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PACIFIC NORTHWEST LABORATORY
MONTHLY ACTIVITIES REPORT
MARCH 1974

Division of Production and Materials
Management and Hanford Plant
Assistance Programs

Battelle

Pacific Northwest Laboratories
Richland, Washington 99352

APRIL 1974

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PACIFIC NORTHWEST LABORATORY
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MONTHLY ACTIVITIES REPORT

MARCH 1974

Division of Production and Materials Management
and
Hanford Plant Assistance
Programs

by the

Staff of Battelle-Northwest
E. L. Alpen, Director

April 1974

BATTELLE
PACIFIC NORTHWEST LABORATORY
RICHLAND, WASHINGTON 99352

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PACIFIC NORTHWEST LABORATORY
MONTHLY ACTIVITIES REPORT
DIVISION OF PRODUCTION AND MATERIALS MANAGEMENT
AND HANFORD PLANT ASSISTANCE PROGRAMS

ASSISTANCE TO ATLANTIC RICHFIELD HANFORD COMPANY

Summary

PROCESS TECHNOLOGY - ENGINEERING DEVELOPMENT DEPARTMENT

Storage of High-Level Liquid Radioactive Waste

In studies of grouting around monitoring well casings, an injection of a Pond Sealant-sand-Portland Cement mixture at 250 psi produced >90% casing coverage, good bonding to the casing, coating of aggregate and filling of voids.

A program was initiated to evaluate a wiped film evaporator for concentration of the residual liquor produced in waste concentration operations.

Corrosion tests indicated the minimum current density required to cathodically protect mild steel in contact with solidified waste is between 5 and 10 ma/ft².

Evaluation of electromagnetic acoustic and ultrasonic methods for waste tank inspection was initiated. Early results with ultrasonic "point probes" appear favorable for detection of stress corrosion cracking.

Work was started on experimental evaluation of near-field soil properties to obtain data for use in developing the waste tank leak model.

Audit of FIC system is continuing on maintenance logs and other components. The new detent counters have some problems that can result in data inaccuracies. Revision of computer software system is underway and should improve the system reliability.

Experiments on ultrasonic logging of waste tank contents have shown that several inches of simulated salt cake can be penetrated with the present breadboard system.

In work on the radiofrequency liquid level detection systems, new probe configurations have been devised which give a reading of about 600 cycles per inch of level variation. The instrument is capable of recording information over a 300,000 cycle band and this indicates the system could record a change in liquid level over a projected span of 500 inches.

Preparations are complete for a field test of a means of detecting leaks in waste storage tanks based on measuring changes in soil electrical resistivity. Numerous other potential techniques for detecting tank leakage are being evaluated.

Evaluation of emergency procedures associated with waste handling and storage in the Hanford 200 Areas was continued.

Waste Concentration and Encapsulation Development

Several modifications to the CsCl encapsulating equipment were completed. An in-cell filtering system was provided for installation in the plant.

PROCESS DEVELOPMENT - RESEARCH DEPARTMENT

Plutonium Scrap Processing Development

An experimental program is being developed to evaluate the NaOH - Na₂O₂ fusion process for recovery of Pu from incinerator ashes for the treatment of other Pu-containing solids.

PROCESS TECHNOLOGY - RESEARCH DEPARTMENT

Plutonium Trench Soil Characteristics

The first pulsed neutron source experiments were completed on the 216-Z-1A Tile Field. Preliminary analysis of the data indicates no significant amount of reactivity to be associated with the 216-Z-1Aa Test Well.

Two library tapes have been generated for the GAMTEC-II cross section averaging code for use with the new CYBER computer.

A previously observed reduced rate of leaching of Pu from soil apparently due to dissolution of soil components was not observed in a nitric acid leachate of the mineral anorthite feldspar or of olivine. Accelerated leaching was noted in the presence of a leachate of common hornblende, presumably due to fluoride in the solution.

Soil samples from 216-Z-1A Tile Field were mounted and polished in preparation for optical and autoradiographical examinations.

Plutonium Processing Development

Two capacitance interface and pulse amplitude control systems for use in Plutonium Reclamation Facility development columns were completed.

Tank Farm Support

The computer program for calculating soil parameter data input to the PST model used for simulating and evaluating high-level waste leaks has been rewritten and updated.

Hydraulic conductivity and fluid moisture retention relationships were measured using synthetic waste solutions.

Prevention of Accidental Releases

● Surficial Contamination and Airborne Release Studies

Initial experiments were performed to give indication of the respirable particles airborne in winds of 2.6 and 10 mph during soil-moving operations.

The estimated average annual air concentration at the FFTF site derived from the B-C crib contamination was calculated to be 1.3×10^{-10} $\mu\text{Ci-hr/cc}$. This is a factor of about 1000 lower than MPC for unrestricted occupancy if the radioactivity was all Sr-90; a factor of 10^5 lower if all Cs-137. Data taken at the Meteorological Station tower during 16 years of hourly wind measurements and recent resuspension data were used in the estimate.

Airborne radioactive material in large volume air samples taken near the U-Pond ranged from 0.076 to 0.184 fCi/m^3 for Pu-239; 0.008 to 0.029 fCi/m^3 for Pu-238; and from 0.036 to 0.094 fCi/m^3 for Am-241.

A comparison of single-station trajectories and multi-station windfield trajectories strongly indicate that the spatial variation of wind over the Hanford reservation is so great that computation of transport from a single location for releases occurring over a period of several days can be very much in error.

Over fifty references which describe and analyze dust devil development, duration, and properties were collected. This literature is under review for a study of the potential seriousness of dust devils and other unusual wind conditions in the Hanford area.

A substitute air sampling programmer to replace the relay system now in use is being developed to allow greater flexibility in the choice and adjustment of air velocity increments.

- Groundwater Management Studies

- Radionuclide Transport Model

- The macro-micro ion transport (MMT) model was tested and verified on a large scale simulation using data from the variable thickness transport (VTT) model as input.

- The results of the 44-month VTT simulation have been obtained and the overall improvement in the model performance was not as great as expected. Work with the volumetric flow balance program is continuing to attempt to identify parameters that are in greatest error.

- The groundwater surface temperature map of the Hanford Project has been completed.

- Biological Transport Studies

- Collection of fish and ducks from the Gable Mountain Pond and analysis of them for radionuclide content was continued.

- In studies on feeding alfalfa contaminated with Cs-137 and Sr-90 to a goat it was shown that there is a strong discrimination between soil and alfalfa plant in regard to cesium uptake; but, once in herbage, cesium is more readily incorporated into soft tissues of animals than is strontium.

ASSISTANCE TO ATLANTIC RICHFIELD HANFORD COMPANY
PROCESS TECHNOLOGY - DEVELOPMENT ENGINEERING DEPARTMENT

Storage of High Level Liquid Radioactive Waste

Task 1. Systems Study of Waste Storage and Monitoring Systems
(J. L. McElroy, Process Demonstration Section)

On March 8, a complete program review was presented to ARHCO management to familiarize them with the personnel working on the program and with the approach being used to provide solutions to the problems of minimizing the number, size and consequences of waste tank leaks. Each of the nine program tasks was reviewed regarding current and planned activities and how these relate to the overall program.

Task 2. Waste Characterization
(R. E. Burns, Chemical Technology Department)

- Grouting Soil-Well Casing Interfaces
(P. L. Koehmstedt, Corrosion Research and Engineering Section)

Soil-casing interfaces of monitoring wells in the waste tank area are potential paths for waste leaked from the tanks to reach groundwater. A concept for sealing these paths is being studied. It consists of perforating the existing well casing, inserting an inner casing sealed at the bottom and injecting a high alkalinity stable grout into the annulus and out into the soil surrounding the perforated casing.

Test injections at 250 psi using a grout composed of 38.5 w/o Armah pH 12-13 13 MR Pond Sealant, 38.5 w/o 30-mesh sand and 23 w/o type I or II Portland cement provided >90% casing coverage, excellent bonding to surrounding soil and total filling of artificial aggregate voids. A four-day exposure to 5 M NaOH did not affect the integrity of the soil-casing seal.

A test injection of Portland cement-water (5.3 gal/ft^3) at 415 psi using the same apparatus as above was made for comparison. This injection did not produce either significant casing coverage or casing-to-soil bonding. It did produce total filling of an artificial aggregate void. The cement grout appeared to be dehydrated by the soil and penetration was prevented. The test soil moisture content used was as recommended by the drilling consultant. Further tests will be made at higher water to cement ratios.

A large scale injection test at 100 psi was completed. A rigidly mounted pressure sensor, which extended to within three inches of a casing perforation and which had a sensing range of from 0 - 100 psi, did not indicate any pressure transmission. Dismantling of the test apparatus is in progress so flow patterns, penetration depths, casing coverage and transducer response can be observed. Pressure transmission tests in the field are planned.

- Wiped Film Evaporator Studies
(R. D. Dierks, Process Demonstration Section)

Plans were completed for a preliminary test of the application of a wiped film evaporator for further concentration of the residual liquor produced in the waste concentration program. A horizontal, tapered barrel unit having 5 ft^2 of heat transfer surface will be used. Simulated non-radioactive residual liquors will be used as feed; feed rate and steam pressure will be varied; pertinent product properties will be determined. If these preliminary experiments indicate successful application of the wiped film evaporator, further work with feeds treated with various chemical additives will be planned.

Task 3. Tank Integrity

- Corrosion Studies
(R. F. Maness, Corrosion Research and Engineering Section)

Mild steel specimens cathodically protected in simulated solidified waste were examined after 1,850 exposure hours. Exposures were in a waste containing 15% excess water and held at 85°C ; current densities were 2.5, 5.0, and 10 ma/ft^2 . The specimens exposed to current densities of 2.5 and 5.0 ma/ft^2 corroded at rates of 1 to 2 mils/year as evidenced by weight loss. However, pitting attack was rather severe ($\sim 5 \text{ mil}$ penetration during the 1850 exposure hours) in both cases.

The specimen exposed to a current density of 10 ma/ft^2 evidenced no pitting attack and corroded at a rate of 0.8 mpy as determined by weight loss. Thus, the minimum current density required to protect mild steel under the test conditions lies between 5 and 10 ma/ft^2 . Plans are being made to confer with a specialist in cathodic protection engineering regarding the feasibility of cathodically protecting Hanford underground tanks subsequent to in-tank solidification.

- Waste Tank Inspection
(G. L. Posakony, Nondestructive Testing Section)

The laboratory evaluation of electromagnetic acoustic (EMAC) methods and ultrasonic methods for application to waste tank inspection was started. EMAC and ultrasonic equipment has been assembled in the laboratory and initial studies are underway. Specialized EMAC and ultrasonic probes have been designed and fabricated for evaluation. Initial results with ultrasonic "point probes" appear favorable for the detection of stress corrosion cracking. The specially designed ultrasonic probes can be operated in the transmit-receive mode and do not require a liquid couplant. These probes are currently being evaluated on the laboratory test specimens.

Specially designed EMAC transducers were fabricated and tested on the laboratory specimens. These transducers exhibit good sensitivity to the stress corrosion cracking condition. However, the overall sensitivity of the EMAC transducers is considerably less than the ultrasonic "point probes". Evaluation of these probes is continuing.

Task 5. Tank Leak Model
(B. C. Fryer, Fluid and Energy Systems Section)

The purpose of this task is to develop a mathematical fluid mechanics model that can be used to estimate tank leak rates based on: 1) probable failure modes and location; 2) raffinate characteristics; 3) near-field soil/fluid properties; and 4) hydrostatic head above the leak point.

Prior work has defined and cataloged parameters relevant to the waste tank leak model, e.g., tank geometries, probable liquid depths, liquid types, etc. A simple first case near-field soil hydrology model has been set up for computer analysis. Work on experimental evaluation of the near-field soil properties has been initiated.

Task 6. Leak Detection

- Liquid Level Measurement

Engineering Audit - FIC System (J. T. Crowe, Nondestructive Testing Section)

Work on this study is continuing at a reduced level of effort. Current efforts consist primarily of periodic review of maintenance logs on the FIC system and a laboratory evaluation of the new detent counters. Evaluation of the counters has revealed that some degree of contact "bounce" can occur at the wiper contacts which present data to the level transmitter boards. Some data inaccuracy could result. We have been informed that revisions currently being made in the computer software should reduce the possibility of error from this cause. Testing of the counter is continuing. The fail-safe electronics boards have not yet arrived. A brief laboratory evaluation of one of the boards will be made as soon as they become available.

Ultrasonic Logging of Waste Tank Contents (J. T. Crowe, Nondestructive Testing Section)

Additional funding has been allocated for fabrication of a demonstration prototype of the ultrasonic logging system. Laboratory samples of simulated tank wastes have been obtained from ARHCO for evaluation in the laboratory mockup system. Ultrasonic impedance and attenuation measurements have been made on the simulated liquid wastes. The measurements indicate that the liquid wastes are slightly more attenuative than water. This should present no significant problem in transmitting ultrasound through the liquid waste over reasonable distances (10-15 ft).

Ultrasonic attenuation measurements have also been made on simulated salt cake with the laboratory test apparatus. A 4-in. thick layer of salt was used to simulate salt cake buildup on the wet well probes. Although the salt material was shown to be significantly more attenuative than the liquid waste material, a useful ultrasonic signal could be transmitted through the salt layer. These measurements are to be used as a guideline for determining the transmitter pulse power requirements for the demonstration model of the ultrasonic logging system. Other aspects of the transmitter pulse requirements are also being investigated.

RF Liquid Level Measurement

(O. H. Koski, Chemical Development Section)

Previous testing and evaluation of the ASI (Automation Systems, Inc.) radiofrequency liquid level system showed that the system had the sensitivity to be of potential use in waste tank monitoring. Further testing showed that liquid composition, temperature and tank-probe geometry are system variables. However, the probe design can be so altered that the capacitive impedance of the probe is the only substantial system variable. This results in good linearity, low temperature coefficients and insensitivity to liquid phase composition but to a lower sensitivity.

A test using a probe with an air gap of about 0.070 in. between the probe wire and the concentric housing gave a sensitivity of 600 frequency units per inch with a projected span of 500 in. of liquid. Composition variation in the liquid phase from tap water to 4M NaNO_3 and saturated NaNO_3 did not show any appreciable effects. Temperature effects, however, became appreciable at temperatures above 125°F. Dimensional changes in the polyethylene outer probe cover may be responsible. Voltage supply variations from 100 to 150 volts at 60 Hz also showed no short-term effects on the output.

- Material Balance

(D. P. Grandquist, Safeguards Systems Section)

A rough draft report describing the results of the computer model study on the 242-T Waste Evaporator System material balance was written. No new data analyses were conducted on the material balance and MUF calculations during the month.

- External Measurements

(M. R. Kreiter, Process Evaluation Section)

A concept for improved waste tank leak detection based upon soil electrical transmissivity change with leakage is being investigated to establish leakage resolution limits.

Preparation for a field test is complete. All electrode and injection well casings are installed. The necessary NaNO_3 mixing equipment and tanks, meter-equipped pump and rain simulation equipment are assembled. The field test is now scheduled to begin April 1. A composite soil sample from the field test site was forwarded to Boeing Company for electrical transmissivity measurements.

A tank farm monitoring system based on detecting leaking radiation with GM tubes was examined. Since a virtually identical system has been in operation for over six years, the technique is already proven. The advantages of this approach are continuous monitoring, relatively rapid and economical installation, and proven reliability.

A demonstration of the system in operation was provided ARHCO personnel.

Other techniques considered for detection of waste tank leaks include dielectric constant, radiofrequency, voltaic, electrochemical and quasi ion chamber measurements on soil adjacent to the tanks. Also considered are ultrasonic measurements for sub-tank leakage and infrared area scanning for near surface leakage in transfer lines. Evaluation of these techniques will continue.

Task 7. Emergency Procedures

(J. D. Smith and W. S. Kelly, Fluid and Energy Systems Section)

The work in this task is an evaluation of emergency procedures associated with ARHCO's underground storage and handling of high- and intermediate-level radioactive liquid waste in the 200 Areas.

The effort for this reporting period was a continuing review of procedures, documents, engineering flow diagrams and piping plans pertinent to the study.

Thirty Savannah River emergency procedures, earlier identified as necessary input to this study, were requested through the AEC Richland Operations Office. Contacts are being made to determine if similar information from Idaho Falls and Oak Ridge would provide useful input to the evaluation of the Hanford procedures.

Waste Concentration and Encapsulation Development

CsCl Encapsulation

(B. Norton, Chemical Development Section)

Modifications to the casting magazine of the encapsulation equipment have been completed. The modifications were required to permit adhering to the new fill level requirements.

A new fill head nozzle plate assembly with modifications was requested as an outcome of last month's test results. The assembly has been fabricated and is ready for installation. Fewer weld seal problems should occur with the new design.

A filtering system to be located in-cell in series with the capsule leak detector and an oil mist eliminator in the exhaust was requested. The filter assembly was designed for remote installation and disposal. Filter element material is of 10 micron sintered, porous stainless steel. This equipment has been delivered for installation.

A delay in plant startup date has delayed the leak detector training schedules mentioned in last month's report. Training should begin in the near future.

PROCESS DEVELOPMENT - RESEARCH DEPARTMENT

Plutonium Scrap Processing Development

Incineration Development

(J. A. Partridge, Chemical Development Section and
E. J. Wheelwright, Applied Chemistry Section)

Work on this task has demonstrated that a caustic-peroxide fusion process can be used to recover Pu from the regular ARHCO incinerator ash. Plutonium recoveries of 95 percent or higher were achieved and it appears that the residual solids can be recycled for complete recovery of the Pu. Sufficient work has not been done, however, to optimize the process in terms of such parameters as ash to salt ratio in the fusion mixture.

The experimental program is now being modified to investigate Pu recovery from "processed" solids by peroxide fusion. These "processed" solids will include (1) solids accumulated by centrifugation after solvent extraction contacts have been made, and (2) incinerator ash which has been treated with nitric-hydrofluoric acid for Pu recovery.

PROCESS TECHNOLOGY - RESEARCH DEPARTMENT

Plutonium Trench Soil Characteristics

(S. R. Bierman and G. J. Konzek, Criticality Research Section)

216-Z-1A Trench Reactivity Measurements

Pulsed neutron source measurements were performed in the first of three test wells currently planned for the 216-Z-1A Tile Field. The measurement data

obtained at this initial test site, 216-Z-1Aa, are currently undergoing computerized reduction and analysis. Preliminary analysis of the data, however, indicates there is no significant amount of reactivity associated with the 216-Z-1Aa Test Well (k_{eff} will likely be less than 0.3).

In addition to the pulsed neutron source measurements, a neutron flux traverse of the 216-Z-1Aa Well also was made utilizing the neutron detector in the pulsed neutron source measurement. The data from this traverse show that the maximum concentration of fissile material lies between 11 and 12 feet below the top of the well liner. The traverse also indicated that the fissile material was symmetrically distributed about this 11 - 12 foot depth and that most of the material was within about 4 feet of this level.

Computer Codes

(E. D. Clayton, Criticality Research Section)

Library tapes for the GAMTEC-II cross section averaging code were created for use with the CYBER computer. One tape contains the original GAMTEC-II library data, and another tape contains data from the ENDF/B-III (Evaluated Nuclear Data File). These tapes, which are now ready for production use, are designated:

TSN = GTLIBU2589	(original GAMTEC-II
ID = CMLTAPE	library)
TSN = ENDFB3LIB	(ENDF/B-III data)
ID = CMLTAPE	
CN = U3957	

Plutonium Trench Chemistry and Mineralogy

- Plutonium - Soil Chemical Reactions
(J. L. Swanson, Chemical Development Section)

The current objective of this program is to establish a better understanding of soil-plutonium interactions, especially in high salt solutions as were charged to the 216-Z-9 trench. The effect of nitric acid leachate of three minerals on the leaching of sorbed Pu from soil was examined, but the effect previously observed with a soil leachate (much slower leaching of sorbed Pu) was not duplicated with any of the three. With leachates of anorthite feldspar,

$\text{Ca}[\text{Al}_2\text{Si}_2\text{O}_8]$, or olivine, $(\text{Mg}, \text{Fe})_2\text{SiO}_4$, little if any effect was observed while with a leachate of common hornblende, $(\text{Ca}, \text{Na}, \text{K})_{2-3} (\text{Mg}, \text{Fe}, \text{Al})_5 [\text{Si}_6(\text{Si}, \text{Al})_2\text{O}_{22}](\text{OH}, \text{F})_2$, much more rapid leaching of sorbed Pu was observed, presumably caused by the presence of fluoride in the solution. Other minerals are being obtained for study.

Earlier results showed the formation of soil-sorbable Pu species to proceed moderately rapidly in the simulated waste solution at pH 1.6, quite rapidly at pH 2.0, but very slowly if at all at pH 2.5. Recent work at pH 3.0 also shows the formation of very little if any sorbable Pu species (in a month at $\sim 23^\circ$). Even though considerable amounts of solids form when the pH is raised to 3.0, the plutonium passes through a 0.05 micron filter, indicating it to remain in solution (the Pu concentration of the solution is 0.1 mg/ml). These results indicate that the Recuplex procedures of neutralizing the waste stream to pH 2.5 had little effect on the sorbability of the Pu present in the solution.

- Characterization of 216-Z-9 Trench Soil Samples
(L. L. Ames, Water and Waste Management Section)

Soil samples from a well drilled into 216-Z-1A facility were received for mounting. There was a total of 14 samples taken at depths below the 216-Z-1A Tile Field bottom of from 50 cm to 460 cm. The plutonium content of the sample series falls from about 400 mg Pu/l of soil at 50 cm to about 7 mg/l of soil at 210 cm depth.

Eight of the above soil samples, contained in one-inch diameter tubing, were vacuum-impregnated, mounted, sawed, ground and polished for autoradiographs, optical viewing and photographs. Some microprobe work will be done if soil fragment mineral attack or actinide distribution warrant it.

Plutonium Processing Development

Instrumentation for the Plutonium Reclamation Facility (O. H. Koski Chemical Development Section)

Two systems composed of capacitance measuring instruments, converters and controllers and a laboratory-developed pulse amplitude to DC converter for use

in the 1/4 to 2 cycle-per-second range were provided to the Plutonium Recovery Facility. This instrumentation is for interface and pulse amplitude control in PRF development pulse columns. The capacitance system was basically constructed on an ARHCO design and revised to include filtering to permit its use in pulse column service. The variable portion of the interface position signal is used to generate a DC output voltage which is proportional to the average value of the pulse amplitude. This signal is then used for amplitude control and/or recording and indicating.

Review of data generated in previous work on in-canyon monitoring resulted in a choice by ARHCO to further investigate use of televised counter readouts versus other forms of data telemetry. Vendors capable of producing either the television link or the gamma counting system are being requested to provide a response to a system description.

Tank Farm Support

Partially Saturated Transient (PST) Flow Model

(A. E. Reisenauer and S. J. Phillips, Water and Land Resources Section)

An updated computer program using an exponential curve fit has been written for computation of relative hydraulic conductivity vs. capillary pressure, capillary pressure vs. saturation and relative hydraulic conductivity vs. saturation. These curves fit the data well in the drier part of the saturation curve. Data received from this program will be input into the PST model used in simulation and evaluation of high-level waste leaks.

Measurement of hydraulic conductivity and fluid moisture retention relationships utilizing synthetic dilute unprocessed wastes, early separator slurries and late separator slurries, has been implemented in order to more closely approximate flow parameters of future leaks in 200 East and 200 West Tank Farm Areas.

Sieve analysis data and drillers logs have been reviewed in order to characterize backfill and below tank soils and delineate representative soil types.

Prevention of Accidental Releases

- Surficial Contamination and Airborne Release Studies

B-C Crib Studies

(J. Mishima, L. C. Schwendiman and T. W. Horst, Gaseous and Particulate Waste Research)

Potential Airborne Release of Surface Contamination During a Range Fire

Experiments to measure the airborne release of Cs-137 and Sr-90 during the charring below ignition of contaminated flammable material from the B-C Controlled Area were continued. The decrease in weight of the organic components during heating at 400°C ranged from 54 to 94 percent. Measurement of Cs-137 or Sr-90 contained in the volatile fraction was delayed due to equipment failure.

Potential Airborne Release of Surface Contamination During Decontamination Operations

The aerodynamic behavior of soil typical of that in the B-C Crib Area is being investigated to help determine the possible radiological health significance of some soil disturbances during area decontamination operations. These experiments have determined the amount and sizes of particles which are carried away in wind during soil disturbance which might be similar to digging operations. In a wind tunnel a paddle was passed repeatedly through a mound of soil and the amount and particle size of the fraction airborne were measured. About 16 percent was carried beyond 1 foot of the soil sample at a wind speed of either 2.6 or 18 mph. The amount transported in the duct to the large vessel some twenty feet away was 12 percent for the higher wind speed compared to 0.4 percent for the 2.6 mph wind. The aerodynamic equivalent diameter of airborne particles was 4.5 μm during the 2.6 mph test. Because the mass collected on two lower stages of the impactor was too small to weigh with an analytical balance, a mean particle diameter could not be determined for particles airborne at the higher velocity. It is estimated that nearly all the mass was associated with particles less than 10 μm .

This rough simulation of soil-disturbing operations shows that a rather large fraction of soil can become initially airborne, but that most of this soil will settle by gravitation in a short distance. A significant fraction of particles in the respirable size range is transported.

Safety Analysis of B-C Crib Contamination

An estimate was made of the average annual air concentration of radioactivity to be expected downwind of the B-C crib site, using 16 years of hourly wind measurements from the Hanford meteorology tower and the standard Gaussian plume model. This showed that the possible annual exposure at the FFTF site would be 1.3×10^{-10} $\mu\text{Ci-hr/cc}$. This is a factor of about 1000 lower than MPC for unrestricted occupancy if the radioactivity was all Sr-90; a factor of 10^5 lower if all Cs-137.

In order to investigate the airborne pattern of resuspended material from the B-C crib site, a computer program was written which calculates the atmospheric diffusion from the detailed distribution of material on the surface in the B-C crib area. The isoplethed contours of Cs-137 activity as surveyed by EG&D are currently being digitized at 100 m intervals for input to this program.

Resuspension from Contaminated Surfaces - Field Studies

(G. A. Sehmel, F. D. Lloyd, L. C. Schwendiman, Particulate and Gaseous Waste Research Section)

Radiochemical analysis results were received for five air filter samples collected during the low water level period at U-pond from August 20 to September 10, 1973. Airborne plutonium, americium, and cesium were reported. Calculated average airborne concentrations and concentration per g of airborne soil are:

	<u>Air, aCi/m^3*</u>	<u>Airborne Soil, pCi/g</u>
Pu-239 and Pu-240	76 to 184	0.99 to 7.8
Pu-238	7.9 to 28.9	0.14 to 0.55
Am-241	36.8 to 94.7	0.47 to 4.0

*Units of 10^{-18} Ci/m^3

Concentrations for Cs-137 were larger - 23 to 29 fCi/m^3 air and 0.3 to 1.8 nCi/g airborne soil. Mass spectrometer plutonium analysis indicated the Pu-240 atom percent ranged from 2.6 to 7.5. Pu-241 was not detectable.

Sr-90 and Cs-137 analyses have been received for filter samples of airborne material collected at B-C crib area in June and from August to September 1973. In general, results indicate airborne Sr-90 and Cs-137 concentrations are

comparable (i.e., usually within 50% in the value of $\mu\text{Ci}/\text{cm}^3$). Sr-90 concentrations were usually around $10^{-15} \mu\text{Ci}/\text{cm}^3$ except for two samples of greater concentration which were 1.3×10^{-14} and $1.5 \times 10^{-14} \mu\text{Ci}/\text{cm}^3$. In comparison, Cs-137 concentrations ranged from 1.9×10^{-15} to $2.8 \times 10^{-14} \mu\text{Ci}/\text{cm}^3$.

Equipment installation was completed for operating the 100-foot air sampling tower at U-pond area. High volume air samplers and cascade impactors on the 100-foot tower are operating simultaneously with samplers located on a 20-foot upwind tower. Three sets of samplers are operating for wind speeds from 3 to 8 mph, 8 to 13 mph, and 15 to 21 mph.

Equipment installation is continuing for upwind and downwind tower sampling as a function of wind speed at B-C area.

One additional flight in the Atmospheric Sciences Cessna 411 was flown over the 200 Area plateau. Three large volume air samples were taken in the flight and are being analyzed.

Wind Trajectory Studies

(L. L. Wendell and W. F. Sandusky, Atmospheric Physics Section)

Trajectory plots for material released from the B-C crib area were prepared by computer programs using wind data solely from the 50 foot level of the 400-foot Meteorological Station tower. The data used covered the period April 16 through May 2, 1973 during which period wind data were simultaneously taken at several stations as well. Trajectories calculated on the assumption that the wind data taken at the Meteorological Station tower applied over the whole Hanford reservation are analogous to trajectories resulting from using only the time-varying source wind to transport the material released (rather than taking into account wind fields actually in existence). A comparison of trajectories using the single point wind data with windfield-constructed trajectories revealed a number of significant discrepancies.

There were several instances in which the single station trajectories showed little or no transport to the Tri-Cities while the wind field trajectories showed definite flow to the Tri-City area. In one situation the hypothetical material released from the B-C crib site was shown by the single station flow to be moving off the Hanford site in a straight line to the east-northeast. For the same time period the wind field data carried the material in a circle and caused it to pass over the 200-East Area. Admittedly a 17-day period is a small sample,

but the indications from this data set are that there is enough spatial variability in the flow over the Hanford site and vicinity that computing transport from the wind at a single location can be very unreliable.

Existing wind data available during the last four aircraft sampling runs, in which SF_6 and a constant volume balloon served as tracers, was used to construct wind field trajectories for comparison purposes. Two of the trajectories compared favorably, but the other two appear to suffer from sparseness in the available data. An attempt to improve their validity is being made by including data from the Rattlesnake Mountain station and the Richland and Pasco airports. The transport and dispersion model will also be used to compute plume concentrations to compare with the SF_6 samples for these tests.

The terrain heights, which have been extracted on a 54 x 56 mile grid covering the Hanford site and surroundings, were analyzed and corrected through the use of the printer contouring program. The data set should now be ready for use in a study of the drainage flow over the area.

Significance of Dust Devils and Other Anomalous Winds

(M. M. Orgill and L. C. Schwendiman, Particulate and Gaseous Waste Research Section)

This study, progress on which is reported for the first time, was undertaken to determine the frequency, duration, energy dissipation, and potential seriousness, from a resuspension standpoint, of dust devils and unusual wind conditions. Observers have reported persistent dust devils which have removed large quantities of earth. The possible result of such a wind in a significantly contaminated area or when occurring during a critical outdoor operation involving radioactive material must be evaluated from the standpoint of probability and consequence.

Statistical occurrence and phenomenological data on dust devils are being assembled and studied. Important atmospheric elements for their spontaneous formation and maintenance include a thick vertical layer of unstable stratification and a large vorticity. Temperature structure conducive to formation has been identified; however, elements inducing the whirling motion (vorticity) have not been established. Several speculations have been put forth.

Dust devils occur most frequently in early afternoon. In Arizona deserts, up to 4 per day per square mile have been observed. In the Mojave Desert in California as many as 2,400 per square mile in a day were observed, based on those seen in a specially prepared 300 x 500 meter area.

A study is underway based on temperature data and the research of Ryan⁽¹⁾ to determine the probable frequency of dust devils for the Hanford reservation.

Environmental Surveillance Instrumentation
(O. H. Koski, Chemical Development Section)

A radiofrequency system capable of producing a resolvable change in frequency for a change in probe to ground plane impedance of one part in 10^5 is being prepared for testing in the field in conjunction with the simulated waste tank leak experiment. Also to be included in the test, where possible, are sensors designed to react to electrochemical changes so as to detect caustic or NaNO_3 but to have little reaction to groundwater.

A substitute for the relay programmer in the air sampling system is being constructed for use in airborne particulate studies. The relay system does not allow the flexibility in the choice and adjustment of air velocity increments for which each air sampler is dedicated.

● Groundwater Management Studies

Groundwater Simulations

(D. R. Friedrichs, K. L. Kipp, A. E. Reisenauer, and S. W. Ahlstrom, Water and Land Resources Systems Section)

The Micro-Macro Ion Transport (MMT) model was tested and verified on a large scale simulation using velocity data computed by the Variable Thickness Transport (VTT) model as input. In addition, a data loading sequence was developed for processing the voluminous amounts of data required for the MMT model.

The results of the 44-month 1968-1971 test VTT simulation were obtained with the new hydraulic conductivity distribution. The differences between the

⁽¹⁾ J. A. Ryan, "Relation of Dust Devil Frequency and Diameter to Atmospheric Temperature," Journal of Geophysical Research, Vol. 77, No. 36, pp. 7133-7137 (1972).

computed and measured September 1971 hydraulic potential surfaces formed the following classes:

	<u>New K Distribution, % of Node Points</u>	<u>1971 K Distribution, % of Node Points</u>
0-1 ft	22	27
1-2 ft	20	21
2-4 ft	24	18
4-8 ft	23	18
8-15	10	12
> 15 ft	1	4

This classification shows a reduction in the number of large differences accompanied by a reduction in the number of small differences. The other statistics for the simulations are compared below:

	<u>New</u>	<u>1971</u>
Average Difference	- 0.25 ft	- 1.1 ft
Root Mean Square Difference	5.3 ft	6.3 ft
Maximum Difference	28 ft (Under 216-U-10 Pond)	33.1 ft (South side of Gable Butte)
Minimum Difference	0.002 ft (Near Columbia River Southeast of 200 East Area)	0.003 ft (Southeast of 200 East Area)

The overall improvement in the VTT model performance was not as great as expected. There appears to still be problems with the accuracy of the hydraulic conductivity distribution, the storage coefficient values, and aquifer boundary definition (under 200 West Areas), in the vicinity of Gable Mountain Pond and Old Hanford Townsite. Work with the volumetric flow balance box calculation is continuing to attempt to identify the parameters that are in greatest error. This program is an additional aid in the investigation of the internal consistency of the computed aquifer parameters. When the investigation is completed, areas in which the measured potential surface, measured temporal rate of change, assumed storage coefficient and calculated hydraulic conductivity values are inconsistent should be more closely defined.

Field Measurements and Monitoring Assistance

(A. E. Reisenauer and K. L. Kipp, Water and Land Resources Section)

Temperature logging of the Hanford wells was completed and the groundwater surface temperature map has been completed for the Impact Statement.

Moisture content of the soils in the lysimeter was monitored with the neutron probe on March 4 and 5 and again repeated on March 19 and 20, 1974.

- Biological Transport Studies

Aquatic Studies at Gable Mountain Pond

(D. G. Watson and C. E. Cushing, Freshwater Ecology Section)

Analyses of Sr-90 from fish collected each month from May to January have revealed extremely low concentrations of this radionuclide. The mean concentration of nine fish was 2.28 pCi/g dry weight with a range of 1.0 ± 0.4 to 3.5 ± 0.6 pCi/g dry weight.

Concentrations of Cs-137, Zr-95, and Co-60 in wild mallards were lower than corresponding values in wild mallards collected in November. The concentrations of the same isotopes in coot muscle and carcass were of the same order of magnitude as those sampled in the fall.

- Biological Interactions

Feeding Alfalfa Grown in Sr-90 and Cs-137 Contaminated Soil to a Goat

(W. H. Rickard, Terrestrial Ecology Section)

The purpose of this study was to obtain information concerning the transfer of strontium-90 and cesium-137 from alfalfa to the various tissues and organs of a large herbivore (goat). Although there are studies that evaluate the herbage to herbivore transfers of radionuclides, there are few studies that have used herbage contaminated through the soil→root→shoot pathway. There are apparently no studies of this kind that have used isotopes that have been aged and weathered for a long time under field conditions. The herbage used in this study was obtained from field plots located at the 100-F Area. These plots were contaminated with Sr-90 almost 20 years ago. A goat was selected as a large herbivore because size and food habits are thought to be similar to the mule deer, the most important wild, large herbivore on the Hanford Reservation.

Radiochemical analysis of alfalfa leaves showed Sr-90 concentrations of 2.37 nCi/g as compared to a Cs-137 concentration of 0.091 nCi/g. Over the 13 days of feeding the goat ingested about 4,400 nCi of Sr-90 and about 170 nCi of Cs-137. During the feeding period the goat eliminated about 860 nCi of Sr-90 through the feces and excreted 17 nCi through the urine. About 80% of the ingested Sr-90 remained in the goat. At the same time the goat eliminated 17 nCi of Cs-137 through feces and about 8 through the urine. About 74% of the ingested Cs-137 remained the goat.

The urinary excretion of Sr-90 and Cs-137 was lower than the two and forty percent, respectively, reported by Comar et al (1961)⁽¹⁾ and by Wasserman et al (1961).⁽²⁾ A possible explanation is that plant assimilated isotopes are more readily assimilated by animal tissues than isotopes added superficially to plant tissues.

At the end of the experimental period the goat was sacrificed and various tissues and organs analyzed radiochemically. The results are presented below:

	Isotope, nCi/g Fresh Weight	
	<u>Sr-90</u>	<u>Cs-137</u>
Liver	0.004	0.0047
Kidney	0.0023	0.0038
Spleen	0.0010	0.0019
Muscle	0.012	0.0081
Bone	0.0095	Not Detectable
Serum	0.0019	0.011
Whole Blood	0.0034	0.020

The values obtained are generally similar to those reported in the literature for goats, although the Sr-90 content of muscle appears abnormally high.

⁽¹⁾ Wasserman, R. H., C. L. Comar and A. R. Twardock, 1961, Int. J. Rad. Biol. 4:299-310

⁽²⁾ Comar, C. L., R. H. Wasserman and A. R. Twardock, 1961, Health Physics, 7:69-80.

Based upon the data gathered in this study, discrimination factors between soil and plant and plant to animal can be estimated roughly. For example, the concentration of Sr-90 per gram of dry soil is about the same for plants expressed as grams Sr-90 per gram dry weight when plants are grown in that soil. The discrimination factor is 1. However, for Cs-137 only about 1/100 of the amount in the soil is taken up by the plant; in this case, the discrimination factor is 0.01. The discrimination factors between the concentration of Sr-90 and Cs-137 in alfalfa and goat tissues are shown below.

	<u>Sr-90</u>	<u>Cs-137</u>
Soil to Plant	1	0.01
Plant to Muscle	0.005	0.09
Plant to Liver	0.002	0.05
Plant to Kidney	0.001	0.04
Plant to Spleen	0.0004	0.02
Plant to Bone	0.004	--
Plant to Serum	0.0008	0.12
Plant to Whole Blood	0.0014	0.22

Clearly there is a strong discrimination between soil and plant in regard to cesium uptake; but, once in herbage, cesium is more readily incorporated into soft tissues of animals than is strontium.

TECHNICAL ASSISTANCE TO THE HANFORD PLANT

Summary

Environmental Evaluations

Quarterly audit surveys of waste disposal sites were completed. Bone samples from rabbits collected in the B-C crib area showed much higher Sr-90 concentration than samples elsewhere on site.

Radiation Protection

Statistical analysis of prior lung counts showed that the currently used detection limits are too low by a factor of two. The higher detection limits will be adopted April 1.

Radiation Standards and Engineering

A solution has been found for problems associated with unwanted response of alpha probes to beta, gamma, and neutrons. The bench monitor contract has been closed out. Effort continues in improving calibration facilities and associated quality assurance.

TECHNICAL ASSISTANCE TO THE HANFORD PLANT

Environmental Evaluations

(J. P. Corley, Environmental Evaluations Section)

Audit surveys of inactive and active waste disposal sites for the calendar quarter were completed on schedule. Although a few minor housekeeping items were observed and reported to the responsible contractors, the sites generally showed evidence of improved conditions since last year's survey.

Routine road surveys detected only contaminated tumbleweeds reading up to 10,000 c/m (GM) along the 200 East Area fence. Several ground survey plots near 200 East Area continued to show surface readings up to 500 c/m (GM), compared to a background reading of 100-200 c/m. Water, air, and dosimetry results were generally within expected ranges. A deer collected near 100-H in January showed no radioactivity attributed to plant sources. Bone samples from rabbits collected in the B-C crib area in February showed about 200 pCi/gm of Sr-90, much higher than samples from animals collected elsewhere on site in 1973.

Radiation Protection

(H. V. Larson, Personnel Dosimetry Section)

Statistical analysis of 84 lung counts collected over a period of four years on a group of background subjects revealed that our current stated detection limits for americium and uranium lung counting are too low. This has been suspected for some time. The statistically supportable detection limits, which are about a factor of two higher, will be adopted April 1.

Six Hanford contractors reported incidents involving radioactive materials. None of the incidents is expected to result in a significant deposition of any radionuclide. One of the incidents resulted in an extremity exposure of 29 REM to the skin. This is in excess of the quarterly limit.

Some final and some preliminary results of the Eu depositions that occurred in October 1973, have been reported. In-vivo measurements and bioassay analysis are continuing on two employees.

Year-end plutonium deposition reports to the field have been completed.

Radiation Standards and Engineering
(J. M. Selby, Radiation Standards and Engineering Section)

The unwanted response of alpha probes to beta, gamma, and neutrons was investigated and a report written. The problem is common to both scintillation and air proportional probes. It was found that beta and gamma response can be minimized or eliminated in fields up to 200 RAD/hr by reducing the gain of the system. This technique also reduces the neutron response and permits use of the probes in neutron fields of a few tenths of a MREM/hr. Alpha response is reduced 30-50% under these conditions.

The last two reworked bench monitors have been returned from the manufacturer. One of the two instruments still did not meet specifications and was rejected. This action reduces the total order from 38 to 37 units and closes out the contract.

Cross calibration of the high energy Radacon chambers with the appropriate standard chamber is essentially complete. Steps are being taken to establish calibration factors for the medium energy chambers. The radiation source for this effort will be the 320 KVP x-ray machine.

Progress continues on the development of a Cf-252 fast neutron exposure facility and a Pu-238 Be, D₂O moderated thermal neutron exposure facility.

Meteorological Services
(E. H. Phinney, Synoptic Meteorology Section)

Meteorological services, viz., weather forecasts and observations and climatological services were provided to plant operations and management on a routine basis.

<u>March 1974</u>		
<u>Type</u>	<u>No. Made</u>	<u>% Reliability</u>
Production Forecasts:	62	80.4
General Forecasts:	62	85.2
Special Forecasts:	240	90.4
Other Requests:	280	
Publications Distributed:	139	
Number of Calls Processed by Code-A-Phone:	<u>4,019</u>	
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