calculations
 in this technique are containment and
 isotope. The goals expected to be achieved
 next, further pathway for the responsible
 application for each isotope is based on the
 appropriate protection criterion. The
 isotope which would present negligible
 contribution for each pathway and for each
 and calculate the limiting quantity in
 in contact with populations or individuals.
 in which the United Radioactivity Index was
 for populations, evaluate a series of ways

[illegible]

of establishing both covers and combinations of material are being investigated. A few feet of cover material are sufficient to reduce gamma radiation to acceptable levels. In conclusion, available data indicate that some of the methods used thus far to establish radiation shielding have been a costly saturation solution. Some of the methods examined were exhibited short-term advantages, but no economical long-term solutions have become apparent. (u)

<129> C-129

Geological and Hydrological Aspects of the Disposal of Liquid Radioactive Wastes (1)

Geological and hydrological aspects of liquid radioactive disposal at Hanford are discussed. Hanford lies in a structural and topographic basin of volcanic and sedimentary rocks which receive 7 inches of rainfall annually. The water table is found at 200 to 350 foot depth. The oldest rocks are fresh, unaltered basaltic lavas and associated pyroclastics with sedimentary interbeds of the Columbia River basalt series of Pliocene to Pliocene age. In the Hanford, the Yakima basalts of the Pliocene and the Ellensburg formation and the Tertiary basalts of Pliocene are present in a complexly interfingering and interbedded pattern. The structure in the area consists of doming of the basalts to form the Pliocene basin, which is part of a series of asymmetrical anticlines and synclines in the area. While there are numerous joint planes there is no indication of extensive faulting of the lavas as has been suggested. Permeability of the lavas is generally low, although artesian aquifers do exist in the interbedded zones in the basalt capped by tuff beds of the Ellensburg formation. Lying conformably above the basalts are Pleistocene age fluvial and lacustrine silts, sands, gravels, and clays (Pigold formation) which are 1200 ft thick. This formation, too, has low permeability but contains large amounts of montmorillonite-type clays. While low permeability and high montmorillonite content are ideal for decontamination, there is a considerable lateral and vertical variation. As a result of the variation microgeologic and microhydrologic techniques had to be used to determine the extent of the variations. Exploration techniques to determine the stratigraphy and structure were cable tool drilling, scintillation probe studies, and seismic reflection studies. In doing the field studies, the ground water basins were defined and estimate of the amounts of water that may be available on a long-term basis from artesian aquifers was made. The water table was also monitored by using over 100 wells. Since Hanford currently discharges about 10 million gallons of process water per day geochemical studies as well as flow rate studies were made. The gradient was found to be less than 5 ft/mi. Mathematical studies were also done by applying the Laplace partial differential equation solution for saturated ground water movement. All the above studies are designed to aid in the determination of waste performance of the Hanford area. (SDV)

Depth to Water Table; Mean Precipitation;
Stratigraphic Unit Thickness; Hydraulic Gradient

<130>

Wetman Nuclear and Development Corporation

Tulsa, P.T. 1976, September. CNP-780901; Packaging and Transportation of Radioactive Materials, Proceedings of the 8th International Symposium held in Miami Beach, Florida, September 22-27, 1976, (p. 863-876), 1067 pp. (CNP-780901).

Radioactive Shipments from Operating Stations, An Overview (1)

A review of the packing techniques and shipping experiences at eleven nuclear power stations (six BWR, five PWR). The BWR's sample showed a greater tendency towards utilization of large containers (80-170 cu ft)

than the PWR's. The specific activity of the various waste types generated at BWR's ranged between 1.01 Ci-G.5 Ci per cu ft with the greatest volume generated in the 0.1 to 0.5 Ci per cu ft range. No such data were presented for PWR's. Wastes generated at BWR's were classified as either 1) leached filter sludges, 2) devaluated resins, or 3) liquids (evaporator concentrates and/or regenerative solutions). Wastes generated at PWR's were classified as either 1) leached deep bed resin, 2) evaporator concentrates, or 3) spent filter cartridges. Author concludes that 1) there is a trend towards using larger containers in place of drums, 2) activity levels vary significantly between plants, 3) activity levels are dependent on extent of fuel failure, performance of processing equipment and operating methods, and 4) for a particular plant, radioactive activity levels will increase with operating time till the same degree of equilibrium is reached. (JF)

General review of the packing techniques and shipping experiences of BWR's and PWR's. Data are presented in graphic form. (DS/JF)

<131>

Humble Oil and Refining Company, Houston, TX

Gardner, R.O., D.V. Peaceman, and A.L. Pozzi, Jr. 1962, December. Society of Petroleum Engineers Journal, 8(1), 26-36.

Numerical Calculation of Multidimensional and Miscible Displacement by the Method of Characteristics (3)

A new numerical method is proposed for the solution of multidimensional miscible displacement problems. Besides the usual stationary grid associated with numerical procedures, the method uses moving points for which positions and concentrations are computed each time step. Based on the method of characteristics for treating combined transport and dispersion, the method applies equally well to any number of dimensions and, in contrast with other numerical procedures, properly takes into account the physical dispersion, no matter how small. Two-dimensional calculations using the new method were carried out to simulate laboratory model displacements in which gravity caused overriding of solvent. Good agreement between observed and computed profiles and measured and computed concentrations of produced fluid was obtained for a viscosity ratio of 1.89; at higher viscosity ratios, fair agreement was obtained. Computed results were found to be significantly affected by vertical dispersion, and negligibly affected by dispersion in the direction of flow, in agreement with conclusions based on experimental observations. (Ruth)

Classic paper on one method to solve mass transport equations. Still valid discussion of method of characteristics. (DS/JF)

<132>

Knolls Atomic Power Laboratory, Schenectady, NY

Cherebin, L.J. 1956, October. TPD-7517 (Part 1B); Sanitary Engineering Aspects of the Atomic Energy Industry, Proceedings of a Seminar held in Cincinnati, Ohio, December 6-9, 1955, (pp.

<312> CONT.

406-873, 409 pp. (TID-7517, Part 1B).

Potential Hazards Associated with the Release of Laboratory Liquid Waste to the Mohawk River (2)

The potential hazards of liquid waste release from the Knolls Atomic Power Laboratory (KAPL) were presented. Originally all low-level wastes were evaporated. However, it became apparent that dilution by the Mohawk River adequately met the permissible drinking water limits. Before June 1955, total activity released to the Mohawk River was 10 to 23 ac. After June 1955, the annual release was expected to be about 25 curies. Currently, the laundry wastes are pumped directly to the 25,000 gallon retention tanks while the laboratory and shop wastes are collected in the 10,000 gallon stainless steel receivers. The wastes are analyzed for activity content and sent to retention tanks which are then sampled. If it is within acceptable limits the waste is released at about 7 gallons/minute into the river. The important dilution criteria were: 1) Sr activity; 2) the 3 gpm release rate was a such for adequate dilution; 3) a dilution factor of 30 was required to reduce activity levels to 10% of the maximum permissible level; 4) 11 ppb of phenols would require a dilution factor of about 4; and 5) other chemicals, pH, and suspended solids presented no problems. It was found the Mohawk River flow averages 5,000 cubic feet/sec (cfs). The average dilution of laundry wastes was about a factor of 20 and 50 at points 100 and 500 feet downstream, respectively. Tracer tests measured to indicate a minimum 4-fold dilution at 150 feet downstream and a 11-fold 300 feet downstream for sewer effluent. The average dilution factor 7.7 miles downstream appeared to be 7.1×10^{12} . The beta-gamma activity was measured upstream and downstream and found to be 55 plus or minus 12 $\mu\text{Ci/g}$ and 68 plus or minus 11 $\mu\text{Ci/g}$, respectively. As of September 1955 the fission products released were closer to 1 Ci/month rather than 1.6 Ci/month expected. The maximum daily average concentration of fission products at Winch's Ferry Dam did not exceed 10 (2-7) $\mu\text{Ci/cc}$. The net beta activity at the Sewer Outfall was less than expected, 900 vs 2000 $\mu\text{Ci/g}$, but net activity at 100 feet from Outfall was 1000 $\mu\text{Ci/g}$ vs 400 $\mu\text{Ci/g}$. The beta activity was measured on shell fish and ranged on the average from 0.6 to 12.0 $\mu\text{Ci/g}$. In the fish bone 50% of the fission products was Sr, while in the fish scales rare earths comprised 41%. No concern was expressed about consumption of fish taken from the Mohawk River. Sediment activity in the river, a pipe is currently at levels a magnitude higher than expected, 9 x 10 (2-6) $\mu\text{Ci/g}$. As yet, no adverse effects have been found, but monitoring is continuing. (200)

Mohawk River which varies in flow from less than 1000 cfs (cfs) to over 100,000 cfs. With this flow rate the river affords potential dilution all year round. The laboratory draws 100 million gallons/year from the facilities of the City of Schenectady; this is collected for discharge to the river by three sewer systems. Of this discharge, 75% comes through the sewer which receives cooling water, treated water from the closed-system liquid waste disposal system, and laundry discharge water. The industrial sewer system carries off clean water from laboratory sinks, cooling water discharge lines, and other sources which are 15% of the total wastes. The remaining 15% goes into the sanitary sewer system from the usual sources. The solid waste is collected, segregated, packaged, and stored for ultimate disposal. It was found that baling was more effective in reducing the volume of material than was burning, 77% vs 9%, respectively. Those who generate wastes are asked to sort their waste into the following categories: 1) highly radioactive waste which must be stored underground; 2) intermediate waste which can be shipped; 3) balance low-level waste; 4) non-balance low-level waste. The solid radwastes are then handled and disposed of with appropriate procedures. The liquid wastes are put in evaporators and condensers which reduce the waste by a factor of 100 to 1. It is then put into steel tanks for permanent storage. Several procedures have been eliminated either because their cost was too great for the amount of reduction acquired or the procedure was inefficient. Some of the abandoned methods were: a steam heated drying drum in the evaporation system and limestone as a neutralizing tank in the industrial sewer system. (200)

<313>

Law Engineering Testing Company, Cincinnati, OH

Grant, J.L. 1956. Law Engineering Testing Company Report; 23 pp.

Report on Honey Flats Toxicologic Investigation (2)

The report presents the results of a brief investigation of the toxicology of the Honey Flats Disposal Site (see 3112) and reviews several previously published documents. Two of these documents that are given extensive review are the "A month study by EDNR," and the "Preliminary Data on the occurrence of 'transient' facilities in the environment of the Radioactive Waste Disposal Site, Honey Flats, Kentucky by Meyer." Several conclusions are presented. (20)

Good summary with some specifics of the hydrologic status of the Honey Flats Disposal site. (20/200)

Stratigraphic Unit Thickness

<315>

National Lead Company of Ohio, Fernald, OH

Featherston, R.C. 1956, October. TID-7517 (Part 1B); Sanitary Engineering Reports of the Atomic Energy Industry, Proceedings of a Seminar held in Cincinnati, Ohio, December 4-9, 1955, (pp. 274-283), 600 pp. (TID-7515, Part 1A).

<315>

Knolls Atomic Power Laboratory, Schenectady, NY

Wyer, R.Y. 1955. WASH-275; Sanitary Engineering, Proceedings of a Conference held in Baltimore, Maryland, April 15-16, 1956, (pp. 166-170) (WASH-275).

Summary of Sanitary Engineering Activities at Knolls Atomic Power Laboratory (3)

The aspects of the sanitary engineering operations at Knolls Atomic Power Laboratory are discussed. The site is located on the

< 375 > CONT.

Disposal of Fluoride Wastes (3)

Generation, treatment, and disposal of fluoride waste: From uranium and thorium processing is discarded. Excess and process hydrofluoric acid and metal fluoride by-products are obtained from the processes. Hydrofluoric gas is condensed as either anhydrous or hydrous HF. The anhydrous HF is used in the 90% to 97% conversion and hydrous HF is sold. A 12 scrub solution is used to clean HF from the off-gas and the HF solution is sold. Neutralized soluble fluorides are discharged with other treated waste liquors to the river. Insoluble fluorides are stored in the ground in a specially prepared pit on the site. Since the flow of the Miami River varies from 25,000 to 100 cfs with an average of 1000 cfs only additions that will add no more than 0.5 ppm fluoride to the stream are permitted. Peak concentration of 1.5 ppm are permitted if the average does not exceed 1.2 ppm. If the flow is 100 cfs, then 650 pounds of fluoride discharged in one day would raise the fluoride level above the maximum allowable concentration. In some months not more than 2,000 pounds could be discharged each day. The storage pit has 500,000 cu ft capacity which holds the fluorides until the river can handle the load. In the first months of the year 15,000 pounds of fluoride were discharged and contributed 0.1 ppm to the river. Also, 50,000 gal of liquor/day was discharged. At the time did the amount of fluoride introduced raise the fluoride level above the maximum permissible concentration. The estimated cost of removal of HF from the condenser gas is 10.00/pound of HF using lime scrub and 10.00/pound of HF using 500 scrub. Using the storage pit and the lime scrubber the cost is 10.00/pound HF. In 2.5 years of operation there is no evidence of fluoride pickup in the groundwater. (374)

River Flow

< 376 >

National Marine Fisheries Service, Atlantic
Estuarine Fisheries Center, Beaufort, NC

Lee, T.R., and J.P. Baptist. 1970. *Neon and Ecologic Effects of Nuclear Power Plants*, L.A. Sagan (Ed.), Chapter 10. Charles C. Thomas Publisher, Springfield, Illinois, (pp. 371-379).

Ecologic Effects of Radioactive Emissions from Nuclear Power Plants (3)

The effects of emissions from nuclear power plants on the environment are reviewed. In general, around nuclear plants the radioactivity is dilute enough so as to not be significantly higher than background levels. In some cases the assessment had to be done on fallout levels. Once in the environment the radioisotopes may be dispersed, diluted, or concentrated. A radioisotope may be released in a dilute form and later concentrated by organisms. When and where this concentration will occur is poorly understood. In the terrestrial environment the radioisotopes are cycled through the atmosphere, soil, plants, animals, and bacteria. Of these principal pathways the most important is plants. They may be contaminated by fallout during the growing season or through the root system where radioisotopes have leached into the soil. Accumulation is affected by: source of radioisotope; physical and chemical state of radioisotope; type of soil; species of plant;

and amount of rainfall. Animals may accumulate radioisotopes by inhalation, ingestion, and/or some enter through the skin or wounds. The most important source is ingestion. In the aquatic environment, damage may occur from the introduction of power plant wastes from the discharge plume. The radioisotopes may be dispersed or diluted by currents, turbulent diffusion, isotopic dilution, and biological transport. Concentration occurs either by biological mechanisms or by chemical and physical mechanisms. The specific mechanisms are uptake directly from water and through food webs. The other physical mechanisms are adsorption, ion exchange, co-precipitation, flocculation, and sedimentation. It is unclear as to the exact effect of radioactivity in the aquatic environment at low levels. Generally, organisms in the aquatic environment are more sensitive to doses over a shorter time than the same dose over a longer time. The most significant aspect of environmental radiation is the effect on the population rather than on the individuals. If radiation is accompanied by unsatisfactory conditions, then the population will undergo a steep decline whereas it might not have if only radiation had been a factor. For aquaticists are of the view that ionizing radiation is genetically undesirable. For a better understanding of environmental radioactivity more research needs to be done. Included in the study should be: cycling of radioisotopes, rates of movement and residence time, accumulation, turnover, and tissue distribution. (377)

< 377 >

Nuclear Engineering Company, Inc., Louisville, KY

Gohin, E.A., and L.J. Hansen. 1971. *Neutron*. U.S. Patent Document 3,610,100; 12 pp.

Radioactive Waste Disposal of Water Containing Waste Using a Formaldehyde Resin (2)

The invention presented uses a hydrophilic resin to immobilize radioactive wastes for storage and/or burial. The resin is intended to replace the use of Portland cement in the appropriate circumstances. The resins suggested are the urea-formaldehyde compositions which are available in a partial polymerized state and are capable of curing to a high polymer upon the addition of an acidic curing agent. The solid block of resinous material may further be waterproofed by a waterproof resin coating or cover. The radioactive material comes from the water in the cooling loop of a reactor. For this radwaste it is then advantageous to concentrate the radioactive ions such as iron, nickel, and cobalt before using the resin. Suggested ways to concentrate the ions are: ion exchange resin beds (cation preferred), distillation, earth, powdered filter aid, and wood cellulose filter. Also vacuum evaporation of the water may be used to concentrate the radwaste. A filler is also suggested to increase the shielding ability of the resin block against hard gamma rays. The urea-formaldehyde is mixed 7 part urea to 2 parts formaldehyde. A typical catalytic agent will have a formaldehyde content of about 10(2-5) to 10(5-5). Examples are provided to illustrate the sizing of each of the concentrates. Generally, however, the concentrate is sized into the resin, an acid (sodium bisulfate) is added and when the gel is sufficiently firm stirring stops and the curing begins. (378)

(338)

Nuclear Fuel Services, Inc., West Valley, NY

Jump, R.J. 1976. NRC Symposium Series No. 140(72): Radioactive Waste from Nuclear Fuel Cycle, (pp. 65-50), 178 pp.

Current Practices for Disposal of Solid Low-Level Radioactive Waste (1)

Nuclear Fuel Services, Inc., has operated a commercial low-level radioactive waste burial ground at West Valley, N.Y., since 1963. The burial site was selected on the basis of topography, geographic location, geology, meteorology, hydrology, and the normal usage of ground and surface waters in the general area. The soil in the burial area consists of a layer (more than 90 ft thick) of silty till with 0 to 6 ft of granular glacial till overburden. The silty till is a very fine grained heterogeneous mixture of clay and silt that contains minor amounts of sand and stones. It is water-saturated, but it is not an aquifer. The vertical permeability of the soil was analyzed to be in the range of 0.002 gal/(day) (square foot). The maximum expected flow of water through the silty till would be about 5 x 10⁻⁶ ft/day. The soil also has been shown to have good natural ion exchange capacity and it has a very large potential capacity for sequestering radioactivity from groundwater compared to the amount of radioactivity that is buried. During late 1973 and 1976, a study was undertaken to determine the extent of any migration of radionuclides from existing trenches at the West Valley burial facility. Based on measurements of soil ion exchange capacity prior to the commencement of operations, it was known that most radionuclides were sorbed by the soil. Therefore, tritium, which behaves like hydrogen in water and has no affinity for the soil, was chosen to determine the extent of migration. Results of the study showed some evidence of tritium migration adjacent to trenches that contain water. However, the concentration was very low, and the concerns about migration of radionuclides can be substantially reduced by minimizing water contact. Trench water may be removed to attain this objective and processed to meet applicable regulatory limits. Laboratory studies of the soil were also conducted to determine the sorption properties of the soil for Cs 137, Sr 85, I 131, Pu 106, and Co 60. The soil proved to have excellent sorption characteristics for cobalt, cesium, ruthenium, and strontium and although the sorption of iodine was low, some degree of protection is provided by the burial area soil. The distribution coefficients for Co 60, Cs 137, Pu 106, Sr 85, and I 131 are 6,225; 1,546; 1,225; 59; and 1.2 respectively. (JMW)

Infiltration Water Distribution Coefficient

(339)

Nuclear Safety Association, Bethesda, MD

Volger, W.A. 1976. NRC Symposium Series No. 140(72): Radioactive Waste from Nuclear Fuel Cycle, (pp. 33-47), 178 pp.

Critical Evaluation of the Limit of Transuranic Contamination of Low-Level Waste (1)

The suggested limit for transuranics of 10 concentration/gram as a break point at which wastes should go to a national repository is

seriously questioned. It is shown that insofar as protection of water supplies is concerned, the key to the problem is Sr 90, not transuranics, and in any case, the limit should be based on a site-determined inventory, not on concentration. Concentration is only important as a protection for future stakeholders who might dig into the waste. Calculations are presented to show that for this purpose the limit should be higher by several orders of magnitude. The 10 concentration/gram should be used as a definition of complete innocuousness. (Aeth)

(340)

WUS Corporation

Hollister, T.D., T.L. Jents, J.H. Connolly, and J.P. Kane. 1976, October. HW/USP-000; A Survey and Evaluation of Handling and Disposal of Solid Low-Level Nuclear Fuel Cycle Wastes, Section 6, (pp. 87-92), 103 pp. (HW/USP-000).

Current Land Burial Techniques for Radioactive Wastes and Alternative Methods of Disposal (1)

At present there are six licensed shallow-land burial sites in the United States and they are: West Valley, New York; Barnwell, South Carolina; Haney, Idaho; Kentucky; Sheffield, Illinois; Buxley, Nevada; and Richland, Washington. Each of these sites has specific requirements for burial of liquid, gaseous, and solid wastes. At present specifications and restrictions for packaging and shipping commercially generated low-level waste to a government site are in draft form. Burial site criteria are not hard and fast and there are few regulations by either the state or federal governments. Burial techniques include excavating, rain water control and removal, package placement in trenches, and backfilling. Retrievable storage techniques for transuranic wastes are also discussed. The technique provides for aboveground storage of low-level, solid TWS waste with a 20 year retrieval capability. Recommendations for improving burial practices are: 1) burial sites be on flat terrain for seismic use; 2) trenches be as deep as the hydrology and soil characteristics allow; 3) trench water removal systems where necessary; 4) efficient use of trench volume by careful package placement; and 5) containers and transport shields be designed to allow a minimum of handling. The two alternative disposal methods are sea disposal and on-site burial. Sea disposal is under a moratorium. For on-site burial a decommissioned facility could be used. Projected waste volumes will fill the existing sites by 1990 but with alternative volume reduction and alternative disposal methods this could be put off until 2000. (JWW)

An extensive table documenting the requirements for burial of solid, liquid, and gaseous wastes for the six sites is included. (USC/USW)

(341)

WUS Corporation

Hollister, T.D., T.L. Jents, J.H. Connolly, and J.P. Kane. 1976, October. HW/USP-000; A Survey and Evaluation of Handling and Disposal of Solid Low-Level Nuclear Fuel Cycle Wastes, Section 5, (pp. 83-86), 103 pp. (HW/USP-000).

<301> COS.

Summary of Nuclear Fuel Cycle Waste Projections
(3)

Significant quantities of radioactive waste are being produced by commercial LWR's (light-water reactors); government installations and operations; and industrial, institutional and private users. Additional power reactor fuel cycle wastes will be from high temperature gas cooled reactor waste, fast breeder waste and decommissioning waste (from LWR's) by late in this century. Industrial, institutional and private users have annually disposed of $1 \times 10^{(2+6)}$ cu ft and this value will remain constant through the year 2000. Government installations and operations input $2 \times 10^{(2+5)}$ cu ft/yr and this will remain the same until the end of the century. Waste from ORR's will be negligible because only one is in operation and no new plants are planned. Also, fast breeder reactors have not been included in the estimate because they will not be significant before the end of the century. If one reactor facility is decommissioned every five years between 1975 and 2000, 500,000 cu ft of radioactive waste will be added with each decommissioning. Therefore by the year 2000, $52.6 \times 10^{(2+6)}$ cu ft will be generated by all processes except LWR's. If the high growth of LWR's the total waste produced will be $856.6 \times 10^{(2+6)}$ and with low growth of LWR's it will be $285.6 \times 10^{(2+6)}$ cu ft. Using alternative methods without backfitting the LWR's the waste production will be 193.6 and $162.2 \times 10^{(2+6)}$ cu ft for high and low growth of the LWR's, respectively. Using alternative methods with backfitting the wastes will be 120.6 and $90.4 \times 10^{(2+6)}$ cu ft for high and low growth of the LWR's, respectively. All wastes other than LWR remain the same, only the LWR varies. (BWP)

Projected waste volumes are presented tabularly and graphically. (ESEC/BWP)

<302>

BWS Corporation

Hollarky, T.E., T.L. Jentz, J.E. Connolly, and J.P. Kane. 1976, October. BWP/BESP-000; A Survey and Evaluation of Handling and Disposal of Solid Low-Level Nuclear Fuel Cycle Wastes, Section 8, (pp. 37-43), 103 pp. (BWP/BESP-000).

Commercial Spent Fuel Reprocessing (3)

For the reprocessing of one equilibrium reload of one 1000 MWe LWR plant, high-level wastes contain 99.54 of mixed fission products formed in the spent fuel. The specific activity is on the order of $1 \times 10^{(2+5)}$ Ci/cu ft and the final volume of solid waste is estimated to be 125 cu ft. Intermediate-level wastes will have an estimated specific activity of 1 to 10 Ci/cu ft of mixed fission products (BWP), 0.01 Ci/cu ft of 129 I, and more than 10 nCi of transuranic elements per gram of material. The total volume of the solidified wastes will be 325 cu ft. The cladding shells and hardware will contribute 300 or 600 cu ft, compacted and uncompacted, respectively. The specific activity will be 500 Ci/cu ft of Co 60. Contaminated equipment such as processing tools is expected to have a radiation level of less than 1 R/hr resulting from residual mixed fission products with a specific activity of less than 10 nCi of transuranic elements per gram of waste. Burial volume will be approximately 530 cu ft. The low specific

activity waste (trash) will have radiation levels not higher than 500 mR/hr gamma, less than 0.5 Ci/cu ft alpha-beta radionuclides, and 10 nCi/transuranic elements per gram. Alpha wastes will have about 3 g Pu/cu ft. High-level wastes will be shipped in shielded casks, intermediate-level wastes by commercial truck to a government repository and low-level wastes stored onsite in retrievable storage casks before shipping to a burial site government repository. Initial disposal will be in a retrievable underground pilot facility to test the concept of terminal storage in a specific geologic formation. Waste projection for low to moderate growth of nuclear power is 3100 to 3300 cu ft, of which 2250 cu ft will be non-transuranic. (BWP)

<303>

BWS Corporation

Hollarky, T.E., T.L. Jentz, J.E. Connolly, and J.P. Kane. 1976, October. BWP/BESP-000; A Survey and Evaluation of Handling and Disposal of Solid Low-Level Nuclear Fuel Cycle Wastes, Section 3, (pp. 31-35), 103 pp. (BWP/BESP-000).

Travine and Mixed Oxide Fuel Fabrication (2)

The light-water reactor nuclear power industry is supported by uranium fuel fabrication plants. Three of these plants are capable of producing uranium-plutonium mixed oxide fuel assemblies. The solid wastes from MOX fabrication plants are only slightly contaminated and end up in commercial burial sites. This is also true for the liquid effluents. The liquid effluents from the mixed oxide plants, however, are cement fixed and buried when plutonium alpha contamination is detected. For a standard 1000 MWe LWR 302 wastes will range from 275 to 350 cu ft with an activity level of 25 nCi and MOX wastes will range from 300 to 400 cu ft with an activity level of $3.23 \times 10^{(2+9)}$ nCi. Wastes from these types of fabrication plants will be packaged in 55 gallon drums and shipped to a repository. Minimal effect on the environment by handling and transporting these wastes is expected. (BWP)

<304>

BWS Corporation

Hollarky, T.E., T.L. Jentz, J.E. Connolly, and J.P. Kane. 1976, October. BWP/BESP-000; A Survey and Evaluation of Handling and Disposal of Solid Low-Level Nuclear Fuel Cycle Wastes, Section 2, (pp. 19-29), 103 pp. (BWP/BESP-000).

Alternative Radwaste Treatment Methods and Projections (3)

Processes for reducing the volume of current wastes and improving the processing of liquids are identified and evaluated using the 1000 MWe reactor plant as a standard. The processes include incineration, horizontal wiped-film evaporators, vertical thin-film dryer, crystallizer, extruder-evaporator, calciner, acid digestion, improved compaction, and improved solidification. Incineration, vertical thin-film dryer, extruder-evaporator, and acid digestion are not considered economically feasible at this time. Those not listed above are economically feasible now or should be incorporated with the newer plants.

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As an alternative to new process methods the waste systems should be designed with the "worse case" in mind for expansion. Operations minimizing waste generation, various waste packaging, and segregation of contaminated materials should be practiced. (197)

<385>

WDS Corporation

Tullerley, T.D., T.L. Jentz, J.R. Connolly, and J.P. Kane. 1976, October. AIF/NEEP-008: A Survey and Evaluation of Handling and Disposal of Solid Low-Level Nuclear Fuel Cycle Wastes, Section 1, (pp. 1-17), 181 pp. (AIF/NEEP-008).

Current LOR Radwaste Management Practices (2)

Types of radwaste and their contributions to the total waste for operating plants and projection of solid radwaste are compiled. For BWR reactors, wastes from the filter/separator plants generate 31.6 cu ft/BWU/yr while deep bed resin plants produce 45.6. In fact the deep bed resin plants produce more total waste than do the filter/separator plants. The major sources of waste are from the sludge and precoat (70%) and the BWR produces about 81% (trash) as a major waste. Future BWR plants are expected to reduce their solid wastes. For PWR reactors the waste generated from CPS (condensate polishing system) is 16.7 cu ft/BWU/yr of solid waste and for non-CPS 26.9. Solidified wastes account for 56% of the total annual waste volume. Included in the paper is analysis of the standard reactor radwaste volumes which has an exponential predictive function. Finally, for deep bed resin BWR reactors it will cost \$894,000 per annum. The CP PWR reactor will have an annual cost of \$925,000 for waste disposal. (198)

Extensive tabular data present radwaste volumes by various breakdowns including cost analysis. (EJIC/SDV)

<386>

WDS Corporation

Tullerley, T.D., T.L. Jentz, J.R. Connolly, and J.P. Kane. 1976, October. AIF/NEEP-008: 181 pp.

A Survey and Evaluation of Handling and Disposing of Solid Low-Level Nuclear Fuel Cycle Wastes (2)

For a 1000 MWe reactor plant major conclusions and recommendations are presented with respect to solid radwaste. Categories considered are: available land burial space; light-water reactors; and fuel fabrication and reprocessing facilities. Concerning available land burial space--existing licensed burial sites will be filled by 1990 and may be filled by as early as 1980. However, reduced waste generation, resulting from improved reactor plant design and volume reduction techniques, may extend the life of the burial sites to 2000. Also, due to limited space in the East the wastes may have to be shipped to western burial sites. It is recommended that additional land burial sites be identified, licensed, and developed by 1975. Also, existing burial sites should be enlarged if hydrologic characteristics permit and industry

and government investigate alternative disposal methods and sites. Finally, mechanized handling will be used as well as increasing the permissible activity limits per cubic foot of waste by a factor of 20. Light-water reactors will produce 89% of the total volume of solid radwaste disposed of by 1980, and volume reduction processes could reduce the annual solid waste volume from 1980's by a factor of 2.5. A special effort should be made to reduce the waste volumes by minimization at the plants and by packaging methods. Also, onsite storage or disposal should be evaluated with respect to environmental, economic, engineering impact, regulatory requirements, and public acceptance. By 1980 about 14% of the cumulative low-level non-transuranic waste volume will be generated by fuel fabrication and reprocessing facilities. Transuranic activity will be contained in 30 to 50% of all wastes, and disposal methods are uncertain. A ruling on the method of disposal of transuranic waste should be made quickly. Each category of waste generated in fabrication and reprocessing facilities should be evaluated for its transuranic content. Six articles were separately input into the data file. (199)

<387>

Palo Alto Laboratories of Isotopes, Earth Sciences Section, Palo Alto, CA

Holly, D.L., and P.R. Fenske. 1966, May. COSY-660580: Memoir 110: Nevada Test Site, L.B. Eckel (Ed.), Proceedings of the 19th Annual Meeting of the Rocky Mountain Section, Geological Society of America, held in Las Vegas, Nevada, May 11-18, 1966. Geological Society of America, Inc., Boulder, Colorado, (pp. 171-183), 290 pp. (COSY-660580).

Transport of Dissolved Chemical Contaminants in Groundwater Systems (1)

The dimensional half-space dispersion-convective solute analytical solution for contaminant transport for two different boundary conditions are derived. One case is constant concentration at origin, the other is decaying concentration at origin (one subcase is natural radioactive decay, the other subcase natural combined with artificial decay due to mixing with input filtrant). (100)

Analytical solutions presented are outdated, not very original, and better current treatments exist, e.g., J. Bear's book: "Dynamics of Fluids in Porous Media", 1972. (101/10)

<384>

Phillips Petroleum Company, National Reactor Testing Station, Idaho Falls, ID

Willing, H.W., and D.W. Rhoads. 1961, November. IDO-10428: 57 pp.

Removal of Radioisotopes from Solution by Earth Materials from Eastern Idaho (1)

Several local earth materials from the NRTS were evaluated for their potential for use as decontamination agents. Basalt, clayey sediments, lignite, and clinoptilolite were evaluated because of their abundance in proximity to the facilities at the NRTS. The results of these evaluations revealed that the

<348> COST.

most promising candidate appeared to be clinoptilolite. This candidate was selected because of its excellent physical and chemical stability, its favorable cation exchange capacity of 0.3 meq per gram, its adsorptive capabilities over a wide pH range and the availability of thousands of tons of the material nearby the WTS. Column breakthrough experiments and batch equilibrium tests were performed on these materials. Distribution coefficients for strontium and cesium were shown to exceed 1000 at favorable pH values. The effects of complexing agents on adsorption phenomena were also investigated. Citrate was shown to depress the adsorption of ruthenium while EDTA was shown to depress adsorption of strontium, cobalt, and ruthenium more than the adsorption of cesium and chromium. (NRM/JC)

Although the data presented are not strictly for the low-level waste burial site, this report does present adsorption data for some of the more important site materials. (NRM/JC)

Distribution Coefficient; Cation Exchange Capacity

<349>

Robert A. Taft Sanitary Engineering Center, Division of Radiological Health, Cincinnati, OH

Straub, C.P. 1964. U.S. Atomic Energy Commission, Division of Technical Information; 435 pp.

Low-Level Radioactive Wastes, Their Handling, Treatment, and Disposal (7)

This book is concerned with low-level radioactive wastes resulting from continuous nuclear operations. Accidental releases are not considered. The three main concepts involved in handling these waste are dilute and disperse, concentrate and contain, and delay and decay. This book describes the techniques used in applying these concepts so that radiation exposures can be kept to a practicable minimum. Specific examples of waste handling practices employed at atomic energy installations and their results have been described in some detail to serve as guides to the types and degree of treatment to be afforded these wastes. Five chapters were separately entered in the data base. (CN)

Some chapters contain pertinent information. General overview may be of value. (NRM/CN)

<350>

Robert A. Taft Sanitary Engineering Center, Division of Radiological Health, Cincinnati, OH

Straub, C.P. 1964. Low-Level Radioactive Wastes, Their Handling, Treatment, and Disposal, C.P. Straub, Chapter 2. U.S. Atomic Energy Commission, Washington, D.C., (pp. 17-50), 430 pp.

Sources, Quantities and Composition of Radioactive Wastes (3)

This chapter gives a general overview of the major processes by which radioactive wastes are produced in the United States. Brief discussions of the uranium mining and milling industry, uranium purification and fuel element manufacturing processes, and nuclear

reactor operations are given, including form, quantity, and composition of radioactive wastes produced. Typical values are given in cases where operational experience exists. Wastes produced by various national laboratories and some miscellaneous sources are also described. (CN)

General discussion of sources of radioactive waste. Not directly applicable to shallow land burial. (NRM/CN)

<351>

Robert A. Taft Sanitary Engineering Center, Division of Radiological Health, Cincinnati, OH

Straub, C.P. 1964. Low-Level Radioactive Wastes, Their Handling, Treatment, and Disposal, C.P. Straub, Chapter 3. U.S. Atomic Energy Commission, Washington, D.C., (pp. 51-84), 430 pp.

Collection, Sampling, and Measurement (3)

This chapter describes various waste collection systems together with the methods used to monitor levels of radioactivity before and after release to the environment. Flow charts of some typical waste processing systems are included. Specific sampling methods, including equipment descriptions, are given for various environmental media. These include water, bottom sediments, fish and other aquatic biota, gaseous air particulate, and solid waste collection and monitoring systems are also discussed. (CN)

Some information on environmental sampling methods for monitoring purposes applicable to shallow land burial. (NRM/CN)

<352>

Robert A. Taft Sanitary Engineering Center, Division of Radiological Health, Cincinnati, OH

Straub, C.P. 1964. Low-Level Radioactive Wastes, Their Handling, Treatment, and Disposal, C.P. Straub, Chapter 5. U.S. Atomic Energy Commission, Washington, D.C., (pp. 123-128), 430 pp.

Discharge to the Soil Environment (7)

The discharge of liquid radioactive wastes into surface and sub-surface soils is discussed. Geological and hydrological factors affecting disposal site selection are discussed and illustrated with descriptions of five specific sites: Hanford Atomic Products Operation (HAPO), National Reactor Testing Station (NRTS), Oak Ridge National Laboratory (ORNL), Savannah River Plant (SRP), and Brookhaven National Laboratory (BNL). The capacity of soils to adsorb specific radionuclides from waste solutions is reviewed. Mineral composition of the soil, element concentration, pH, other cations in solution, and total salt concentration are the major factors affecting radionuclide adsorption and are discussed in some detail. The diversity of conditions utilized for underground waste disposal is described. The area of the HAPO has a generally deep water table of approximately 350 ft below the surface. The average rate of movement of groundwater in the saturated zone of the Ringold formation is about 1/2 to 1 ft/day in the vicinity of some waste disposal sites.

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The transmissibility of the Vinland sediments is 10,000 to 50,000 gal/(day) (ft) under unit gradient. Ion-exchange capacity of the soil at Sanford is about 5 meq/100g of soil. In the HOTS area of the Snake River basalt, depth to the water table varies from 200 to 500 ft. Transmissibility through the basalt is on the order of 1 million gal/(day) (ft). The gravelly alluvium has a cation-exchange capacity of approximately 1.5 to 7 meq/100g of soil. Surface pits for the disposal of intermediate-level wastes at OBNL are composed primarily of Coconino shale. This formation has a cation-exchange capacity of approximately 9 to 20 meq/100 g of soil. Soils of the SBR area are predominantly kaolinitic; consequently, the exchange capacity is low (3 to 5 meq/100g of soil). The normal water table is generally at a depth of 30 to 60 ft. At OBNL, the glacial sand and gravel have a cation-exchange capacity of about 0.8 to 1.8 meq/100 g of soil. Transmissibility for the sand was found to be 200,000 gal/(day) (ft). Descriptions are given of the following waste disposal facilities, crib disposal at HAFB, deep-well injection at HOTS, and open pit disposal at OBNL and SBR. Liquid volumes and activities discharged are given. Techniques and equipment used in monitoring ground waters to follow the movement of radionuclides introduced into the soil are also discussed. (62) (C57)

Good general description of migration through soils of important radionuclides. Specific sites discussed. (58/62)

Depth to Water Table; Horizontal Flow Rate; Transmissivity; Cation Exchange Capacity

<353>

Robert A. Taft Sanitary Engineering Center, Division of Radiological Health, Cincinnati, OH

Straub, C.P. 1966. Low-Level Radioactive Wastes, Their Handling, Treatment, and Disposal, C.P. Straub, Chapter 16. U.S. Atomic Energy Commission, Washington, D.C., (pp. 313-326), 430 pp.

Handling and Treatment of Solid Wastes (4)

Techniques used in handling and disposing of solid low-level radioactive wastes are described. Methods of collecting, packaging, monitoring, and transporting of untreated wastes are discussed, along with subsequent treatment of compressible or combustible waste by baling or incineration. Final disposal by land burial or ocean disposal is also described. Operational experience gained at specific sites and facilities is included in the discussions, and some cost data is given. (62)

Brief discussion of solid waste sources, processing, and disposal. (58/62)

<354>

Robert A. Taft Sanitary Engineering Center, Division of Radiological Health, Cincinnati, OH

Straub, C.P. 1966. Low-Level Radioactive Wastes, Their Handling, Treatment, and Disposal, C.P. Straub, Chapter 15. U.S. Atomic Energy

Commission, Washington, D.C., (pp. 329-339), 430 pp.

Public-Health Implications (3)

The pathways by which populations can be exposed to radioactive contaminants are reviewed. Releases to the water, soil, and air environments are discussed and a variety of exposure routes are considered so that public health implications may be correctly evaluated. (62)

Reviews factors that must be taken into account when disposing of radioactive wastes. (59/62)

<355>

Stone and Webster Engineering Corporation

Evans, H.T. 1957. Advances in Nuclear Engineering, Vol. 1, Part 1, J.R. Dunning and P.H. Prentice (Eds.), Proceedings of the 2nd Nuclear Engineering and Science Conference held in Philadelphia, Pennsylvania, 1957. (pp. 630-662).

Structural Features of the Waste Disposal System for the Shippingport Atomic Power Station, Shippingport, Pennsylvania (4)

The discussion considers various important features of the waste disposal system plant for the Shippingport Atomic Power Plant. A fairly detailed description of the necessary tanks and piping to safely discard the various wastes is given. The plant will occupy over an acre and the structural aspects represent over 60% of the total construction costs. Criteria used for the project are: 1) adequate shielding for the tanks and pipes; 2) adequate monitoring of tanks and pipes; and 3) proper shielding for operating personnel. Two, 11,600 gallon stainless steel resin storage tanks will be in the facility. They will be put on concrete slabs and surrounded with gutters. Four, 29,100 gallon surge and decay tanks will also be used. These six tanks will be placed underground in chambers and will represent 30% of the total structural cost. Seven more tanks will be placed above ground to handle the less hazardous wastes. The slabs for the seven tanks will represent 7% of the total structural costs. The ion exchange vault will be 12% of the total structural costs. Basic building features such as plumbing, ventilation, heating, lighting and power supply are 27% of the structural cost. The remaining cost will be on the 17 covered trenches and miscellaneous yard work. (50/6)

Schematic drawings and cross-sections of the important structures are included. (55/6/50/6)

<356>

TEMA Corporation, Berkeley, CA

Night, L.W., and P.G. Hinesworth. 1977. COMF-770512; Management of Low-Level Radioactive Wastes, Proceedings of a Symposium held in Atlanta, Georgia, May 21-27, 1977, (11 pp.) (COMF-770512).

A Radionuclide Transport Model for Shallow Land Burial Sites (2)

A computer program was developed using the latest concepts that calculate the transport

(354) CONT.

of pollutants through soils. This is in response to the fact that at six licensed commercial disposal sites through 1973 about 9.1 million cu ft of solid radwaste containing about 2.1 billion curies of hydroflect material and 15.1 million cu ft of radwastes (solid) containing 14 million curies had been buried at lateral facilities. For sites to be effective in retaining the radioactive materials, the geology and hydrology must be well defined and one method is to use a model. The model is a one-dimensional transient response of a soil column to infiltrating water carrying a pollutant that interacts with the soil. The input parameters can be set to pore volume water, and varying rainfall or pond height are considered. The interaction includes both adsorption and diffusion. Since the solution to the differential equation is highly nonlinear, a difference equation is used and the derivatives become discrete ratios. Considered in the model as important aspects are: hydraulic conductivity of the material or sludge to transport fluid in the soil column; leachability of residuals (sludge, etc.); release of particulates; and chemistry of interstitial fluids. The soil characteristics accounted for are: hydraulic conductivity; chemical environment and microbial environment. To get the desired information field investigations must be conducted on the soil, laboratory leaching rates determined, and a parametric survey of soil response is needed. This model and the resulting assessment will produce concentration-time flux-time curves at depths corresponding to aquifers. (SDV)

(357)

United Nuclear Industries Inc., Environmental and Radiation Control

Dabrowski, T.E. 1976, June 28. USI-SA-00038; 12 pp.

Management of Low-Level Radioactive Waste in United Nuclear Industries, Inc.-Managed Facilities (6)

United Nuclear Industries manages the W reactor, a light-water-cooled graphite moderated reactor, located near Richland, WA, for ERDA. This report describes the basic sources of radiation, the treatment and handling of the waste, and the impact of the radwaste discharges on the environment. Airborne waste comes from either the gas atmosphere surrounding the graphite moderator, or from the primary coolant. The 50 year whole body population dose commitment due to all airborne effluent discharged from W reactor during CY 1975 was 0.88 man rem, compared to 25,000 man rem from background radiation. The 50 year whole body population dose commitment due to airborne uranium discharges during CY 75 was 0.00056 man rem. Liquid radwaste is released to a soil column, and to date many thousands of curies have been released and retained by the soil column. Included in the report is a cost assessment of a storage basin cooling water recirculation system, a fuel quality monitor system, and a waste treatment facility, which would eliminate the use of soil columns. (PTO)

(359)

United Nuclear Industries Inc., Richland, WA

Curtiss, D.H., and H.W. Leacock. 1976, October. U.S. Patent Document 3,988,254; 6 pp.

Radwaste Disposal by Incorporation in Matrix (2)

An invention is presented for incorporating radwastes in a matrix using a cement-type binding agent that eliminates or minimizes contraction from hardening and poor shipping efficiency. It was found in developing the process that the addition of an alkali or alkaline earth silicate produced a number of benefits and advantages. These advantages are: 1. direct solidification of all common nuclear power radwastes including boric acid solutions; 2. rapid hardening to a gel in less than 2 minutes, eliminating the necessity for continuous mixing to insure homogeneity; 3. solidification of various hardness in less than 7 days as compared to 29 days for cement alone without the alkali silicate additive; 4. increased water retention over non-silicated processes due to the high capacity of silicates for water fixation by hydration; 5. production of more fluid mixes causing ready adaptability to batch or continuous processing of radioactive wastes; and 6. minimum operator training and control required to obtain solidified wastes in a form suitable for safe handling and shipment. Cementing materials used in the process are: Portland cement (all types), natural cement (all types), masonry cement (all types), gypsum, gypsum cement or plaster, Plaster of Paris, lime (slaked or unslaked), and Pozzolans, all materials which harden by a combination of hydrolysis and hydration reactions upon the addition of water. The preferred cement is Type II Portland. Although any alkali or alkaline earth silicate may be used sodium silicate is preferred due to low cost and ready availability. General proportions of radwaste-cement-additive mixture are: 100 parts (by weight) radwastes, 20 to 100 parts (by weight) cementing material; and 5 to 50 parts (by weight) silicate additive. By using the additive the narrow liquid tolerance of the cements was broadened and increased the liquid absorption which increased shipping efficiency. Also, increased container use is obtained because waste molding does not have to be used. Finally, borate solutions can be solidified where it was not feasible before. If Portland cement is used the portions of radwaste-cement-additive are: 100 parts (by weight) radwaste, 25 to 70 parts cement, and 5 to 25 parts of silicate. The silicate is included in the slurry before being transferred to the container. The methods used to mix the solution is similar to those already used in mixing the radwastes and cement. (SDV)

Also see "A Critical Review of Solid Radioactive Waste Practices at Nuclear Power Plants, A.H. Kibbey and H.W. Godbee: ORNL-4924, 1974. (EITC/SDV)

(359)

Westinghouse Electric Corporation, Atomic Power Division, Idaho Falls, ID

Barnes, L.C. 1954, WASH-275; Sanitary Engineering, Proceedings of a Conference held in Baltimore, Maryland, April 15-16, 1954, (pp. 196-197) (WASH-275).

Summary of Westinghouse Atomic Power Division

<75> COST.

Waste Disposal Operations (3)

The Westinghouse Atomic Power Division was formed in 1949 at the Bettis Site in Pittsburgh. It was originally to develop and manufacture the Sibarine Reactor. In 1954 work was progressing on the PWS reactor and the plant was enlarging for that and other projects. Radioactive materials were used in a number of different metallurgical operations in both development and manufacturing, chemical processing, and engineering tests. The Physics Department also operated a "hot lab". Disposal of all radwastes was at sea, except for scrap or waste from accountable or valuable radioactive materials which were returned to the supplier. Separate drains were used in areas where radioactive materials were used and this system terminated in the Monitor Tank Room containing eleven 1500 gallon tanks. Areas where there were accountable radioactive materials collected these materials in a special drain system. Other areas in the plant were equipped with two drain systems, the Special Monitor System and a Monitor System. The Special System had a limited number of outlets and was intended

for collection of only those liquids which were expected to be contaminated. High-level wastes were collected in individual batches. The other system collected the water that would not normally be contaminated. The Monitor System, 98% of the time, contained no significant radwaste and was released into the storm sewer. The liquids from the Special Monitor System were processed through an evaporation system for concentration into a slurry. The slurry was then drained into drums where a liquid absorbent was added and the drums were then shipped. Contaminated paper and wool were burned and this ash was prepared for shipment in drums. Contamination was low and had created no particular problems. Solid scrap radwaste was prepared for shipment by placing such materials in the drum and then covering them with concrete. Lead shielding was used if necessary. Hydrofluoric acid was neutralized and precipitated and the insoluble fluoride is placed on a dump. Otherwise it was released from the plant in the effluent water. (SDW)

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Aerofjet Nuclear Company; Idaho National Engineering Laboratory, Office of Waste Management, Idaho Falls, ID

Burgess, V. R., and S.E. Baestas. 1976, July. IDN-W065: 36 pp.

The 1975 INEL Core Drilling Program, A Further Investigation of Subsurface Radioactivity at the Radioactive Waste Management Complex, Idaho National Engineering Laboratory (1)

In 1975, subsurface investigations were initiated at the Idaho National Engineering Laboratory, Radioactive Waste Management Complex to conclusively establish the presence of or absence of downward migration from the waste burial trenches. This work was the result of the apparent positive identification of radionuclide contamination observed in two distinct sediment horizons in the thick basalt sequences underlying the Snake River Plain from the 1971-1972 coring program. It was believed, however, that the contamination observed could have been introduced downhole during the drilling operations. This program was designed to resolve the contamination questions arising from the 1971-1972 program. The 1975 coring program was accomplished utilizing very stringent anticontamination procedures. These anticontamination procedures include the use of a filtered air rotary drilling system with extensive ground surface protection and the use of double casing. These procedures contrast strongly with the fluid rotary drilling operations used during the 1971-1972 program when little attention was paid to contaminated surface soils. The radiochemical analyses of samples obtained during the revised 1975 program did not reveal the presence of statistically significant contamination thus illustrating the importance of stringent anticontamination procedures. (JC)

This report offers an excellent discussion on anticontamination procedures for subsurface investigations near nuclear facilities. (DN/JC)

Stratigraphic Unit Thickness

114

<161>

Robert A. Taft Sanitary Engineering Center, Cincinnati, OH; South Dakota State Department of Health, Water Pollution Section

Tsivoglou, E.C., D.C. Kaldas, and J.P. Dearwater. 1958. A/CORF.15/P-2359; Peaceful Uses of Atomic Energy, Proceedings of the 2nd United Nations International Conference held in Geneva, Switzerland, September 1-13, 1958, Vol. 10, (pp. 170-183) (A/CORF.15/P-2359).

Waste Characteristics for the Resin-in-Pulp Uranium Extraction Process (2)

A field study of liquid wastes resulting from the extraction of uranium from its ore was conducted during the summer of 1957 at the uranium refinery at Edgemont, South Dakota. The refinery is a typical example of the acid-leach resin-in-pulp process, of intermediate ore-processing capacity. At the time of the study, it was processing slightly more than 500 tons per day of ore assayed about 0.28% U₃O₈. Virtually all liquid wastes were delivered to tailings ponds for storage and volume reduction by evaporation and seepage. For the ore processed during the study, about 17% of the gross alpha activity was due to the presence of radium. At the ore-processing rate of 517 tons per day, the liquid and solid wastes from ore processing contained about 0.6 sq of radium per ton of ore processed, or a total of approximately 300 sq/day. 99.8% of this radium remained in undissolved form throughout the process and was effectively retained in sands- and slimes-tailings ponds. About 0.2% of the radium that entered the mill either left the refinery in the final uranium concentrate or was delivered in dissolved form to the slimes and sands ponds. Effective retention and confinement of these solids and of the tailings-pond liquids resulted in practically no radium leaving the plant site during the survey, except for that contained in the uranium concentrate. The very small amount of direct drainage to Cottonwood Creek was from the sands pond and contained little or no radium or nitrate nitrogen. (JMT)

28

<352>

Cleveland State University, Chemical Engineering Department, Cleveland, OH

Novak, L.T. 1977. AIChE Symposium Series No. 166: Water-1976: 1. Physical, Chemical Wastewater Treatment, G.F. Bennett (Ed.), Vol. 73, (pp. 348-357).

Transport and Reactions of Ions in Soils (4)

The paper addresses itself to the physical and chemical factors influencing the transport of ions in soils. The main factors are: flow phenomena, interphase mass transfer, adsorption/desorption, and surface reactions. It is shown that the kinetics of orthophosphate removal from solution by a soil can be described as a series process involving interphase mass transfer, adsorption, and surface reaction. The mathematics of the kinetics is presented in some detail. Applications of these theories to certain heavy metals and transuranic elements are discussed briefly. (Auth) (809)

<363>

Colorado School of Mines Research Institute, Golden, CO

Verritt, R.C., R.E. Peterson, and C.W. Wentz. 1976, July 6. PB-261127; Bureau of Mines Open File Report 110-76; 163 pp.

Heap Leaching Studies on Uranium Ore (4)

Fundamental and comparative data on the relationship between particle size, leaching rate and percolation rates during the heap leaching of low-grade uranium ores from Wyoming, New Mexico, and Colorado are derived. The three ores are sandstones and they are from Western Nuclear's Golden Goose Mine waste dump, Wyoming; Anaconda's Jackpile Mine, New Mexico; and Union Carbide Nuclear's Sunday mine waste dump, Colorado. The assayed value is 0.066%, 0.062% and 0.080% U₃₀₈. The Sunday Mine also assayed 0.020% V₂₀₅. Agitated-leach conditions were sufficient to extract 95% U₃₀₈ from the Wyoming ore, 76% from the New Mexico ore, and 90% from the Colorado ore. Acid consumptions were not proportional to U₃₀₈ yields with 64 lb/ton for Wyoming and 155 lb/ton for Colorado ores. The acid demand depended on the type and quantity of reactable minerals and the demand for acid to achieve a final pH of 1.0. For the percolation-leach conditions 94% U₃₀₈ was extracted from the Wyoming ore; 81% from the New Mexico; and 84% from the Colorado ore. Leaching time was increased 150 hours and this had little effect on the Wyoming and Colorado ores. Also the size of the particles was larger and this had little effect on the Wyoming and New Mexico ores. Pelletizing the fines in the New Mexico ore increased the uranium extraction in the flow tests. With the longer leaching times (up to 120 days) the U₃₀₈ extraction was enhanced for the New Mexico ore and with larger particle size reduced for the Colorado ore. More tests to define the relationship between flow rates and U₃₀₈ extractions are recommended. Also, recommended is packing the ore into the column better simulate heap conditions. (PDV)

PH; Percolation Rate; Grain Size Distribution

<364>

Colorado State University, Fort Collins, CO

Edtzell, R.L., and R.E. Sunada. 1970, June. Hydrology Paper No. 61; 79 pp.

Numerical Simulation of Dispersion in Groundwater Aquifers (7)

A fundamental flow equation for a mixture of miscible fluids, derived by combining the law of conservation of mass, Darcy's Law and an equation of state describing the pressure-volume-temperature-concentration relationship, was solved using an implicit finite difference technique for several different cases of dispersion relationships and various geometries. The resulting code was used to simulate salt water intrusion problem. (00)

Comprehensive treatment of mathematics of dispersion in several dimensions in porous media. Mathematics are somewhat messy (not streamlined) but thorough. Large list of references of dispersion and numerical simulation. (DH/00)

<365>

Georgia Institute of Technology, School of Nuclear Engineering, Atlanta, GA

Chasplin, J.B.V., and G.C. Eichholz. 1976, February. Health Physics, 30(2), 215-219.

Fixation and Remobilization of Trace Contaminants in Simulated Subsurface Aquifers (3)

The role of fine particulates and bacteria are demonstrated experimentally in movement and retention of trace contaminants in a sand bed. The sand bed was an aquifer and had an equivalent flow rate of an aquifer of 5 cm/hr. Scandium 46 was initially deposited on fine kaolin particles and moved 60 cm down the sand bed. After two beds of water leaching it was 20 cm further down the length of the bed. This behavior was typical of all ionic species studied. Radioiodine mobilized at about 10(E-7) M NaCl. Clays, kaolin, and montmorillonite, may be remobilized by modifying ionic characteristics of the liquid flowing through the sand. This in turn would move the radionuclides. Bacteria may be induced to move by this manner. Rubidium 86 showed the greatest moved over 180 cm along the bed on kaolin particles. Leaching on bacteria only moved 30 cm and scandium on kaolin particles moved 80 cm. The tank was allowed to sit for 9 months, the subjected to leaching with I 131, Pb 210 and I 131 were readily remobilized. Scandium was only partially mobilized. The experiments showed that mechanism for filtering or fixing is surface interaction rather than physical hindrance. Addition of phosphate caused the nuclides to remobilize. It was seen by the experiments that any change in the water flowing through the sand can have the ability to remobilized changed by complexing agents natural or otherwise. (809)

<366>

Harvard School of Public Health, Department of Industrial Hygiene, Boston, MA

Silverman, L. 1966. CONF-651202; IAEA-SR-71/25; Practices in the Treatment of Low- and

INDEX CONT.

Intermediate-Level Radioactive Wastes,
Representative of a Response Held in Vienna,
September, December 4-10, 1966, (pp. 22-115)
TID-5470, 1966-50-71/24.

Disposal of Low-Level Combustible Solid Wastes by Incineration (8)

The safe disposal of low-level combustible solid wastes by incineration is a desirable method for small laboratories and institutions using radioisotopes. It is also a useful technique for nuclear power and research reactors where the volume of wastes generated are not so large as to necessitate a routine billing and off-site shipping procedure. Such incinerators have a capacity ranging from 10 lb (4.5 kg) up to 150 lb (68 kg). The general features of such incinerators, and their performance in several United States institutions and AEC laboratories are described. The composition of off-gases and solids on several research studies are detailed with information on burning a variety of combustible wastes. These incinerators have proved satisfactory for disposing of paper and textile wastes, animal carcasses and litter, as well as various other organic materials. Volume reductions from 99% to 99.5 have been obtained in practice. A comparison of incinerators operating with and without auxiliary fuel such as gas or oil is given. The effects of various factors on gas-cleaning requirements are shown. Data on various research investigations conducted at Harvard and elsewhere, on effluent cleaning, are presented. This includes: (a) Work by the United States Bureau of Mines on prototype institutional incinerators; (b) Joint studies by the United States Bureau of Mines and Harvard; (c) Harvard studies; and (d) Development of a 50-lb/hr incinerator and gas-cleaning system at the United States Army Chemical Center. It can be concluded that at low (10 lb/hr) burning rates with auxiliary fuel, it is possible to minimize the loss of particulates in the effluent. With higher rates and self-firing, it will be necessary to provide some gas-cleaning device. If liquid-waste disposal facilities are available, some scrubbing devices may be satisfactory followed by a high-efficiency filter, if high levels of activity are present. If only dry wastes are to be handled, dry gas-cleaning devices such as electrostatic precipitators can be used. High-efficiency filter temperature limits must be met by the use of dilution air or spray-cooling techniques. (auth)

Not directly relevant to shallow land burial.
(D/W/2)

< 167>

Harvard University, Division of Engineering and Applied Physics, Cambridge, MA

Phonix, R.A., Jr. 1956, October. TID-7517 (Part 18): Sanitary Engineering Aspects of the Atomic Energy Industry, Proceedings of a Seminar held in Cincinnati, Ohio, December 6-9, 1955, (pp. 457-470), 469 pp. (TID-7517, Part 18).

Disposal of Low-Level Liquid Radioactive Wastes in Inland Waterways (1)

An investigation of the ability of rivers and lakes to purify themselves of radionuclides was conducted. Self-purification mechanisms include precipitation and deposition,

absorption on the bottom, and biological uptake in aquatic plants and animals. These mechanisms depend on the following factors: hydro-meteorological; chemical, biochemical, and physical; sedimentative characteristics; stream size; cost of disposal relative to alternative methods; and feasibility of procedure for monitoring and control. Of all these factors the major one is longitudinal mixing (hydro-meteorological). The mixing is brought about by: 1) the non-uniform distribution of velocity caused by the curvature of and shear at the solid boundaries of the flow; 2) eddy diffusion associated with the turbulence of the moving stream; and 3) irregular displacements such as caused by wind and thermal currents. Tests were conducted on the Hobart River near Albany, N.Y. and Cockichewick, near Laurence, N.S. In the Hobart River test 0.5 curies of P 32 was released to a flow of 1100 cu ft/sec. It was found that the peak of activity diminished from stress and the peaks became broader. A mathematical model was derived to calculate the longitudinal dispersion coefficient. By combining the experimental and mathematical results it was computed that 1600 curies could be added to the Hobart River daily and not exceed the maximum permissible concentration for drinking water (7×10^{-6} uCi/liter). Furthermore, the uptake of radioisotopes is dependent on the amounts of non-radioactive elements of the same chemical species and upon the concentration of these naturally occurring in the stream. Several radioisotopes were used in the Cockichewick Brook tests: Pb 84, I 131, Sr 90, Na 22, P 32, and Ce 141. From these tests it was found that large recoveries are correlated with larger flow rates in the stream when bottom deposits containing activity from prior runs are eroded. (DDV)

River Flow; Dispersion Coefficient

< 168>

Iowa State University of Science and Technology,
Ames, IA

Scott, A.D. 1976, August. CDD-1680-23; 11 pp.

Exchange of Interlayer Cations in Micaceous Minerals, Final Report for Period February 1, 1967-August 31, 1976 (1)

Laboratory experiments were carried out to establish a comprehensive understanding of the processes and factors governing the sorption and release of interlayer cations in micaceous minerals. A diverse approach with several lines of work was used to delineate the effects of different procedures, solution compositions and mineral properties. It was soon clear that the major factors controlling the exchange of interlayer cations are the blocking effects of dissolved fixable cations and the limiting effects of small particles. By using sodium tetraphenylborate to reduce the blocking effects and by excluding particles that were smaller than 2 μ , however, the subtle effects of many other factors were brought out. The redox status of structural iron, the hydroxyl groups, the interlayer spacing and the layer charge of the minerals are indicative of the type of factors involved and the fact that they are mainly interactive in nature. One conclusion from this work is that most experimental results for interlayer cation exchange are bound to reflect some combination of the controlling factors. More important, however, was the observation that proper management of interlayer cation exchange can take micaceous minerals a good

(1402)

Link for design and source of potassium.
(Auth)

(1403)

Johns Hopkins University, Baltimore, MD

Torrey, J.E., Jr. 1955, December. DID-7517
(Part 18): Sanitary Engineering Aspects of the
Atomic Energy Industry. Proceedings of a Seminar
held in Cincinnati, Ohio, December 4-5, 1955,
pp. 241-249, 409 pp. (DID-7517, Part 18).

Considerations in Evaluating a Burial Ground for
Solid Wastes (2)

At present, radwastes are buried at five
different sites. It is suggested that a
national land burial area be used to sequester
radioactively contaminated materials. The
life of such burial areas should be at least
one hundred years. One square mile of burial
area with a buffer zone of one-half mile
should be acquired in an "empty" section of
the country. Topography, geology, surface and
ground water hydrology, meteorology, soil
conditions, and transportation facilities are
the physical factors affecting the
feasibility of any particular site. The
general geology should show an absence of
faults and folds. The area should not have
limestone or dolomite formations in addition
to having no previous seismological history.
The topography should be flat or gently
rolling for ease of burial equipment operation
and covered with vegetation. Streams in and
near the proposed area should be observed with
respect to hydraulic and hydrology factors,
silt load, bed scour, variations in flow,
vertical mixing and stratification. Lakes
would be included in the study. Exhaustive
information on the ground water conditions
with special emphasis on shallow aquifers will
be necessary. In the study attention should
be paid to movement, natural recharge,
discharge, depth to water table, permeability,
and transmissibility of the aquifer and the
velocity of flow. Any incineration ought to be
practical when there is a wind velocity of at
least 10 mph and the prevailing direction away
from site headquarters and nearby communities.
A low rainfall area is preferable. Also
areas where known inversions occur are to be
avoided. The area should be chosen with a
right clay soil to inhibit ground water
movement and maximize adsorption. The proposed
site should be within 1 miles of a major
highway and should have all-weather access
road and railroad siding. Also the area
should have an interlacing network of dirt and
semi-improved roads for easy local
transportation. The site should be located in
the geographic center of the major waste
producers. The cost of land burial may range
from \$1.52 to \$9.00/cu yd. (Auth)

(170)

Kansas State University, Department of Chemical
Engineering, Manhattan, KS

Choi, S.K., L.T. Yen, and L.E. Erickson. 1972,
February. Health Physics, 22, 177-186.

Simultaneous Dispersion and Decay of Radioactive
Wastes (2)

A mathematical model is derived to describe
the rate process governing the transport and
decay of a radioactive substance in a
solidified waste and a surrounding fluid.
Steps of the derivation are shown. A certain
radioactive component distributed in the
solidified waste dissolves in the water and
then diffuses out of the slab to the
surrounding fluid because of the concentration
difference. The decay of the radioactive
substance in both the slab and the surrounding
fluid of the system is an irreversible first
order rate process. The analytical
expressions for the change of concentration of
the radioactive substance are derived through
the use of a Laplace transformation technique
both as a function of time and position for
the porous body and as a function of time for
the surrounding fluid. The mathematical
expressions are useful in predicting
concentrations in the system as well as in
determining the effective diffusivity and the
decay coefficient of the radioactive
substance. (Auth) (200)

(171)

Louisiana State University, Baton Rouge, LA

Kozmann, R. 1970, November-December. Ground
Water, 12(6), 410-426; Ground Water Quality,
Proceedings of the 2nd National Symposium held in
Denver, Colorado, September 25-27, 1970, (9 pp.).

Waste Surveillance in Subsurface Disposal
Projects (2)

The usual procedure of monitoring subsurface
waste is the pressure in an injection well.
However, this procedure is not sufficient to
detect the leaks that are slow and of small
volume. Experimental and theoretical results
may indicate how wastes can be contained
safely for periods of 10,000 to 100,000 years.
If the waste is denser than the native fluid
in a horizontal aquifer the waste will go to
the base of the receiving formation. A
computer model was designed to indicate the
progression of a waste front and the
theoretical results were verified by a
laboratory model. A gently sloping aquifer
with no existing groundwater movement is a
favorable target particularly if the waste is
denser than the native waters. Therefore, if
the waste can be injected into such an
aquifer, it will provide a storage area where
monitoring will be minimal. In order to store
wastes for long periods of time the regional
geology of the target aquifer should be known.
Parameters included thickness, dip, faults
obstructing regional flow, density
distribution of the native waters, porosity,
permeability and storativity. Field example
was done for waste injection rate of 700 gpm
or 2.7 cu m/min. The aquifer, the waste was
injected into had: porosity of 20%;
permeability of 700 gpd/100 ft (9.5×10^{-2}
cm/sec); thickness of 100 ft (30 cm), a dip of
of 1/8 mile (0.0075). The density difference
between the native and injected liquids was
2.19 gm/cc. The minimum distance between the
well and boundary would be 2.5 miles (4.0 km)
where the waste water would pond. (Auth)

Effective Porosity; Intrinsic Permeability;
Thickness of Upper Aquifer

<372>

Massachusetts Institute of Technology,
Radioactivity Center, Department of Physics,
Cambridge, MA

Schroter, G.L., R.W. Koster, and B.D. Evans.
1965, January. Journal of Geophysical Research,
70(2), 871-876.

Diffusion of Radon in Several Naturally Occurring
Soil Types (2)

Diffusion coefficients for radon in several
naturally occurring soil types were determined
experimentally. The diffusion coefficients
ranged from 0.02 to 0.05 sq cm/sec with
 0.03 sq cm/sec appearing to be a fair
approximation of the diffusion coefficient for
moderately dry sandy soil. Data indicate that
atmospheric convection forces, resulting from
barometric pressure oscillations, affect the
interstitial motion of radon. Radon flux
measurements ranged from 0.32×10^{-12} pCi/sq
cm-sec to 2×10^{-12} pCi/sq cm-sec as a
function of soil type. (auth) (J7)

Provides experimental data on flux and diffusion
coefficients of radon in soil. (JW/JT)

Dispersion Coefficient

<373>

Michigan State University, Department of Chemical
Engineering, East Lansing, MI; Michigan State
University, Department of Crop and Soil Sciences,
East Lansing, MI

Shah, D.P., G.A. Coulman, L.T. Novak, and D.T.
Ellis. 1975. Journal of Environmental Quality,
4(1), 87-92.

A Mathematical Model for Phosphorous Movement in
Soils (2)

Land application of municipal and industrial
wastes is increasingly being looked upon as an
alternative for treatment of effluent. Since
phosphorous compounds constitute a major
potential source of ground water
contamination, a model for the movement of P
was developed. Phosphorous moves through the
soil in the form of soluble orthophosphates
which can undergo precipitation,
crystallization, and/or adsorption-desorption
reactions in the soils. In order to predict
the concentration profiles of phosphorous as
functions of depth and time, some experimental
data are needed. Hydraulic conductivity and
capillary potential should be known over the
whole range of saturation values. Also needed
are the P equilibrium relationship between the
solid phase and the liquid phase and the value
of the overall volumetric mass transfer
coefficient. The comprehensive model
describing the quantitative behavior of water
and P shows that the water saturation profile
travels much faster than the P profile and
that water redistribution between irrigations
in the barriered Landscape Water Renovation
System (BLWRS) treatment system had a
negligible effect on P movement. Under these
conditions, the velocity of water through the
bed in the zone of interest can be considered
constant. Calculations are reduced by this
assumption and predicted results agree very
well with field data. Such a model is very
useful in designing waste water irrigation
sites. To get the most out of an irrigation
system, it must be designed and operated so as
to minimize P leakage to ground water. This
type of model with predictive capability can

be very well used for such a purpose. (JW)

Hydraulic Conductivity; Density

<374>

New Mexico Institute of Mining and Technology,
Department of Physics, Socorro, NM

Clements, S.L., and S.E. Wilkening. 1970,
November 20. Journal of Geophysical Research,
75(33), 5825-5829.

Atmospheric Pressure Effects on Radon 222
Transport Across the Earth-Air Interface (2)

The effect of large-scale atmospheric pressure
changes on the Rn flux across the soil-air
interface is investigated. Field data
collected during 1972 and 1973 show that
pressure changes of 1-24 associated with the
passage of frontal systems produce changes in
the Rn 222 flux from 20 to 50%, depending upon
the rate of change of pressure and its
duration. A simple model of molecular
diffusion combined with pressure-induced
transport in the soil has been confirmed by
laboratory experiments using a vertical column
of 2226-bearing sand. On the basis of this
model, pressure changes of 10-20 mbar
occurring over a period of 1-2 days produce
barry velocities of the order of 10^{-12} cm/s
near the surface of a soil having a
permeability of 10^{-12} sq cm. The
corresponding variations in the Rn 222 flux
predicted by the model are in agreement with
those observed from valley alluvium in central
New Mexico. (auth)

A first attempt at a model to explain radon flux
variations with pressure useful background data
for mills in the area. (DR/LS)

<375>

New Mexico Institute of Mining and Technology,
Socorro, NM

Sabinowitz, D.D., C.D. Holmes, and G.D. Crost.
1971. CONF-710609; Tritium, A.L. Nighizel and
H.V. Carter (Eds.), Proceedings of a Symposium
held in Las Vegas, Nevada, August 30-September 2,
1971. Messenger Graphics, Las Vegas, Nevada,
(pp. 871-884), 887 pp. (CONF-710609).

Forced Exchange of Tritiated Water with Clays (2)

Report presents data relating to: exchange of
tritium with exchangeable cations, replacement
of tritiated water molecules with water of
crystallization or hygroscopic water, and
replacement of lattice aluminum sites by
tritium in clay minerals. Reference clay
minerals used in this study were: kaolinite
90 from Tucson, AZ, kaolinite 99 from New
Mexico, NM, and illite 915 from Pithman, IL.
Numbers are from the American Petroleum
Institute. Electrolysis of clay minerals,
kaolinite and illite, (53-70 microns) at 2
V/cm indicated an exchange rate of 60 pCi/h
with kaolinite 90 at pH 5.5, tritium loss of
100 pCi/h with clay-water compartment pH at
1.1. Illite 915 showed a strong retarding
effect on tritium migration under the electric
field, as shown by the no equilibration across
the cell after 28 days. A control test was
run without clay and equilibration was reached
in 6 days. Data showed no net tritium loss.
Total cation exchange capacity for kaolinite

CHICAGO, ILL.

On the 11.5 m²/10³ g, baseline 88 was 122 m²/10³ g, and illite 85 was 14.2 m²/10³ g. The total of values for the clay-water cell were as follows: baseline 88 122, baseline 85 14.2, and illite 8.4. The final contribution to the clay-water cell were as follows: baseline 88 116 pphs/cc, baseline 85 102 pphs/cc, and illite 8.4. Twenty percent of the exchange capacity of the baseline was due to exchangeable Al³⁺. The fractional increase in the water was exchanged over equilibrium value was 21% for baseline 88, 100% for baseline 85, and 7% for illite 8.4. From the change in total activities, the entire exchange appears to be a linear process in time. (1973)

A study of exchange capacities of baselines and illite with cations by electroanalysis. (1973/74)

Cation Exchange Capacity: Hydraulic Conductivity: 20

(1974)

Pennsylvania State University, Department of Geosciences, University Park, PA

Agar, W.A., and D. Langmuir. 1973. November-December. Ground Water, 9(6), 74-84; National Ground Water Quality, Proceedings of a Conference held in Denver, Colorado, October 25-27, 1973, (2) pp.

Ground Water Pollution Potential of a Landfill Above the Water Table (2)

The results of a study on the characteristics and movement of leachate from a landfill through unsaturated soil. The landfill was located in a gently sloping valley which was underlain by residual sand-clay to sandy loam soils which were underlain by a sandy foliated bedrock. The depth to the water table was in excess of 200 feet. Results of the study showed that the quality and quantity of leachate produced varied with respect to topographic setting and relative cell setting. Upslope cells received only infiltration from precipitation while the downslope cells received precipitation, surface runoff, subsurface water, etc. Vertical migration of leachate beneath the cell was found to range between 4-15 feet/year. Decreases in pH, SO₄, metal cation concentration, inorganic salts, and chloride occurred as depth beneath cells increased. The study concludes that location of sanitary landfills in carbonate terraces will cause ground water contamination. This contamination has been attributed to the channeling of leachate from fractures in shallow bedrock or infiltration through sink holes. (1974) (27)

Although the emphasis is on sanitary landfill, the overall concept is applicable to shallow land burial of radioactive wastes and the potential for the migration of certain radionuclides. (1974/75)

(1975)

Pace University, New York, NY

Adams, A.S. (Ed.), and R.H. (Ed.) Lowder. 1968. Natural Radiation Environment. University of

CHICAGO, ILL.

The Natural Radiation Environment (10)

State papers on environmental radiation sources and environmental monitoring are presented. An address entitled "Radiation and Other Environmental Factors in Human Biology" by V. Loeferer is also included. The appendices include sections on an intercalibration experiment on instrumentation used in environmental radiation measurements, properties of the uranium and thorium series, and abbreviations used in the text. (1975)

Information pertinent to radon emanation from buried wastes and environmental monitoring of waste sites are presented. (1974/75)

(1974)

Stanford University, See - y Department, Stanford, CA

Workshop, U.S. 1977, February. OHP/CSO-77-1; Issues Pertinent to the Development of Environmental Protection Criteria for Radioactive Wastes, Proceedings of a Workshop held in Boston, Virginia, February 3-5, 1977, Vol. 1-37 - 1-20 (1977/CSO-77-10).

Geologic Aspects of Criteria Development for Radioactive Waste Management (1)

The discussion is primarily aimed at high-level radioactive wastes, but some of the information is applicable to shallow land burial of low-level wastes also. The usefulness of geology in determining suitable locations for radioactive waste burial and in analyses of the possible pathways by which radionuclides might migrate is discussed in general terms. The experience of geologists in handling the long time spans necessary to render land-based radionuclides harmless is pointed out. (1974)

Little information of use for shallow land burial. (1974/75)

(1975)

Temple University, Radiation Safety Office, Philadelphia, PA

Zelen, R.E., J.W. Bernier, and R. Han. 1977. Health Physics, 12, 852-853.

Effectiveness in a University Health Center Setting of a Commercial Compactor for Dry Solid Radioactive Waste (1)

Since the volume of solid radioactive waste increased from 122 cu ft in 1967 to 225 cu ft in 1970, a compactor was bought for Temple University. The compactor incorporates a boot with an absolute filter to control the dust that is frequently found in the 20 gal plastic bags from the radwaste. After compaction the radwaste is placed in 55 gal steel drums. During the first eight months of operation the compactor reduced the solid dry waste volume to approximately 1/3 to 1/4 of the original volume of the waste collected. The unit is definitely cost-effective. The net saving over the 20 month period covered in the report was \$5800 with no down time. Anticipated yearly savings are expected to be at least \$6700. The savings are realized in the form

SCIENTIFIC

<1975> CITE

of selected free storage space, record keeping, labels, and technician time. (JST)

<1975>

University of Arizona, Agricultural Experiment Station, Tucson, AZ

Voller, W.W., R.T. Vetter, C.E. Siehl, and S.L. Smith. 1976. Soil Science, 122(4), 223-235.

Contribution of the Soil to the Migration of Certain Cations and Trace Elements (2)

Thirteen U.S. soils were investigated to determine the contribution which they make to the mobility of some common and trace elements as influenced by four characteristic waste stress and leachate vehicles, space water, tilate acid, solutions resembling industrial wastes, and municipal landfill leachates. The soils investigated were soils from the following soil series: Bagras, Axi, Ballast, Davidson, Molokai, Chalmers, Nicholson, Pima, Payson, and Bohave (2). They ranged in pH from 4.2 of the highly acid Ultisol, Bagras loamy sand, to pH 7.8 of the alkaline Aridisols, Anthony sandy loam, and Bohave clay loam. The cation exchange capacity ranged from 2 to 17 meq/100g and the clay content from 4 to 61 percent. Two Bohave soils, which exhibit lime content with depth, were included to provide an opportunity to compare two genetically similar soils, with and without lime. The clay mineral composition of the less than 2 micron of the 11 soils varied widely from largely montmorillonite-type in Anthony sandy loam, and Chalmers silty clay loam to largely kaolinite-type in Davidson and Molokai clays and Bagras loamy sand. Results of the soil column testing showed that the mobility of the soil anions and cations, and trace elements, migrated in quantities often several times greater in the presence of soluble Al and Fe. The solubilizing effect of such highly reactive systems as AlCl₃ and FeCl₃ on soil constituents must be considered in the management of industrial waste stress disposals where they and like substances are likely to be included in the waste system. Finding that the municipal solid-waste landfill leachate, even after 15 soil pore-space displacements, did not add significantly to the migration of potentially hazardous pollutants through the 11 soils over that of pure water was encouraging. One way to interpret these data is indicating that under certain favorable soil conditions, municipal solid waste landfills do not pose a serious potential hazard for contamination of the underground water or soil, above that of rainwater. (JST)

Extensive tabular data are presented in this report. (JST/C/JST)

pH; Cation Exchange Capacity; Clay Content; Density

<1975>

University of California, Division of Civil Engineering and Irrigation, Berkeley, CA

Orcutt, P.G., J. Saor, G. Elston, and S.J. Kaufman. 1956, October. TID-9637 (Part 1); Sanitary Engineering Aspects of the Atomic Energy

Industry. Proceedings of a Seminar held in Cincinnati, Ohio, December 4-6, 1955, (pp. 191-211), 475 pp. TID-9519, Part 11p.

Hydraulic and Ion-Exchange Phenomena in the Underground Movement of Radioisotopes (4)

Theory and experimental results are presented for flow of a two density liquid system in an aquifer and the related ion exchange. Factors considered to influence the movement of radioactive wastes are: difference in density between the injected and displaced liquids causing an intrusion wedge; fissures; solution cavities; and regions of high permeability. A detailed discussion is presented on various ideas of the microscopic nature of laminar flow through a complex system of interconnected capillaries and the dispersion of a liquid interface. It is found that the steeper breakthrough curves result from a homogeneous media of relatively high permeability. These media would be more satisfactory for a disposal formation. The model used in the experiments is the Hele-Shaw model of Two-Fluid flow. This model was used to determine the magnitude and relative significance of density tilting and to evaluate the applicability of the Hele-Shaw viscous flow model to the study of gross velocity variation created by the existence of a difference in densities between injected and displaced liquids. Since the position of the boundary between the two fluids is continually shifting the flow pattern of the interfacial liquid was resolved into two independent motions, a "longitudinal translatory motion" and a "rotational tilting motion." These two were presumed linear and could be added algebraic addition for a general solution. The density tilting is related to the formation parameters and can contribute significantly to the various rate of underground waste travel. The chemistry of ion exchange is considered in general theoretical terms. Considered to be important in controlling the property are: the degree of ionization of the media, the presence of other cations, and particularly hydrogen ion. With a favorable equilibrium relatively steep breakthrough curves result. A flattening of a breakthrough curve due to either an unfavorable equilibrium constant or, to a failure to achieve equilibrium between the liquid and solid phases, would cause the inefficient utilization of the ion-exchange component of the storage capacity of a formation. It was found that ion-exchange may increase the storage capacity of a medium by ten fold. The storage capacity of a formation will be determined by the breakthrough of the waste at the various permissible concentration. When the radionuclides have a selective affinity for the exchange medium the concentration front may be sharp and a more complete utilization of the radionuclide will travel further into formation. (JST)

Good presentation of theoretical fluid mechanic and ion-exchange considerations is given. (JST/C/JST)

<1975>

University of California, Laboratory of Nuclear Medicine and Radiation Biology, Los Angeles, CA

Siehl, W., P. Taylor, S.V. Alexander, and R.W. Larson. 1962, July-December. Soil Science, 90, 187-197.

Influence of Stable Cesium and Potassium on the Reactions of Cesium 137 and Potassium 42 in Soils

(100) CONT.

and Clay Minerals (10)

Experiments were conducted to study the influence of stable Cs and R on the reactions of tracer quantities of Cs 137 and R 87 in soils and clay minerals, using an equilibrium batch method. The cation exchange capacity at various pH values were tested for the clays. Tracer quantities of both Cs 137 and R 87 were strongly sorbed in soils and clay minerals. Cs was more strongly sorbed than R. Since the initial trace quantities of carrier-free Cs 137 were strongly sorbed, the sequence of the addition of the tracer radioisotope in relation to the addition of stable Cs and R determined the level at which equilibrium was attained. The absolute amount of Cs and R sorption depended on the kind of clay mineral and soil. Cation sorption relative to R was greater in Ca-clay than in K-clay. The concentration of the stable Cs and R present was also an important factor. When the tracer Cs 137 was diluted to a negligible fraction of the total Cs in solution, only a negligible fraction of Cs 137 was sorbed. In equimolar mixtures of Cs and R, the sorption of Cs relative to R decreased as the ionic concentration increased. As a corollary to this effect, under conditions of low ionic concentration, stable Cs was much more effective than R in releasing Cs 137 from soils. In high concentrations, however, R may be, in certain soils, as effective as stable Cs. (Auth)(JST)

Cation Exchange Capacity; pH

(101)

University of Cincinnati, Cincinnati, OH

Cosentino, S. L., R. R. Emmerich, and J. E. Leonard. 1978, August. Protective Packaging Inc. Interim Report; 88 pp.

Interim Report on Evaluation of Solidification Techniques for Low-Level Nuclear Waste Materials (12)

A simple, rapid and reproducible test of leachability has been developed and applied to aqueous radioactive solutions solidified with either cement, urea-formaldehyde resin, or modified urea-formaldehyde resin. Dilute aqueous solutions of 22-Na, 57-Co, 60-Co, 85-Sr, 109-Cd and 137-Cs as soluble ions were solidified with each agent in proportions spanning the range of nuclear power plant practices. Samples were cured, and the gamma activity counted for each nuclide before and after immersion in gently flowing tap water. Samples were temporarily retrieved weekly for counting to residual activity. Results, expressed as initial activity fraction retained with increasing leach time, indicate that leach rates differ significantly for individual nuclides, and are strongly dependent on liquid proportion for all solidification agents tested. No correlation has been observed between leach rates and physical characteristics of the solidified product. With cement, leach rates are dependent upon the presence of boric acid in the liquid. With urea-formaldehyde resins, leach rates are dependent upon source and prepolymer composition, and upon the presence of added sodium sulfate. Modification of urea-formaldehyde formulations can markedly improve leach resistance. Additional tests are in progress to evaluate other characteristics pertinent to the transportation and burial of

Solidified Wastes. (Auth)

The attributes of urea formaldehyde are somewhat overstated. (DN/JC)

Leaching Rate

(102)

University of Illinois, Urbana, IL

Gris, V. E. 1968. McGraw-Hill Book Company, New York, New York, 2nd Edition.

Clay Mineralogy (2)

An in-depth review of the physical and chemical characteristics of clay minerals including composition, texture, organic content, classification, structure, ion exchange (cation and anion), sorption (water), hydration and dehydration characteristics (with particular emphasis on structural changes), organic reactions (ionic and neutral molecules), optical properties, solubilities, surface area, density, infrared spectra, dielectric constants, and origins and occurrences. X-ray diffraction data for various clay minerals are presented and include discussions of the application of the data in the identification of the minerals. The origin and occurrence of clay minerals are discussed with respect to the synthesis of these minerals from oxide and hydrous oxides and crystalline minerals at both elevated temperatures and pressures and standard temperatures and pressures. The occurrence of clay minerals in hydrothermal deposits is discussed and includes the relationship to parent materials, zones of mineralization (including ore bodies) and the hydrothermal solutions. Other notes of occurrences discussed include occurrences in marine and non-marine environments. Origins and occurrences of clay minerals in recent sediments are discussed with respect to diagenetic processes. An appendix is provided on the chemical analysis of the various clay minerals. (Auth)(JT)

The publication is designed to provide in-depth information on the physical and chemical characteristics of the various clay minerals. Most of the data not directly concerned with shallow land burial but maybe applicable to potential control methods. (DN/JT)

(103)

University of Minnesota, Minneapolis, MN

Straub, C. F. 1975, June. Journal of the Water Pollution Control Federation, 57(6), 1498-1511.

Radioactive Wastes (8)

A literature review is presented concerning the radioecology of water organisms, environmental behavior of radionuclides, management of fuel reprocessing wastes, engineering aspects on siting and operating power plants, nuclear and chemical properties of fission products, and other aspects of waste disposal. Section headings in the review include: ore processing; coagulation; adsorption and ion exchange; fixation; ground disposal; flotation; evaporation; transmutation; extraterrestrial disposal; water environments; and uptake by organisms.

<195> CONT.

One processing emphasizes the role of nonoxidizing bacteria in oxidizing Feo. The process of coagulation-flocculation with ferric hydroxide removes Sr from wastes well. Clays and fumes are discussed as adsorption and ion exchange media. Calcination is emphasized as a fixation process. In the ground disposal section siting and operation of high-level waste storage areas. Ionic flotation is discussed as a process for extraction of microamounts of Pu 106. Reports on emphasizes the creation of salt cakes from reprocessed fuel. Transmutation section considers the rate at which radionuclides in high-level waste were transmuted in the blanket section of a CTR. All aspects and concepts of the process are included. A variety of water environments, such as hot springs, oceans, rivers, ice sheets, and lakes, are examined with respect to concentration of radionuclide present. Uptake section is concerned with the uptake and concentration of radionuclides in fish, fresh and marine algae, and wildlife and non-marine mollusks. (UDV)

<196>

University of Minnesota, Minneapolis, MN

Straub, C.P. 1971, June. Journal of the Water Pollution Control Federation, 53(6), 1085-1088.

Radioactive Wastes (3)

A brief discussion and presentation of the recent literature on radioactive wastes is covered according to topic areas. Reviews on the state-of-the-art of treatment of Canadian ores, incorporation of radioactive wastes in bitumen, field studies on salt and brackish water fish, and a new volume in "Progress in Nuclear Energy" are highlighted. Wastes including solid noncombustible and combustible liquids, water soluble liquids, flammable, organic, and miscible solvents and various ways of handling them such as tetra-potential-controlled clarification, coagulation, activated silica, lemniscatization, and activated carbon are briefly discussed. Precipitation, solvent extraction, ion exchange, and fixation are other methods considered for waste treatment. Short discussions are presented on ground disposal, ocean disposal, uptake on sediments, uptake by organisms such as algae, mussels, and phytoplankton. Also included are guides on toxicity, analysis of seawater, beneficial applications, and monitoring. (UDV)

<197>

University of Minnesota, Minneapolis, MN

Straub, C.P. 1972, June. Journal of the Water Pollution Control Federation, 54(6), 1115-1123.

Radioactive Wastes (4)

A book on all aspects of radioactive wastes was published by Rodier and Verhezen. A symposium on the developments in the management of low- and intermediate-level radionuclides was held in France. Topics covered included standards for the control of effluents, nuclear power as an energy source, effluent control and monitoring,

considerations affecting steam power station site selection, and benefit-risk assessments. The Transactions of the American Nuclear Society included summaries of 501 papers and about 259 references to published literature and reports produced by the Oak Ridge National Laboratory were listed. Improved processes on using activated carbon in a clarifier-coagulator increased decontamination factors. Other processes employing precipitation, evaporation, and ion exchange were discussed. It was found that a two-step process of coagulation with the same consumption of iron sulfate increased decontamination of radwaste water by 12 to 20-fold and 2 to 5-fold with respect to alpha and beta activities, respectively. Consideration was given to a book on the theory of froth flotation of colloids as carriers of radioactive microcomponents and the processes and flotation methods. Solvent extraction was used to process irradiated nuclear fuels for Pu 107 as a mixture of lanthanides. Ion exchange by natural and synthetic materials was mentioned. The clay minerals were from White Oak Lake bed and the synthetic materials with more promise were phyllosilicate minerals. Fixation by calcining and solidification in polyethylene or asphalt were discussed. Ground burial by hydraulic fracturing was found to have no significant present or future hazard to the public or the environment. Liquid wastes were placed in a deep underground chimney and allowed to self-boil. The rock refracts, trapping the radioactivity in an insoluble rock matrix. Burial in salt deposits is being further researched. Pu radwaste concentrations were reported in Milan, even though 1 131, 83 203, and 85 109 were disposed of in the sewers. Low-level Co 60 has been detected in localized areas of harbor bottom sediment around a few piers at operating bases and shipyards servicing vessels over a period of several years. The psychological impact on sea disposal was examined. Studies on the uptake by organisms of radwaste under current standards, guidelines, and operational experience indicated that possible biological effects would be undetectable. (UDV)

<198>

University of Minnesota, University Health Service, Minneapolis, MN; University of Wisconsin Medical School, Department of Radiology, Madison, WI

Hollan, R.O., J.W. Steiger, and R.J. Sage. 1971, September. American Industrial Hygiene Association Journal, 32(9), 625-632.

Disposal of Low-Level Radioactive Wastes at a Large University Incinerator (4)

The University of Minnesota incinerator is used for disposal of low-level combustible radioactive waste. Calculations have been made to determine the concentration of radioactive material in the air and ash effluent. Air dilution volumes are determined by continuous airflow and temperature monitoring devices. It is demonstrated that such an incinerator can be used to dispose of low-level radioactive waste within prescribed limits. These limitations are dependent on the volume of air dilution and the volume of nonradioactive refuse incinerated.

<199>

University of New Mexico, Department of Geology,
Albuquerque, NM

Brookins, D.G. 1976. Environmental Geology, v.
255-259.

Shale as a Repository for Radioactive Wastes:
the Evidence from Ohio (9)

Study of the 1.9 billion-year-old fossil
nuclear reactor zones at the Ohio line in the
Republic of Gabon shows that many of the
elements produced by fission have been almost
completely retained, as evidenced by proper
weights of stable daughter elements.
Plutonium, ruthenium, the rare earth elements,
zirconium, and palladium have been effectively
retained while most chalcophile elements
exhibit some degree of remobilization. The
alkali and alkaline earth elements have
migrated to varying degrees but their presence
in gangue affected by younger periods of
alteration suggests redistribution not far
removed from sites of formation. More
important, such migration may not have started
until some 75,000,000 years after the reactor
shut down. The noble gases xenon and krypton
escaped with apparent ease during the 500,000
years the reactor was operative, and ^{136}Xe
seems to have been mobile. The Ohio reactor
area, significantly occur in shale infill?
into a fracture system in organic-rich
sandstone. So many of the fission-produced
elements retained in this shale along with
evidence that most others may have been only
locally redistributed lends support to
considering shales in geologically stable
areas for radioactive waste disposal. (Auth)

<199>

University of Pittsburgh, Graduate School of
Public Health, Department of Industrial
Environmental Health Sciences, Pittsburgh, PA

Schlager, K.J. 1977, April. ODP/CSO-77-2;
Policy and Technical Issues Pertinent to the
Development of Environmental Protection Criteria
for Radioactive Wastes, Proceedings of a Workshop
held in Albuquerque, New Mexico, April 12-16,
1977, (pp. 2-85 - 2-87), 358 pp. (ODP/CSO-77-2).

Radioactive Radon-Radon Risk (9)

Disposal of thorium 230/radium 226 bearing
wastes is usually accomplished by burial with
the prime objective being the minimizing of
contact with water and subsequently leaching.
The rate of radon emanation from these wastes
is dependent on several factors including
concentration of radium in waste; total
thickness of waste material; the nature of
waste material (e.g. physical
characteristics); and the nature of the cover
material (if any). The primary radon emitting
waste produced is uranium mill tailings, with
phosphate tailings being secondary. The
critical dose from radon decay is not
attributed to radon but its progeny. The EPA
has selected a dose conversion factor for
radon of 5 rem/yr for a concentration of 1.0
pCi/liter. The organ receiving this dose is
the lungs, primarily the bronchial epithelium.
Due to the concentration of radium in
naturally occurring soils (average 0 pCi/g),
the author recommends a "de minimus"
concentration in the range of 15-20 pCi/g. A
review of the Colorado River Basin and the
associated uranium and radium source terms
used in the loss rate calculations are
summarized. The calculated fractional loss

rates for uranium range from 5×10^{-12} to 8×10^{-12} per year. Calculated fractional
loss rates for radium were, on an average, 3rd
order of magnitude lower. The author's
conclusions include (1) radium and radon
represent potential major hazards, (2)
reduction of radon inhalation exposures is an
important management objective and (3) there
is a need to establish "de minimus"
concentrations for regulatory purposes. (JH)

Generalized discussion of radiation risk with
emphasis placed on radium-radon potential
hazards. (JH/JT)

<191>

University of Texas, Sanitary Engineering
Research Laboratory, Department of Civil
Engineering, Austin, TX

Bernhard, E.V., and E.P. Clough. 1956, October.
TID-7517 (Part 1A): Sanitary Engineering Aspects
of the Atomic Energy Industry, Proceedings of a
Seminar held in Cincinnati, Ohio, December 6-9,
1955, (pp. 27-86), 609 pp. (TID-7517, Part 1A).

Seminar of Investigations on the Removal of
Radioisotopes from Waste Water by Oxidation Ponds
(2)

Oxidation ponds were used in laboratory and
pilot-plant investigations to test the
possibility of using these to concentrate
certain radioactive isotopes and stabilize
potentially hazardous wastes. The value of using the
oxidation ponds lies in the effects of
biological processes, chemical precipitation
and ion exchange in combination with
relatively long detention periods. The
radioisotopes involved in the study were P 32,
I 131, Cs 137, Sr 89, Sr 90, Ce 141, and an
aged fission product. Biological activity and
stable phosphorus controlled the amount of P
32 removed. When the waste solution was free
of silt and clay Cs 137 was readily removed.
While the decontamination factor of Sr 89 and
Sr 90 was 1.5, it is encouraging to note that
the uptake is partly dependent on the
biological population. For Ce 141 a
decontamination factor of 20 is obtained and
is dependent on the number of organisms and
the rate of growth. The pH also affected the
removal of Ce 141. A decontamination factor
of 5 can be had in oxidation ponds for aged
fission products when a forcing cycle is used
on a period of once every 10 days. The
primary advantage of using oxidation ponds as
a storage and treatment device is to equalize
the concentration in the effluent and also remove some
radioisotopes. The most economical filter of
the algae were the coarse grades of
diatomaceous earth. Chemical coagulation was
found to cost 3 cents/1000 gallons and the
sludge concentrate still requiring further
filtration added 2 cents/1000 gallons to the
cost. Tests were run to determine the
operating criteria for the oxidation ponds:
light, temperature, surface agitation, depth,
recirculation, and detention. Evaporation in
hot, dry areas will increase the retention
time of the wastes due to evaporation. (JH)

<192>

Washington State University, Department of
Materials Science and Engineering, Pullman, WA

Subramanian, R.V., and R.A.V. Noff. 1976. AICHE

(1972) CONT.

Swenson Series No. 154(72): Radioactive Wastes from Nuclear Fuel Cycle, (pp. 62-66), 178 pp.

Immobilization of Low-Level Radioactive Waste (19)

Experiments were done with nonradioactive waste solutions considered typical of reactor effluent wastes or their essential components, for the purpose of studying various materials that could be used for encapsulation of low-level radioactive waste. The wastes that were considered result from the operations of nuclear power generation stations and usually occur in one of four forms: 1) as ion exchange resin beads, 2) as finely ground ion exchange resin used for filtration as well as ion exchange, 3) as precoat filter wastes, and 4) as evaporator bottoms containing sodium sulfate or boric acid. All are of low level radioactivity. The materials studied were aqueous solutions of sodium sulfate, aqueous solutions or slurries of boric acid, spent ion exchange resin beads, finely ground ion exchange resin, and precoat filter aid (Solka Floc). In all cases, the simulated wastes were dispersed in water extensible polyesters to form stable emulsions that subsequently can be set, by the addition of peroxide catalysts, to form lightweight (50 to 70 lb. per cubic foot), homogeneous, coherent, rigid, impervious structures. These would not decay under the gamma radiation encountered from the actual radioactive waste. When the casting of these structures is carried out in metal trays, subsequent transportation to burial grounds could be carried out safely and at low costs with minimal danger of underground contamination by the encapsulated wastes.

(JMT)

(1973)

Yale University, Department of Chemistry, New Haven, CT

Thomas, R.C. 1966, July-December. Journal of the American Chemical Society, 66, 1666-1666.

Heterogeneous Ion Exchange in a Flowing System (10)

A mathematical description of the performance of a cation exchange column for the case of the rate of exchange is determined by a second order law. The equations are derived from the consideration of flow processes and describing them by differential equations. The mathematical approximation of kinetics of the ion exchange takes the form of a hyperbolic differential equation which is solved according to the method of Picard. The boundary conditions for the kinetics equation are found by the zeroth order Bessel function. From these equations the total milliequivalents of cations passed and total milliequivalents of exchangeable cation per unit cross section of preceding resin can be found. The effect of the reverse reaction is included without approximation. (1967)

<390>

University of Kentucky, Department of Mechanical Engineering, Lexington, KY; Kentucky Department of Human Resources, Frankfort, KY

Gat, W., J.D. Thomas, and P.T. Clark. 1976. March. Health Physics, 30(3), 291-299.

Radioactive Waste Inventory at the Harey Flats Nuclear Waste Burial Site (U)

In March 1963 burial operations at the Harey Flats Disposal Site were initiated. Information contained in the radioactive shipment records were transferred to magnetic computer tape in 1971. Inventory is given by several classifications: activity of the site and burial pits; accumulated activity by isotope; and waste volume. The total activity on site in 1976 was estimated at 1.4×10^{10} (Bq). The total volume of waste disposed of on site until 1976 was calculated to be 5.98×10^6 cubic feet of solids and 5.11×10^6 gallons of liquid. Review of the records indicate various discrepancies between recorded quantities and actual quantities. (Both) (J7)

A general review and evaluation of the radioactive shipment records of Harey Flats. Deposited activity is corrected for decay and the postulated present (1976) activity is presented. (Both) (J7)

<395>

University of Tennessee, Knoxville, TN; U.S. Atomic Energy Commission, Oak Ridge, TN

Stockdale, P.D., G.D. DeBouchanne, and E.J. Vlasper. 1951, August 1. ORO-58: 92 pp.

Geologic Conditions at the Oak Ridge National

Laboratory (R-10) Area Relevant to the Disposal of Radioactive Waste (2)

A summary of the results of field investigations at the Oak Ridge Bethel Valley disposal area is presented. Surface and subsurface geologic and hydrologic conditions were examined during a program consisting of geologic field mapping and drilling of 51 bore holes in the Bethel Valley area. Bedrock beneath Bethel Valley is the Chattanooga limestone which was subdivided into 8 mappable units mainly on the basis of lithology. Bedrock in the area strikes SE-SW and dips toward the SE at 30-40 degrees. Rocks are broken by thrust faults dipping toward the SE. Fifty-one borings were drilled in the Chattanooga shale. Sludge and water samples were taken from borings and analyzed for radionuclide contamination. Apparent contamination was encountered along White Oak Creek in the subsurface beneath waste seepage ponds, near liquid waste tank farm and at one meandering locality remote from obvious sources of contamination. Data indicated that groundwater occurs at the site under water table conditions and that groundwater is effluent to streams locally and periodically. Depth to the water table ranges from 5.6 to 33.3 ft. Soils were found to be thinest and more permeable and depth to ground water the least under valleys. It was recommended that solid waste burial activities be moved to an area in Bethel Valley underlain by Chattanooga Shale. (RAD) (CS7)

This report is mainly concerned with contamination by radioactive liquid wastes. Briefly discusses solid wastes. Good background data on geology and hydrology of the Oak Ridge Bethel Valley disposal site. (RM/CAB)

Depth to Water Table

<1965>

University of California, School of Public Health, Berkeley, CA; Sanitary Engineering Research Laboratory, Department of Engineering, Berkeley, CA

Orcutt, P.G., R.W.E. Pifai, G. Klein, and W.J. Kaufman. 1957, July. Sewage and Industrial Wastes, 29, 791-808.

Underground Movement of Radioactive Wastes (1)

The feasibility of ground disposal is discussed with regard to elimination of radionuclides from the immediate environment. In designing a suitable system, spreading of the radwastes due to infiltration through the surface strata, formation permeability, and the exchange capacity of the isotopes must be considered. If the material is injected into deep formations, chemical and physical properties of the media and radwastes must be compatible. Such properties considered are average velocity of flow, direction of flow, hydraulic gradient, porosity, existence of capillary forces, and hydraulic dispersion. The extent of hydraulic dispersion is determined along with exchange capacities of several natural media for Sr 90, and the influence of rate controlling steps in ion exchange. Hydraulic dispersion is expressed by differential equations which give a family of S-shaped curves. The curves are breakthrough curves and describe the molecular diffusion taking place. The ion exchange phenomena are expressed by differential equations for material balances and kinetic relationships. These, too, are S-shaped breakthrough curves. Ion exchange capacities were determined for a California agricultural soil, several oil sands, and halloy site clay which range from 0.3 to 13.0 meq/100g. The ion exchange kinetics in natural media are also discussed. (SDV)

<197>

University of Cincinnati, Department of Chemical and Nuclear Engineering, Cincinnati, OH; Protective Packaging, Inc., Cincinnati, OH

Leonard, J.W., and R.A. Tablin. 1978. American Society of Mechanical Engineers, 78 (9), 3 pp.

Leachability Evaluation of Radioactive Waste Solidified with Various Agents (1)

A simple readily reproducible leachability test has been applied to radioactive liquids solidified with Portland Cement, Urea Formaldehyde (UF) resin, and an augmented UF-base agent known as Tiger Lock. Dilute aqueous solutions of univalent Sr 22 and cesium 137, divalent strontium 90, cobalt 60, cadmium 109, and trivalent cobalt 60 soluble ions were prepared and mixed in varying liquid to solidification agent mixtures in activity ranges spanning the range expected in nuclear power plant waste. Small cylindrical samples were immersed continuously in gently flowing tap water and liquid samples were obtained on a regular basis. The results of these tests expressed as the fraction of the initial activity solidified versus time leached indicate that leach rates are substantially different for different radionuclides and that higher ionic valence decreases leachability. The proportionality of liquid to cement or UF also markedly affects leachability with leachability increasing with increasing water to solidification agent ratio. The effect of chemical composition of the waste is also investigated. Leachability was observed to exhibit no set relationship with physical strength. (Auth)(JC)

The data on urea formaldehyde in this report represent a large part of the available published leachability data. (DR/JC)

<398>

Academy of Sciences of the USSR, Institute of Plant and Animal Ecology, Ural Scientific Center

Tolchanova, I.V., and E.K. Karavayeva. 1976. Tav-June. Soviet Journal of Ecology, 7(3), 185-190; Ekologiya, 7(3), 105-106.

Dependence of Vertical Migration of Strontium 90 in Soil on the Regime of Soil Moistening (2)

Soils mixed 1:1 with sand were placed in galvanized iron columns. Strontium 90 was introduced into the surface soil layer and soils were moistened to various degrees. The tests showed that Sr 90 migration from the contaminated soil layer increases with the introduction of increasing amounts of soil moisture. The distribution of the isotope in the soil solution correlated well with the distribution in the soil itself. The concentration of Sr 90 in solution was found to be inversely related to the degree of soil moistening, while the soil with less moisture (highly isotope concentration in solution) has the smallest quantity of Sr 90 carried beyond the limits of the zone of its initial introduction. (CAS)

Laboratory experiment proving exactly the Sr 90 behavior one would expect. (DS/CAS)

<399>

Academy of Sciences, Institute of Physical Chemistry, Moscow, USSR

Spitsyna, V.I., V.D. Balukova, V.V. Gromov, S.I. Tikhonov, B.I. Zhigalov, and P.T. Spiridonov. 1969. Disposal of Radioactive Wastes, Proceedings of a Conference held in Moscow, November 16-21, 1959, (pp. 821-838).

Sorption Regularities in Behavior of Fission-Product Elements During Filtration of their Solutions through Ground (1)

The distribution of major fission products in soils of natural formation under conditions of a steady vertical filtration were studied with a clayey carbonaceous soil with thin sand lenses. The ground water depth was at 30 m and the absorption capacity was 13 to 20 meq % liquid was filtered into the soil at a rate of 0.005 m/day and four months later drillings were made so samples could be taken to determine the sorption. Radioisotopes were detected to a depth of 10 m. Although the upper layers of soil did not absorb all the radioisotopes introduced, as was indicated in laboratory experiments, a marked decrease occurred at 1 to 2 m depth. At depths of about 2 m activity decreases more slowly and contamination approaches a constant magnitude. This type of radwaste migration is related to diffusion and capillary phenomena. The lower filtration coefficient (0.005 m/day) was found to exist at the 2 m depth. From the study, it is apparent that processes associated with capillary and diffusion phenomena are important, particularly in a heterogeneous soil. The best mineral sorbents of Sr 90 are: montmorillonite (99.9%); kaolinite (68%); mica (87%); hydronites such as glauconite, vermiculite, biotite, (80%); pyroclastic (99.9%), halloysite (88%); peat (91%); phosphorite (90%); and nepheline syenites (70%). However, common soil minerals such as calcite, gypsum, quartz, and feldspars have a low sorption capacity (10 to 15%) for Sr 90. Hence, sorption of Sr 90 is controlled by the clayey minerals in the soil. Further

study was done on the "montmorillonite-strontium ion-calcium ion" system because of the influence calcium has on the sorption of Sr 90. Using various clays and temperatures the ion exchange capacity ranged from 99 to 116 meq/100 g. The exchange constants of calcium for strontium ranged from 0.88 to 1.82 and strontium for calcium 0.62 to 1.72. It was found that as the temperature was raised less strontium was taken up than calcium. Further dependence of Sr 90 sorption on the presence of calcium was demonstrated when the migration rate was measured at 6 cm/day, the same as the speed of ground water flow. However, the activity was not found any further than 1 m from the point of discharge in the soil in the early part of the study. After 15 months, though, Sr 90 was found 6 m from point of origination in the soil. Migration rate of Sr 90 in the soil is 1.1 to 1.3 cm/day which is 5 times slower than the rate in water. (DSU)

Intrinsic Permeability; Depth to Water Table; Ion Exchange Capacity; Cation Exchange Capacity; Percent Adsorption; Migration Rate; Infiltration Rate

<400>

Agricultural Research Center, Vammala, Finland

Rakkisen, U.L., and E. Laksanen. 1976. COSP-730817; IAEA-SM-175/37; STI/PDB/388; Nuclear Techniques in Comparative Studies of Food and Environmental Contamination, Proceedings of a Symposium held in Otaniemi, Finland, August 27-31, 1973, (pp. 249-258), 621 pp. (COSP-730817, IAEA-SM-175/37, STI/PDB/388).

The Adsorption and Extraction of Strontium 90 and Cesium 137 in Finnish Soils (1)

Adsorption and extraction of Sr 90 and Cs 137 in Finnish top soils are investigated. The test soils consisted of 669 mostly-arable-top soil (0 to 20 cm depth). These samples included 225 fine mineral (silt and clay) soils; 196 coarse mineral soils; and 248 organic soils. The experiments were arranged so multiple regressions could be run on the data at a 5% significance level. For all soils Sr 85 was strongly adsorbed, (91.1 to 96.6%). The extraction by ammonium acetate removed a considerable amount (71%) of adsorbed Sr 85 from mineral soils but the extraction was lower in organic soils (55%). Differences in particle size appeared to affect Sr 85 adsorption in mineral soils. Sand is a particularly negative factor in coarse mineral soils and coarse silt in fine mineral soils. By increasing pH or exchangeable calcium the adsorption of Sr 85 increases in all soil groups except Sphagnum peat. With increasing organic material extraction of Sr 85 decreases in mineral soils and would and decreases in peats with increasing nitrogen. Strontium 85 extraction decreased when the clay content increased in all-mineral soil groups. Extraction also decreased when pH was increased in mineral soils and would but increased in peats. Cesium 137 was strongly adsorbed in mineral soils and would but was considerably less so in peats (98 and 83%, respectively). Cesium was not easily extracted from the mineral soils and would (28.8 and 13%, respectively). Extraction in peat was far more effective (65%). Cesium 137 was highly dependent on soil type and was lowest in fine mineral soils. By increasing the exchangeable calcium, adsorption increased in all soil groups other than Sphagnum peat. With an increase in organic matter adsorption in would

<000> CONT.

and Caron peat decreased. Extraction of Cs 137 decreased in mineral soils with increasing clay content. In fine mineral soils, pH value decreased the extraction. By increasing the organic content, cesium extraction is greatly enhanced in mineral soils and Caron peat which was the opposite effect for strontium. The strong fixation of Sr 85 in organic and organic containing soils is probably due to the formation of insoluble coordination complexes and chelates between the organic matter and strontium. Increased extraction of Sr 85 was probably due to increased exchangeable calcium and potassium in fine mineral and all mineral soils. In contrast, Cs 137 was weakly fixed in organic soils by delaying the effect the organics had on the cesium fixing to the clay. This was due to differences in binding energy between mono- and divalent cation and weak ion exchangers in a low pH. Finally Cs 137 adsorption and extraction was much more effected by peat types than was Sr 85. (BOW)

Good summary table of soil types, mean values, and variations of analytical data provided. Excellent correlation to soil chemistry. (BSC/SOV)

Cation Exchange Capacity; pH; Grain Size Distribution; Percent Adsorption

<001>

Atomic Energy Commission, Research Center, Division of Chemistry, Fontenay-aux-Roses, France

Protiques, C., C. Blain, C. Devillers, R. Baguella, and J.C. B. Fenach. 1975. EPRN-tr-67; CONF-750611; IAEA-SR-204/24; Oslo Phenomenon, Proceedings of a Symposium held in Libreville, Gabon, June 23-27, 1975, (pp. 509-520), 652 pp. (EPRN-tr-67, CONF-750611, IAEA-SR-204/24).

Conclusions Drawn from Study of Migration of Fission Products (2)

The Oslo fossil reactor is interesting and so far unique in the study of migrations of the uranium fission products after an exceptionally long cooling and storage time amounting to 1.8 billion years. The specimens studied are located along a drilling core which passes through a reaction zone. Mass spark spectrometer analysis was used in the investigation. The results are shown in the form of diagrams obtained by plotting on a logarithmic scale the intensities measured for various included between 90 and 160 and the curve of fission yields of the uranium 235 in the case of thermal neutrons. It was found that the majority of the fission products settled into the clayey sediments which form the reactor. The elements that were spread are the alkalis: Rb, Cs, the alkaline earths (Ba and Sr), the rare gases and iodine. Chemical and isotopic measurements should confirm migration of the molybdenum, however, the fission molybdenum does not possess a radioactive isotope with a duration of life sufficient to be troublesome. The ruthenium remained for the most part in situ. In certain samples, a deficit in the vicinity of 10% was seen of which one part can be attributed to a migration of the technetium 99. In spite of the mobility of the alkaline earths, there was not detected any departure of Sr 90 during its lifetime (1/2-29 years). Examination of the transuranic elements shows that it is reasonable to infer stability

inherent in the largest part of the plutonium 239 formed. The same should be true with both other isotopes Pu 240 and Pu 241 formed in small quantities in this reactor. Examination of the thorium demonstrates the great stability of the Th 236 formed and that of the thorium, its descendant. The stability of the thorium in the terrain is similar to that of the rare fission earths. Finally, examination of the bismuth does not allow a conclusion to be made concerning the stability of the neptunium 237. (JRT)

<002>

Atomic Energy Establishment, Trombay, Bombay, India

Thomas, K.T. 1966. CONF-651202; IAEA-SR-71/53; Practices in the Treatment of Low- and Intermediate-Level Radioactive Wastes, Proceedings of a Symposium held in Vienna, Austria, December 6-10, 1965, (pp. 931-940) (CONF-651202, IAEA-SR-71/53).

A Review of Research and Development for the Treatment of Low- and Intermediate-Level Radioactive Wastes (4)

This paper reviews a research and development program on more efficient and economical waste-treatment methods for low- and intermediate-level radioactive wastes. Laboratory and pilot-plant studies on chemical treatment to determine the optimum dosage for removing fixed fission products in various combinations of wastes and tap water have been carried out. The filtration of sludge, obtained from chemical treatment, has received special attention. The suitability of natural inorganic cation exchange materials for the treatment of liquid wastes is being studied in both the laboratory and pilot plant. Extensive studies are being carried out in the field of waste incineration and gas cleaning. A well-equipped gas-cleaning laboratory has been set up for this purpose and for testing filters. Development work in the disposal of RBP/hexosene wastes by means of combustion and distillation are being carried out. Other processes that are currently being studied are foam separation, radiant-heat-spray calcination, evaporation, fixation in concrete and asphalt and fixation in stable solid media. Some of these show promise but considerably more work is required before use on a plant scale would be warranted. (Auth)

Discusses some new methods of treating liquid and gaseous low- and intermediate-level wastes to reduce cost of waste management. (BN/GS)

<003>

Atomic Energy of Canada Limited, Biology and Health Physics Division, Chalk River, Ontario, Canada

Herritt, W.F., and C.A. Newton. 1967. CONF-670512; STI/PUB/156; Disposal of Radioactive Wastes into the Ground, Proceedings of a Joint IAEA/ENEA Symposium held in Vienna, Austria, May 29-June 2, 1967, (pp. 79-98), 666 pp. (CONF-670512, STI/PUB/156).

Experiences with Ground Disposal at Chalk River (3)

The areas selected for use as disposal areas

<03> COST.

at the Chalk River facility are underlain by glacial till and sand deposited on a granite bedrock. These areas have been utilized for the disposal of low and high-level liquid and solid radioactive waste. Low-level solid wastes were placed in trenches and covered with sandy soil. Low-level radioactive waste is defined as waste having an exposure rate of less than 100 mR/hr at a distance of 30 centimeters. High-level solid radioactive waste is disposed of in concrete trenches, concrete tile hole, spent fuel holes, and concrete monoliths. High-level liquid wastes, generated as a result of spent fuel reprocessing, are contained in stainless steel tanks. Seepage pits, and a process sewer were used to dispose of low-level waste. Impact on the environment was considered minimal. An accidental discharge of reactor cooling water to the disposal area in 1952 resulted in minor environmental contamination. The various lateral movement through the soil of radionuclides contained in the cooling water was 250 meters in 15 years. Investigations indicate that the rate of strontium 90 movement through the soil is 0.27 times the rate of movement of groundwater. It is concluded that decay of radionuclides during this slow movement makes ground disposal a safe operation if ground conditions are known. (Auth) (J7)

A general review of disposal operations at Chalk River. No data presented on environmental impacts of these disposal practices. (08/J7)

<04>

Atomic Energy of Canada Limited, Chalk River Nuclear Laboratories, Chalk River, Ontario, Canada

Tasson, C.A., and A.E. Russell. 1970. COM-700905; IAEA-SR-137; STI/PB/264; Developments in the Management of Low- and Intermediate-Level Radioactive Wastes, Proceedings of a Symposium held in Aix-en-Provence, France, September 7-11, 1970, (pp. 833-859) (COM-700905, IAEA-SR-137, STI/PB/264).

Canadian Experience With a National Waste-Management Facility (2)

Canadian radioactive waste management policy requires that all radioactive waste be shipped to and disposed of at one location, the Chalk River Nuclear Laboratories in Ontario. The transportation hazards and inconvenience inherent in such a centralized disposal system are pointed to as unnecessary, especially in the case of low-level wastes. It is proposed that more local disposal sites be opened. Suitable sites must be designated for new waste disposal facilities. The sites must have limited access, must not drain to waters used by man, should be well drained and have a high cation exchange capacity, should have at least 5 m of soil, slowly moving ground water and be owned by a government agency. A brief discussion is included of how operating procedures at disposal sites and limits on discharge of radioactive materials to the environment are established. It is pointed out that aesthetics and public sensitivities are often more important than scientific determinations of safety in establishing such rules. (CMB)

Interesting discussion of practical problems involved in developing policies, rules and regulations and in operation of burial sites.

(05/CMB)

<05>

Atomic Energy of Canada Limited, Chalk River, Ontario, Canada

Parsons, P.J. 1963. Health Physics, 9, 333-362.

Migration from a Disposal of Radioactive Liquid in Sands (1)

A migration study was done on radioactive wastes that were disposed of in a pit at the Chalk River Project. The pit is in a low lying area with many lakes and swamps. Sand and till cover bedrock terraces and the soils are sorted into bands oriented along the terrace with the coarser material lying over the inner regions and the finer material deposited near the outer limits of the terrace. In some places the sand is 50 ft thick. The soil has a low permeability of 2 cc ft/sq ft/day and the sand has a cation exchange capacity of 1 meq/100 g. The total activity from all waste solution was estimated to be 1000 to 1500 Ci of mixed fission products, which contains 700 to 1000 Ci of Sr 90 and 200 to 300 Ci of Cs 137. To trace the migration of the radionuclides in soil and groundwater, samples were taken in an arc approximating a flow line of water with transverse lines to determine the cross section of the migration. Strontium 90 was found to vary from zero near the pit to 2.50 Ci/ft at 325 ft from the pit and it diminished to near zero again at 650 ft from the pit. Cesium 137 remained in the sand beneath the pit where the concentration was 0.05 uCi/g and diminished with depth to 1.0 uCi/g. At the water table the contamination dropped another 2 orders of magnitude. Sampling also showed that the Sr 90 moved away from the pit rapidly with the groundwater. It is postulated that the Sr 90 moved close to the surface of the water table taking a more direct route across the terrace than the Cs 137. Ruthenium entered the surface water after a 3-yr underground migration. Strontium migrated 250 ft after the first year and in the five subsequent years only 160 ft. At this rate the surface anticipated concentration of Sr 90 entering the stream is 6.5×10^{-7} uCi/ml. While the area is far from the ideal disposal area with the shallow water table and low cation capacity, it is noteworthy that 1500 Ci has migrated only 650 yards. (SDF)

Depth to Water Table; Permeability Coefficient; Stratigraphic Unit Thickness; Cation Exchange Capacity

<06>

Atomic Energy of Canada Limited, Chalk River, Ontario, Canada

Parsons, P.J. 1962, March. TID-7629; Ground Disposal of Radioactive Wastes, J.W. Morgan, Jr., et al (Eds.), Proceedings of a Conference held in Chalk River, Canada, September 26-29, 1961, (p. 17-68), 635 pp. (TID-7629).

Movement of Radioactive Waste through Soil. 1. Investigating the Migration of Fission Products from High-Ionic Liquids Deposited in Soil (1)

Radioactive liquids poured into the soil at a solid waste burial site having moved outside

<096> COST.

The disposal area by leaching and percolation to the water table and subsequent migration with the ground water. Rates and patterns of movement through the soil were studied. Soil, vegetation and groundwater samples were analyzed to detect migration of the contaminants. Fracts of strontium and cesium were found to move in tongues at rates of approximately 15 feet per year for strontium and 7 to 7.5 feet per year for cesium. Test of the movement of strontium relative to local groundwater movement indicated that strontium 90 moved 9.027 times the velocity of the groundwater. It was deduced that cesium travelled slightly for about 5 years after disposal and reached an equilibrium velocity of about 8.019 times the velocity of groundwater. Rapid movement of both cesium and strontium after disposal is attributed to the pH and to the presence of high ionic concentrations of calcium, ammonium and nitrates. It is concluded that strontium will rise to the surface as it approaches a nearby lake which is down the groundwater gradient. Estimates indicate that approximately 2 Ci of strontium 90 will rise to the surface of a nearby swamp and disperse slowly into the surface water after having decayed through 5-1/2 half-lives. No appreciable radioactive leakage was found from the solid waste burial ground at the site. (CAB)

Radionuclide migration in soils is discussed. (CAB/CAB)

<097>

Atomic Energy of Canada Limited, Division of Biology and Health Physics, Environmental Research Branch, Chalk River, Ontario, Canada

Verritt, F.V., and P.J. Parsons. 1960. Disposal of Radioactive Wastes, Proceedings of a Conference held in Moscow, November 16-21, 1959, (pp. 329-338).

Sampling Devices for Water and Soil (3)

A number of sampling devices for monitoring radionuclides in the ground water and soil are presented. The porous cup and porous bronze piezometer are used to take ground water samples. The porous cup is actually extraction thimbles sealed with rubber stoppers. Two polyethylene tubes are sealed through the stopper one extending to the bottom of the thimble. These are then tied to a supporting rod and positioned inside a 6 in. casing. The casing is withdrawn and the sample is taken. The porous bronze piezometer works in much the same manner. Soil sampling can be done by a multiple sampler or in a sampler that does not disturb the sample strata. The device collects samples of granular soil at different depths below the water table. A rod is withdrawn 2 in. to allow the wet soil to enter and the rod is withdrawn to 6 in. to move a closing piston over the opening. The assembly can then be extracted. Undisturbed samples can be taken with a sampler using an air pressure-diaphragm valve. These samples are collected from below the water table. They help explain the existence of discrete horizons of radioactive groundwater soil, and the sample can be tested for porosity and permeability. These samplers have been used at Chalk River. (PDB)

<098>

Atomic Energy Research Establishment, Chemical Engineering Division, Harwell, England

Grover, J.P. 1958. Transactions of the Institution of Chemical Engineers, 36, 81-90.

Disposal of Long-Lived Fission Products (3)

A process for the permanent fixation of strontium 90 and cesium 137 is described. By 1965 it is expected that 5000 to 6000 megawatts of electricity will be produced by nuclear power. The disposal problem becomes larger when it is realized 1 megawatt day of heat energy is produced by 1 gram of uranium. After one year the 1 gram of fission products have a heat level of 1 watt which is equivalent to about 500 calories. Therefore, by 1965 the yearly output will be 1.1×10^{10} calories. The bulk fission products (strontium, yttrium, zirconium, cerium, cesium, cerium, promethium) will decay faster if strontium and cesium are removed. Since strontium has a toxicity 25 times greater than the others, its removal will decrease the overall toxicity by a factor of 25,000. Removing Sr 90 will enable disposal of bulk waste after 10 to 15 years of storage. The method of storage considered here is fixation by montmorillonite clays. Montmorillonite is a desirable medium because it is a naturally occurring clay, highly stable, readily available, inexpensive. It also has an ion exchange capacity of 0.8 meq/g and its structure can be altered by heating to 1200 degrees C to lock the nuclides into the structure. A detailed description of the experimental pilot plant is given. Covered in the discussion is the design of the disposal canister, the remotely operated make and break joints, the high temperature firing, remote handling, and the general operation of the plant. (PDB)

<099>

Atomic Energy Research Establishment, Harwell, England

Napthlett, C.B. 1956, June. Nuclear Engineering, 1, 119-122.

Fixation of Radioactive Effluent (2)

A new and promising approach to fixing effluents is to absorb the radionuclides on siliceous materials. The siliceous materials are then fired to decrease their leachability. Clays seem to be highly suited as the absorbing material. They have exchange capacities of 5-10 meq/100 g for the kaolinites and 80-150 meq/100 g for montmorillonites. When the clays are heated to temperatures of 1000 degrees C or greater, water is irreversibly lost from the clays and the structure alters, irreversibly fixing the absorbed cations. Montmorillonite was used in an experiment and it sorbed mixed fission products (Cs 137, Sr 90, Y 90, Co 60, Fe 59, Pu 239, Am 241, and Np 237) in a 1:1000 ratio, 85, 17, and 10 % activity at 110, 665, 720, and 835 degrees C, respectively. However, the process suffers when there are competing polyvalent and hydrogen ions. These make the process rather ineffective. An alternative is to use natural silicate minerals as bases into which the cations of the waste are fixed. This process would eliminate the problems with inactive contaminants and acid neutralization. Also, higher loadings could be achieved. Natural silicates from the nepheline-syenite

COST.

1975) series when used only liberated 1975-76 1975-76 activity when leached. This is a promising method but more work is needed. Natural soils are the other source of natural silicates. Using the soils offers the same degree of fixation as by ion-exchange and firing, but much higher loadings have been obtained. Also, the presence of large excess inactive ions and acids has no effect. This process can be operated with either separated or unseparated wastes. It, in principle, may be used with solid wastes, slurries, or active incinerator ashes. Once the wastes are fixed they can be buried. (JW)

Ion Exchange Capacity

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Atomic Energy Research Establishment, Harwell, England

Burns, P.R., J.R. Clarke, and T.D. Wright. 1966. COW-651202; IAEA-SR-71/95; Practices in the Treatment of Low- and Intermediate-Level Radioactive Wastes, Proceedings of a Symposium held in Vienna, Austria, December 6-10, 1965, (pp. 221-254) (COW-651202, IAEA-SR-71/95).

Filtration and Ion-Exchange Plants in Use at the Atomic Energy Research Establishment, Harwell (J)

The plants used for the filtration and subsequent ion-exchange decontamination of low- and medium-level effluent are described. Details are given of plant operation at 2.3 cu m/h together with the decontamination factors achieved and the volumes of waste produced. It is shown that the filtration system only produced a waste of 0.2% of the volume filtered. This low figure is attributed to the efficiency of the simple system used for de-watering the backwash liquors. Results for decontamination by filtration indicate that a large proportion of alpha activity can be removed at this stage. Although removal of beta-gamma activity is lower and more variable, it is shown that it can be sufficient to necessitate shielding the de-watering section of the plant. The details given for the ion-exchange plant include the efficiency of removal of both inactive and active ions. These show that the plant produces a reasonable quality demineralized water (circa 15 mho/cm) and gives average decontamination factors of 1000 for alpha and 1250 for beta activities. It is shown that, by using a split-regeneration technique, the waste from the plant can be kept down to 1.9% of the volume treated, making a total of only 2.1% for the combined treatment. Some anomalies found in the behavior of the plant are discussed and suggestions made for further reduction of the waste which arises. (Juth)

Describes a filtration and ion-exchange plant in use at Harwell. (JW/GS)

COST

Atomic Energy Research Establishment, Harwell, England

Burns, P.R., and J.R. Clarke. 1970. COW-700905; IAEA-SR-137/7; STI/PUB/264; Developments in the Management of Low- and Intermediate-Level Radioactive Wastes,

Proceedings of a Symposium held in Aix-en-Provence, France, September 7-11, 1970, (pp. 833-859) (COW-700905, IAEA-SR-137/7, STI/PUB/264).

Harwell Experiences in Waste Management (J)

The paper discusses the waste management experiences of A.E.R.E. Harwell. Details are given of the plant and equipment provided in 1967/68 along with the philosophy existing at that time. Discharge of liquid effluents into the Thames Catchment Area is permitted. Waste streams were segregated into "intermediate", "low" and "very low" activity streams. Three treatment methods were considered for the low-level waste streams, distillation, ion exchange, and chemical precipitation. No provisions were made, initially for the disposal of solid radioactive waste. Solid wastes were routinely classified low-level wastes provided the following limits are not exceeded. One mCi alpha, 10 mCi beta, an exposure rate of 100 mR/hr at the surface and 10 grains or 1 millicurie of fissile material, which ever was lower. Incineration and compaction of solid waste were used wherever possible in order to achieve a reduction in waste volume. Disposal of low-level radioactive waste was accomplished through burial in a geologically satisfactory area 400 m from Harwell and sea dumping. (JW)

Discusses the experiences and problems associated with low-level waste management at Harwell. Minimal data relevant to shallow land burial of low-level radioactive waste are presented. (JW/JW)

COST

Australian Atomic Energy Commission, Research Establishment, Lucas Heights, Australia

Davy, D.R., R.S. Giles, and S. Conway. 1973. IAEA-SR-172/6; STI/PUB/305; COW-73050; Environmental Behavior of Radionuclides Released in the Nuclear Industry, Proceedings of a Symposium held in Aix-en-Provence, France, May 14-18, 1973, (pp. 37-49), 749 pp. (COW-73050, STI/PUB/305, IAEA-SR-172/6).

Pre-Operational Assessment of the Discharge Limits and Relative Importance of Radioactive and other Factors from Uranium Production in Australia's Northern Territory (J)

The paper examines the sources and nature of the wastes likely to arise from the uranium extractive industry now being developed in the Northern Territory of Australia. The area in question is tropical and has a season of seasonal rain with heavy run-off, which alternates with a long dry season. In the dry season river flow is minimal and parts of the river systems become isolated and subject to heavy loss from evaporation. In consequence, the environmental problems associated with the uranium mines and mills are unusual. Ecological mapping to define sensitive habitats and toxicity studies undertaken on sensitive species indicate that the levels that can be allowed for heavy metals will dictate criteria for treatment and containment of wastes from extraction plants. On the other hand, radiological considerations will govern disposal of pit water and run-off from storage and overburden dumps. The naturally occurring levels and transfer mechanisms have been examined for uranium, radium and lead. These characteristics can be used to assess the environments of particular mines. For each of four probable mine locations four

(412) CONT.

possible exposure routes for Pa 226 and Th 230 can be identified and have been evaluated separately. Although the local environments are very similar, the critical exposure routes differ for at least three of the possible site sites. This is because transfer and dispersion mechanisms, and land use, differ between the sites. (Auth)

(413)

Belonucleaire, Centre d'Etude de l'Energie Nucleaire, Mol, Belgium

Van de Voorde, K., and E. Peeters. 1970. COMF-700905; IAEA-SR-137/65; STI/PUB/264; Developments in the Management of Low- and Intermediate-Level Radioactive Wastes, Proceedings of a Symposium held in Aix-en-Provence, France, September 7-11, 1970 (pp. 433-459) (COMF-700905, IAEA-SR-137/65, STI/PUB/264).

Developments in Treatment of Low- and Intermediate-Level Radioactive Liquid Waste at Mol (B)

The methods used at present to treat low-level active waters at Mol create important volumes of radioactive sludges which are difficult to filtrate. The process of transforming these concentrates into unleachable solid bulk by incorporating them into bitumen because expensive and cumbersome because of the large quantities and the colloidal state of sludges. Research work was thus carried out to find a method to avoid this cumbersome step. As most volumes of liquid waste to be treated at Mol consist mostly of lightly contaminated drinking water, a net of utilizing ion exchangers and sorbers was sought. Conventional organic ion exchangers are generally too expensive to be stored after saturation. Moreover, when bituminized, they give rise to a porous final product. On the other hand, cheaper ion exchangers such as sulphonated coal also cause difficulties when incorporated into bitumen, since large quantities of SO₂ partly destroy bitumen at higher temperatures. By partly sulphonating bitumen itself, an attempt was made to obtain an ion exchanger with sufficient capacity and structure to allow its use in water treatment, but at the same time presenting a sufficient fusibility after saturation to produce a fusible matter when moderately heated. Conditions were also determined whereby a fusible sulphonated bitumen could be prepared, and this appeared to be practicable although its preparation only resulted in fusible products with limited capacity. The break-through curves of some radioisotopes in contaminated drinking water are to be considered as satisfactory. More promising are the possibilities found in certain synthetic selective mineral sorbents that display a noteworthy selectivity for well-defined ions. They present, however, poor column properties. By simultaneously synthesizing some sorbents, other polyvalent selective sorbents also arise; they show very interesting column properties. (Auth)

Information on treatment of radioactive drinking water supplies. (DR/CAR)

(414)

Belonucleaire, Mol, Belgium; Public Health Ministry, Brussels, Belgium; Eurochemic, Mol, Belgium

Van de Voorde, K., G.E. Castillon, C. De Baets, E. Decilleux, and E. Spriet. 1969. COMF-700905; IAEA-SR-137/65; STI/PUB/264; Developments in the Management of Low- and Intermediate-Level Radioactive Wastes, Proceedings of a Symposium held in Aix-en-Provence, France, September 7-11, 1970, (pp. 433-459) (COMF-700905, IAEA-SR-137/65, STI/PUB/264).

Low- and Intermediate-Level Radioactive Waste Management in Belgium, in Particular at Mol (B)

The Radioactive Waste Disposal Department of the Belgian Nuclear Center (CBN) is designed to handle all liquid and solid radioactive wastes originating from CBN, plus the wastes generated from the Eurochemic Reprocessing Plant and local hospitals and laboratories. Discharge of liquid effluents is restricted to the Mol-Beet effluents and is limited to 0.500 weighted uCi/month. Liquid wastes, not discharged to Mol-Beet, are collected, analyzed and classified as (a) category one effluents: suspect or normally inactive waste; (b) category two effluents: wastes with specific activities of less than 10(E-2) uCi/ml beta-gamma, 2 x 10(E-4) uCi/ml Sr 90, 2 x 10(E-5) uCi/ml alpha and 0 x 10(E-6) uCi/ml Pa 226; and (c) category three wastes: wastes with specific activities of less than 1 Ci/ml beta-gamma, 2 x 10(E-2) uCi/ml Sr 90, 2 x 10(E-3) uCi/ml alpha and 0 x 10(E-4) uCi/ml Pa 226. Solid wastes are classified as "normal" solid wastes (surface radiation levels less than 200 mR/h) and "special" solid waste (surface radiation level exceeds 200 mR/h). Eurochemic facility wastes are routinely classified as low-level or medium-level wastes. (JT)

Major emphasis is placed on the classification of the various wastes processed at the facility. No data are presented on disposal methods operations. (DR/JT)

(415)

Bhabha Atomic Research Centre, Biology and Agriculture Division, Trombay, Bombay, India

Mistry, K.B., B.N. Bhajjal, and T.J. D'Souza. 1971. IAEA-SR-172/10; STI/PUB/305; COMF-730503; Environmental Behavior of Radionuclides Released in the Nuclear Industry, Proceedings of a Symposium held in Aix-en-Provence, France, May 10-16, 1971, (pp. 303-319), 769 pp. (COMF-730503, STI/PUB/305, IAEA-SR-172/10).

Influence Of Agronomic Practices on Uptake of Fission Products by Crops from Soils of Regions Adjoining Nuclear Installations in India (2)

The influence of a variety of agronomic practices on the transfer of Sr 90, Cs 137, Ba 106, and Ce 144 to two major crops, maize and rice, from black soils was examined. These soils are typical of the regions where river and ground or well waters which are used for irrigation could be contaminated by low-level effluent discharges and accidental releases from nuclear installations, namely the Rajasthan and Tarapur Atomic Power Stations and Fuel Reprocessing Plant at Trombay. Black clay loam, medium black clay loam, and laterite soil types were studied for pH values, percent of cation exchange capacity, and the percent of total organic carbon

(C15) C15.

content. Of the three types of soil, laterite showed the lowest pH factor (5.4) while the red-brown black clay loam was the highest (5.5). Cation exchange capacity ranged from 19.1 μ for laterite to 20.5 μ for black clay loam, and the total organic carbon content showed a higher value of 0.78 μ for black clay loam as compared to a low 0.29 μ for red-brown black clay loam. Parallel data on radioisotope uptake by plants from a typical laterite were also obtained. Studies on radioisotopes indicated that the addition of compost results in reduced uptake from both black and laterite soils. Composting action of the polysaccharide fraction of compost on radioisotope uptake lowers its availability to plants. Beneficial effects of liming action in soils with low exchangeable calcium status. A reduction in the radioisotope content of plants was obtained with nitrogen and potassium fertilizers; phosphate fertilization had no consistent effects. No significant differences were observed between various nitrogen or potassium carriers. Greater downward movement of radioisotopes in soil profiles was observed with moderately high calcium irrigation water than with either moderately high sodium irrigation water or simulated rain water. Radioisotope was less mobile in black soil than in laterite. A flooded regime did not significantly influence the radioisotope content of rice grown on both soils. Studies on gamma emitters indicated that, over comparable durations, Cs 137 uptake was markedly greater than that of Pu 106 and Co 106 in both soil types. While Pu 106 uptake was higher than that of Co 106 in the black soil, in the laterite Co 106 uptake was not affected, while variable effects were observed on Co 106 uptake. Flooding resulted in marked increase in Cs 137, Pu 106 and Co 106 accumulated by rice in the laterite. In the black soil, however, a similar effect was obtained only on Cs 137 uptake. (Roth) (C57)

Extensive tabular data is presented on the effects of soil characteristics and agricultural practices on the uptake of fission products by plants. (RSC/28)

PR: Cation Exchange Capacity; Total Organic Carbon Content

(C16)

CEB, Vol. Belgium

Souffrian, J., E. Simpson, L. Baetse, and P. Dejonckhe. 1962. March. TID-7628; Ground Disposal of Radioactive Wastes, J.R. Forgan, Jr., et al (Eds.), Proceedings of the 2nd Conference held in Chalk River, Canada, September 26-29, 1961, (pp. 155-160), 635 pp. (TID-7628).

Investigations on the Movement of Radioactive Substances in the Ground; Part 2. The Copper-64 Method for Measuring Groundwater Flow (2)

Attempts at detailed measurement of water movement in the phreatic zone were made using silver-plated copper rods and ^{64}Cu as a tracer. The tracer is introduced by injection into a central well and rods are placed in the ground in a radial pattern at various distances from the injection well. The rods are removed and the number of counts measured on various parts of the rod is proportional to the velocity of the groundwater at that depth and location. Field tests were run and

indicate that the method is practical for measurement of flowpaths and dispersion. (C59)

Description of a practical method for measuring dispersion and groundwater flow. (RSC/28)

(C17)

CEB, Nuclear Energy Research Center, Mol, Belgium

Berens, P., P. Dejonckhe, J. Billiet, E. Gelinckx, and P. Laga. 1976, August 2. BNL-TR-195; COW-760110; IAEA-SR-297/9; Management of Radioactive Waste, Proceedings of a Symposium held in Vienna, Austria, March 22-25, 1976, (25 pp.) (BNL-TR-195, COW-760110, IAEA-SR-297/9).

Investigations on the Possibility of Ultimate Storage of Radioactive Waste in a Subterranean Argillaceous Formation (2)

Investigations on the characteristics of clay layers for radioactive disposal in Belgium are reported. The relief in the area is flat with the height above sea level ranging from 20 to 80 m. The soil is generally sandy and poor for agriculture. The Paleozoic surface is flat with a slight dip to the north-northeast. This surface is covered with sediments of marine origin and these are overlain with Tertiary deposits which consist of alternating sands and clays. The first clay layer, the one of interest for this investigation, is the Oligocene Boom clay which is covered by Miocene, Pliocene, and Pleistocene sands. From extensive drilling done in the area, the Boom clay occurs at about 200 m, is homogeneous and consistent (about 50 m) at that depth. To determine the general properties, resistivity, density, gamma radiation, diameter and temperature were recorded as a function of depth. All the above information will be correlated with sediment samples for a complete analysis. Above the Boom clay is the phreatic water table in the Tertiary sands 1 to 2 m below the ground surface and there is indication of confined aquifers below the Boom clay. To protect these water sources intensive theoretical and experimental studies must be undertaken. Chemical and mineralogical tests including: weight loss after attack by perhydrol; weight loss after attack by hydrochloric acid; gravimetric analysis; quantitative chemical analysis of the main components; determination of non-argillaceous minerals; and determination of the relative proportions of argillaceous minerals need to be done. The physical and mechanical properties such as density, permeability, and shearing resistance need to be known. Laboratory experiments determining the ion exchange of the clays with respect to transurans, fission products, and actinides were done. Rock-fluid interaction studies were also run. Assuming the conclusions are positive, a gallery will be excavated at the 200 m depth and extend to the 750 m depth. (RSC/28)

Isopach map, stratigraphic column and cross-section are included. (RSC/28)

Stratigraphic Unit Thickness; Depth to Water Table; Distribution Coefficient; Grain Size Distribution

(419)

CPS, Saclay, France

Terre, P., E. Destre, J. Bourdrez, and S.D. Blalock, Jr. (Translator). 1965. ONSI-tr-0022; COWP-651202; IAEA-SR-71; Practices in the Treatment of Low- and Intermediate-Level Radioactive Waste, Proceedings of a Symposium held in Vienna, Austria, December 6-10, 1965, (pp. 703-716) (ONSI-tr-0022, COWP-651202, IAEA-SR-71).

Treatment of Low-Activity Wastes by Co-precipitation at the Saclay Nuclear Studies Center (1)

Ten years' experience of operating the low-activity liquid effluent treatment plant at Saclay has led to improvements and modifications of the treatment cycle. Among them, the authors consider certain aspects of flocculation, and in particular techniques for solidifying sludge. The increasing specific activity and volume of effluent requiring processing made it necessary to perfect the techniques employed, to provide greater protection and, above all, to complete the effluent treatment cycle by devising a means of handling the sludge resulting from the treatment itself. Apart from its increasing specific activity this sludge consists of 80% water. These two factors necessitate a reappraisal of the problem of handling and storing the concentrates, and the paper describes in detail modifications to the plant affecting principally: (1) remote control of the valves; (2) settling and filtration; and (3) solidification and final packaging of the sludge. The operating results are also analyzed thus throwing light on the economic aspects of the problem. (auth)

(419)

Centre d'Etude de l'Energie Nucleaire, Mol, Belgium

Van de Voorde, H., E. Hoffmann, and S.D. Blalock, Jr. (Translator). 1965. ONSI-tr-0016; COWP-651202; IAEA-SR-71; Practices in the Treatment of Low- and Intermediate-Level Radioactive Waste, Proceedings of a Symposium held in Vienna, Austria, December 6-10, 1965 (pp. 527-540) (ONSI-tr-0016, COWP-651202, IAEA-SR-71).

Operation of the Radioactive Waste Treatment Station at Mol (1)

The Belgian Nuclear Research Center (C.E.N.) is located in a rather densely populated area. Waste disposal into the river and the storage possibilities are extremely limited because the river Meuse-Wet is too small and the sandy sub-soil is considered as source for drinking water. Besides, soil retention appears to be rather low. A ministerial regulation states that the disposal into the river of aqueous radioactive waste must be controlled to such an extent that drinking water tolerance is respected. Therefore, river water concentration, after dilution, must be below 10×10^{-6} uCi/cc. A wide range of waste problems arose from the large variety of C.E.N. laboratory activities during chemical, metallurgical, and radioisotope production, from the D1, D2, and D3 reactors, and finally from the peculiar nature of neighboring nuclear plants such as Berchemic (reprocessing of irradiated nuclear fuel), BCWP (Central Office for Nuclear Research). During the treatment of radioactive waste it was necessary to pay

special attention to the collection system actually developed so far because the active waste separation already takes place where these residues are produced. Next, the waste must be conveyed to the processing plant either through special pipes or under standardized packing. The administrative set-up which regulates this collecting system allows an easy and exhaustive inventory of the stored radioactive materials, as well as the determination of reduction and decontamination factors at any step during the processing stage. On the other hand, the processing itself must be specific for each type of waste dealt with separately. For cold and warm liquid waste processing, co-precipitation and ion-exchange techniques are mostly applied to continuous or batch treatment, resulting in a total decontamination of 99.9%. The presence of complexing agents and detergents produces interferences that can be overcome by using suitably adapted techniques and reagents. The ultimate insolubilization and storage of radioactive concentrates was specially emphasized. By homogeneous dispersion of filtered precipitates into hot asphalt (200 degree C), a stabilized mixture containing 80% radioactive material is obtained. The leaching rate tested with ground- and sea-water is kept below 10×10^{-6} uCi/cc. Such a process corresponds to a total concentration factor of around 3000. After a preliminary selective sorting of combustible and non-combustible waste, residues undergo different processes according to their respective category, i.e., size-reducing, balling or incinerating then before ultimate insolubilization with asphalt. These specific operations require a plant thoroughly equipped with cutting and balling devices, incinerator provide with off-gases scrubbing and with a various incinerating capacity of 200 kg/h, leading to a total concentration factor of 90. Various decontamination techniques such as degreasing, steam and abrasive blasting, melting, etc. permit the recovery of valuable and useful equipment or instruments. Moreover, contaminated clothing is decontaminated and washed in a special laundry before being returned to the respective users. The radioactive waste processing plant was run at Mol by the Belgian concern from 1961 to 1964 and Belgonucleaire took it over in 1965. During this period operation was on an industrial scale and, simultaneously, a detailed cost calculation system was set up. (auth)

(421)

Centre d'Etude de l'Energie Nucleaire, Mol, Belgium

Van de Voorde, H., and E. Peeters. 1976; 1977, May. CO-3167a; COWP-760507; Bituminization of Low- and Medium-Level Radioactive Wastes, Proceedings of an IAEA Seminar held in Antwerp, Belgium, May 18-19, 1976, (pp. 99-107) (COWP-760507, CO-3167a).

Experience with Bituminization in Belgium (2)

The bituminization of low-level liquid radwastes in Belgium is described. The process is a "high temperature" one and consists of two steps. The first is to prepare the sludge to be incorporated in the bitumen. This is primarily to extract as much water as possible from the sludge and this is done by decantation of the liquid sludges by centrifuging; filtration of the decanted sludges, which have been frozen for some time; and filtration on a suction filter until a

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solid material contains about 40% water. The sludge is then added to the bitumen and the mixture is heated and intensely stirred by a high-speed mixer to achieve a nonmolecular coating (step two). The plant consists of: 1) a unit for storage and transfer of sludges from the collecting reservoir to a centrifuge; 2) a thickened sludge reservoir; 3) the freezing unit, consisting of 2 well insulated tanks of 1 cu m capacity; 4) a reservoir to feed the section filter; 5) a drum type-section filter; and 6) an insolubilizer for mixing the filtered sludges with bitumen. The steam released from the bitumen bath is condensed and collected. The average activity of the residual non-condensable gases is $10(12-13)$ $\mu\text{Ci}/\text{al}$ alpha and $10(7-9)$ $\mu\text{Ci}/\text{al}$ beta-gamma. The activity of the scrubbing solutions averages $10(12-7)$ $\mu\text{Ci}/\text{al}$ alpha and 5 to $10(12-5)$ $\mu\text{Ci}/\text{al}$ beta-gamma. Every 6 months during the maintenance period the mixer blades are replaced due to abrasive action of some types of sludge (B3509). The "MURKIN" system has been operating since mid-1964 and has processed a total of about 750 tons of wet sludge (300 tons dry sludge). One and a half million cu m of liquid wastes were treated to obtain the above tonnage. The ultimate volume was about 550 cu m with a total activity of 10,000 Ci. The leaching rate of the bitumen was $10(12-5)$ to $10(12-7)$ $\mu\text{Ci}/\text{sqm}/\text{day}$ after 90 days. The reduction factor using this process is on the order of 2000. For operation of the plant since 1964 the cost was 16,750 Belgian francs. A pilot plant for processing liquid radioactive wastes and for insolubilizing them in bitumen was also discussed. (197)

philosophical problems with using the ocean floor for dumping. While ice sheets are unlikely to be used by man, limited understanding of the geophysics of large ice-caps and the mechanisms controlling the low temperature climate eliminate this as a present possibility. Also, an international agreement forbids dumping of radwastes in Antarctica. Rock salt, argillaceous sediments and hard rocks (igneous and metamorphic) are the prime formations to be used for disposal under land areas. Rock salt is usually completely free of circulating ground water and its plasticity seals fractures and openings. However, salt is highly soluble and other potential uses may be more important. Argillaceous sediments have pore water migration which over geologic time are significant but sorption by the clay minerals would reduce the radwaste migration rate. These sediments are also self-healing. The disadvantages to using argillaceous sediments are mining problems and less effective containment of certain radionuclides. Unfortunately there are important questions about the effects of heating and radiation on the rock and the pore fluids which must be resolved by research and development. Hard rocks have fracture problems and no plasticity. Also there are questions about the possible effects of heat expansion and its consequences for the sealed fractures. In doing a safety analysis it is hard to predict the climate changes and whether or not future man will intrude. (197)

C022

College of Engineering, Baghdad, Iraq

Rehman, N.S. 1956, December. Transactions of the American Geophysical Union, 37(6), 702-712.

Analysis of Data from Pumping Tests in Leaky Aquifers (19)

The theory and graphical methods for determining the coefficients of transmissibility, storage, and leakage of an effectively infinite leaky artesian aquifer are considered. First the solution of non-steady distribution of drawdown caused by pumping a well at a constant rate from an infinite and perfectly elastic aquifer of uniform thickness is presented. Various drawdown or the steady state distribution of drawdown is then obtained from the previous equations. The leakage coefficient is finally defined. An example of the graphical method for the steady distribution of drawdown is presented. The theory with appropriate equations is presented for the non-steady distribution of drawdown. Several examples are provided showing the use of the graphs and equations. Also discussed are how to correct for improperly chosen inflection points. Compressibility of the aquifer, which is composed of limestone, is finally considered. (197)

Storage Coefficient; Transmissivity; Hydraulic Conductivity; Drawdown; Leakage Factor; Leakage Coefficient

C023

Comitato Nazionale per l'Energia Nucleare, Divisione di Sanitaria e Protezione Controlli, Rome, Italy

C023

CSPN-CNV Casaccia, Rome, Italy

Gera, P. 1977. IAEA-CN-36/111; Nuclear Power and Its Fuel Cycle, Proceedings of an International Conference held in Salzburg, Austria, May 2-11, 1977, (12 pp.) (IAEA-CN-36/111).

Radioactive Waste Disposal in Geological Formations (1)

The major source of radwastes that need to be disposed of are produced by the electro-nuclear industry. High-level wastes pose the most difficult technical problem. These wastes contain more than 99.9% non-volatile fission products, about 0.5% of uranium and plutonium, and almost all other actinides formed in the fuel by transmutation of uranium and plutonium. From inhalation hazard potential and ingestion potential hazard computations, disposal of hundreds of cubic meters of short-lived wastes should be for a few hundred years. For the few tons of cubic meters of long-lived wastes should be confined about a hundred thousand years. The short lived wastes could be disposed of by: shallow land disposal in trenches or concrete pits; sea dumping; or emplacement in deep cavities free from circulating ground water. Several ideas have been proposed to dispose of long-lived wastes, such as geologic disposal and extraterrestrial. At present the geological disposal concepts are feasible. They are: disposal into geological formation underlying the sea bed; disposal in glaciated areas; and disposal into geological formations underlying the land areas. For sea bed disposal the areas would have to be in mid-gyre and mid-plate, the most stable regions. However, there are severe

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Gera, P. 1978, July. *Health Physics*, 27, 117-121.

The Classification of Radioactive Wastes (1)

Various proposals of classification of radioactive wastes are reviewed. It is suggested that the need for standardized waste categories could be satisfied by simply defining the meaning of the terms presently in use. In the past the classification of radioactive wastes has been considered necessary in order to facilitate communication, but has not been intended to provide indications on subsequent operations of treatment, conditioning, storage and disposal. In addition to a waste classification of such limited scope, it would be advantageous to adopt a classification of an operational nature. It is suggested that the wastes should be classified and segregated on the basis of the duration of required containment. A simple and probably sufficient subdivision should be in two groups: (1) the first one formed by wastes requiring relatively short-term containment and acceptable for disposal by shallow burial; (2) the second group would contain wastes requiring long-term containment and destined for dispersal in deep geologic formations. (Auth)

Not germane to SLS other than to define low-level waste and distinguish it from high-level waste. (24/38)

<826>

Comitato Nazionale per l'Energia Nucleare, Rome, Italy

Franci, G. 1979. ENP-8736 e; CSNP-700452; Health Implications of the Storage of Radioactive Substances on and in the Ground, J. Sheets and R. Leavitt (Eds.), Proceedings of a Symposium held in Cherbourg-Le Havre, France, April 14-15, 1979, (pp. 57-75), 122 pp. (CSNP-700452, ENP-8736 e).

Interaction Between the Environment and Radioactive Solid Wastes Disposed of on or in the Ground (1)

The processes through which the environment can degrade wastes, liberate the associated radionuclides, and affect the temporal and spatial behavior of the nuclides are considered briefly. The effects of wind and water upon wastes released in free form into the environment are mentioned. A brief review is presented of the possible causes of alteration and degradation of materials which form the support, packaging, or matrix of solid radioactive wastes, and the consequences thereof. The materials are divided into metallic and non-metallic forms, with the latter including discussions of cemented mortars and concretes, wood, paper, woven fabrics, asphalts and bitumens, plastics, ceramics, and glass. For the purpose of studying the dispersion of radionuclides in the environment, the possibility of grouping all natural phenomena into an overall model which could be treated by appropriate mathematical methods is considered. (JTH)

<825>

Commissariat à l'Energie Atomique, Centre d'Etudes Scientifiques, Fontenay-aux-Roses, France

Veckali, B. 1979. ENP-8736 e; CSNP-700452; Health Implications of the Storage of Radioactive Substances on and in the Ground, J. Sheets and R. Leavitt (Eds.), Proceedings of a Symposium held in Cherbourg-Le Havre, France, April 14-15, 1979, (pp. 89-94), 122 pp. (CSNP-700452, ENP-8736 e).

Consequences for Health of the Storage of Radioactive Waste in the Ground and Assessment of the Storage Capacity of a Site (1)

The possible contamination of underground waters by radioactive wastes and their subsequent utilization are considered. The pathways by which man can be affected by contaminated water are examined briefly, along with the derivation of admissible limits of exposure of the public. When considering creating a disposal site it is necessary to make an evaluation of doses which could be received by the critical population group or groups. The studies required to answer this question can be grouped in four categories: studies on the liberation of radioactive substances depending on the characteristics of the packaging material and storage conditions, studies on the movement of radionuclides in the ground and in the waters, studies on the use of water, and studies of the characteristics of the population groups which may be exposed. The data gathered will permit evaluation of doses which could be received by the critical population group or groups. (JTH)

<826>

Commissariat à l'Energie Atomique, Centre d'Etudes Nucleaires de Cadarache, Cadarache, France

Vancon, J. 1972, March. CEA-R-8279; RNL-Trans-931; 35 pp.

Practical Use of the Distribution Coefficient in Measuring the Radioactive Contamination of Minerals, Rocks, Soil and Underground Water (1)

The uptake of radioisotopes by soils or the diffusion in subterranean waters are often estimated with the distribution coefficient (K_d) of the radioisotope between the solution and the solid. In practice, many precautions have to be taken so that the K_d measurements will be representative of natural media. As a matter of fact the K_d depend on the chemical form of the radioisotope, on the nature and composition of the solution and on the nature of the minerals constituting the rock. But it is also necessary to take into account the texture and the grain size of the material. The K_d does not represent a physico-chemical characteristic when applied to consolidated rocks of very low permeability, since it is dependent upon specific surfaces according to a determined law. Accordingly an alternative concept has been defined for uptake by rocks of this nature; the surface distribution coefficient or K_d (S). Experience has shown that the value of K_d (S) was constant and characteristic of a consolidated rock and radioisotope for a specific contact time. (Auth)

Distribution Coefficient; pH; Grain Size Distribution; Cation Exchange Capacity

<827>

Commissariat à l'Énergie Atomique, Centre
d'Études Nucléaires de Cadarache, Département de
Protection, St-Paul-lès-Durance, France

Rancou, D. 1973. IAEA-SR-172/55; STI/PUB/305;
CONF-730503: Environmental Behavior of
Radionuclides Released in the Nuclear Industry.
Proceedings of a Symposium held in
Aix-en-Provence, France, May 16-18, 1973, (pp.
333-366), 789 pp. (CONF-730503, STI/PUB/305,
IAEA-SR-172/55).

The Behavior in Underground Environments of
Uranium and Thorium Discharged by the Nuclear
Industry. (2)

Following various studies on the radioactive
contamination of soil by fission products from
a variety of effluents, it has been found
necessary also to establish in what way
long-lived heavy radionuclides could be
diffused in underground environments. A
proposal is made for the study of the behavior
in the soil of uranium and thorium originating
from outside, as compared with the uranium and
thorium existing as natural constituents of
the soil. Work was made on various types of
soil (acid and alkaline) and of various
minerals (argillaceous minerals, calcite and
quartzite). Uranium in solution, or uranyl ion,
has a certain degree of mobility in soils.
The coefficient for the distribution of uranyl
ion between the solution and the mineral was
measured at various concentrations. The
distribution coefficient decreased with
increasing concentration and reached 0 when the
concentration reached 10 g/l. The influence
of the pH of the soil-water solution is very
considerable: the retention of uranium by the
soil shows a marked increase within certain
narrow ranges (approximately pH 4-5.5, 6.5-10,
and 11-12). Thorium is subject to high
retention by argillaceous and calcareous
soils, some of the latter strongly fixing the
whole amount. The influence of various
parameters (pH, concentration, soil
composition) is also substantial, as retention
can be very much reduced under certain extreme
conditions. The distribution coefficient of
thorium increased with increase in pH from 1
to 8 and that of alluvium decreased at pH
values greater than 8. When concentrated,
acidic thorium solutions (greater than 0.1
g/l) were applied to calcareous soils rich in
citric matter, CO₂ was released and thorium
was precipitated in the form of Th(OH)₄. The
risk of the spread of thorium in dilute
solution over long distances is negligible in
most soils. On the other hand, a certain
degree of uranium diffusion under the
influence of ground-water movements is to be
anticipated; diffusion evaluations are
presented. (auth) (JTE)

Good information on the effects of soil
conditions on the distribution of U and Th is
presented. (ESTC/JK)

Distribution Coefficient; pH

<828>

Commissariat à l'Énergie Atomique, Centre
d'Études Nucléaires, Saclay, France

Scheidtman, J. 1970. EUR-6736 or CONF-700052;
Health Implications of the Storage of Radioactive
Substances on and in the Ground, J. Sauts and R.
Amis (Eds.), Proceedings of a Symposium held in
Cherbourg-Le Havre, France, April 10-15, 1970,
(pp. 103-106), 122 pp. (CONF-700052, EUR-6736 or).

Surveillance of the Radioactive Waste Disposal
Site at La Hague (Ranch Centre) (3)

The Centre de la Hague is described as a site
for the storage of solid radioactive wastes.
Four kinds of storage are being considered for
the site: surface storage of cement blocks
and cased drums with grass cover, storage
in simple drained trenches providing surface
tightness of low activity wastes in drums,
storage in concrete compartments of other
wastes in drums and of loose wastes, and
temporary transit storage, outside or under a
shelter. The surveillance program which is
mainly directed at the underground and surface
hydrological system is discussed briefly.
(JTE)

<829>

Commissariat à l'Énergie Atomique, Centre
d'Études Nucléaires, Département de Chimie
Appliquée, Fontenay-aux-Roses, France

LeFollatre, S. 1976. CONF-760507;
Bismutization of Low- and Medium-Level
Radioactive Wastes, Proceedings of an IAEA Seminar
held in Antwerp, Belgium, May 10-19, 1976, (24
pp.) (CONF-760507).

Fixation of Low and Medium-Active Radioactive
Wastes in Bitumens (3)

Development studies of fixation by bitumens
has been concerned with a number of
approaches. Fixation of evaporation
concentrates and wastes produced by
light-water reactors, both boiling water and
pressurized are briefly presented. Direct
bismutization of effluents is a new process
that has as yet been applied industrially.
Spent fuels with the characteristics of
pH-9.2, 2.02 g/l salts containing 320 mg/l
boron, total gamma activity 1.3×10^6 Ci, total
beta activity 1.26 and total alpha
activity of 0.5×10^6 Ci/tonne from the PWR
of SENA have been solidified. Other reactor
effluents are listed. The decontamination
factors range from 860 to 1200 according to
process compared against and radioisotope
considered. Characterization of the
distillates and waste wastes is presented.
Also considered are the fixation abilities of
triisopropylamine and triethyl phosphine.
Leaching tests showed that in demineralized
water the rates ranged from 1×10^{-6} to 1×10^{-5}
Ci/day for a variety of radioisotopes.
Studies were also undertaken as to the
thermal and biological stabilities of the
bismutized radwastes. At present
bismutization assures storage of low and
intermediate-level radwastes with an
acceptable degree of safety and of cost. (BBV)

<830>

Commission of the European Communities,
Luxemburg, Belgium

Grison, G. 1970. EUR-6736 or CONF-700052;
Health Implications of the Storage of Radioactive
Substances on and in the Ground, J. Sauts and R.
Amis (Eds.), Proceedings of a Symposium held in
Cherbourg-Le Havre, France, April 10-15, 1970,
(pp. 17-50), 122 pp. (CONF-700052, EUR-6736 or).

Long-Term Forecasts of the Production of
Radioactive Waste in the European Community (2)

<830> CONF.

Statistics of the annual production of solid radioactive wastes for the European Community are presented, including low-level, intermediate-level, and high-level forms. The development of the nuclear power industry in Europe is discussed, and predictions of waste production by various nuclear facilities including research centers, industry, power reactors and reprocessing plants by the year 2050 are presented. (JTE)

<831>

Commission of the European Communities,
Luxembourg, Belgium

Grison, G. 1970. EWR-7736 e; CONF-760452; Health Implications of the Storage of Radioactive Substances on and in the Ground. J. Sweet and P. Anavis (Eds.), Proceedings of a Symposium held in Cherbourg-Le Havre, France, April 14-15, 1970, (pp. 79-87), 122 pp. (CONF-760452, EWR-7736 e).

5. Line of Storage Facilities for Radioactive Waste (2)

The problem of choice of disposal sites in the European Community has been considered by the European Commission. A study contract was concluded to this end in the beginning of 1965 which permitted the working out of a method offering great flexibility. The basic principle is the following: A colored translucent map must be provided showing the entire European Community, light-colored zones would indicate those zones offering the maximum of theoretical guarantees, and darker zones those which, theoretically, should exclude all possibility of the installation of a disposal site. The parameters considered in the project include geography, population, meteorology, geology, pedology, hydrology, seismology, and economy. A brief explanation of each of these is presented. (JTE)

<832>

Commission of the European Communities,
Luxembourg, Belgium

Sweets, J. (Ed.), and P. Anavis. 1970. EWR-8736 e; CONF-760452; Health Implications of the Storage of Radioactive Substances on and in the Ground. J. Sweets and P. Anavis (Eds.), Proceedings of a Symposium held in Cherbourg-Le Havre, France, April 14-15, 1970, 122 pp. (CONF-760452, EWR-8736 e).

Health Implications of the Storage of Radioactive Substances on and in the Ground (1)

The management of radioactive wastes give rise to many delicate problems, particularly in the six member states of the European Community. This meeting surveyed existing problems and assessed future ones so as to work out rational plans for action either by coordinating national activities or by international cooperation. Each delegation outlined its own views on the management of radioactive wastes, reported on the solutions adopted, and supplied information on its future policy. Four sections of the contents of the document are devoted to: (1) the extent of the problems of the storage of radioactive waste in the European Community, (2) the interaction of radioactive waste with

the environment, (3) establishment of a storage site, and (4) practical organization or monitoring and surveillance of radioactive pollution in the area of a radioactive waste burial ground. Seven papers have been selected for separate input into the data base. (JTE)

<833>

Ecole Nationale Supérieure des Mines de Paris, Centre "Informatique Géologique, Fontainebleau, France; Commissariat à l'Énergie Atomique, Institut de Protection, et de Sécurité Nucléaire, Département de Sécurité Nucléaire, Saclay, France; Bureau de Recherches Géologiques et Minières, Service Géologique National, Orleans, France

De Marsilly, C., E. Lefebvre, A. Barbereau, and J. Margat. 1977. August. Science, 197(4303), 519-527.

Nuclear Waste Disposal: Can the Geologist Guarantee Isolation? (1)

The confining power of deep geologic formations over very long time periods for highly toxic radionuclides with long half-lives is discussed. Of major concern is the high-level wastes produced by the reprocessing of spent nuclear fuel from light-water reactors (LWRs). The three major elements which have geologically significant half-lives are: iodine 129 (16 billion years); neptunium 237 (2.1 million years); and plutonium 239 (24,000 years). These elements have a wide range of physicochemical properties which are important in interactions with rock formations. Such behavior is indicative of other elements such as Am 241, Am 243, Pu 243, Pu 244, Pu 245, Pu 246, Th 230, Th 232, Ac 225, and U 235. Before placing the radwaste into a deep formation, the best way to contain it would be to put it into a glass matrix. Glass would provide a good firing medium because the coefficient of diffusion is only $10(E-6)$ to $10(E-10)$ sq cm/sec at 100 degree C for borosilicates. Therefore, a cylinder of glass 3.75 m high and 0.5 m in diameter would require 20 to 200 million years for 99% of the initial load of radionuclides to be extracted. The geologic barrier may be considered as one of total confinement, or one of relative confinement with respect to radioactivity, or one of relative confinement by conforming to the recommended standards of radiological protection. When considering the geologic barrier there are different mechanisms that affect formations. These are: groundwater flow, faulting, diapirism, erosion, fall of meteorites, magma intrusion, and modification of the drainage level of water. Using these considerations two models were constructed. One is a straight line model relying on the distribution coefficient of the radionuclide and rock. The other, is a step function response. To use the models five different types of geologic formations with permeability (m/sec) ranging from $10(E-6)$ to $10(E-10)$; and effective porosity of 2 to 20% are employed. When testing the step function response the distribution coefficient ranged from 0 to 2000 ml/g. If the integrity of the glass matrix is guaranteed indefinitely, then the rate of release will be very slow. This slow release will then make the choice of a confining geological formation less difficult. The release of radioactivity will be 1 to 1/1000 of the maximum permissible concentration. If the integrity of the glass can not be guaranteed, then the formation must have a sufficient ion exchange capacity of the radionuclide considered. Deep burial will

<337> COST.

also depend on the ability of the upper environment to receive the flux of elements and to dilute them. Finally, the natural geochemical barrier can be reinforced by an artificial one set up around the wastes. (30V)

Distribution Coefficient: Permeability
Coefficient: Effective Porosity

<338>

Ente Nazionale per l'Energia Elettrica, Rome, Italy

Antonucci, L., L. Bracci, P. Fiorentino, and S. Nicosi. 1978. COST-703905; IAEA-SR-137/80; STI/PUB/260; Development in the Management of Low- and Intermediate-Level Radioactive Wastes, Proceedings of a Symposium held in Aix-en-Provence, France, September 9-11, 1978, (pp. 261-278) (COST-703905, IAEA-SR-137/80, STI/PUB/260).

Management Experience with Radioactive Wastes from Small Nuclear Power Stations (3)

The operation and type of waste management of three Italian reactors of different types are discussed. At the first reactor, a SWR, activated metal scrap is dumped in a pit lined with stainless steel. At the second power station, a graphite-moderated, CO₂-cooled reactor, solid waste is stored in special buildings or in shielded, water-proof pits. At the third power station, a light-water pressurized reactor, solid wastes are placed in steel drums or mixed with cement in shielded containers and kept in pools. (CAB)

Only brief mention of shallow land burial of solid wastes. (DE/CAB)

<335>

Eraton, Institute for Atomic Sciences in Agriculture, Wageningen, Netherlands

Frissel, H.J., and P. Poulsen. 1967, August. Plant and Soil, 27(1), 20-22.

Chromatographic Transport through Soils. 2. Column Experiments with Strontium and Cesium Isotopes (B)

The rate of transport of calcium and strontium ions in resin-sand mixtures was measured at water fluxes ranging from 75 to 50,000 cm³/sqm/yr. The distribution coefficient for these ions varied from 0 to 800. These values are so wide that they include most possibilities existing in the soil. Thus, in soils for which no slow exchange or reaction occurs between the calcium or strontium ions and the soil minerals, the mean transport velocity can always be calculated. The rates measured agreed quite well with the calculated values. The dispersion pattern which developed during chromatographic transport was compared with some calculated dispersion patterns, the calculations being based on different theoretical approaches. The plate theories of Glueckauf and Reid gave correct curves for the set-up used. Simplified plate theories of Butt and Thornthwaite did not give curves which fit the experimental points. The experimental band-broadening and peak height confirm statements made in a previous paper.

Since the rate of exchange did not play a significant part the theory of Verwey and Hester could not be used. The theory of Lapidus and Amundson and the diffusion theory is expected to give the same curves as Glueckauf's theory so the theories were not tested separately. (30V)

Distribution Coefficient: Cation Exchange Capacity

<336>

Fisheries Radiobiological Laboratory, Lowestoft, Suffolk, United Kingdom

Mitchell, R.T., and R.V. Jefferies. 1973. IAEA-SR-172/75; STI/PUB/305; COST-730503; Environmental Behaviour of Radionuclides Released in the Nuclear Industry, Proceedings of a Symposium held in Aix-en-Provence, France, May 14-18, 1973, (pp. 633-645), 709 pp. (COST-730503, STI/PUB/305, IAEA-SR-172/75).

Control of Low-Level Liquid Radioactive Waste Disposal: UK Experience in the Derivation and Use of Environmental Capacity (3)

Methods used for assessment of environmental capacity are considered. Detailed studies of the behaviour of radioactivity after release to the environment and the pathways which lead to public radiation exposure are involved. Each assessment is valid only in relation to the appropriate food consumption rate or other habits of the exposed population resulting in exposure. Each pathway can be visualized as involving several stages such as dilution, dispersion, reconcentration, and public use of the environment, culminating in radiation exposure. Each of these stages is discussed to show the factors that must be considered. The procedures adopted in the UK for the evaluation of environmental capacity are discussed in the context of disposal of liquid radioactive wastes to freshwater lake and river systems, particular reference being made to the nuclear power station site at Trawsfynydd and the supporting radiobiological research conducted there. Recent experience in re-assessment of environmental capacity in relation to changing factors, such as effluent composition, is discussed and the paper concludes with an account in terms of public radiation exposure of how application of a control policy dependent on the assessment of environmental capacity has ensured the continued safety of waste disposal and the maintenance of very high standards of environmental protection. The crucial test of any radioactive waste disposal policy must be the extent to which the public are exposed to radiation as a result of its application. Departmental policy within the UK is to restrict discharges so that they fall within an environmental capacity based on ICRP radiation exposure criteria, often by a very large margin; as a consequence, public radiation exposure should be small. Estimates of actual levels of radiation exposure, a requirement which the critical path approach is especially suited to meeting are given and include both somatic and genetic considerations. These estimates show that a very high standard of radiation protection is maintained. (Auth) (3V)

<337>

Gesellschaft fuer Kernforschung mbH, Karlsruhe,

<437> COST.

German Federal Republic

Krause, H. 1970. EUR-4736 e; COSP-700452: Health Implications of the Storage of Radioactive Substances on and in the Ground. J. Smeets and B. Masvis (Eds.), Proceedings of a Symposium held in Cherbourg-Le Hague, France, April 14-15, 1970. (pp. 27-39), 122 pp. (COSP-700452, EUR-4736 e).

Establishment of a Radioactive Waste Disposal Site (2)

Factors to be considered when establishing a storage area for radioactive wastes are discussed very briefly, including: activity of the waste, nature of the waste, transport, health policy requirements, psychological questions, and capacity. (JTE)

<438>

Gesellschaft fuer Kernforschung mbH, Karlsruhe, German Federal Republic

Krause, H. 1970. EUR-4736 e; COSP-700452: Health Implications of the Storage of Radioactive Substances on and in the Ground. J. Smeets and B. Masvis (Eds.), Proceedings of a Symposium held in Cherbourg-Le Hague, France, April 14-15, 1970. (pp. 103), 122 pp. (COSP-700452, EUR-4736 e).

Practical Monitoring of a Waste Storage Site (3)

Recommendations for radiological monitoring before, during, and after the usage of a radioactive waste disposal site are presented very briefly.

<439>

Gesellschaft fuer Kernforschung mbH, Karlsruhe, German Federal Republic

Hild, H., W. Flugel, and H. Krause. 1970. COSP-741017; COSP-741086; American Nuclear Society Winter Meeting, Proceedings of a Conference held in Washington, D.C., October 27-November 1, 1970, (p. 206) (COSP-741017, COSP-741086) Transactions of the American Nuclear Society, 19, 206.

Bituminization of Radioactive Wastes at the Nuclear Research Center, Karlsruhe (3)

The operation of a self-cleaning screw-extruder-evaporator in the Karlsruhe Nuclear Research Center bituminization plant is discussed. It is operated at 200 degrees C and has the evaporation capacity of about 140 kg H₂O/hour at very low residence times (2 to 3 min) and low material holdup. The apparatus concurrently is homogeneously mixing and coating the radioactive salt residues and efficiently evaporating the water contained in the evaporator concentrates. In the past two years more than 1000 drums were filled with bitumen products (50 wt% final humidity less than or equal to 0.5 wt%). These products contained 80,000 Ci fission products from more than 25,000 cu m low- and intermediate-level radioactive effluents. Disposal is in the Asse salt mine. A bench scale screw-extruder unit is used to guarantee the production of bitumen products of the same characteristics as those in the full-scale plant. Also, this has been used for determining the optimum conditions for power reactor wastes, concentrates

containing chemically and thermally instable compounds. Bituminization is a safe and effective means for the solidification of low- and intermediate-level radwaste. (SDV)

Waste Volume

<440>

Gesellschaft fuer Kernforschung mbH, Karlsruhe, German Federal Republic

Fraus, R. 1977. Kerntechnik, 19(4), 171-179.

Experiences in the Treatment of Radioactive Wastes (3)

A general discussion on the methods of handling low- and medium-level radwastes is presented. For treating liquid radwastes chemical precipitation, ion exchange, and evaporation have been and are being used. Chemical precipitation is good for treating low activity, strongly polluted effluents of high salt content. The decontamination factors may range up to 10²(2.3) but are typically 2 to 100. Ion exchangers work well when the effluent has a low salt content. Evaporation is the most effective, most universal, and the most expensive with decontamination factors of 10²(2.3) to 10³(2.6). Before the disposal of the effluents from the three processes above solidification must be done by either cementation, bituminization, or incorporation in plastics. The advantages and disadvantages of the three methods are briefly discussed. Tank storage for highly active fission product solutions is very satisfactory in spite of leakage in some of the earlier tanks. Highly active fission product solutions can be solidified by calcination or by converting them into glass. The technique of first storing high-level wastes in tanks and then converting them to glasses appears promising. Compaction and incineration are two ways of treating solid radwastes. The ash would then be fixed in cement as would the compacted wastes. Those wastes containing plutonium would require extra processing. (SDV)

<441>

Gesellschaft fuer Kernforschung, Abteilung Behandlung Radioaktiver Abfalle (ABZA), Karlsruhe, German Federal Republic

Jakubick, A.T. 1976. COSP-751105; IAEA-SN-199/1; STI/PUB/810; Transuranium Nuclides in the Environment, Proceedings of a Symposium held in San Francisco, California, November 17-21, 1975, (pp. 47-62), 724 pp. (COSP-751105, IAEA-SN-199/1, STI/PUB/810).

Migration of Plutonium in Natural Soils (3)

The migration of plutonium in surface soils as it applies to both fallout and industrial contamination is evaluated in this study. The study plot investigated was the vicinity of Heidelberg and comprehensive fallout from ISPA (1950 to 1954) was extrapolated to determine input quantities. Calculated cumulative depositions were shown to agree well with observed Pu concentrations in the Heidelberg soils. Data on Pu distribution in soils provided by the Health and Safety Laboratory (HASL) were applied for the study plot in southwestern Germany. The removal of Pu02

(a01) COST.

particles from a given layer was observed to behave exponentially with a turnover time of approximately 5 to 6 years. The case of instantaneous soil contamination is considered with the development of a box model leading to Poisson-type equation which computes a migration velocity of 0.8 cm per year. The comparative migration velocities of PuO_2 and $\text{Pu}(\text{NO}_3)_3$ were evaluated and PuO_2 was shown to migrate two orders of magnitude faster than the nitrate form. (Auth) (JC)

Applicable for surface spill considerations at waste disposal facilities. (PW/JC)

(a02)

Gesellschaft für Kernforschung, Karlsruhe, German Federal Republic

Jakubick, H.F. 1976, August. ACS Symposium Series No. 35: Actinides in the Environment. H.B. Friedlander (Ed.). Proceedings of a Symposium held in New York, New York, April 3, 1976. pp. 81-89, 107 pp.

Application of the Box Model Theory to the Geophysical Transport of Plutonium Dioxide: Geochemistry of $\text{Pu}(\text{NO}_3)_3$ (?)

The use of box models to define the geophysical transport of PuO_2 and $\text{Pu}(\text{NO}_3)_3$ in distinct soil horizons is outlined. This paper emphasizes the importance of the interface between the lithosphere and the biosphere, namely the soil zone. This zone acts between both the lithosphere and biosphere like a sieve in both directions. Conditions affecting soil zone plutonium distribution include bioturbation caused by worms and burrowing animals as well as plant uptake and accumulation with subsequent plant death decay, and surficial soil dispersal. The interaction of plutonium with clay particles under varying pH conditions is discussed. Physical soil properties identified as being important include seasonal and diurnal variations of temperature and moisture. The soil horizons can be treated as a series of reasonably well-mixed boxes. Transport velocities of PuO_2 were obtained from arrival of 50% of the contaminant and time observations. A mean velocity of 0.4-1 cm/yr was estimated for a loamy soil and annual precipitation of about 1000 mm. The relative migration velocities of soil water, PuO_2 and plutonium initially in nitrate form are estimated to be in the ratio 10(E+5):10(E+3):10, respectively. (JC)

Distribution Coefficient; pH; Total Cation Concentration

(a03)

Institut für Chemie der Kernforschungsanlage Jülich GmbH, Jülich, German Federal Republic

Knieper, J., R. Printz, and R. Wolfle. 1977. Atomkernenergie, 70, 11-16.

A Contribution to the Problem of Solidification of Medium and Low Radioactive Liquid Wastes (?)

The use of hitherto described methods for the solidification of sodium and low radioactive

liquid wastes is associated with some drawbacks. Solidification of strong acid solutions has been a particular drawback. Some of these can be eliminated in a newly developed procedure (patent pending) based on the reaction of gypsum with water. Using the gypsum-water glass method, 1 kg gypsum is mixed with 200 to 300 ml of sodium or potassium water glass by continuous stirring. Then up to 500 ml of radioactive solution can be added to the above grainy, powdery mixture. Gypsum holds the water chemically and by crystallization. It is also capable of binding water due to capillary effects resulting from the porous monoclinic crystalline structure. A series of tests were conducted on specimens containing fission nuclides to determine the release of volatile radionuclides to the air; leaching experiments in water and concentrated salt solutions were also performed. The leaching rates which are in the order of $10(E-2)$ cm²/s can be lowered substantially ($10(E-6)$ cm²/s) by suitable additives or coatings. Paraffin coating was the most effective in lowering the leaching rates. Besides, several significant advantages in comparison with other methods are stirring during solidification not necessary and no troublesome evolution of gas and heat. Finally, some aspects concerning the application of the method for subterranean long-term storage of radioactive waste solutions are discussed. (Auth) (PW)

(a04)

Institut für Chemie, Forschungszentrum Seibersdorf der Österreichischen Studiengesellschaft für Atomenergie, Wien, German Federal Republic

Zeger, J., and K. Knotik. 1977. Kerntechnik, 19(4), 188-195.

Studies on the Thermal Stability of Bitumen-Salt Mixtures (?)

The results of a study of the thermal performance of various bitumen/salt mixtures are presented. When PuO_2 is added to the bitumen, the salt is not affected in air but at low temperatures some decrease in weight was a result of evaporation of volatile components. In nitrogen no visible effect was noted. $\text{K}_2\text{PuO}_4 \cdot 3\text{H}_2\text{O}$ has no observable effect on the bitumen in the mixture. $\text{K}_2\text{PuO}_4 \cdot \text{Na}_2\text{SO}_4 \cdot 10\text{H}_2\text{O}$ again caused no detectable changes in the bitumen/salt mixture with the exception of bitumen B 90. In this bitumen the stability was reduced in a temperature range of 180 to 200 degrees C. No reaction between $\text{KCl} \cdot \text{NaNO}_3 \cdot \text{Na}_2\text{SO}_4 \cdot \text{K}_2\text{PuO}_4 \cdot 3\text{H}_2\text{O}$ and the bitumens occurred in either air or nitrogen. While no measurable effect of $\text{ZrSO}_4 \cdot \text{PbCl}_2 \cdot \text{K}_2\text{PuO}_4 \cdot \text{Na}_2\text{SO}_4 \cdot 10\text{H}_2\text{O}$ on the bitumen was noted the stability was markedly poorer than that of pure bitumen particularly for bitumen B 90. Sudden combustion was observed when the mixture was heated at 370 to 375 degrees C. A molten salt fraction coalesces and forms a salt block after cooling which is no longer enveloped in bitumen. A similar combustion reaction occurs at 180 degrees C for the $\text{PuO}_2 \cdot \text{PuNO}_3/\text{bitumen}$ mixture, burning the bitumen and forming a fused salt block. $\text{PuO}_2 \cdot \text{PuNO}_3 \cdot \text{K}_2\text{PuO}_4 \cdot \text{Na}_2\text{SO}_4 \cdot 10\text{H}_2\text{O}$ remains in the bitumen after heat treatment up to 500 degrees C. $\text{Pu}(\text{NO}_3)_3 \cdot 9\text{H}_2\text{O}$ and $\text{Pu}(\text{NO}_3)_3 \cdot 9\text{H}_2\text{O} \cdot \text{PuO}_2$ had an extremely violent reaction completely burning the bitumen. A full study was done on the iron nitrates and chromium nitrates. The results showed salts which release oxygen at relatively low

(444) COST.

temperatures have the greatest effect on the thermal stability with the important factors being kind and rate of oxygen release. However, thermally unstable hydrous salts had hardly any effect on the surrounding bitumen. Nitrites and nitrates release strongly oxidizing gases which attack the bitumen. Hence, low to medium-level liquid wastes generated in the course of operation of nuclear power plants are suitable for submergence in bitumen after concentration and drying. The liquid wastes from nuclear fuel reprocessing plants will have to be specially dried and embedded due to nitrate and heavy metal ions. (SDV)

(445)

Institute for Strahlenbiologie, Gesellschaft für Strahlen- und Umweltforschung MBH München, München, German Federal Republic

John, W., J. Wendt, and R.P. Schatzler. 1973. (AEA-SR-172/19; STI/PDB/345; COSP-73050); Environmental Behavior of Radionuclides Released in the Nuclear Industry, Proceedings of a Symposium held in Aix-En-Provence, France, May 14-18, 1973, (pp. 347-361), 749 pp. (COSP-73050; STI/PDB/345; AEA-SR-172/19).

Transport of Iodine 131, Cesium 137, Ruthenium 106, Cesium 144, and Rhenium 54 in an Undisturbed Soil under Natural Environment Conditions (2)

An unusually large, undisturbed and overgrown soil sample with a diameter of 1.9 m and a height of 1.5 m was taken from a site assigned for a reactor. Over a long period of time the translocation of a mixture of fission products, containing 200 μCi each of I 131, Cs 137, Ru 106, Ce 144, and Rh 54 was investigated in the soil sample under natural atmospheric conditions. The whole specific surface activity was $4 \times 10^4 (\text{Bq}) \mu\text{Ci}/\text{sq cm}$. Composition of the soil column showed that the clay content was 22.6 % and the total organic carbon content was 2.3 %. The surface activity corresponded to an accident situation that might occur when activity is released through the chimney. The penetration of the radionuclides into the soil was determined by gamma spectroscopy and autoradiography. For 10 months after the contamination the fission products, mainly cationic, could only be found in the superficial (20-30 cm) soil layers. Additional investigations with I 131 and inactive iodine, determined by activation analysis, showed that anionic iodine penetrates deeper into the soil within a shorter period of time than do cations (80 cm in 1-2 days). This offers the possibility of determining in advance the extent of a casual iodine contamination by investigations with inactive iodine in a specific soil. (Auth) (JTE) (CSP)

Clay Content; Total Organic Carbon Content

(446)

International Atomic Energy Agency, Division of Health, Safety and Waste Management, Vienna, Austria

Neuge, E.D. (Ed.). 1971. Atomic Energy Review, 9(1), 195-207.

Leach Testing of Immobilized Radioactive Waste Solids: A Proposal for a Standard Method (2)

An important preliminary treatment to the disposal of radioactive waste is its solidification and incorporation into a stable medium from which the radioactive components cannot readily be leached by water which may come in contact with the waste after disposal. In order to test the quality of any solidified form of waste and to intercompare various products from different processes or different laboratories, it is desirable to have a standard method of measuring the leach rate by water of the radioactive components in the solid waste. Two leach rate tests are presented which were the result of recommendations by a panel of experts convened by the International Atomic Energy Agency in August, 1969. One method is for intercomparison purposes and the other to approximate the behavior of an immobilized solid under the conditions of the storage environment. The details of the methods include specimen preparation, leachant containers, leachant specifications, experimental conditions and reporting of results. A section is given on extrapolation of test results to a disposal program. Although these leach rate tests are not official it is hoped that they will find acceptance by workers in the field and lead to recognized standard methods. The methods proposed in this report are subject to revision as experience is gained in their application. (Auth)

Proposed standards for determination of leachability of solidified radioactive waste are presented. (DA/JC)

Leaching Rate

(447)

International Atomic Energy Agency, Division of Health, Safety and Waste Management, Vienna, Austria

Neuge, E.D. 1971. Atomic Energy Review, 9, 195-207.

Leach Testing of Immobilized Radioactive Waste Solids: A Proposal for a Standard Method (2)

Two leach rate tests are presented as a standard method of measuring the leach rate by water of solidified radwastes might be had. One of the tests is for intercomparison purpose and the other to approximate the behavior of an immobilized solid under the storage conditions. Detailed information on the important aspects of methods is outlined. The important aspects are: specimen preparation, leachant containers, leachant specifications, experimental conditions, and reporting of results. Also included is a section on extrapolating test results to a disposal program. (SDV)

(448)

International Atomic Energy Agency, Vienna, Austria

1968. Technical Reports Series No. 27; 167 pp.

Technology of Radioactive Waste Management

(400) CONT.

Simplifying Environmental Disposal (2)

Reported on are the extent of radioactive waste management methods and practices can approach the ideal of total containment. Also noted are present research and development activity designed to minimize discharges to the environment. All types of radioactive wastes from milling and mining, fuel fabrication, reactor operation, fuel reprocessing, labor wastes, medical and industrial radioisotope uses, and decontamination operations are considered. The report is divided into two parts, one on theory, the other on operational experience and research progress. Part one is divided into the following sections: collection and segregation and treatment and storage. Methods, materials used, and efficiencies of the various processes are discussed for the latter section. Part one is concluded with a section on promising research and development work. Part two discusses operational experience listed in part one. Plants included in the discussion are: C.T.S., Argonne National Laboratory, A.E.C. (OR), Nuclear Research (OR) Institute, Chalk River (Canada), Viso Research Institute, Oak Ridge National Laboratory, various U.S. power reactors, Los Alamos Scientific Laboratory, Hanford Laboratories, and Howard Air Cleaning Laboratory. (SDV)

(400)

International Atomic Energy Agency, Vienna, Austria

Lehmann, W.L., H.E. Parker, and P.J. West. 1976. Annals of Nuclear Energy, 1, 245-294. (OXY-75041); European Nuclear Conference held in Paris, France, April 24-25, 1975. (11 pp.) (OXY-75041).

Management of Radioactive Wastes (2)

Areas bordering on or regarding radioactive waste management in the nuclear fuel cycle are discussed. Better management and control over mill tailings, a shortage of irradiated fuel storage space, and decommissioning criteria are areas that require immediate attention or preparation for future implications. Radionuclide 226 is the chief concern with respect to mill tailings not because of its low concentration, 800 pCi/g, but due to its long half-life, 1620 yr and the radon gas decay daughter. The tailings should be disposed of in areas where they can ultimately be stabilized and regenerated. It has been tacitly assumed that the fuel reprocessor would provide for adequate management of spent fuel so now there is a problem of fuel storage space. But storage is and will be a viable alternative to reprocessing for the next 10 years. Storage may be achieved with existing technology at reactors with appropriately planned storing capability. Decommissioning of facilities should be included in the design. Criteria should be set up by governmental regulatory bodies. Techniques need to be developed for concentrating and containing Krypton and tritium from fuel reprocessing effluents. The work is as yet experimental and involves incorporation in to polymers and resins. Another serious problem is resolving how high-level and alpha-bearing wastes are disposed. The most promising disposal method is disposal in suitable (salt, granites and shales) geologic formations. This method should be proven as the problem is a critical issue to the nuclear power industry. Regional

fuel and management centers have been shown by cost analysis to be the best way of handling the wastes with the exception of tailings and fuel storage. It minimizes the potential hazard of handling. International cooperation is a must to achieve nuclear maturity. (SDV)

Good overview of the state of the art and potential problems is presented. (ESIC/SDV)

(450)

International Atomic Energy Agency, Vienna, Austria

1967. Technical Report Series No. 78.

Operation and Control of Ion-Exchange Processes for Treatment of Radioactive Wastes (3)

The principles behind and procedures for the application of ion exchange to the treatment of radioactive wastes is reviewed. Also given is a review of the procedures currently in practice at facilities using this mode of waste treatment. Included in the text are chapters on the history of radioactivity removal from reactor systems and wastes, principles of ion exchange, ion-exchange materials, limitations of ion exchangers, application of ion exchange to waste processing, operation procedures and experiences, and costs of ion exchange treatment. The appendices include a list of producers of ion exchange materials, conversion factors, regeneration data, glossary, references, and a bibliography. Three chapters were separately entered in the data base. (WT)

Pre-berial ion exchange waste processing is discussed. (DS/WT)

(451)

International Atomic Energy Agency, Vienna, Austria

1967. Technical Reports Series No. 78; Operation and Control of Ion-Exchange Processes for Treatment of Radioactive Wastes, Chapter 6, (pp. 38-63) 187 pp.

Application of Ion Exchange to Waste Processing (3)

The principal applications of ion exchange in the nuclear industry are in the purification of reactor coolant and in the treatment of some liquid reactor wastes. Three limitations on waste solutions to be treated by ion exchange are (1) the solutions should have low suspended solids concentrations (less than 5 ppm), (2) the solutions should contain less than 7500 mg/l total solids, and (3) the radioactivity associated with non-electrolytes and colloids should be very low. In the event waste solutions are amenable to or can be readily converted to meet these specifications, two principal techniques with variations are available for contracting waste solution and exchanger (excluding electrodialysis). These are: (1) batch operation and (2) column operation. The batch operation consists of placing a given quantity of waste solution and a predetermined amount of exchanger in a vessel, mixing the components well and permitting them to remain in contact until equilibrium is reached.

(45) COST.

Column operation is essentially a large number of batch operations in series. Cation and anion exchangers in the same vessel. Mixed bed systems are in present use for the treatment of the general radioactive waste solutions produced at atomic energy installations. In intermittent use they have an advantage over the multiple bed systems in that ion leakage following shutdown periods is much lower. For treatment of wastes containing mixed fission products, efficiencies obtained by the mixed bed system will be higher than those obtainable with cation-exchange resins alone due to removal of the active ions. Dual column systems also find widespread use for treatment of liquid wastes. Less than 100% of the total ion exchange capacity of a resin is operationally used as a balance between regenerant costs, capital cost, the need for minimum leakage, and the desire to maintain low column radioactivity. As applied to ion exchange practices, shielding for protection from gamma radiation is usually accomplished by wrapping units in lead sheets, by providing lead barriers, or by using concrete walls of sufficient density and thickness. (Auth) (RT)

Pre-burial exchange waste processing is discussed. (DN/RT)

process evaporator overheads and miscellaneous wastes with Cs 137 concentrations at 0.05 to 0.10 $\mu\text{Ci}/\text{ml}$. Ion exchange constitutes the second step of the low-level waste treatment process at the Tokai Research Establishment in Japan. In the treatment of radioactive wastes by ion exchange, it may become necessary to transport contaminated materials to other locations for further processing. These materials might include exhausted exchangers, spent regenerant solutions, spent regenerant sludges, incinerated resin ash, and evaporator spent regenerant residues. Locally and nationally established regulations for the safe transport of these materials must be complied with. (Auth) (RT)

Pre-burial ion exchange waste processing at some existing nuclear facilities is discussed. (DN/RT)

(453)

International Atomic Energy Agency, Vienna, Austria

1967. Technical Report Series No. 78; Operation and Control of Ion-Exchange Processes for Treatment of Radioactive Wastes, Chapter 8, (pp. 78-88), 187 pp.

Cost of Treatment by Ion Exchange (3)

A large number of variables are involved in comparing costs of use of ion exchange for waste treatment among various sites. In addition to the normal variables such as differences in wage rates and costs of materials, few facilities are identical in their manner of employing ion exchange, the extent to which it is employed or the type of solution being processed. In many facilities ion exchange is established as a polishing operation to be used when effluent activities have not been reduced sufficiently by other means. Building and equipment costs are included in the capital cost items to be considered. The comparative costs of vertical storage tanks constructed of a number of materials increase with increasing capacity. The range of investments in existing ion-exchange facilities is provided in the 5 included test examples. Operating cost estimates for ion exchange should include: (1) labor (actual cost including benefits), (2) chemicals (cost of exchanger and regenerant chemicals), (3) utilities, services (costs of steam, gas, electricity, plus the costs of services specifically assigned to the ion exchange operation), (4) current maintenance (cost of maintaining the ion exchange facility in good repair), (5) direct or operating overheads (costs of supervisor, secretarial, and clerical staff, insurance, travel, etc.), (6) depreciation (the annual charge for amortization based on 20 year building life and 7 1/2 year equipment life), and (7) total costs (this will not include cost of general overheads or applied research). The operating cost per cubic meter of waste treated ranged from \$0.79 to \$36.50 for several installations which vary widely in their application of ion exchange to waste processing. An equation is provided for calculation of total operating costs. (RT)

Cost analysis of ion exchange, pre-burial waste processing is discussed. (DN/RT)

(452)

International Atomic Energy Agency, Vienna, Austria

1967. Technical Reports Series No. 78; Operation and Control of Ion-Exchange Processes for Treatment of Radioactive Wastes, Chapter 7, (pp. 68-77), 187 pp. Chapter 7.

Operational Procedures and Experiences (3)

The treatment of reactor waters is a very specific problem which has been solved in the majority of cases in a very similar manner. Laboratory and plant waste solutions differ widely and the many problems which have been solved in whole or part by ion exchange have utilized almost the entire range of materials and methods known. At most localities it is a small part of the total capability and in many, it is merely a polishing operation. Ion exchange treatment is used at the Hahn-Weitzner-Institut für Kernforschung in the Federal Republic of Germany when certain nuclides, particularly Cs 137, have not been removed to satisfactory levels. The chemical waste treatment plant effluent can be treated through cation-exchange resins, anion-exchange resins, mixed bed resins or through the three columns in series. Ion exchange is employed for similar polishing reasons at Belgoe Nuclear, Reactor Centrum Nederland, and the Atomic Energy Research Establishment in the United Kingdom. In another application at the Atomic Energy Research Establishment, filtered medium-level radioactive waste is demineralized in a series of cation-anion exchange columns. Large volumes of water from a storage basin for irradiated fuel elements are routinely processed through four parallel sets of two zeolitic ion-exchange columns in series at the National Reactor Testing Station in Idaho. Strontium-90 is reduced in wastes from Los Alamos Laboratory in New Mexico by two ion exchange columns at the effluent end of the chemical treatment facility. A synthetic chabasite ion exchanger is used at the Savannah River Plant in South Carolina to

<050>

International Atomic Energy Agency, Vienna, Austria

1965. IAEA Safety Series No. 35; 111 pp.

Radioactive Waste Disposal into the Ground (3)

A general review of the various parameters which affect the disposal of low and intermediate-level radioactive wastes based on the experiences of facilities which practiced radioactive waste disposal into the ground. The report discusses, in general terms, 1) the site characteristics which affect disposal i.e. climate, hydrology, geology, 2) the potential physical and chemical interactions between the wastes and the rock i.e. sorption, flow, 3) the order of release into the ground as a function of waste form (liquid or solid), 4) the means of evaluating the acceptability of a site for the potential for radionuclides entering the biosphere, and 5) the standards and control techniques including site monitoring. The report concludes that although geological and hydrological studies may not identify the absolute pathway to the biosphere, investigation of these parameters is important in assessing the potential for hazard to the environment. Appendices on the pretreatment of waste, the movement of radioactive wastes in the ground, disposal operations, and methods of investigation are provided. (Roth) (J7)

A general review of waste disposal practices and controlling parameters. Specific data are limited and where presented are not discussed in sufficient detail. (DH/JT)

<055>

International Atomic Energy Agency, Vienna, Austria

1976. CORF-751105; STI/PUB/810; IAEA-SM-199; Proceedings of an International Symposium held in San Francisco, California, November 17-21, 1975, 728 pp. (CORF-751105, STI/PUB/810, IAEA-SM-199).

Transuranium Nuclides in the Environment (3)

A total of 81 papers representing work done in seven nations on the transuranium isotopes are presented in this volume. Major topics included the ecological behavior of plutonium in terrestrial, aquatic and marine environments, biological uptake, accumulation and transfer, pathways to man, environmental monitoring, and health effects.

Contains a handful of papers highly relevant to shallow land burial. (DH/JC)

<056>

International Atomic Energy Agency, Vienna, Austria

1976. STI/PUB/857; Safety Series No. 80; 50 pp.

Management of Wastes from the Mining and Milling of Uranium and Thorium Ores (3)

The environmental protection aspects of radioactive and chemical wastes arising from all stages of mining and milling operations

conducted with the primary or secondary objective of recovering uranium and/or thorium, up to and including the production and packaging of the first uranium and/or thorium concentrates, are considered. Descriptions are given of the wastes produced by these operations, along with waste management practices found satisfactory by experience and proposed solutions warranting evaluation. Problems in decommissioning and responsibility for long term maintenance, inspection, and monitoring programs are discussed. (CM)

Discusses environmental considerations affecting siting and discharge limits, including responsibility for long term maintenance, inspection, and monitoring programs. (DH/CM)

<057>

International Atomic Energy Agency, Vienna, Austria

Pradel, J., P.J. Foxworth, and E. Balazsek. 1970. STI/PUB/10/106; Technical Reports Series No. 106; 88 pp.

The Volume Reduction of Low-Activity Solid Wastes (3)

Techniques for volume reduction of low-level radwastes are presented. Two categories of reduction are considered: fragmentation and compaction (mechanical) and incineration. The mechanical techniques reduce the volume whereas, incineration yields a reduction in both volume and weight. It is estimated that 70% of the wastes produced are compressible or combustible, while 20% are hard materials, and 10% debris from plant conversions. Low-level solid wastes are produced at a rate between 0.25 and 0.5 cu m/employee annually. Waste sorting is essential to this kind of waste management because it will improve the efficiency of the chosen method. Decontamination of weakly contaminated scrap may be highly desirable in the overall efforts to reduce wastes from a plant. Compaction reduces waste volume by relieving the voids while fragmentation by reducing the size of large pieces, makes them easier to handle by other processes. Material easily compacted are paper, fragments of plastic or rubber, rags, glassware, and small metallic items. The compacting techniques, and experience are discussed in detail. Fragmentable wastes are a result of dismantling and elimination of large items of equipment such as waste tanks, heat exchangers, ventilation hoods, glove boxes and fluid supply lines. Such wastes are cut apart in cutting rooms. Several different techniques are discussed along with practical experience. Packaging of the wastes depends on the final method of storage. A large proportion of low-level radwastes is combustible and the quantity of ash is such that the reduction factor is on the order of 100 by volume and 11 to 25 by weight. Combustible wastes are divided into three types: cellulose materials; plastics and rubber; and animal carcasses. Important characteristics such as physical state, chemical state and calorific value also must be taken into account. The physical state affects the combustion rate with material compacted too tightly or perforated. The chemical state governs the degree of corrosion. The calorific value determines the temperature in the furnace. Waste sorting is very important in combustion because it increases the homogeneity. Techniques and practical experience are included in the

(057) COST.

discussion. While the principal of incineration is simple, difficulties with gas clean-up pose a problem. Hence the method may not be as economical as for conventional waste. Other techniques briefly considered are lead melting, ferrores materials and special steels melting, acid reduction, and neutralization of animal carcasses. The disadvantages and advantages, choice of process, economic aspects, utilization of reduction facilities, influence of the storage possibilities, and importance of the choice of storage method are also covered. (00V)

(058)

Japan Atomic Energy Research Institute, Health Physics and Safety Division, Tokai-mura, Ibaraki-ken, Japan

Watanabe, K., S. Koriyama, Y. Uedauchi, and A. Ito. 1977, June. Health Physics, 32, 529-534.

Leaching Behavior of Cesium 137 in Cement-Waste Composite (2)

Intermediate and low-level wastes have been routinely confined in cement. To assess the safety of such disposal a study was done on leaching of Cs 137 from a radioactive waste cement composite. Cement have many practical advantages for being used as a matrix and they are low cost, easy operation, and radiation and thermal stability. However, it does not reduce the volume of the wastes and it is highly leachable. Specifically investigated was the waste-cement ratio (W/C), concentration of salt, temperature of leachant, and curing time. A simulated 300 regeneration solution 100-120 uCi specimen and two types of cements were used, Portland and slag. The Portland cement contains less SiO₂ and Al₂O₃ than the slag and more CaO. Generally, the leachability is lower when the W/C ratio is decreased with longer leaching times and increasing salt concentration the leachability increases. Low temperature (2 degree C) curing time of a specimen significantly affects the leachability. The slag cement composite gives a leachability which is superior to that of the Portland cement. The slag cement after a 100 day leaching period had a leaching fraction of 0.1-0.15 which compares favorably to 0.3-0.5 of the Portland cement. If a low temperature curing is used the cement must be cured for about 50 days before there is an elimination of the apparent temperature effect. (00V)

(059)

Japan Atomic Energy Research Institute, Tokai Research Establishment, Tokai, Ibaraki-ken, Japan

Nachida, C., and N. Suzuki. 1975, March. Nukun Butsuri, 10(7), 17-21.

Material Composition of the Low-Level Radioactive Solid Waste (3)

The survey of material composition of the low level radioactive solid waste was performed in connection with the design work of the new incinerator in Tokai Establishment, JAERI. Five large facilities were selected on the representation of more than 20 facilities, and 500 packages were chosen out of 2,169 packages

discharged during 2 months, June and July 1977. They consisted of the combustible and compressible waste but did not include filters and contaminated equipments. The survey showed the following results: plastics 33%, waste cloth 20%, paper 10%, rubber 9%, clothes 5%, timber 1% (total of above mentioned materials 97%). Metal 7%, glass 2%, concrete and sand 2%. Eighty-nine percent of the total quantity is combustible material in principle, then it will be expected that the incineration treatment get a wider application to reduce the volume of final disposal. (00V)

(060)

Japan Atomic Energy Research Institute, Tokai-mura, Ibaraki-ken, Japan

Fukuda, R. 1976, November. Health Physics, 31(5), 976.

An Assessment of Population Dose Caused by Low-Level Radioactive Waste Discharged to the Coastal Area (3)

A method for estimating the population dose caused by low-level radioactive waste discharged to a coastal area from a nuclear fuel reprocessing plant is presented. The population intake is a summation function which is summed over season, position and season. Data required for the estimation are: catches of fishes, the fishing field distribution, the fishing season, the fishing layer, the fishing method, the concentration factor of radionuclides for each kind of fish and oceanic diffusion models for radionuclides. The population dose can be estimated by dividing the population intake by the value of intake of radionuclides which corresponds to the dose equivalent of 1 rem. (00V)

(061)

Japan Atomic Energy Research Institute, Tokai, Ibaraki, Japan

Koriyama, S., S. Dojiri, and N. Watanabe. 1977, June. Health Physics, 32, 509-512.

Leaching of Cesium 137 from the Ion-Exchange Resin Incorporated in Polyethylene or Cement Composite (3)

The leaching behavior of Cs 137 from and ion-exchange resin and cement: two methods used were a diffusion equation derived for a plane source model and a rate equation for diffusion coupled with a first-order reaction. The data was analyzed by an empirical polynomial equation. The resin was in a polyethylene matrix. The fraction of cesium leached was a function of the square root of the leaching period for both the cement and the polyethylene. The leaching rate changed after about 30 days indicating that after 30 days the diffusion rate slows due to the lengthening on the diffusion path. Diffusion coefficients predicted by method 1 are 5.0×10^{-6} and 9.7×10^{-10} sq cm/day for the cement and polyethylene, respectively. For method 2, 2.1×10^{-10} and 1.7×10^{-10} sq cm/day for the polyethylene and cement, respectively. It was found by the experiments that method 1 did not describe the whole leaching process but simulated the leaching in the longer period due to its simplicity.

(061) COST.

Method 2 had limited application in this study and method 3 provided a convenient polynomial approximation when a rate equation could not be derived. (1989)

Dispersion Coefficient

(062)

Forschungszentrum Karlsruhe, Abt. für Behandlung Radioaktiver Abfälle, Karlsruhe, German Federal Republic

Frank, E. 1976, August. HW-2255: Review on the Treatment of Radioactive Wastes from Fuel Processing Plants, pp. 7/1-7/10, 100 pp.

Progress on the Treatment of Radioactive Waste from Reprocessing Facilities (3)

In the past, 6000 cu m of storable wastes have been concentrated from 50,000 cu m/yr which contain 1 billion Ci of beta-gamma emitters and 10 billion Ci of alpha emitters. From a volume point of view weakly-active and medium-active waste waters predominate, not from a radioactive standpoint the fission product solutions predominate. While storage in double-lined stainless steel tanks is acceptable for high-level wastes, it would be better to solidify the wastes. Calcining and phosphate glass entrainment have been used with minimal success. Other glasses, such as borosilicate glasses, appear to be more successful. High-level liquid wastes are converted to solid materials by: evaporation, distillation, drying, calcination, and melting. Medium-level wastes are important for their volume as well as the fission products and actinides they contain. At Karlsruhe the wastes are evaporated and fixed in bitumen. To date 2000 cu m (100-600 mCi/cu m) had been processed and a loading of the slats of about 10 (10⁴-10⁵) Ci/cu m results. This is only 1/1000 of the permissible concentration. Fixing in bitumen of medium-level radwastes has proved to be moderately successful. Work is being done on separating the sodium salts and processing the residue as weakly active wastes. Low-level waste water is decontaminated by vapor compression and so far 70,000 cu m has been so evaporated. HF-containing solvent wastes are washed with soda, mixed with concentrated phosphoric acid, and extracted from hexane. The water used to wash the solvent and the diluted phosphoric are treated as medium-level waste and the "top" is solidified. The hexane is reused after filtering. Fuel shells are accumulated in a barrel and cemented before final storage. Combustible radwastes are incinerated and the ash is mixed with concrete for storage. Approximately 5000 cu m of solid and liquid wastes have been incinerated. Wastes containing over 500 pCi/g or Po of greater than 10 µg/200 liters have not been incinerated. Alpha wastes need stringent handling requirements due to toxicity and long half-lives. (1989)

(063)

Kyoto University, Department of Sanitary Engineering, Kyoto, Japan

Inoue, Y., and S. Morisawa. 1976; 1977. OPR/17/0025; 20 pp.; Nippon Genshiryoku Taktu

Shi. W (7), 524-530.

Distribution Coefficients of Radionuclide Between Sample Soil and Water (1)

A discussion of factors influencing distribution coefficients of radionuclides in soil and water is presented. The document examines chemical precipitation as a process which increases the distribution coefficient (K_d) to values higher than those obtained by ion exchange alone. Coexisting ions such as calcium, magnesium, sodium, potassium, and hydrogen affect K_d . Distribution coefficients for 17 soils and 9 radionuclides were measured by batch and/or column methods along with other soil characteristics. The cation exchange capacity of the soils ranged from 11.3 - 206.0 meq/g. Soil density ranged from 1.62 - 2.95 g/cm³. Uniformity coefficients ranged from 1.01 - 9.30 based on effective diameters which ranged from 0.02 - 0.51 mm. In descending order of distribution coefficients Cr, Co, and Sr had the highest overall K_d s of the nuclides tested. A positive correlation was observed between the distribution coefficients of Sr 90 and the cation exchange capacity of the soil. (1976)

Distribution Coefficients: pH; Cation Exchange Capacity

(064)

Kyoto University, Department of Sanitary Engineering, Kyoto City, Japan

Inoue, Y., and S. Morisawa. 1976, January. Health Physics, 26, 51-61.

On the Selection of a Ground Disposal Site for Radioactive Wastes: An Approach to Its Safety Evaluation (1)

All radioactive solids generated at a nuclear power station located along a coast are assumed to be buried on site. Equations are discussed for calculating the rates of leaching of nuclides from solidified wastes, migration of radionuclides in the ground, diffusion of nuclides in seawater, the concentration of nuclides in foods, and human dose rates through three critical pathways: drinking water, seafoods, and vegetables. The leaching rate of a nuclide in a concrete solid ranges from 1.0×10^{-12} to 7.5×10^{-12} g/cm²/day. Cesium 137 was assumed to leak at the same low rate as Sr 90 and I 131. Cobalt 60, 60 showed the highest leaching rate. Migration rates of the nuclides in the ground were from 1.2×10^{-12} to 6.5×10^{-12} cm/day for the average case and 1.1×10^{-12} to 7.5×10^{-12} cm/day for the saturated zone. The distribution factors ranged from an assumed value of 1 ml/g for I 131 to 1000 ml/g for Cs 137. Three types of disposal are discussed: (1) solidification with portland cement in a drum and storage in a reinforced concrete pit, (2) solidification with portland cement in a drum and disposal in the ground, and (3) solidification with portland cement and disposal in the ground. It is concluded that (1) the most dangerous nuclides in this method of disposal are Sr 90 and I 131, (2) the largest internal dose is absorbed through the intake of vegetables, (3) the method of ground disposal of radioactive wastes appears to be safe and promising because of the low internal dose estimated, and (4) the method of entombment discussed in this report is also applicable to other problems of the same type such as the sanitary land-fill of industrial wastes. (1976) (25)

<064> C57-

Distribution coefficient values in Table 5 are for a soil sample consisting mainly of sand and a little clay. (ESTC/J77)

Testing Date: Distribution Coefficient: Migration Rate

<065>

Kyoto University, Department of Sanitary Engineering, Kyoto, Japan

Inoue, Y., S. Horisawa, and Y. Eiyatake. 1976; 1977. OSHL-tr-0020; 17 pp.; Nippon Genshiryoku Gakkaishi, 10(7), 445-451.

Migration of Non-Ionic Yttrium 90 through Sand Column (2)

An experiment was conducted using yttrium 90, a daughter nuclide of Sr 90, to determine how it behaves in a nonionic form as compared to its ionic form. The separation of Y 90 from Sr 90 was achieved by passing a tap water solution of Sr 90 and Y 90 in a state of radiation equilibrium in a hard glass column packed with Amberlite MB-3 mixed bed ion exchange resin, adjusted to Ca-type. The Y 90 was then treated with 1N HCl or 1N NaOH for proper pH level, the adjusted pH range was 3.0-10.0. The solution of 5.6 x 10⁻⁵ g/l Y 90 (2-10 g/l concentration) was then passed through a hard glass column with the desired amount of sample sand and ion exchange resin. After the pH adjustment, Y 90 aqueous solution was poured in the column, and the Y 90 density in the effluent was measured at certain time intervals. The conclusions drawn from the study are summarized as follows: 1) The existing condition of the Y 90 in its extremely low concentration aqueous solution varies greatly depending upon the pH level. In a low pH range, most of the Y 90 exists in a cationic form, while in a high pH range, Y 90 exists in an uncharged nonionic form. 2) The degree of sorption of the ionic Y 90 on the cation exchange resin and the sample sand was large, and the sorption of the nonionic Y 90 on the resin and the sample sand was small, but it did not reach zero. 3) Since ionic Y 90 and a portion of the nonionic Y 90 was sorbed on the sand, their migration speed is small in the sand layer, but the rest of nonionic Y 90 migrates in the sand layer at almost the same speed as water. It has been speculated that most (about 80% or more) of the Y 90 is in the range of ordinary groundwater exists in the nonionic form. 4) The study does not give an answer as to whether the nonionic Y 90 was a real colloid or absorbent colloid. (JNT)

Distribution Coefficient; Cation Exchange Capacity; pH

<066>

Kyoto University, Department of Sanitary Engineering, Kyoto City, Japan

Horisawa, S., and Y. Inoue. 1976, November. Health Physics, 27, 447-457.

In the Selection of a Ground Disposal Site for Radioactive Wastes by Means of a Computer (2)

A program for site selection is based on some

reasonable assumptions and includes the data required to estimate the dose of radioactivity in the human body due to the disposal wastes of a nuclear facility along a coast. The calculations were made for a model nuclear facility that was chosen to show the general method of selecting a ground disposal site. An optimum location for a ground disposal site is defined as a location with minimum internal dose caused by the disposal wastes. Four locations were selected using a computer, each location having a minimum internal dose based on the assumption of 0.1 Ci/yr leakage of Sr 90. The minimum internal dose for the four locations was estimated to be lower than 10 (2-80) mrem/yr. The method of selecting optimum locations is reasonably promising for solving current problems of site selection for disposal. A chart to compare the safety of sites by evaluating each with reference to eighteen environmental factors is included. (auth)

<067>

Kyoto University, Department of Sanitary Engineering, Kyoto City, Japan

Horisawa, S., and Y. Inoue. 1976, March. Health Physics, 26, 251-261.

In the Selection of a Ground Disposal Site by Sensitivity Analysis (2)

The desirable conditions for the ground disposal of radioactive wastes and the approximate method for estimating the internal dose are discussed by means of a sensitivity analysis. Calculations were made for Sr 90 which is said to be the most important radionuclide in the ground disposal of radioactive wastes. Eighteen out of some 26 factors in the three ecological paths through which leaked radionuclides migrate (i.e., drinking water, sea foods and plants) were quantitatively examined by sensitivity analysis. The depth to the water table is 2 m. Porosity of the strata is 40 % (sandy loam), and the density of the soil is 2.65 g/cm³. The horizontal flow rate of ground water in a saturated zone was assumed to be 10 cm/day as was the vertical infiltration rate of rain water in an aerated zone. The relationships between the internal dose and the many factors concerned are shown in the tables. The difference between strict calculation and approximation of internal dose is also examined. The approximation is shown to be useful especially for the quick estimation of the safety of a site for the ground disposal of radioactive wastes. (auth), 2) (CST)

Depth to Water Table; Total Porosity; Density; Horizontal Flow Rate; Saturated; Infiltration Rate

<068>

Kyoto University, Department of Sanitary Engineering, Kyoto, Japan

Inoue, Y., S. Horisawa, and A. (Translator) Bach. 1976. OSHL-tr-0020; 11 pp.; Nippon Genshiryoku Gakkaishi, 10(5), 304-312.

Land Requirement for a Radioactive Waste Disposal Yard (4)

A model and the rationale were presented with

<060> COST.

respect to land use requirements for a hypothetical waste burial site. The thrust of the study was to minimize the intake by humans, of radionuclides through the food and air. A two-source transportation diffusion equation was used to describe the migration of the radionuclides in ground water. The numerical solution was obtained by solving the equation was used to describe the migration of the radionuclides in ground water. The numerical solution was obtained by solving the equation by Crank-Nicolson type differential approximation and successive over relaxation. A sample run was made for a power plant with a total output of 2000 Mw. Numerous environmental land requirements and socio-political factors were considered. With this model it is possible to locate a burial site which ensures the greatest radiological safety. To locate burial site it is necessary to include a zone where ground water use is prohibited; a zone where use is restricted and a buffer zone. The necessary land area will increase with increasing permeability coefficient, decreasing distribution factor and increasing stratum porosity. Variations in the diffusion coefficient do not change the land requirement greatly. (1977)

A numerical-computer model is presented with use of computer graphics. (EITC/707)

<069>

Kyoto University, Department of Sanitary Engineering, Kyoto, Japan

Inoue, Y., S. Morisawa, and A. (Translator) Bach. 1976. OBNL-tr-0087; 11 pp.; Nippon Genshiryoku Gakkai Shi, 10(6), 44-50.

Migration of Radionuclides in a Model Saturated Zone. 2. Comparison of Strontium 90 Distribution between Predicted and Observed (8)

Techniques for predicting the migration of Sr 90 in a model stratum are derived. The first technique is the numerical solution of a transportation-diffusion equation describing the transportation phenomena of Sr 90 in the stratum. The second one is a time-transformation technique which predicts a Sr 90 distribution in the stratum based on the distribution of a tritiated water. The model is built on the equation of migration of radionuclides in saturated zones. This is then, coupled with the Laplace equation for flow velocity. The solution is arrived at by using a Crank-Nicolson type differentiation and a successive overrelaxation method. Results, described at discrete time intervals, and indicated that the tracer at 45 cm in the model stratum reached a level of 1.4×10^{-11} after 8.5 days. The experimental results show the first technique has difficulties predicting a Sr 90. This may be minimized by considering local disturbances in the stratum. Results using the tracer were agreeable to the observed distribution and it took only about 1/10 of the time required for the actual distribution of strontium in the stratum. (1977)

Hydraulic Velocity

<073>

Kyoto University, Department of Sanitary Engineering, Kyoto, Japan; Central Research Institute of Electric Power Industry

Inoue, Y., S. Morisawa, and A. (Translator) Bach. 1976. OBNL-tr-0088; 10 pp.; Nippon Genshiryoku Gakkai Shi, 10(6), 54-59.

Radionuclide Migration in Saturated Zones. 2. Migration Characteristics of Strontium 90 Leached Out from Cemented Solid (2)

The effects on the saturated zone of the migration of strontium 90 solidified in portland cement was studied. Coarse sand was used in the experimental apparatus and the average porosity was 42%. The sand was principally silica and had a cation exchange capacity of 9.40 meq/g. For a 90.5 cm layer the saturation coefficient was 0.12 cm/sec. The cement contained 5 mCi of Sr 90 and 5 mCi of H 3. The Ca + Mg and pH changes indicated the leaching effect of the cement, both increased. The pH would be the factor to use as a preceding indicator for predicting the migration of Sr 90. Results also showed that H 3 leached from the solid rather rapidly. Sr 90 cannot be used as a precursor indicator of Sr 90 migration, when it is contained in cements, because very little Sr 90 migrates into the soil. Sr 90 can be used if a radioactive substance leached into the ground. The saturation of the soil stratum reached an equilibrium value that depended on the horizontal water supply. It occurred soon after the beginning of the experiment. The value increased with depth and then became constant at a given depth. For this experiment the value was 50 cm. Sr 90 was believed to reflect the movement of ground water and was not even at a given cross-section. It was greatest under the solid. (1977)

Cation Exchange Capacity; pH; Migration Rate; Effective Porosity; Grain Size Distribution

<071>

Kyoto University, Division of Waste Disposal, Kyoto, Japan

Tsutsui, T., I. Nishinaki, and A. (Translator) Bach. 1975. OBNL-tr-0079; 12 pp.; Nippon Genshiryoku Gakkai Shi, 10, 79-86.

Safety Evaluation of the Ground Disposal of Radioactive Wastes. I. Influence of Ca²⁺ on the Distribution Coefficients of Radioactive Cations to Ion Exchangers (3)

The calcium ion influence on adsorption of radioactive cations was studied by experimentation. Three ion exchangers were used in place of clay minerals and they were Amberlite MB-3 mixed bed, Green Sand, and KUN Sand. The radionuclides were Na 22, Cs 137, Mn 56, Co 60, Zn 65, Sr 85 and Ba 133. Ion exchange capacities for Amberlite, Green Sand, and KUN (Kyoto University Reactor Experimental Station) Sand were 0.8, 0.15, 0.031 meq/g, respectively. The KUN Sand had the smallest grain size. Calcification was done on the ion exchangers before the experiments. When the calcium ion concentration was held constant the distribution coefficients for the radionuclides did not change. Upon varying the calcium ion concentration the distribution coefficients decreased logarithmically. From this determination an empirical equation was derived. Factors on the coefficients were

<671> CONT.

found to be: apparent number of electrical charges of the radioactive cations; hydrated ionic radius; and, the group and the type of exchange adsorbent. (BBT)

Ion Exchange Capacity; Distribution Coefficient;
Grain Size Distribution

<672>

Kyoto University, Faculty of Engineering, Kyoto, Japan

Inoue, Y., S. Horisawa, Y. Sahara, and A. (Translator) Bach. 1975. OBNL-tr-0042; 15 pp.; Nippon Genshiryoku Gakkai Shi, 17(7), 376-386.

Radionuclide Migration in Aerated Zones. 1. Migration Characteristics of Nuclides Contained in Percolating Water. (2)

An experiment was run to study the effects an aerated zone has on radionuclide migration. The radionuclides used were Sr 90 (2.2×10^{-3} $\mu\text{Ci}/\text{ml}$), Co 60 (1.6×10^{-3} $\mu\text{Ci}/\text{ml}$) and Hg (1.0×10^{-3} $\mu\text{Ci}/\text{ml}$). This solution was run through a model stratum made of coarse sand 130 cm high. The ion exchange capacity was 9.88 meq/g and the porosity was 81.7%. The coefficient of saturation was 1.1×10^{-2} cm^3/sec . Initially when the percolating solution came in contact with stratum the Ca + Mg concentration increased. However, as the experiment continued the concentration decreased and it was noted at successive depths. There was a direct relationship between the Ca + Mg concentration and migration velocity of the nuclides. The diffusion coefficient was 0.92 cm² or better if the saturation was constant or increased. By using Y 90, Sr 90 and Co 60 it can be monitored. Aerated zones slowed down the Co 60 and Sr 90 to 1/30 and 1/55, respectively of the water velocity in the stratum. Using time conversion factors the probable damage done by the radionuclides can be deduced. (BBT)

Ion Exchange Capacity; Effective Porosity; Grain Size Distribution; Storage Coefficient; Distribution Coefficient; Dispersion Coefficient

<673>

Kyoto University, Kyoto, Japan

Inoue, Y., S. Horisawa, and A. (Translator) Bach. 1976. OBNL-tr-0040; 13 pp.; Nippon Genshiryoku Gakkai Shi, 18(5), 42-50.

Migration of Radionuclides in a Model Saturated Zone. 1. Experiments and Discussion. (3)

Leaching of radionuclides from solidified wastes and their migrating characteristics were tested using a sand layer model. The radionuclides solidified in Portland cement were Sr 90, Cs 137, Co 60, Zn 65, Na 50, Fe 59, and Ag 110m. The sand layer was 50 cm thick, had a porosity of 35.6%, and was essentially sand with no clay. The cation exchange coefficient was found to be 9.7 plus or minus 0.6 meq/g. Distribution coefficients for each of the radionuclides were: Sr 90, 8.9; Co 60, 25.8; Cs 137, 690.6; Na 50, 35.2; Zn 65, 30.0; Fe 59, 1.4; and Ag 110m, 15.7 ml/g. Of the seven radionuclides sealed in

the cement, Sr 90 was detected as having been leached from the matrix. Stratum was leached in great amounts initially but as the experiment continued it was noted that the Sr 90 concentration decreased downstream. This indicated that the sand had the ability to sorb some of the radionuclide. Most of the Sr 90 was leached from the cement after 600 to 500 days and the concentration was considered in a steady state. Just prior the detection of Sr 90 in the sand but fluctuations in pH, Ca⁺⁺, and H⁺ alkalinity were noted, particularly in the pH. It was generally possible to forecast the time required for Sr 90 to reach the end of the bed by using the distribution factor value and a factor in an equation presented. Na 50 and Fe 59 were also controlled by internal diffusion and the dissolution of the cement, while Zn 65 and Ag 110m were controlled by dissolution of the cement. The former was considered to be a Sr 90 pattern and the latter a Co 60 pattern. (BBT)

Cation Exchange Capacity; Distribution Coefficient; Effective Porosity; pH; Dispersion Coefficient; Grain Size Distribution

<674>

Kyoto University, Kyoto, Japan

Iwai, S., T. Goto, and Y. Inoue. 1960. Disposal of Radioactive Wastes, Proceedings of a Conference held in Monaco, November 16-21, 1959, (pp. 435-444).

A Fundamental Study on the Infiltration Characteristics of Radioactive Liquid Wastes. (2)

The behavior of various radioactive substances in a waste liquid flowing through porous media is considered theoretically and experimentally. The theoretical analysis takes into account only one dissolved substance in the waste liquid, one-dimensional downward flow, and flow through a homogeneous, unsaturated porous soil media. Two fundamental laws are used to derive the new theory; they are Horton's Law of infiltration and Langmuir's theory on monomolecular adsorption. The equations representing the above laws are solved using differential equation techniques, and the mathematical presentation is detailed. Two experimental runs were made, one using a sand with 82.9% porosity and moisture content of 3.21%. The second run media was a surface soil with porosity of 40.8% and moisture content of 46.4%. Qualitatively the experimental and theoretical results coincide well, both are S-shaped. Quantitatively the mutual correspondence is uncertain due inability to determine a constant which controls adsorption behavior. (BBT)

Effective Porosity

<675>

Kyoto University, Kyoto, Japan

Aoyama, I., N. Yamamoto, and Y. Inoue. 1976, November. Health Physics, 31(5), 479.

A Hazard Assessment of the Deep Sea Disposal of Radioactive Wastes. (3)

A model was designed to assess the hazard of

<875> CON*

deep sea disposal of low level radioactive solid wastes which originate from nuclear power reactors in Japan. Emphasis was included in the model as a newly considered mechanism. From estimated maximum and average concentrations of radioactivity in the upper mixed layer, the various individual dose and population dose for the Japanese people were calculated. A sensitivity analysis was performed to determine the uncertainty of the parameters and consideration was given to which parameter had most important effect on the average concentration of radionuclides in the upper mixed layer; and how does environmental fluctuation affect the concentration. (JUV)

<876>

Ministry of Public Health and Environmental Protection, Leidschendam, Netherlands

Corneilis, J. Ch. 1976. Nuclear Inter. Jura 75 Congress, Aix-en-Provence, France, September 29, 1975, (5 pp.).

Legal and Administrative Problems Related to the Treatment and Disposal of Radioactive Wastes (8)

As a result of the increase of radioactive waste some legal and administrative problems have arisen. Some of these problems are international in scope. Disposal of radwastes, particularly final disposal, means placing it in a natural or engineered (facility) with no further action taking place other than monitoring. If burial is in the ocean or in deep geologic strata such as rock-salt deposits the problem becomes international because the country producing the radwastes may or may not be where burial takes place. Also, if shallow land burial is done it may contaminate groundwater that flows into another country. Regulatory measures for final disposal should then include the following steps: 1) assemble all wastes in a central location; 2) reduce the volume of wastes; 3) condition the wastes; 4) intermediate storage; and 5) final disposal should separate the radioactive waste from the environment for many centuries to come. A permanent organization such as the federal government would be best suited to overseeing the above measures. The alternative to federal regulation is to have the nuclear installations take care of disposal. However due to human nature detailed rigid laws may have to be enacted to protect the environment. Field laws are unwanted because they may thwart the use of newer technologies. The federal system is also tormented with rigidity due to red tape. A well-considered choice must be made. Finally with the growth of the nuclear industry it may be unwise to have a financial liability system when responsibility cannot be proven in the case of wastes being processed by some other agency other than the producer. (UDV)

<877>

Moscow, USSR

Burenkov, B. N., and A. A. Khonikovich. 1973, September. NS-160-70; 7 pp.; Gijana i Semiotiya, 39(9), 55-57.

Feasibility Study of Underground Storage of Bitumen Blocks Containing Radioactive Wastes (1)

The degree of danger from storage of bitumen blocks buried in soil with a high water table is evaluated. In the area of interest, the sand and clay formations are the result of marine, lake-glacial, and glacial deposition. The soil and vegetation layer is up to 0.2 m and the layer below is a marine medium granular sand, 0.7 to 2.6 m thick. Under the sand layer are clays at the 1.2 to 4.0 m level. Ground water was found to occur from 1.2 to 5 m in depth. Of the three bitumen blocks, two were placed in the saturated zone and the other in the aerated zone. The blocks were 25 to 30 liters in volume and contained beta activity of 5×10^4 (E-5), Sr 90 of 2×10^4 (E-5), and Cs 137 of 2×10^4 (E-6) Ci/kg for the first block and 6×10^4 (E-5), 3×10^4 (E-5), and 4×10^4 (E-6) Ci/kg, respectively for blocks 2 and 3. On the last two blocks a 2 to 4 mm layer of pure bitumen was put on the outside. After six months of burial, the concentration of Sr 90 and Cs 137 did not exceed the average annual allowable concentration established for drinking water. The highest concentrations came from block 1, which did not have the bitumen coating. Calculations were done to estimate travel time of the isotopes. For Sr 90 it would take 280 years to travel 1 km and Cs 137 would take 860 years. During the respective travel times, Cs 137 would decay by a factor of 1.6×10^4 (E-7) and Sr 90 by a factor of 10^4 (E-7). Using the rainfall of 170 cm/year an estimate of contamination of ground water and dilution were made. It was found that the granular sand would allow contamination to leak and Sr 90 would be increased by a factor of 22. From these experiments the researchers felt that burial of treated bitumen blocks is acceptable. (BTV)

Depth to Water Table; Stratigraphic Unit Thickness; Mean Precipitation

<878>

National Institute of Radiological Sciences, Department of Environmental Contamination, Anagawa, Chiba-shi, Japan

Ijino, H., P. Picot, A. Saas, and A. Graubly. 1971, June. Health Physics, 20(6), 665-672.

Determination of the Diffusion Coefficients of Radionuclides in the Rhone Sediments (2)

Transfer phenomena of Co 60, Co 60, Cs 137, Mn 54, Sr 85, and Zn 65 in Rhone sediments were studied. Data obtained indicate that the transfer of various radionuclides in the environment investigated followed Fick's second law of diffusion. The diffusion coefficients of Sr 85 and Mn 54 were determined as 2.1×10^{-12} (E-2) sq cm/day and 1.1×10^{-12} (E-2) sq cm/day respectively. The diffusion coefficients for Co 60, Co 60, Cs 137 and Zn 65 were not determined due to their fixation near the sediment bed surface. Stable elements were analyzed for by spectrophotometric methods and by neutron activation analyses. Diffusion coefficients were shown to be a function of the chemical composition of the sediments. (Auth)(JT)

Experimental techniques and procedures are adequately described. Applicability to general diffusion model with respect to shallow land burial questionable. (DR/JT)

Dispersion Coefficient

<876>

National Nuclear Energy Commission, Rio de Janeiro, Brazil

Barrett, P. L. C. 1975. COSY-730913a; COSY-730913b; Panel held in Washington D.C., September 6-7, 1975, (pp. 124-150), 173 pp. (COSY-730913a, STI/OSDS/341).

Radon 222 Emanation Characteristics of Rocks and Minerals (1)

The activity, emanation rate and percentage of radon 222 escape were investigated for a variety of rocks and minerals using alpha scintillation counting techniques. Rocks show a wide range of leakage with values ranging from 1 to 20% and an activity of 2 to 80 x 10¹² (Bq) per kg under identical laboratory conditions. The strongest emanations were found among granite rocks and conglomerate whereas basic and calcareous rocks showed the lowest values. Accessory minerals, although rich in uranium, show very low radon emanation, i.e. less than 1 to 2%. The lack of dependence of emanation on parent uranium concentrations was clearly established. Also a positive correlation was observed between weathering and radon escape and between natural alpha dose and emanation. High-temperature experiments (up to 1200 degree C) on minerals demonstrated a progressive decrease in the percentage of radon loss. This phenomenon appears to be the result of annealing on natural radiation damage. As expected, an increasing radon loss with decreasing particle size was observed. The temperature dependence of radon emanation in the range of -80 degree C to +250 degree C was investigated and showed a strong absorption for temperature below -20 degree C. The use of some of the low emanations as good natural shielding materials i.e. tailings piles, is discussed. (Auth) (LS)

A good paper with interesting conclusions e.g. the best natural shielding for low-level radioactive waste would be limestone, etc. An interesting discussion follows the paper. (DS/LS)

<880>

National Radiological Protection Board, Harwell, Didcot, Oxfordshire, England

Webb, G.A.N., and P.D. Greenwood. 1976, December. 1977-1978; 19 pp.

A Revised Oceanographic Model to Calculate the Limiting Capacity of the Ocean to Accept Radioactive Waste (3)

A model was constructed for calculating the limiting capacity of the ocean. Sedimentation and sorption are taken into account as well as surface and deep circulation. Sorption of radionuclides depends on the particle size and the chemical interaction between the sediments and the radionuclides. Activity is principally incorporated into the sediments by the scavenging action of particles during sedimentation. Depth of penetration of the activity is determined by: sediment movement due to water currents, burial of sediments due to further sedimentation, sediment mixing due to biological activity within the sediments, diffusion of activity within the sediment profile and interstitial water movement with the sediments. The distribution coefficients for ocean bed and coastal sediments range from 5 x 10¹¹ to 1 x 10¹⁶. The short term

model is designed to handle surface water concentration from low-level radionuclides disposed on the ocean floor. It evaluates transfer and dilution of activity in the vicinity of the disposal area. The long-term model calculates widespread concentrations by considering the water mass exchange between the basins in the North Atlantic system. Again transport and dilution of activity is evaluated. Examples in the discussion show the usefulness of the model. (DSW)

Distribution Coefficient

<881>

Nova Scotia Department of Mines, Halifax, Nova Scotia, Canada

Pinler, G.F., and J.D. Brodehooft. 1976. October. Water Resources Research, 12(5), 1069-1093.

Application of Digital Computer for Aquifer Evaluation (4)

The unsteady-state flow of a fluid in a confined aquifer can be approximated by linear, parabolic partial differential equations. A digital-computer program was written to solve these equations based upon an implicit finite-difference technique. Calculated values compared favorably with analytical solutions for homogeneous isotropic aquifers of simple geometry. (Auth)

One of the first articles on the modern computer simulation application to groundwater flow and aquifer evaluation. Equations are still valid, but modern practice uses slightly altered forms. (DS/DOO)

<882>

Nuclear Research Center, Prague, Czechoslovakia; Czech Power Enterprises, Prague, Czechoslovakia

Dlouhy, I., and J. Harek. 1976. Nuclear Power Project Planning and Implementation, Proceedings of the INEA Interregional Training Course held in Karlsruhe, Germany, September 6-November 30, 1976, (21 pp.).

Management of Radioactive Waste from nuclear Power Plants (3)

A review of the sources of radioactive wastes in the nuclear power industry is discussed briefly and approaches to radioactive waste storage used by the Czechoslovakian nuclear industry are presented. Since Czechoslovakia is a densely populated inland country it must either store its nuclear wastes in surface storage facilities or in abandoned geotechnical objects. A storage site must meet the following criteria: 1) volume of a storage facility should correspond to waste amounts expected to be produced by the generating facility; 2) radiation safety for the operating personnel and the relations between the control system for nuclear and broader environment; 3) storage methods should correspond with the type of wastes placed in the facility; 4) storage facility must be economical as well as safe for the environment and man. Siting criteria estimates are: 1) technical feasibility of construction and operation of the facility; 2) protection of the environment; 3) social importance of other

<002> 1097.

interests to exploiting the territory; an economy of the construction and operation. In selecting a site two criteria stages are used. The first is related to geology and hydrology of the area and the second is related to the convenience of the site. Sites meeting the criteria have been found and at present 4 to 5 regional storage places should secure radioactive waste from Czechoslovakian nuclear power program at least up to 2020. (SDV)

<007>

Ontario Hydro, Toronto, Ontario, Canada

Carter, T.J., and G.A. Bentzen. 1976. COSP-76020; Waste Management, Proceedings of a Symposium held in Tucson, Arizona, October 3-6, 1976, (95 pp.) (COSP-76020).

Ontario Hydro Waste Storage Concepts and Facilities (W)

Waste storage concepts and facilities at Ontario Hydro are outlined. To handle the low and medium-level wastes produced by their heavy water reactors a Radioactive Waste Operations Site (RWOS) was established within the Bruce Nuclear Power Development on Lake Huron. The site includes a 19 acre Storage Site and a Radioactive Waste Volume Reduction Facility (RWVRF) consisting of a radioactive incinerator and waste compactor. At present only 4.5 acres of the site has been developed and will be adequate until 1980. The Atomic Energy Control Board (AECB) regulates and licenses waste management operations and Ontario Hydro has established criteria to meet the AECB requirements. These requirements are: storage facilities are to be located in a low seismic area away from population centers and drinking water supplies; radiation dose to members of the public are to be 1% of the ICSP dose limits; two "control envelopes" are required for storage facilities and the waste package is not a barrier; all wastes are to be stored retrievably; no liquids are to be stored in this facility; and all surface and subsurface drainage is to be controlled and monitored. The RWOS is underlain by bedrock of interbedded silty to sandy dolomites and sandstones that have a permeability of $10(2-3)$ to $10(4-6)$ cm/sec. Overlying the bedrock is a few feet of granular, very dense soil which is overlain by very dense gray glacial till some 10 ft thick. The permeability of the till is $10(2-6)$ to $10(4-7)$ cm/sec. A brown, compact till containing gravel and cobbles overlies the gray till and averages 5 ft thick. A 1 ft layer of top soil rests on the brown till. The water table is 25 ft below the site. The dual envelope for the in-ground facilities are reinforced concrete structures. For above-ground facilities two independent structural concrete barriers are used. Surface drainage, leakage detection, and radiological aspects are covered. The facilities are also described in detail. At present, the cost of waste storage is 0.1 mills/kWh and only tritium escape has been a problem. (SDV)

Stratigraphic Unit Thickness; Permeability Coefficient; Depth to Water Table

<009>

Österreichische Verbundgesellschaft, Vienna, Austria; Österreichische Studiengesellschaft für Atomenergie, Vienna, Austria

Oszuszy, P.J.P., and E. Schlosser. 1970. COSP-700905; IAEA-SR-137/52; STI/PB/264; Developments in the Management of Low- and Intermediate-Level Radioactive Wastes, Proceedings of a Symposium held in Aix-en-Provence, France, September 7-11, 1970, (pp. 213-224) (COSP-700905, IAEA-SR-137/52, STI/PB/264).

Future Management of Radioactive Wastes in Austria (0)

At present the only radioactive waste producers in Austria consist of a nuclear research center, a few small research reactors, some laboratories and some uses in industry and medicine. Erection of a 600 MW(e) nuclear power reactor is contemplated in the near future and planning for future radioactive waste management is described. It appears that current thinking does not include shallow land burial as an option. Underground storage of low- and intermediate-level wastes in caves and mines is the only type of storage mentioned. (KAD)

Discusses future management of Austrian nuclear wastes. No use of shallow land burial is discussed in any detail. (DM/KAD)

<005>

Radiation Center of Osaka Prefecture, Sakai, Osaka, Japan

Negami, K., and T. Kamuro. 1977, February. Journal of Geophysical Research, 82(2), 351-356.

Concentration of Uranium Series Nuclides in Soil Particles in Relation to their Size (1)

Samples of soil originating from the weathering of granitic rock were collected in 8 horizons of Muraho and of Mount Rokko, and then they were separated according to particle size. The concentrations of the uranium series nuclides ^{238}U , ^{234}Th , ^{234}Pa , ^{234}mPa , and ^{238}Pu in each separated fraction were determined by gamma ray spectrometry with Ge(Li) detectors. The activity ratios of all of the measured radionuclides were larger than unity in all fractions. The activity ratio of ^{234}Th and ^{234}mPa was unexpectedly high, reaching 4-5. In the particle size range below 0.15 μ the concentrations of these uranium series nuclides were found to increase with increasing particle size. Such a trend was also found for the elements Fe , Mn , Zn , and Cu . The elements K and Cs , however, were found to have a direct correlation with particle size. (Auth)(JW)

<006>

Radiation Center of Osaka Prefecture, Sakai, Osaka, Japan

Negami, K., and T. Kamuro. 1970, August 30. Journal of Geophysical Research, 75(23), 3157-3160.

Fractionation and Exhalation of Radon and Thoron Gases from Soil Particles (2)

<486> CONT.

Samples of soil originating from the weathering of granite rock were collected in Mt. Pokko and Mt. Ikoma and sieved into eight classes of particle size. Each sieved sample was measured for its content of Ra 226 (parent nuclide of radon), Ra 228 (parent nuclide of thoron), Ac 228 (grandparent nuclide of Ra 226), K, Ca, and Fe as well as for the radon and thoron emanation from it. There was a trend for the contents of Ra 226 and Ra 228 to increase as particle size decreased. On the other hand, the K content showed a different variation with particle size from the variations found for Ra 226 and Ra 228. The size distributions for the soil samples were found to be 1.5% to 36.3% mass fraction for the Pokko sample and 2.6% to 36.0% mass fraction for the Ikoma sample. The radon emanation rate was found to be 2.7×10^{10} (E-8) C/s (E-1) g(E-1), and the radon emanating power to be around 25%. The exhalation rates ranged from 4.4 ± 0.2 or 4.1 ± 0.2 for the Pokko sample and 1.7 ± 0.2 to 4.8 ± 0.5 for the Ikoma sample. The diffusion coefficient was calculated to be 0.1 to 0.2 sq cm. On the basis of the results of the emanation measurements, it was concluded that smaller soil particles take relatively more contribution to radon and thoron exhalations from the ground surface than larger soil particles, but they take absolutely less because of their smaller abundance. (Auth) (CSM)

Interesting paper with useful data on the emanation coefficient for radon. (DM/LS)

Emanation Rate; Grain Size Distribution; Exhalation Rate; Dispersion Coefficient

<487>

Reactor Centrum Sederland, Petten, Netherlands

Smeets, L., and B. Verkerk. 1966. CONF-651202; IAEA-SN-71/10; Practices in the Treatment of Low- and Intermediate-Level Radioactive Wastes, Proceedings of a Symposium held in Vienna, Austria, December 6-10, 1965, (pp. 31-41) (CONF-651202, IAEA-SN-71/10).

Low-Level Waste Treatment at Reactor Centrum Sederland (4)

The waste-treatment facilities on the site of RCN, Petten, were designed to serve a number of radiochemistry laboratories, where work on a millicurie level was foreseen. The facilities have been in operation for about five years at an increasing level, but still have a large over-capacity for low-level liquids. This will be taken up on a large scale next year when an isotope production facility will come into use. In the low-level liquid waste from this facility an amount of organic liquids will be present that may cause difficulties in treatment. Liquid wastes are first stored in a number of 50, 100 and 200 cu m ponds, analyzed for total alpha and beta activity and, if necessary, treated in a flocculation plant, also equipped with a sand filter and an ion-exchange column. Sludges are concentrated by freezing and thawing. Final sludges contain about 25-30% solids. Effluents are again analyzed and disposed of in the North Sea through a 4-km long vulcanite pipeline. Our license allows for a discharge of 15 uCi/d of unspecified activity including alpha-emitters at a maximum concentration of 2×10^{-6} uCi/ml. Design data of the semi-continuous flocculation plant

are given and operational experience on a few different types of wastes, including liquids mixed with laundry effluent, are presented. A brief description is also given of the procedures for treating low-level solids where baling techniques are applied that result in five to ten-fold volume reduction. Operational experience of the Government-RCN waste-collecting service is also given. (Auth)

Describes waste treatment facilities. (DM/GH)

<488>

State Commission on the Use of Atomic Energy, Moscow, USSR

Spitzyn, V.L., E.E. Pimenov, V.D. Balakova, A.S. Leontichuk, I.V. Khorin, F.P. Yudin, and S.A. Sakov. 1966. ORNL-tr-4390; IAEA-CN-36; Nuclear Power and Its Fuel Cycle, Proceedings of an International Conference held in Salzburg, Austria, May 2-13, 1977, (20 pp.) (ORNL-tr-4390, IAEA-CN-36).

Basic Prerequisites and the Practice of Using Deep Water Tables for Burying Liquid Radioactive Wastes (3)

In the USSR one of the major methods for disposing of liquid low-, intermediate-, and high-level radioactive wastes is by injecting them into deep water tables. The factors considered in searching for a disposal site are discussed along with disposal criteria. Water tables of large artesian basins of the platform type which lie in a standing regime zone and contain highly mineralized waters are most suitable. Positive and negative factors that characterize the method are analyzed. Possible emergency situations with subterranean burial are evaluated. The following topics are discussed in general terms: the procedures and methods of the geological survey, hydrodynamic, geophysical, physico-chemical and sanitary-radiation investigations; methods of calculating and predicting the movement of wastes underground; methods of preparing wastes for burial and chemical methods of restoring the suitability of wells; design characteristics and conditions of preparing wells for use; methods of estimating heating and processes of radiolysis for a medium containing highly radioactive wastes; and methods of operational and remote control of the burial process and the condition of the ambient medium, etc. are briefly examined. (JTE)

<489>

United Arab Republic Atomic Energy Establishment, Radiation Protection Department

Mahmoud, K.A., Y.A. Yousef, H. El-Beedy, and A. Chafik. 1966. CONF-651202; IAEA-SN-71; Practices in the Treatment of Low- and Intermediate-Level Radioactive Wastes, Proceedings of a Symposium held in Vienna, Austria, December 6-10, 1965, (pp. 411-417), 988 pp. (CONF-651202, IAEA-SN-71).

United Arab Republic Program for Management and Treatment of Low- and Intermediate-Level Radioactive Wastes (1)

The existing U.A.R. program for management of low and intermediate radioactive waste is described. The volume of solid waste produced

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averages 10 cubic meters/yr. The average volume of liquid waste is 125 cubic meters/yr with a concentration range of 0-8 mCi/ml. The waste treatment plant was designed for a maximum flow capacity of 500 liters/hr. The Yashas site, which was selected as the burial site, is covered with sand and gravel formations to a depth of 10-20 meters, and has a permeability rate of 0.09 to 0.10 m/min. Depth to the water table is 12-12.5 m. The horizontal flow rate is 2-4 cm/d in an east to northeast direction. Estimates indicate retention of radionuclides within 1 km of disposal site for 70 years. (P70)

Permeability Coefficient; Depth to Water Table;
Horizontal Flow Rate

<491>

United Arab Republic Atomic Energy Establishment,
Cairo, United Arab Republic

Nitry, E., A. Gaud, S. Enara, and M.V. Farah. 1965. COSP-651202; IAEA-SR-71/63(C1); Practices in the Treatment of Low-and Intermediate-Level Radioactive Wastes, Proceedings of a Symposium held in Vienna, Austria, December 6-10, 1965, (pp. 921-930), 908 pp. (COSP-651202, IAEA-SR-71/63(C1)).

Further Studies on the Uptake of Long-Lived Fission Products on Some Clays from the United Arab Republic with a View to Potential Ground Disposal (1)

Finely powdered clays from the Ismailia Canal and the El Bassatine District were used to test uptake of Sr 90 under various conditions. It was determined that a contact time of 1-1 1/2 minutes for Sr with the Nile Clay resulted in equilibrium. Tests on effects of pH showed a typical absorption curve for Sr 90 on both Bassatine and Nile samples up to a pH value of 8. Absorption increased to about 90% with a pH of 12. Uptake of Sr 90 on the clays was studied in the concentration range from 10(E-6) to 2.0 M. The results showed a decrease in percentage uptake from about 70% to 25% with the Nile clay, and from 80% to 30% with Bassatine Clay. The process was said to be based on the Freundlich isotherm. Results of studies on the effects of competing ions indicate that with a high concentration of competing ions (10,000 ppm) the higher the valency of the cation, the higher will be its competing effect on the sorption of Sr on the clay. With identical valencies, the smaller the ion radius, the more pronounced will be its effect of reducing the degree Sr sorption. Tests on effects of temperature showed that with the Nile Clay uptake of Sr 90 is about 65% up to a temperature of 300 degrees C after which there is a marked decrease to 600 degrees C. A well defined increase was recorded at 700 degrees C which was not exhibited by the Bassatine clay. On the contrary, a steady decrease in Sr sorption was observed with Bassatine clay at temperatures greater than 400 degrees C. For Bassatine clay heated to 900 degrees C the montmorillonite fraction was destroyed and the kaolinite fraction was damaged. (JTE)

pH; Distribution Coefficient

<491>

United Kingdom Atomic Energy Authority, Harwell,
England

Burns, R.W., and E. Gluckauf. 1950. A/COSP.15/P-300; Peaceful Uses of Atomic Energy, Proceedings of the 2nd United Nations International Conference held in Geneva, Switzerland, September 8-13, 1950, Vol. 10. (pp. 150-163) (A/COSP.15/P-300).

Development of a Self-Contained Scheme for Low-Activity Wastes (2)

The problem of storing large quantities of low-level wastes is considered. Ideally the two final components should be pure water and solid radwaste. However, to get pure water, evaporation must be used and this is a very expensive process. So, a multi-staged precipitation process is discussed. Prior to precipitation, filtration is used. It was found by earlier experiments that the higher the pH the greater efficiency of removal of alpha and beta-emitters (alpha: 98.5%, 89.0%; beta: 75%, 70% for pH: 9.5 and 8.0, respectively). However, the pH was restricted to 9.5 or less so the waste could be discharged into rivers and the total dissolved solids would not be unacceptable. The best precipitator was found to be a calcium-iron-phosphate process in the sludge-blanket filters. The water to be treated is run through the sludge-blanket clarifiers and the sludge is removed at the bottom of the tank and frozen to better consolidate it. The mechanisms for this construction are electrolytes which cause coagulation. The sludge filters and settles well after the treatment. After flocculation, the water is run through an ion exchange process to remove the remaining Cs+1 and Sr+2. The decontamination factor using vermiculite is $5 \times 10(E+3)$ to $10(E+4)$ and the exchange capacity is 0.55-0.75 eq/kg. Electrolytic Fe-ionization and fixation of activity in solid form also included in the discussion. The cost for using a precipitation and controlled disposal scheme is 121.25 Pounds Sterling/ 100,000 gallons of effluent. For precipitation and vermiculite columns is 117 and precipitation and electro-Fe-ionization is 104.1. (SDV)

Cation Exchange Capacity; pH

<492>

United Kingdom Atomic Energy Authority,
Production Group, Windscale and Calder Works,
Cumbria, United Kingdom

Howells, R. 1967. COSP-670512; STI/PUB/156; Disposal of Radioactive Wastes into the Ground, Proceedings of a Joint IAEA/ENEA Symposium held in Vienna, Austria, May 29-June 2, 1967, (pp. 3-16), 666 pp. (COSP-670512, STI/PUB/156).

Trench Disposal of Solid Radioactive Waste from the Windscale and Calder Works of the UKAEA (2)

Trench disposal of low-level radioactive wastes is routinely practiced at the Windscale and Calder Works. Low-level radioactive waste is defined as that waste that arises in controlled areas and has not been in direct contact with processed material. Low-level waste is further defined as 1) having a beta/gamma surface dose rate of less than 750 mrem per hour and 2) having a alpha surface contamination of less than $5 \times 10(E-3)$ uCi per sq cm. Of the 6,000 cubic yards of low-level

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waste generated annually, 70% is paper. Of the total volume disposed of, 40% is contaminated with fission products, 35% is contaminated with plutonium and 5% is contaminated with uranium. Low-level wastes are collected, bagged, labeled and transported in containers designed for dumping operations. These containers are taken to the burial site and emptied into a trench. The trenches are 700 yards long, between 20 to 30 yards wide and 5 to 5 yards deep. It is estimated that these trenches have an average life span of 15-20 years. As dumping proceeds, the waste material is covered with earth. When the waste elevation reaches the top of the trench, earth is mounded over the trench to a depth of three feet. The covers are designed to promote rapid drainage. Drainage water is analyzed on a weekly basis. (Auth)(JT)

A general review of waste classification, waste handling techniques, and cinder blocks. No significant data presented. (DN/JT)

<49>

United Kingdom Atomic Energy Research Establishment, Harwell, England

Smith, A.J. 1969, May. NERE-W-2223; 11 pp.

Leaching of Radioactive Sludges Incorporated in Cement and Bitumen (2)

Cement and bitumen are considered as two solidification media for the final treatment of Harwell sludge, ion exchange resins, incinerator ash, and other radioactive contaminated liquids. The major purposes of the solidification are to minimize contamination risk during storage and transportation and to minimize the elution of radioactivity into groundwater or seawater following land burial or sea disposal. Strength and leaching tests were performed on four inch cubes of cement and bitumen which were cured for twenty-eight days. Tested waste formulations and leaching rates expressed in grams per square centimeter per day are presented in tabular form. Leachants utilized included desalinated water, tap water, and seawater. (JC)

Extensive waste formulation and leaching data are presented in tabular form. Although radionuclides and valence states were not differentiated. (DN/JC)

<49>

University of Alberta, Department of Geology, Edmonton, Alberta, Canada

Schwartz, F.W. 1975. Journal of Hydrology, 27, 51-71.

On Radioactive Waste Management: An Analysis of the Parameters Controlling Subsurface Contaminant Transfer (1)

The problem of subsurface, radioactive-contaminant transfer is investigated theoretically through the development of a two-dimensional model which considers the simultaneous flow of water and mass. The method of characteristics is utilized to solve a mass-balance equation that

considers physical transport by radioactive decay and binary exchange. The study demonstrated the influence of the following parameters on the physical aspects of contaminant transport: hydraulic conductivity, site location within a recharge area and porous-medium dispersivity. With respect to the parameters controlling the chemical and nuclear processes, radioactive half-life, cation-exchange capacity, selectivity coefficient, ion charge and weathering rates play important roles in determining the pattern of contaminant dispersal. Geologic layering adds complexity to the patterns of dispersal because the controlling parameters vary within the flow region. The extent of the contaminant plume is fixed by the physical transport processes. The chemical and nuclear processes tend to reduce the size of the contaminated region to some fraction of that which is attributable to the physical processes alone. Because of the large number of variables that influence the dispersal of contaminants away from sites of emplacement, it is impossible to adequately approach the problem of site location and design utilizing empirical principles or established guidelines. The only satisfactory way of predicting patterns of contaminant migration is to incorporate field-determined parameters in a properly designed and calibrated mathematical model. Only in this way can the effects of all important processes be evaluated simultaneously. (JNT)

Very good discussion of transport and attenuation mechanisms along with derivation of the basic equation. (ES/C/JNT)

Cation Exchange Capacity; Selectivity Coefficient; pH; Erosion Rate; Hydraulic Conductivity

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University of Alberta, Edmonton, Alberta, Canada

Schwartz, F.W. 1977. Journal of Hydrology, 32, 257-277.

On Radioactive Waste Management: Model Analysis of a Proposed Site (2)

The application of a contaminant transport model to a hydrogeologic evaluation of a proposed low-level radioactive waste management site is demonstrated. The proposed site is at the Defence Research Establishment Suffield, Canada and solid low-level wastes with a half-life of less than 3,000 years would be stored there. The model is deterministic and incorporates cost of the physical, chemical and nuclear processes required for a good assessment of subsurface transport and attenuation of radioactive contaminants. Suffield is in an arid to semi-arid climate with temperatures fluctuating from less than -37 degree C to greater than 30 degree C. There is no permanent body of water and as a result of the hummock topography small ponds form after spring melts. All this suggests that the quantity of recharge to the groundwater system will be small and of short duration. Five units are recognized in the near-surface rock and they are: gray silt, upper till, middle sand, lower till, brown silt, and Cretaceous shale. Diffraction analysis of the drift samples showed illite to comprise up to 50% of the clay minerals with montmorillonite, kaolinite, and chlorite comprising the rest. The groundwater flow is predominantly downward at the site. Tests showed the valley is a

(095) COST.

significant discharge area and the mechanism is evapotranspiration because the water table is 3.6 m below the surface. There is a well-defined discharge gradient. The hydraulic conductivities are: gray silt, 1.6×10^{-6} (E-6); upper till, 5.6×10^{-5} (E-5); middle sand, 3.9×10^{-5} (E-5); lower till, 1.3×10^{-6} (E-6); brown silt, 1.0×10^{-6} (E-6); and Cretaceous shale, 7.0×10^{-8} (E-8) cm/s. The cation exchange capacity values are: upper till, 59.6; middle sand, 50.4; lower till, 52.0; brown silt, 93.4; and Cretaceous silt, 92.9 meq/100g. The model assumed that the groundwater flow is steady and the density does not change. This allows for the described velocity field to remain unchanged. To create a contaminant transport model from a mass transport model effective porosity, porous medium dispersivity, and cation exchange parameters are the major ones used. After 2,975 years, according to the model, the contaminants would spread over a small fraction of the entire system. As the rate of radioactive decay increased the apparent rate of contaminant migration would be reduced. The Defence Research Establishment Suffield is recommended as a storage facility. It is expected from the model studies that the subsurface environment would provide confinement and attenuate the concentration of radioactive contaminants. The model provides a consistent evaluation with the empirical studies of the site. (DDV)

Effective use of fence diagrams to show 3-space relationship of geologic and water tables was made. Computer graphics also used. (ESIC/DDV)

Cation Exchange Capacity; Effective Porosity; Stratigraphic Unit Thickness; Grain Size Distribution; Head; Depth to Water Table; Hydraulic Gradient; Hydraulic Conductivity; Hydraulic Velocity

(096)

University of Toronto, Department of Chemical Engineering and Applied Chemistry, Toronto, Ontario, Canada

Phillips, C.F., and B. Lin Pui. 1977. Water, Air, and Soil Pollution, 8, 165-163.

Environmental Impact of Radioactive Waste Management in the Nuclear Industry (7)

Radioactive wastes from the nuclear industry are classified into low, intermediate and high activity levels, and problems of their storage and release examined in detail. Current means of storage are considered with reference to processing of low and intermediate level liquid waste, processing of high level waste, processing of airborne waste, and ground disposal and processing of solid waste. Release is discussed in terms of effluent release limits, monitoring and the use of permanent records, impact of release to the human environment, impact of release to the material environment, and guides for preventing accidental release. Contamination of the shore of Lake Huron from radioactive fallout is discussed as a particular example. Problems to be solved are identified in three main areas: gaseous wastes, actinide-contaminated wastes, and permanent disposal, and some specific suggestions for study are made. (Auth)

Capacities and distribution coefficients for several radioactive ions on several kinds of

soils and minerals in water are given. (ESIC/CSN)

(097)

University of Waterloo, Department of Earth Sciences, Waterloo, Ontario, Canada

Cherry, J.A., G.E. Grisak, and R.E. Clister. 1973. CONF-730919 (vols. 1-2): Underground Waste Management and Artificial Recharge, J. Braunstein (Ed.), Proceedings of the 2nd International Symposium held in New Orleans, Louisiana, September 26-30, 1973, (pp. 436-467), 931 pp. (CONF-730919).

Hydrogeological Studies at a Subsurface Radioactive-Waste-Management Site in West-Central Canada (1)

Hydrogeological studies of the waste disposal site at the Whiteshell Nuclear Establishment in southeastern Manitoba, were conducted during a five year period. The area receives low-, medium-, and high-level wastes and small amounts of liquid waste. The wastes are buried below the ground surface at depths as great as 15 feet, and they are buried below the water table. Only low-level wastes are not protected by metal and/or concrete containers. The stratigraphy of the area consists of silt, clay, till, and sandy deposits which overlie the Precambrian bedrock. The silt and clay units were deposited in a glacial lake that occupied much of southern Manitoba during the last glaciation. The silt unit includes this laminated beds of fine sand, sandy silt, and clay. The clay unit is varved and includes numerous pebbles and clasts of till and silt. The glacial till below the lacustrine clay is a dense overconsolidated, pebbly, clay-loam till deposited as the result of a glacial advance. A layer of Precambrian cobbles and boulders is present at the base of the till. Between the till and Precambrian bedrock there is a sandy drift deposit referred to in this paper as the basal sand. It has an average transmissivity in the vicinity of the waste-management area of 290 gal/day/ft., and an average storage coefficient of 2.0×10^{-6} (E-6). A mass balance calculation using the assumption that 1/10 of the annual precipitation (16 to 26 inches) recharges the groundwater flow system in the eastern part of the area, suggests a bulk transmissivity of about 100 gal/day/ft. To obtain vertical-hydraulic-conductivity values from diffusivities for the till and clay, it was necessary to estimate the specific storage of the till and clay. This was done using laboratory data on void ratios, compression indices and liquid limits of the clay and till. The values obtained from this analysis are in the range of 1×10^{-8} (E-8) to 1×10^{-11} (E-11) ft/sec. (JMT)

Effective Porosity; Storage Coefficient; Hydraulic Conductivity; Transmissivity; Depth to Water Table

(098)

University of Waterloo, Department of Earth Sciences, Waterloo, Ontario, Canada

Cherry, J.A., G.E. Grisak, and R.E. Clister. 1973, September. CONF-730919: Underground Waste Management and Artificial Recharge, Vol. 1, J. Braunstein (Ed.), Proceedings of the 2nd

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International Symposium held in New Orleans, Louisiana, September 26-30, 1973, (pp. 436-447), 921 pp. (CONF-730919).

Hydrogeologic Studies at a Subsurface Radioactive Waste Management Site in West-Central Canada (1)

A summary of the results of the hydrologic and geologic studies conducted at the Whiteshell Nuclear Research Establishment. Low-level radioactive wastes are routinely placed in 4 meters deep unlined trenches that are approximately 17 meters long and 7 meters wide. Medium-level solid and liquid wastes are placed in concrete stand pipes 4 meters deep and 0.7 meters in diameter. Two 450 liter double-walled stainless steel tanks are buried in a concrete container and are used to store high-level liquid wastes. Hydrologic studies were performed on Pleistocene deposits to establish their flow characteristics. These studies include field permeability tests, and hydrochemical and tracer studies. Other studies addressed the containment capabilities of the natural hydrologic regimes, the containment capability of a man-manipulated regime and the waste management properties of other areas. (Neth) (J7)

A study of the hydrology and geology at the Whiteshell Nuclear Research Establishment. Data obtained over a five-year period are directly applicable to shallow land burial considerations. (DN/J7)

Head; Permeability Coefficient; Hydraulic Conductivity; Transmissivity; Storage Coefficient; Depth to Water Table; Distribution Coefficient; Dispersion Coefficient

<499>

University of Waterloo, Department of Earth Sciences, Waterloo, Ontario, Canada

Print, E.O., R.W. Gillham, and J.P. Pickens. 1976. CONF-760709: Finite Elements in Water Resources, Proceedings of an International Conference held in Princeton, New Jersey, July 12-16, 1976, (31 pp.), 800 pp. (CONF-760709).

Application of Unsaturated Flow Properties in the Design of Geologic Environments for Radioactive Waste Storage Facilities (3)

The feasibility of using the unsaturated hydraulic properties of granular soils in the design of geologic environments for radioactive waste storage facilities in the shallow subsurface is investigated. The essential parts of the geologic environment are a gravel layer surrounding the buried waste container, and a fine-grained soil layer overlying and surrounding the gravel. As long as the pressure at the soil-gravel interface remains negative, water infiltrating into the soil layer will not cross the interface but will flow laterally within the soil layer and around the container. A transient saturated-unsaturated finite element flow model is used in the simulation. The results show relationships between the design parameters and the performance of the system, expressed by the pressure head at the soil-gravel interface, for various store conditions. (Neth) (00)

Mathematically an extremely interesting paper. However the concept appears to be academic and unreal. (DN/CO)

<500>

University of Waterloo, Department of Earth Sciences, Waterloo, Ontario, Canada

Cherry, J.A., G.E. Grisak, and R.E. Jackson. 1973, October. Land for Waste Management, Proceedings of an International Conference held in Ottawa, Ontario, Canada, October, 1973, (pp. 131-145).

Hydrogeological Factors in Shallow Subsurface Radioactive Waste Management in Canada (2)

The purpose of the paper is to describe the main hydrogeologic factors important in the management of radioactive waste in shallow burial sites. The sites presently used as disposal areas in Canada are described along with the burial methods used. The necessary hydrogeologic factors to be considered, such as flow patterns and the water table are discussed and directly related to site criteria. The site criteria needed for both intermediate and long-term burial are viewed and a site selection scheme graphically relates those criteria necessary for consideration in a relative sense. (J5)

A review of the hydrogeological factors which must be considered, in terms of intermediate, and long-term burial. (DN/J5)

<501>

USSR Academy of Sciences, Institute of Physical Chemistry

Spitsyn, V.I., V.D. Balukova, A.F. Vassova, V.V. Gromov, P.N. Spiridonov, E.S. Vetrov, and G.I. Grafov. 1958. A/CONF.15/P-2207: Peaceful Uses of Atomic Energy, Proceedings of the 2nd United Nations International Conference, held in Geneva, Switzerland, September 1-13, 1958, Vol. 18, (pp. 839-848) (A/CONF.15/P-2207).

A Study of the Migration of Radioelements in Soils (2)

A study was made of the laws governing the migration of uranium fission products by some natural sorbents, such as soils and soil-forming minerals, from solutions with a varying salt content. Particular attention is paid to Sr 90 as the most hazardous isotope from the physiological standpoint. Experiments were made both in the laboratory and in the field. Among the materials used were alkaline carbonate and acidic non-carbonate sands containing humus, carbonate clay loams, light carbonate clays, medium carbonate clays, a number of clayey minerals, feldspars, the mineral groups of calcites, gypsum, etc. Two types of solutions were studied: (1) An alkaline solution containing NaOH (0-8g/l) and NaNO₃ (200 g/l). (2) An acidic solution, containing HNO₃ (4-8 g/l) and Al(NO₃)₃ (200 g/l). It was found that the pH of the solution had a particularly strong effect on the sorption of cesium. Up to 98-100 % of the Cs was absorbed from an alkaline solution containing sodium nitrate, regardless of the initial concentrations of Cs. In acidic media, for solutions containing aluminum, however, virtually no Cs was retained by the soils. The degree of sorption of ruthenium was extremely low, but in alkaline solution it reached several tenths of a millicurie per 100

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g of soil when cationic Sr was used. Practically no Sr was absorbed from an acidic solution, and anionic Sr was not absorbed at all by the soils. When an alkaline solution with Sr concentration of 5.32×10^{-3} mol/l was used, the soils, regardless of their nature, absorbed roughly 60% of the Sr. Under similar conditions, only 5-6% of the Sr was absorbed from an acidic aluminum solution. With a 10-fold reduction of the quantity of soils, the sorption of Sr in an alkaline medium falls to 27-33%. Many natural sorbents, mainly pure minerals of inorganic origin that make up the soils, were tested. Three solutions were used in the testing. In the first two, only negligible quantities of Sr, of varying levels of activity were used. In the third solution, however, CaCl₂ was added so that the concentration of Ca was approximately equal to that in river water. The pH values of the solutions fluctuated from 7.2 to 9.0. The quantity of sorbent equalled 1 g/50 ml. Results of the tests showed that montmorillonite, kaolinite, mica, hydronics, hydronics, pyrolosite, halloppite, peat, phosphorite, and nepheline syenites best absorbed Sr. The mineral groups common in earths and soils, such as calcite, quartz, gypsum, feldspar, etc. Absorb Sr to an insignificant degree. An additional study was made of Sr⁹⁰ sorption by montmorillonite from solutions containing varying concentrations of the ions, R⁺, Ba²⁺, K⁺, NH₄⁺, Ca²⁺, Mg²⁺, Ba²⁺, Fe³⁺, and Al³⁺. The ionic strength of the solution during the experiments remaining constant, with a pH of 7-8. The cations for montmorillonite may be arranged in the following series in increasing order, according to their ability to reduce the sorption of Sr⁹⁰: Al³⁺, Fe³⁺, Ca²⁺, Mg²⁺, Ba²⁺, K⁺, and Na⁺. The series shows that, in general, the higher the cation valency, and in case of equal valency, the smaller the radius of the hydrated ions, the greater its effect in reducing the degree of Sr sorption by montmorillonite. (JNT)

Extensive tabular and graphic data. (ESIC/JNT)

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USSR Atomic Energy State Committee, Moscow, USSR

Spitsyn, V.I., N.K. Pimenov, V.D. Balukova, A.S. Leonovich, I.N. Kokorin, P.P. Yudin, and V.A. Pavlov. 1977. IAEA-CN-36/385; Nuclear Power and Its Fuel Cycle, Proceedings of an International Conference held in Salzburg, Austria, May 2-13, 1977, (27 pp.) (IAEA-CN-36/385).

Foundational Prerequisites and Practice for Using Deep Water-Bearing Horizons for Disposal of Liquid Radioactive Wastes (1)

The criteria for using deep water-bearing strata for disposal of liquid radwastes are discussed. Requirements of the strata are: lie in stagnant or slow water exchange zone; have large area of propagation, thickness porosity, penetrability securing disposal of the calculated volumes; overlapped by aquicludes that are virtually fracture free; not a water- or mineral-bearing horizon; and be beyond the limits of areas of tectonic activities. Use of such horizons has already proven more profitable for neutralizing, storing, and disposing of wastes at a rate of 50 to 100 cu m/day at a depth of 1000 to 1500 m than evaporation, ion-exchange,

electrodialysis, or a combination of chemical methods. The wastes for storage must, however, have a pH ranging from 6 to 9, must be stabilized chemically, must have a salt content similar to connate waters, and must have a fixed limit of the suspended particles. A brief description is provided for waste preparation at low-, medium-, and high-levels. The test area used is in a pre-Cambrian basin where the Jurassic sediments are 500 ft thick. The particular zone of interests is under- and overlaid with clays and is itself a sandstone with interbeds and lens of conglomerates, gravels and clays. This composition gives the unit a hydraulic conductivity of 25 to 36 sq m/day in the center of the basin and 0.6 to 3.3 sq m/day at the boundaries. The filtration coefficients of the separate interbeds are about 0.2 to 1.4 m/day while the piezoconductivity coefficient is about 1.6×10^{-5} sq m/day. Average effective porosity, then, calculates to be between 7 and 10%. The natural flow of water is 2.2 m/year and the water is weakly mineralized. Up to 1976, 750,000 cu m of low-level radwastes were placed at a depth of 1500 m. Another 2 billion cu m of wastes containing 95 million curies were also placed in the horizon by 1976. From observations of the test area, using a deep water-bearing zone is acceptable for waste disposal for wastes up to 20 to 25 Ci/liter. Emergency guidelines are also given. (DDV)

Stratigraphic Unit Thickness; Hydraulic Conductivity; Effective Porosity; Hydraulic Velocity

<53>

Warsaw Polytechnic University, Institute of Environmental Engineering, Warsaw, Poland

Wawilany, H. 1976. Journal of Hydrological Sciences, 31(1-2), 87-99.

Stochastic Model of Tracer Flow (3)

A "three-velocities" model is proposed to describe movement of a tracer in fluid flow. Stochastic equations are solved by the Laplace transform to yield usable forms. The model includes: the finite flow velocity of the tracer, particles; tracer concentration at a given time and space point; satisfies the law of fluid continuity; and converges to the "piston-flow" model. The model also describes the dispersion phenomenon and the tracer conservation law. From the calculations and consideration concerning relations between the model parameters, the model may be applied to the determination of mean residence time of water in the hydrologic system; calculation of parameters of porous medium estimation based on experiments; and interpretation of the curves of the tracer flow through two adjacent aquifers having different velocities of filtration. (DDV)

<59>

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Kaleny, E., and Y. Tzur. 1968. Soil Science, 98, 66-67.

Precipitation of Strontium by CaCO₃ in Calcareous Soils and Measurement of Cation-Exchange Capacity (2)

(500) C007.

Precipitation of strontium in a carbonate regime and the measurement of the cation exchange capacity are discussed. It was found that Sr is precipitated as SrCO_3 when it comes into contact with CaCO_3 . The solubility product is 0.0001 at 25°C . This relation is true in soils if the initial Sr concentration is greater than equilibrium concentration. In column studies it was found that if the precipitation reaction was sufficiently fast, it would go to completion in a small fraction of the column. Using a 0.01 M SrCO_3 solution and moving through break activities, 60% of the original Sr

concentration was found in a short time. From other column studies a mechanism of Sr precipitation by CaCO_3 exists in addition to cation exchange. Hence, a small percentage of lime in the soil will cause the retention of a much larger amount of Sr than expected from exchange capacity. Cation exchange capacity measurements of calcareous soil with Sr solutions have, therefore, no meaning. (000)

Cation Exchange Capacity

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